The Vodafone Policy Paper Series • **Number 4 • March 2006**

The role of mobile phones in increasing accessibility and efficiency in healthcare

Foreword

I hope you enjoy our fourth Vodafone Policy Paper. Our aim in these papers is to provide a platform for leading experts to write on issues in public policy that are important to us at Vodafone. These are the people that we listen to, even if we do not always agree with them. These are their views, not ours. We think that they have important things to say that should be of interest to anybody concerned with good public policy.

Arun Sarin, Chief Executive, Vodafone Group

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Published by Vodafone Group Plc

ISBN 0-9552578-0-8
ISBN 978-0-9552578-0-3

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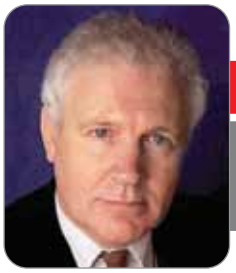

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Introduction

The personal convenience that a mobile phone can bring us is now largely taken for granted. We have all forgotten the frustrations of being stuck on a delayed journey and unable to contact whoever is waiting for us at our destination. The mobile has enabled us to lead more efficient personal lives but we are less clear about the extent to which mobile phones increase business efficiency and productivity.

This is a more difficult question to answer and one that has been studied extensively in the context of the contribution of investment in ICT (Information and Communication Technology) as a whole but not in mobile telecommunications. We wanted to look explicitly at the contribution of mobile phones to productivity and quality of service.

The pressures to improve efficiency and service exist in all sectors but perhaps nowhere more than in health care. Healthcare costs are on a rising trend, increasing at a much faster rate than inflation in the economy as a whole. In addition, people have rising expectations for high-quality care and customer service. As a result, most governments have had to fundamentally review their health policies and a major focus has often been improving the efficiency and effectiveness of the service. In that sense, we thought it was a good sector in which to explore the application of mobile technology and determine whether mobile applications could deliver greater efficiency.

There is a great temptation in a study such as this to be seduced by tomorrow's world; to focus on what might be and assume that all the technological possibilities are both cost-effective and accessible to all. We have resisted that temptation and focussed on the basic voice and text potential of the mobile phone. These functions are accessible to all users irrespective of their handset design and in the case of text, can be mastered with just a little patience and practice.

The potential for mobile applications to contribute significantly to efficiency in health care is quite recent. Once ownership of mobile phones reaches the level it now has in most of Western Europe, it becomes feasible to think of mobile as an interface between service providers and the public. Five years ago this would not have been practical.

In the simplest terms, mobile phones increase the ability to contact individuals who are leading busy and mobile lives. Where service provider – customer communication is important, as in health care, this may translate into opportunities for improved efficiency and effectiveness in service delivery.

But mobile also has other characteristics that are important in the context of healthcare. Privacy and confidentiality is important and because mobile phones are essentially personal and not shared devices, it is more acceptable than alternative means of communication to many users. People who are at work, but need to make a call to their doctor, can be more comfortable about being called back on their mobile rather than their fixed office phone. Similarly, our research suggests that teenagers are using their mobile phones to obtain health advice as the mobile enables them to conduct a call in private without the risk of being overheard.

Mobile phones also extend access to people in different social situations. Students away from home, business travellers, migrants and people in rented accommodation are all more likely to have consistent access to a mobile than a fixed phone, or indeed a postal address.

Some governments are considering implementing internet-based e-health interfaces between health service provider and customer. This is often viewed as a potential source of cost savings and efficiency improvements; yet this would seem to raise significant problems of access for some disadvantaged and mobile groups.

Of course, mobile phones are not the panacea for the challenges of the healthcare sector. There are some parts of the service such as geriatric care and mental health where the potential is probably very limited. But equally, there are other segments where mobile phones would appear to be particularly well suited to tackling some of the sources of inefficiency and ineffectiveness in health care provision.

In this report, as with the previous editions in the Public Policy Series, we have turned to the experts in the sector to analyse the situation and present their views on the subject. We asked the Office of Health Economics (OHE) Consulting to look at the overall trends in healthcare costs in Western Europe and in that context assess the scope of potential applications of mobile phones. We have also turned to Dr Rifat Atun and his team of health economists at the Tanaka Business School, Imperial College London, who collaborated with experts at NHS Direct, the University of Dundee, and other institutions to produce a series of case studies.

Their analysis highlights three areas where mobile applications offer potential value to healthcare providers, patients and funders (whether private or public):

- Tackling inefficiencies in service provision by improving communication between service providers and users, e.g. missed appointments. Missed appointments cost the NHS approximately £780 million per annum in England alone. Extrapolating the rates of improvement in attendance from existing text message reminder schemes suggests the potential for cost savings from this single mobile application are in the range of approximately £240 to £370 million per year in England. This is equivalent to roughly half the projected £600 million deficit for the NHS in 2005-06.
- Improving the effectiveness of healthcare (and the risk of more serious complications) through improved self management and monitoring of patients with chronic conditions e.g. diabetes, and improved adherence to treatment programs e.g. tuberculosis. Chronic conditions such as diabetes place significant, and increasing, demands on healthcare services in Western Europe. In the UK, the cost of diabetes is estimated to be around 9% of the NHS budget.
- Increasing the ability of some hard-to-reach groups such as teenagers, the working population, or the homeless, to access healthcare services by reducing the barriers of inconvenience, confidentiality or privacy.

The conclusions should not really surprise us. Just as we take the convenience of the mobile for granted, perhaps that same complacency is causing us to miss opportunities to configure more efficient and effective business processes founded on the widespread access to mobile phones.

The reports here include a wide range of examples of mobile applications in different countries, many at the pilot stage or not yet widely imitated. Many of the examples come from developed countries where individual access to mobiles is widespread, but there is also a growing number of mobile voice or text applications in developing countries, where mobile penetration is spreading rapidly. There is great scope for health services to consider whether the kind of examples documented here could be applied in their own contexts.

The following reports are in some cases summaries of more extensive work that is published on public websites. The links to those papers are referenced in the texts. We hope this report stimulates debate and we are happy to present the findings in greater detail to interested parties or discuss practical applications. We encourage you to contact us or the authors directly to express your views and ideas. You can contacts us at Vodafone on the following email address: publicpolicy@vodafone.com

We hope you enjoy reading the report and find it thought-provoking.

The Upward Trend in Healthcare Spend

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Introduction

During the twentieth century and into the twenty-first, both the incomes and the health of the population of Western Europe have increased enormously. As people have become richer, their demand for health care has increased. At the same time, the unit cost of health care inputs has risen faster than prices in general. Western Europeans have therefore been spending an ever greater proportion of their income on health care. Most of this spending has been funded through taxation or through premiums paid to insurers – both social insurance funds and private insurance companies. As a result of the persistent upward pressure on health care expenditure, governments and insurers have naturally focused ever more on controlling costs.

Countless health care reforms have been implemented to try and put a brake on spending. Health services are very labour intensive, so an important explanation for the cost pressure is the growth in wages of health workers, which have not been offset by productivity increases.[1] New health care technologies may be another culprit for although they lead to better health for patients, they are often substantially more expensive than the technologies they replace. However, some new technologies can also increase the efficiency with which health care is delivered, and help save on costs.

Mobile telephony may be such an efficiency-improving technology. It may improve access to health care and health information as well, which can be expected to increase demand for health care. If it meets people's health care needs better, it may lead to consequent health gains for the population. The potential of mobile is thus to help provide more accessible and better health care, more efficiently.

In this article we outline the characteristics of health systems across Western Europe, the drivers of escalating health care spending, and the types of health reforms intended to contain costs. This leads on to a discussion of how mobile telecommunications may help in the search for improved efficiency, while also potentially improving the accessibility of health care.

Increasing health care spending in Europe

In 2000 the World Health Organisation reviewed health care systems around the world and highlighted the particular focus on their effectiveness and equity in Europe.[1] Effectiveness revolves around three important concepts:

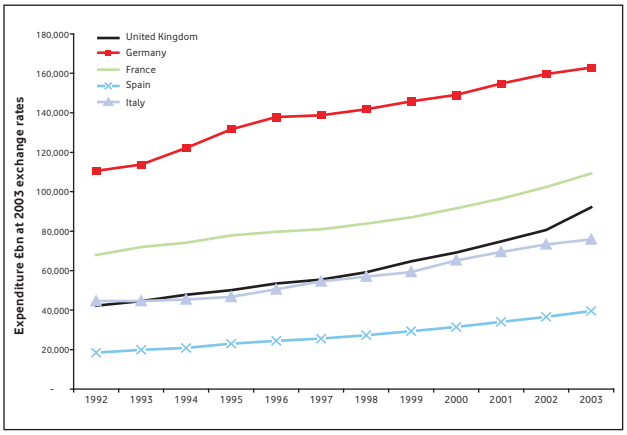
- **Health** – This is the most important aim of a health system. All individuals should be as healthy as possible throughout the whole of their life.
- **Responsiveness** – This refers to how well a health care system performs in meeting patients' expectations about how they should be treated. In the majority of cases this would lead to greater utilisation of health services, but in some aspects of care greater autonomy would mean patients making informed decisions not to take up a particular treatment. As with the other concepts, for the health system to be equitable the same responsiveness should be available to all members of society.
- **Fair financing** – The costs of the health system should ideally be distributed according to ability to pay rather than risk of illness, so that everyone within a health system will be equally protected financially. There are two particular ways in which payments can be unfair. In some cases payments can be regressive meaning that the less well-off have to pay a higher proportion of their income. In other cases there are large unexpected expenses at the time of utilisation.

Western European health systems are, in the WHO's view, generally effective based on these criteria; and in most cases expenditure is low compared with the USA.[2] However, pressures on health systems have led to escalating costs in Europe as elsewhere. Cost containment and efficiency improvement have therefore become a driving force behind reforms, in addition to other objectives such as improving public health, ensuring equitable access, improving quality and building a more responsive health system.

In the last 40 years health care spend has risen at a faster rate than both population and GDP. In 1960 average health care spending in the EU15* was 3.9 per cent of GDP. This had almost doubled by 1980 to 7.2 per cent. Although growth slowed slightly in the 1980s, expenditure is now steadily on the rise again, with an average of 9.4 per cent of GDP being spent on healthcare by the EU15* countries in 2003. Figures 1-3 show how total health expenditure, health expenditure per capita and health expenditure as a percentage of GDP have risen in five western European countries since 1992.

There is no sign of the upward trend in health care spending coming to an end either. A thorough investigation by the UK Treasury of the resources required by the National Health Service concluded that over the 20-year period to 2022 total NHS spending would increase "at an average rate of between 4.2 and 5.1 per cent a year in real terms", faster than even the most optimistic expectations of future GDP growth. The Wanless Report attributes part of this growth to the UK needing to catch up to spending levels, expressed as a percentage of GDP, in the rest of Europe.[3] But part is due to the continuing pressure from exogenous drivers of health care expenditure, which are felt everywhere.

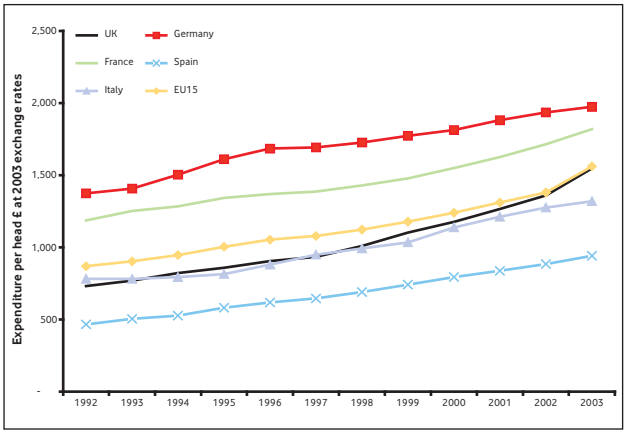
Figure 1: Total health care expenditure, £bn at 2003 exchange rates



Source: OECD, 2005[4]

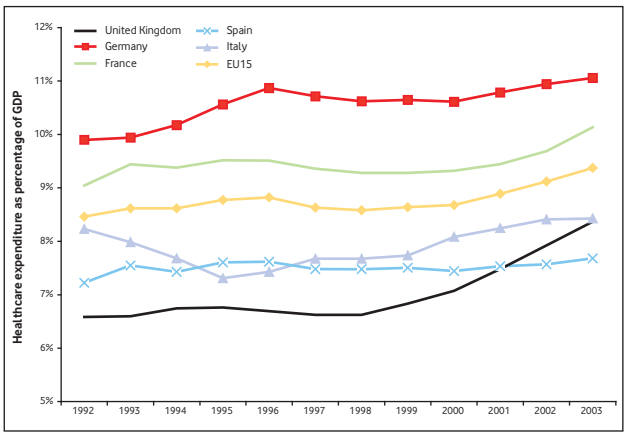
*EU15 represents the 15 member states of the EU as they were before May 2005.

Figure 2: Health care expenditure per head, £ at 2003 exchange rates



Source: OECD, 2005[4]

Figure 3: Health care expenditure as percentage of GDP



Source: OECD, 2005[4]

There has been much debate over the determinants of growth in health care expenditure (particularly as they may suggest avenues for cost-containment), but three factors are commonly seen as the main cost drivers:

- Rising income and patient expectations;
- Demographic change, especially the aging of the population;
- New technologies.

1. National Income and rising patient expectations

Health care expenditure is strongly positively correlated with national income. Lower income countries tend to spend 0.7 to 1.3 per cent of GDP on health care whilst middle income countries spend 2.3 to 4.9 per cent and high income countries spend 6 per cent or more; much more in some cases.[5] Newhouse carried out a classic study where the determinants were examined across 13 countries, and found that national income may 'explain' up to 92% of the variation between countries.[6] In studies published since then, it has been reported that the level of GDP per capita explains around 80 per cent of variation between countries in health care spending. However this relationship may be a proxy for a range of supply (e.g. technological change) and demand side factors (e.g. aging and increased incomes).[7]

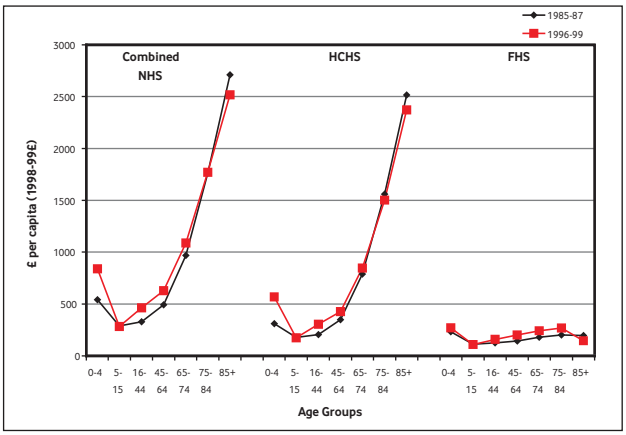
Patient demand for health care rises with increasing incomes. Further, the share of an individual's income spent on health will be higher the greater their income. On the supply side, technological progress means that, as the extent of what is feasible widens, patients come to expect ever more from health services. These are mutually reinforcing effects: growing public knowledge about health care and a desire for more information on ways to improve health, lead to increasing demand for health care. Given the eternal pressure for more and better access to health care, then, technologies that improve efficiency are ever more desirable.

2. Demography and the aging population

One of the benefits of health care is its contribution to life expectancy (Tables 1 and 2). As a consequence of increasing longevity, the average age of Western European populations is rising. Older people consume more health care resources. In the USA health expenditure on those aged over 65 years was three times as great as those aged 19-65.[8] In the UK, spending per capita also increases with age (see Figure 4).

However, the main driver may not be age per se but rather 'proximity to death'. Most health care spend happens in the last two years of life, at whatever age we die. The "compression of morbidity" hypothesis sees the effect of medical innovation and lifestyle changes postponing the most severe adverse health effects of chronic diseases. Additional years of life are more likely to be lived in health rather than disability. As a result, it is proximity to death rather than age that has more impact on health expenditure.

Figure 4: Age-expenditure curves for NHS expenditures



Source: Seshmani and Gray, 2002.[10]

Notes: HCHS = hospital and community health services, i.e. secondary and tertiary health care

FHS = family health services, i.e. primary health care, including prescriptions dispensed outside hospitals.

In a study comparing the effects of age and proximity of death on health expenditures in Oxfordshire, England, the probability of being admitted to hospital increased exponentially in the quarters immediately preceding death.[11] Figure 5 shows the effect of proximity to death on hospital costs by combining the probability of being admitted to hospital with costs incurred in hospital. The study confirmed that proximity to death was a greater predictor of health expenditure compared to age. Nevertheless as an increasing proportion of the population is in the elderly group, the absolute numbers of people in high-health-care-cost stages of life are increasing. Demographic change thereby adds a gradual but persistent upward pressure on health care expenditure.

Table I: Life expectancy at birth in European countries, females, 1950 - 2025

	1950-55	1960-65	1970-75	1980-85	1990-95	1995-2000	2000-05	2010-15	2020-25
EU15*	**69.3**	**7.9**	**75.0**	**77.6**	**79.6**	**80.5**	**81.5**	**82.8**	**83.9**
France	69.5	74.5	76.3	78.9	81.5	82.3	83.0	84.1	85.3
Germany	69.6	72.9	73.8	76.8	79.1	80.4	81.4	82.8	84.0
Italy	67.8	72.6	75.2	78.0	80.5	81.8	83.0	84.2	85.4
Spain	66.3	72.7	75.7	78.9	81.0	82.0	83.1	84.4	85.6
UK	71.8	73.8	75.2	77.2	79.0	79.7	80.6	81.8	82.9

Source: Yuen, 2005[9]

Table 2: Life expectancy at birth in European countries, males, 1950 - 2025

	1950-55	1960-65	1970-75	1980-85	1990-95	1995-2000	2000-05	2010-15	2020-25
EU15	**64.9**	**67.6**	**68.8**	**71.1**	**73.2**	**74.5**	**75.6**	**77.1**	**78.4**
France	63.7	67.6	68.6	70.8	73.3	74.6	75.8	77.3	78.5
Germany	65.3	67.4	67.9	70.3	72.6	74.2	75.6	77.1	78.4
Italy	64.3	67.4	69.2	71.5	74.0	75.7	76.8	78.1	79.4
Spain	61.6	67.9	70.2	72.8	73.8	74.9	75.8	77.2	78.5
UK	66.7	67.9	69.0	71.2	73.6	74.7	75.9	77.3	78.6

Source: Yuen, 2005[9]

Figure 5: Health care expenditure in the quarters preceding death

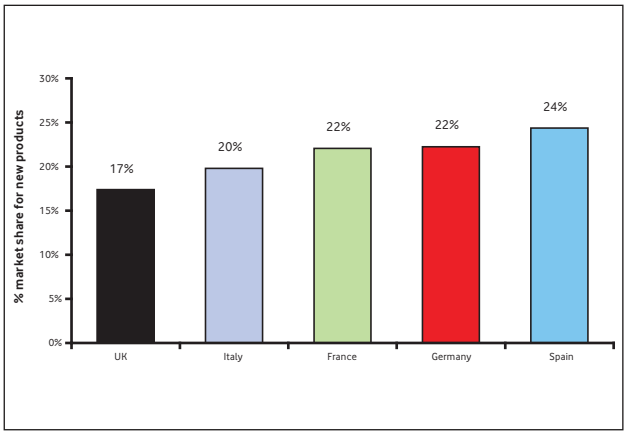
Source: Seshamani and Gray, 2004.[11]

3. New health technologies

In a separate review of health expenditure over the last three decades it has been shown that the effect of age on expenditure may have changed over time. As the elderly have typically become less frail, clinicians have been more willing to use aggressive forms of treatment, thereby decreasing disability, but also further increasing costs.[12]

This is just one aspect of the technological change in medicine that many economists see as a primary reason for escalating health costs. Medical technology is constantly improving, delivering a higher quality of care or health outcomes, but these improvements can be expensive to the health care system by expanding the scope of what is possible, treating conditions that are previously intractable and increasing the number of people who can be treated successfully. This pattern of increased treatment possibilities is particularly obvious with medicines. The newer medicines tend to be more expensive than the older ones and this, in addition to the increase in volume of prescriptions to the elderly, has driven pharmaceutical expenditure.[13] In Western Europe in 2004 the share of the medicines market accounted for by new drugs launched in the five preceding years ranges from 17% to 24% (see Figure 6).

Figure 6: 2004 share in medicines market of products launched in last 5 years



Source: IMS World Health; OECD, 2004.

Technological change in health care goes beyond medical equipment and medicines, though. Information and communication technology (ICT) has had a major impact on the changing health systems in Western Europe. Not only is there increasing access to information for patients and health care workers, but the speed at which data can be processed and communicated means that decisions are made more rapidly. ICT has led to the creation of decision making tools, meaning that roles which were once the preserve of physicians can now be delegated to other health care professionals.

Both the demand for and supply of health care can be heavily influenced by the availability of ICT. Health care expenditures are, in such cases, subject to both upward and downward pressures. Improved accessibility can increase health care spending, but improved efficiency can decrease it. Mobile telecommunication is an area of new technology with the potential for both these characteristics – making some health care more accessible and increasing the efficiency with which health care is provided. This is particularly the case when considering health care for adults in the 16-44 age group, as it is this section of the Western European population that is most likely to use mobile phones to contact health providers.[14]

The increased health care spend resulting from all these pressures is a persistent trend. Consequently, Western European governments and third party payers have pursued a continuous succession of reforms aimed at controlling their costs.

Health Care Reforms

Given the fact of the aging population, health system reforms in Western Europe are limited to managing of technological change and people's expectations in an attempt to control costs through demand management; plus attempts to stimulate efficiency on the supply side.[15]

Demand Management

There are four main methods through which health care reforms are used to manage patient demand for health care:

- **Gatekeeping** in a health care system means that patients can only gain access to non-emergency specialist care if they first see, and are referred on by, a generalist physician. This is thought to improve effectiveness by ensuring continuity of care for the individual, but it also regulates the demand for hospital services and so constrains expenditure.

- **Prospective budgets for prescribers/ referrers** – GPs are given annual budgets to cover prescribing and non-emergency hospital treatment such as diagnostic tests, surgery and maternity care for the population they serve. This approach is based on the belief that primary care physicians may be more effective purchasers than health authorities or insurance companies, as they are closer to patients.

- **Co-payments** – Patients in Ireland and France, for example, face significant co-payments (user charges) for the use of primary care, which should reduce the amount of health care demanded by increasing the price to the patient at the point of use.

- **Coverage restrictions and health technology assessment** – In many European health systems there is an attempt to limit the range of services covered. There are numerous mechanisms through which this may be achieved: the use of positive lists to specify which services are covered; use of negative lists where services are excluded from reimbursement; and use of clinical guidelines or technology assessments to outline clinical and cost-effective practice, such as are undertaken by the National Institute for Health and Clinical Excellence (NICE) in England and Wales.

Increasing efficiency in health systems

In Western Europe a number of reforms have also been implemented in the attempt to increase health system efficiency. Three major aspects have been targeted in these reforms:

- **Provider market** – Prior to the 1990s many tax funded health care systems were vertically integrated, i.e. institutions such as hospitals were both the payer and the provider of a particular service. To permit the development of a more competitive environment, there has more recently been a movement towards the separation of the purchaser and provider functions so that hospitals and other providers of health care compete for funds from local health care purchasers.

- **Payment mechanisms** - In many of the health systems within Western Europe, providers are paid according to activity levels which are then adjusted for case mix. This type of prospective reimbursement is generically known as a diagnosis related group (DRG) based funding, where inpatients are grouped according to their diagnosis and resources used. There is then a price for each episode of care. This encourages health care providers to minimise unit costs, so as to maximise the surplus they earn.

- **Purchaser market** – In a number of social insurance based health care systems (e.g. Germany, the Netherlands and Belgium), the public are now able to choose between sickness funds based on the premium they must pay and perceptions of quality.

We have outlined the drivers of health care expenditure in Western Europe and some of the many health reforms used to try and constrain cost. The success of these health reforms relies on the availability of information. In many European nations the reforms have reinforced the patient choice agenda. Patients can thereby have greater influence over which provider they use or which treatment they receive. Yet if the relevant data on performance, quality of treatment, and in some cases insurance premium to be paid, are not available to enable patients to choose between competing sickness funds in social insurance systems or hospital providers as in the UK, then choices may well be inefficient and not drive improvements.

Of equal importance to patients is information regarding treatment of diseases. Institutions such as NICE which produce guidelines outlining clinical and cost-effective treatments do have sections specifically for patient information, but it is not known whether patients know these exist or know how to access that information. The advent of mobile technology presents an opportunity for improved interface between the provider of health care and the patient, enabling the communication of information about health care and therefore the provision of health care to be more efficient.

Impacts of mobile telecommunications on health care provision

Mobiles provide an information highway (with regards to health care) that has yet to be exploited to its full extent. An attribute that makes its use in health care particularly attractive is the personal nature and the unique number of the device, which could help safeguard the confidentiality required where personal medical information is concerned. Mobile phones now have a wide range of facilities that may be useful in a health care context, such as web access, video, photo messaging, and SMS text messaging.

A note of qualification is, however, necessary. In Western European and other high income countries, the majority of health care spend is in response to chronic diseases rather than acute illnesses. Chronic conditions such as chronic obstructive pulmonary disease, heart failure and coronary heart disease tend to affect the older section of the population more than younger adults or children. Mobile phones are at present somewhat less likely to be utilised by this older age group. Nevertheless there are still a number of chronic diseases that have a significant impact and generate substantial health care expenditure on younger adult age groups, who are more likely to use mobiles as a method of communication. Please see table 2 on page 19 for a breakdown of mobile phone use by age group in the UK.

Before discussing the specific disease areas in which mobile phones might have a particular role, it is worth considering how mobiles could improve the efficiency of health care provision in general. Patients' non-compliance, or incomplete compliance, with treatment is commonplace and can be detrimental to the effectiveness of health care interventions, increase the costs to society and therefore have a significant impact on the economy in the following ways:[16,17,18]

- Increased morbidity and mortality result, which could have been prevented if treatment had been fully complied with;

- Increased cost pressure on health care systems as medicines are prescribed but then wasted, and higher expenditure on these patients due to increasing admissions to hospitals or increasing physician consultations;

- Loss of productivity as non-compliance with medicines causes avoidable illness that may lead to absence from work.

Non-compliance exists in many therapeutic areas but is a particular issue when medicines are taken for preventive

purposes, as patients do not suffer symptoms and so may feel less need to take their medications. Up to 80% of patients may be non-compliant.[19] Therefore both in terms of reminding patients to take medicines and as an information conduit to educate about the reasons to take medicines, mobile phones could be an important technology. Studies have shown that such low cost methods to aid compliance can improve effectiveness of health interventions and produce cost-savings.[18]

A number of models have been suggested as ways to aid compliance with medicines. In a 2003 WHO publication, information, motivation and behavioural skills were described as the main drivers of compliance.[18] Mobile telephony can have a direct effect on motivation and can be used as a channel to enhance patients' information and knowledge about disease.

Treatment of chronic infections such as HIV and TB involves complex medicine regimes. The antiretroviral drugs used in HIV sometimes need to be taken at specific times with regards to food intake, and can have severe side effects. Evidence has shown that medicines should be taken correctly 95% of the time in HIV to ensure a good chance of the medicines working.[20] Thus non-compliance can be detrimental to the effectiveness of treatment and lead to a significant burden on future health care resources. As the majority of HIV sufferers are young adults, the use of mobile phones as the medium for reminder services could be very useful in aiding compliance. Mobile technology in the context of TB is discussed in detail in a later article in this Vodafone Policy Paper.[21]

Chronic diseases such as diabetes also have a substantial effect on young people. A later article discusses the use of a mobile application in the management of diabetes.

Around 1.3 million people are diagnosed with diabetes in the UK. Life expectancy is reduced on average by more than 20 years in type 1 diabetics and 10 years in type 2 diabetics. Around 5-10% of total UK NHS resources (including hospital expenditures) are used for the care of people with diabetes, but if there were better control of the disease, treatment costs could reduce by 25%.[18]

However it is only through education about long-term complications via access to information about the disease that compliance may truly be improved. Mobile technology could be one way of improving communication between health care professionals and patients. This may reduce the disease burden of young diabetics and therefore reduce costs through reduction of admissions and long-term complications.

Other chronic diseases where mobile technologies may be able to play a similar role include asthma, epilepsy and rheumatoid arthritis.

There are 5.2 million people in the UK (9% of the total population) with asthma; the majority being children, adolescents or young adults. It is the most widespread long term condition in children and costs the National Health Service about £1 billion a year. Although the majority of patients are children, the loss of productivity still equates to at least £1.2 billion. Medication is delivered by inhaler devices for the most part, which can sometimes be difficult to self-administer. The patient may therefore not get the required dose to treat the symptoms. As few as 30% of asthmatics may be fully compliant with their medicines, and this may contribute to 18-48% of asthma deaths. It is therefore not surprising that optimal control of asthma could save substantial medical costs.[18] If mobile telecommunications technology could provide reminders and education to the patients (or those responsible for them), the health benefits which should be provided from the use of asthma medication are more likely to be realised and unnecessary cost consequences avoided. Studies obviously need to be carried out on the use of mobile technology to improve compliance, but there is clearly potential.

Epilepsy is a neurological condition characterised by seizures and does not necessarily have any identifiable cause. It is the most common chronic neurological condition in the UK, and affects between 260,000 to 416,000 people. The total annual cost of established epilepsy including direct and indirect costs is estimated at £2 billion in the UK.[25]

As medication is paramount to control seizures in patients with epilepsy, non-compliance can have serious consequences for the patient. Non-compliance could increase costs to the health care system through hospital admissions as well as having social costs, e.g. suspension of driving licence. Reminder text messages could be sent to the patient to aid compliance when a dose is due. In addition the availability of information about the disease on the mobile phone through web-based services could improve compliance through improved understanding. A further possible application arises from the fact that many anti-epileptic drugs can have unusual and severe side-effects, which must be monitored.

As with epilepsy, the prevalence of rheumatoid arthritis increases with age. However 12,000 children in the UK suffer from juvenile arthritis, 80,000 young adults suffer from osteoarthritis and about 20,000 young adults suffer from rheumatoid arthritis.[26] Although the burden of disease is not large, the toxicity of some of the medicines that can result from their prolonged use means that the regimen needs to be complied with and medicines taken appropriately. In both osteoarthritis and rheumatoid arthritis, non-steroidal anti-inflammatory drugs (NSAIDs) may need to be taken to combat the pain. In addition many rheumatoid arthritis

patients have to take disease-modifying drugs in order to prevent progression. As with inhaled steroids in asthma, these medicines do not improve symptoms of disease and therefore are liable to non-compliance. They can also suppress the immune system so it is also important for the white blood cell count to be monitored. In certain patients, these results could be communicated with a change in dose via a mobile phone. This may again reduce the communication costs and reduce the chance of an infection, particularly if the change in dose can be communicated quickly without an appointment with the physician.

Patient access to health care and information

In addition to the health care effectiveness benefits of mobile technology, so apparent in reducing non-compliance with medicines, there are also access benefits. Users of mobile phones could more easily than before access information about performance of local provider, about their diagnosis, and about available local services.

We have already mentioned how performance management reforms across Western European health care systems include giving patients more information on the performance of their health care systems. Aligned with these reforms is the patient choice agenda. Here patients are given a choice of providers at the point of referral. If ICT including mobile telecommunication could be used to make performance information more easily accessible, then patients could make better informed choices between alternative providers of health care. This in turn should be expected to increase efficiency and quality in the system.

In Germany and other social insurance systems in Europe, patients can choose between different sickness funds. Lower premiums are charged when sickness funds have contracted with more efficient providers. If the premiums charged across the different funds could be communicated to the patients via mobile technology (reducing the patient's search costs), then an efficient and informed choice could be made.

Conclusions

Health expenditure has been increasing throughout western Europe. In an attempt to contain costs, there has been much interest in the different drivers of expenditure, and in implementing reforms to counteract them. The two areas most likely to be responsive to these reforms are: rising patient expectations; and technological change in health care (including new medicines). Reforms have therefore been instituted in all countries of Western Europe to manage demand for health care and increase efficiency on the supply side.

ICT has had, and continues to have, a significant part to play in these reforms, particularly in improving the provision of information. Mobile phones have a broad pattern of ownership and use, especially among the 16-44 age group, and present a great opportunity as an information conduit.

Use of mobile technology is evolving within health care and although it is too early to tell from published evaluations how successful it will be, the potential is clear. This is particularly true for patients in those age groups most likely to use mobile phones as their primary means of communication. The potential impacts can be divided into two categories: the efficiency of health care delivery; and the ease with which patients can access health care.

Mobile phones can increase the efficiency of health care provision by reducing communication costs and thereby improving the interface between health care professionals and patients. Such improvements may be particularly valuable where they can improve patients' compliance with their treatments. Reducing poor or non-compliance provides a particularly important example of how mobiles might help reduce the burden of disease on the health system and the economy through better communication.

Mobile phones also provide another avenue to access to health care and health information. This may increase the demand for health care but if the consequent additional services are cost-effective or lead to reductions in future health care costs by improving health outcomes, then the cost impact may be modest relative to the health benefits obtained.

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Analysis of calls to NHS Direct

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Foreword – Dr. Mike Sadler

NHS Direct was created to make healthcare advice and information available and easily accessible 24 hours a day. It has achieved this extremely successfully, and now has over 2 million contacts per month through its multiple channels. NHS Direct has been able to improve access to health services specifically for some sectors of the population that often do not access conventional services such as GPs surgeries – young men aged 16-44 are an example. Men in this age group are also the highest users of mobile phone technology, and there is little doubt that mobile phone technology is a key part of NHS Direct's success in this area. Characteristics such as privacy and mobility are especially important for some users in this age group.

Mobile phone technology is a key part of today's society, and shares some of the characteristics of NHS Direct in its ability to increase access and availability of services and information. The public have demonstrated their desire for continued improvements in access to information about health care. SMS offers further opportunities to deploy the benefits of mobile phone technology and improve access to health care and information. NHS Direct is committed to exploring this area further in 2006.
Dr Mike Sadler is the Medical Director of NHS Direct.

Introduction

Effective health care depends on the accessibility of health care services. Yet the characteristics of modern-day life often work against ease of use. Trends such as increasing foreign travel and the pressures of work can greatly complicate timely and convenient access to a doctor or clinic. The mobile phone, particularly its independence of location, offers a far better prospect of timely interaction between health service and patient.

Yet while the mobile phone is being used by health service professionals to improve their efficiency and their access to information, and while members of the public are also using it for the exact same reasons, it appears that the mobile phone is typically not widely used as the point of contact between the two groups: the health service providers and their patients. To explore whether mobile phones are becoming a more widely used means of communication between health professionals and patients, we analysed the use of NHS Direct in the United Kingdom.

NHS Direct is a nurse-led telephone information service providing basic healthcare advice to callers that is accessible 24 hours a day, seven days a week. It is the largest telemedicine service in the world.[1] We analysed the total number of fixed and mobile calls that NHS Direct received over a six month period. We also studied the characteristics of calls made to NHS Direct from the Vodafone network over the same period. Our aim was to establish the impact that mobile is having on this service. The pattern of calls clearly suggests that mobiles do enhance the accessibility of NHS Direct services for some groups of people.

The data used

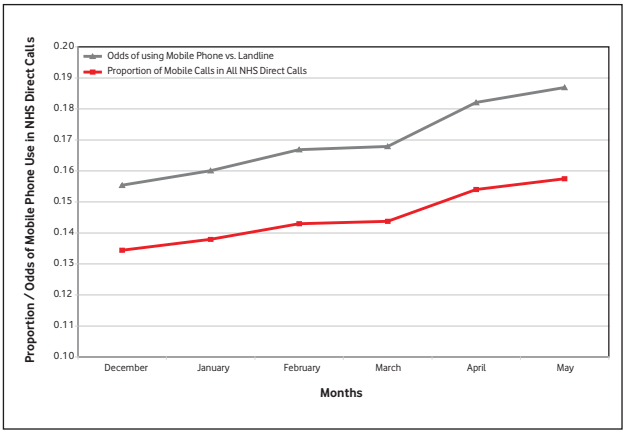
Two complementary data sets were used for this study.

(1) NHS Direct provided data on over 3.3 million calls received during the six month period from December 2004 to May 2005. The date (day/month/year) and the hour of each call is recorded along with information on whether the call originated from either a fixed line or a mobile phone. The gender and age of the patient calling are also included in the data.

(2) Vodafone provided data on over 140,000 calls made by Vodafone subscribers to NHS Direct between December 2004 and May 2005. Postcode information identified the location of the caller and it was possible to follow the calling patterns of individuals to NHS Direct over the given period. The phone numbers of callers were modified for confidentiality and all mobile phone numbers remained encrypted throughout the research.

The total number of calls to NHS Direct during the six months averaged 16,758 per day and was growing at an average monthly rate of 1.5%. Calls from mobiles grew at a much faster monthly average rate of 4.6% compared to just 1% for fixed. The share of calls from mobiles as a percentage of the total number of calls to NHS Direct increased from 13.4% to 15.7% over the period; equating to an increase from 67,067 calls in December to 81,801 calls in May. The odds that a caller to NHS Direct was using a mobile rose from 0.155 to 0.187. (See figure 1). The number of mobile calls to NHS Direct as a proportion of the total number of calls was 19% during the week and 14.5% at the weekend.

Figure 1: Proportion of calls to NHS Direct from mobile telephones

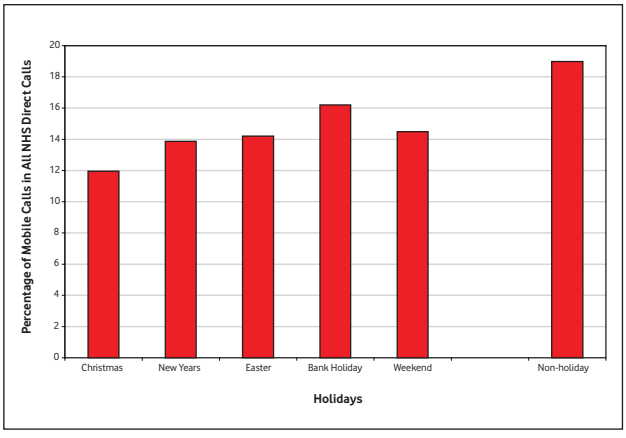


More calls to NHS Direct were made on holidays, with a maximum of 26,316 calls on Good Friday, followed by 26,060 and 25,828 calls respectively on the Christmas Bank Holidays. While holidays were peak times for calls to NHS Direct, the proportion of mobile calls was at its lowest during the holidays (Figure 2). During the Christmas holidays (December 25 to December 28), the number of mobile calls as a proportion of total declined from a non-holiday average of 19% to 12%. Furthermore, approximately 30% more mobile calls are made to NHS Direct during the week than at weekends.

This pattern suggests that using their mobile enables callers to balance their health enquiries with other demands on their time, particularly work. It is on weekdays, when they are not at home, that mobile use is greatest. In these circumstances, mobile also has an important privacy aspect as it is much more convenient and confidential for calls to be made from and returned to mobiles as opposed to a fixed line office phone.

NHS Direct telephone operators provide accessible and private healthcare advice around the clock.

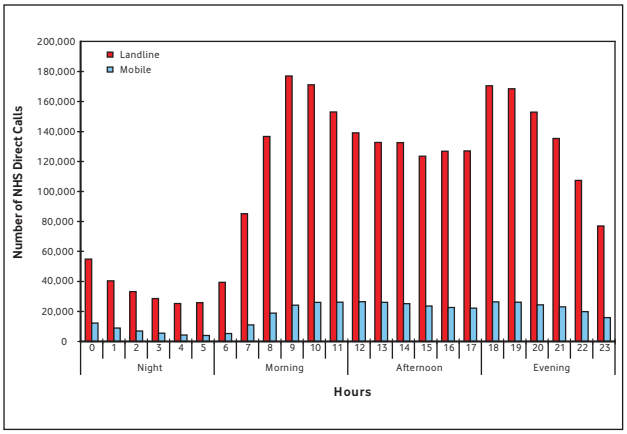
Figure 2: Mobile telephone calls to NHS Direct during workdays, holidays and weekends as a proportion of total calls



The timing of the calls in a given day also supports this hypothesis. The total number of calls is highest at 9am and 10am in the morning (Figure 3). The frequency of calls then declines. A second peak occurs at 6pm, perhaps due to the closure of GPs' surgeries and thereafter it falls gradually until 4am.

These statistics could also support the argument that the bigger driver of NHS Direct use is, in fact, convenience as opposed to "out of hours" access. Enabling convenient access to health services generally improves the customer's experience, encourages greater use of the services available by groups who face particular pressures on their time and ultimately improve the efficiency of delivery. Further breakdowns of the NHS Direct data shed more light on these trends, and we turn to these next.

Figure 3: Timing of calls made to NHS Direct from fixed line and mobile telephones



Analysis of Calls by Gender and Age

The distribution of the callers by gender shows that women call NHS Direct more often than men, accounting for 59.5% of all calls. However, when calling NHS Direct, women use mobile phones less frequently (11.4% of all calls initiated by women) when compared with men (15% of all calls initiated by men).

The age distribution of callers to NHS Direct is shown in Figure 4 and indicates a predominance of younger users of NHS Direct. The most frequent calls are made in relation to infants and children below the age of 5 years, invariably by parents or carers, and these constitute about 18% of all calls. Amongst the adult users, those aged 20 to 24 years of age are the most frequent callers, followed by the age groups 25 to 29 years and 30 to 34 years. The number of calls declines as the age of callers increases beyond 25 years.

The use of mobile phones to call NHS Direct is strongly influenced by age group. A breakdown of all calls to NHS Direct from mobile phones reveals that:

- 7% of all calls to NHS Direct from mobile phones are made by the age group 15 to 19 years.
- 22% for the age group 20 to 24 years;
- 18% for the age group 25 to 29 years;
- 12% for the age group 30 to 34 years;
- In aggregate over 59% of all mobile calls to NHS Direct were made by people within the ages of 15 to 34.

Figure 4: Number of calls to NHS Direct by age group and telephone type

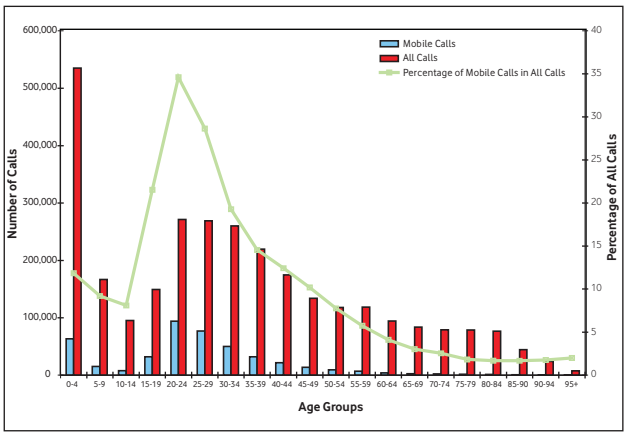
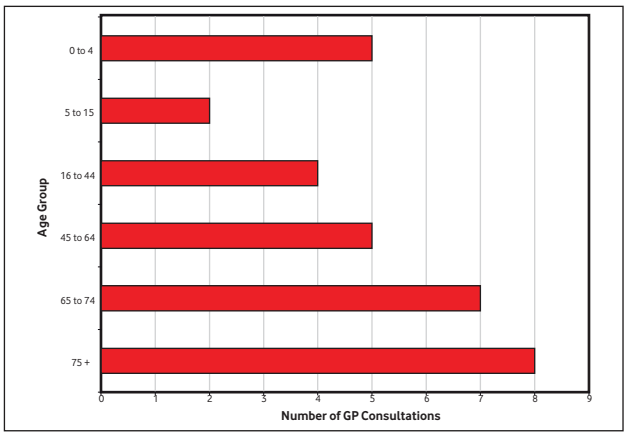
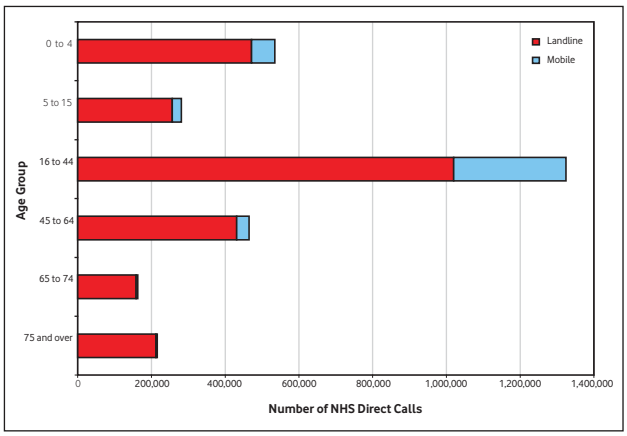


Figure 5: NHS GP consultations and NHS Direct Calls by age group





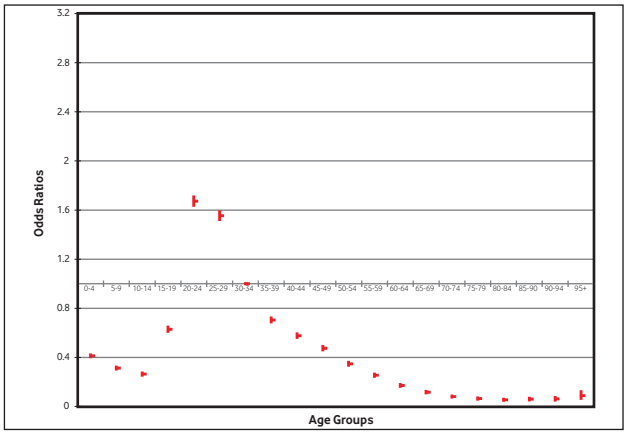
As previously indicated, those aged 20 to 34 years are the most frequent callers to NHS Direct and the elderly (aged 75 and over) are the least frequent callers to NHS Direct. The number of calls they make using mobile phones (on average 1.7% of total) is also the lowest when compared with other age groups; and this level of mobile use is stable throughout the day with a decline at night. Those aged 50 years and above, in particular those aged 75 years or older, are more likely to call NHS Direct during holiday periods as compared with work days and non-holiday periods. For the latter group the number of calls in holiday periods increases two-fold.

NHS GP consultations and NHS Direct calls by age group

The contribution of NHS Direct as a distinctive means of access to health services for certain groups can be seen if compared to the average number of NHS GP consultations by age group from the General Household Survey (2002)[2]. It is striking that the least frequent users of GP services, namely the age group 16 to 44 years, are the most frequent users of NHS Direct and people in this group are the most frequent users of mobile telephones when accessing NHS Direct. In particular, the men in this age group, who are the least frequent users of GP services, are also the most frequent users of NHS Direct. Men in this age group are also the most frequent users of mobile phones when accessing NHS Direct. This reinforces the argument that NHS Direct has increased access to health services for certain groups and furthermore the ability to access NHS Direct via mobile phones further increases choice, access and accessibility for those groups.

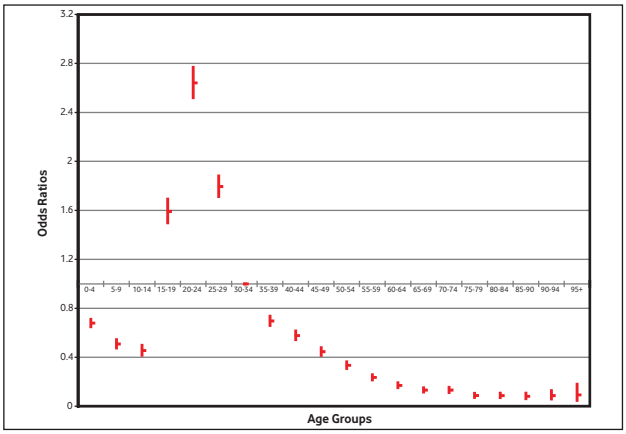
In order to shed greater light on the issues of access and the contribution of mobile, a regression analysis was used to estimate the odds (the likelihood of an event happening when compared with a comparator) of using mobile phones when calling NHS Direct. The analysis controlled for gender and age categories.

Figure 6: Odds of using mobile phones when calling NHS Direct by Age Group for Men



For women, the odds of using mobile phones are more pronounced for younger age groups. When calling NHS Direct, the highest odds of using a mobile phone is at 2.64 for the age group 20 to 24 years. This is followed by age group 25 to 29 when the odds decline to 1.8. Relative to the mean age group of 40 to 44 years, the odds of 1.59 are also high for the age group 15 to19 years. As with males, the odds decline after age 24. (Figure 7)

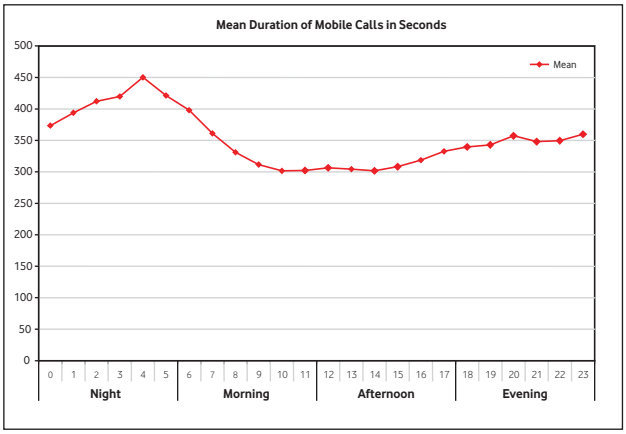
Figure 7: Odds of using mobile phones when calling NHS Direct by Age Group for Women



There is a significant difference in the number of calls placed by teenage girls aged between 15 and 19 when compared to teenage boys. The reasons for the individual calls were not shared with us but teenage girls are significantly more likely to require privacy on medical matters than their male counterparts. The mobile phone enables them to have access to health information which they could perhaps not source from a shared house or fixed line phone. (see Table 4)

The Vodafone data provides an insight into the average duration of a call to NHS Direct. The average call lasted 334 seconds. Call duration varied according to the time of day with longer calls outside of working hours and particularly at night.

Figure 8: Duration and timing of calls to NHS Direct by Vodafone subscribers



The Vodafone data also provides insights into the frequency with which individuals use the NHS Direct service: 99.6% of the callers made fewer than 10 calls to NHS Direct in the six month study period.

Table 1: Distribution of calls by number of callers

Number of calls	Number of callers
1	50259
2	11913
3	3316
4	1147
5 to 10	869
11 to 20	81
>20	167

Conclusions of the case study

NHS Direct has increased access to NHS services amongst the 16 to 44 age group. People in this age bracket have traditionally been low users of NHS services but are now most likely to use NHS Direct and to use a mobile phone when doing so.

The analysis also shows that those accessing NHS Direct most frequently from mobile phones are predominantly in the younger age groups. The enhanced privacy offered by a mobile phone is very important for some groups. Teenage girls are notable in their much greater reliance on mobiles for contacting NHS Direct.

People over 50 are significantly less likely to use telephony or technology in healthcare and are more likely to rely on traditional methods of consultation, such as a pre-booked GP surgery appointment. This could represent a change in demand and user patterns for specific groups of customers who are accessing health services and this is likely being driven by convenience and accessibility. It is not possible to say for sure whether today's young people will continue to access health services in this manner as they grow older. However, it is fair to pose the question as to whether their greater reliance on mobile communications could indicate both an opportunity and a requirement to adapt methods of access to health services.

Notes

1 Anon 2005. Issue Briefs: NHS Direct. 18 December 2005 [Internet]. Available from: < http://www.politics.co.uk/issues/nhs-direct-$2413582.htm > [Accessed 18 December 2005].

2 National Statistics (2004) "Living in Britain 2002: General Household Survey" Data downloaded from: http://www.statistics.gov.uk/lib2002/downloads/health.pdf

A Review of the Characteristics and Benefits of SMS in Delivering Healthcare

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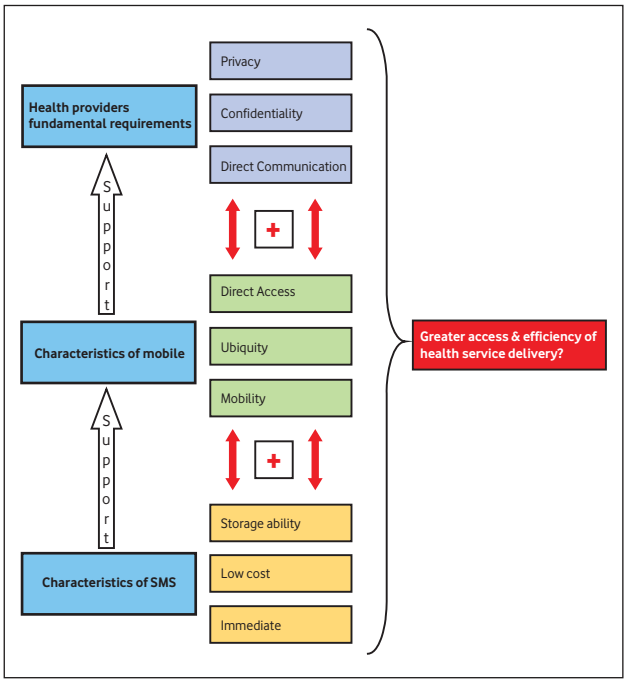
Introduction

Increased accessibility is the anticipated consequence of providing a telephony based e-health service to a market saturated with mobile phones. However, further analysis of the health sector consistently showed that large amounts of data are frequently communicated between different parts of the service and ultimately stored and retained. In trying to ascertain how mobile communications could help facilitate this information cycle, our analysis repeatedly pointed us in the direction of the SMS and the question of whether an application that has revolutionised communications can be applied to health care deserves to be asked.

The SMS has many characteristics that make it particularly suitable for use in a healthcare setting. Table 1 identifies some of these characteristics and demonstrates how they support the fundamental requirements for the transfer of health information: privacy, confidentiality and direct communication. The table also shows how the mobile phone supports and builds on the characteristics of the SMS by adding further benefits to the transfer of health information whilst also maintaining the fundamental requirements of health providers.

Table 1: Characteristics of SMS and Mobile Phones in Healthcare



The high penetration rate of mobiles in most social groups makes it possible for SMS to be used as a core communications channel.

A survey by MORI in March 2005 showed that 82% of respondents in the UK used mobile phones[i] and the proportion of mobile phone and SMS users in different social groups was quite evenly distributed. The use of SMS by different age groups varied but was significant and consistently high until the over 55 age group where approximately only 40% of users had communicated by SMS (Table 2).

In 2005, Ovum estimate that there will have been a total of 1.25 trillion SMS messages sent globally. More than 15 billion SMS messages were sent in Europe each month in 2003 with the average mobile phone user sending 35 SMS per month[ii]. SMS usage has surpassed all expectations and is now one of the most widely used methods of communication in society.

The SMS itself is a simple form of data transfer usually communicated person to person but which can also be sent computer to person and vice versa. The internet and email have some of the same characteristics but, in the context of health care management, the fact that the device is held by, and is personal to, the user (patient) is key. Mobility has the further potential to increase efficiency by the ability to reach the patient directly.

Apart from it's widespread usage, the SMS application also has many further characteristics that make it appropriate for use in a healthcare context.

The 'one-to-many' feature of SMS systems means that messages can be sent to many recipients simultaneously and potentially in several different languages.[iii] These messages can also be pre-written, minimising time and effort in data entry and communication for providers,[iv, v] but it also allows manual or custom messaging.[vi]

Messages are also held until the recipient can read them thereby increasing convenience. Furthermore, messages sent to a mobile phone that is switched off are stored at an SMS Centre and delivered when the handset is switched on again.[vii] This feature is, once again, highly valued by clinicians as recently articulated by a physician in England: "If text messages arrive at inconvenient times – for example, while patients (or doctors) are driving, when they are in a meeting, or at night – they are held until patients are ready; there is no need for urgent or immediate action. Such text messaging facilities beat any other avenue of contact, such as the postal service, the telephone, and email, for sheer portability and convenience".[viii]

SMS messages usually reach the recipient within seconds, allowing for an immediate response, and a delivery receipt can be added to the message to confirm that delivery has taken place.[ix]

SMS messages can be sent anonymously[x] to further protect the confidentiality of the individuals involved. It is possible to save and store SMS on a mobile phone to enable individuals to reference and access the content at their convenience and as often as they like.

Table 2: Use of mobile phones and SMS by social class and age

Mobile Phone & SMS Use by Social Class						
Social Class	**AB**		**C1**	**C2**		**DE**
Proportion who use SMS	58.8%		65%	60%		51%
Age Group (Years)	**15-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
Proportion who use SMS	89%	85%	76%	61%	37%	11%

Source: MORI, 2005.[i]

Table 3: Characteristics of NHS Communication

	Postal Letter	Call to Fixed line	Call to Mobile	SMS
Immediacy	**Slow** 2 days	**Immediate** If person at home. Return call may be necessary.	**Immediate** If person answers – higher probability than fixed. Return call may be necessary.	**Immediate** Or stored.
Privacy & Confidentiality	**High** Personally addressed	**Low** Confidentiality prevents message being left as others may answer or retrieve it.	**High** Personal device enables possibility of message being left.	**High** Personal device
Delivery Confirmation	**Yes** But at significant expense	**N/A** Uneccessary if call answered. No if message left	**N/A** Uneccessary if call answered, No if message left	**Yes**
Cost	**Moderate**	**Low**	**Moderate**	**Low**

The delivery characteristics of SMS compares very favourable with other forms of NHS communications measure very favourably. (Table 3)

As mobile phone penetration approaches 100% of the population in many countries, the potential exists to utilise the distinctive characteristics of mobile and SMS to increase the efficiency and effectiveness of health service delivery. While there are a number of interesting and promising examples, a systematic review of the opportunities to leverage SMS technology in health service provision has not been conducted. It is long overdue.

The Systematic Review

This section draws on the first systematic review of SMS use in healthcare, carried out by Dr Rifat Atun and Soalen Sittampalam of the Tanaka Business School at Imperial College London. The full systematic review and list of references can be found at http://www.imperial.ac.uk/healthmanagement/mobiles

There are three types of benefit from SMS applications which emerge from the systematic review. These are:

- efficiency gains in the delivery of healthcare;
- direct benefits to patients in terms of better health outcomes and quality of service;
- public health benefits.

We summarise below the studies in terms of these three categories.

It is important to note that none of the studies we reviewed included any formal economic evaluations to quantify the monetary benefits of the different SMS applications. However, one can see the potential benefit by extrapolating the findings from the published studies and applying them elsewhere.

For example, one of the areas of efficiency gain we report below is the reduction in the number of missed appointments when patients are sent text reminders. In England, the annual direct cost of missed appointments to the NHS is £180 million for GP appointments and £34 million for practice nurse appointments. Studies of primary care text reminder schemes in the UK report 26% to 39% decline in the number of missed appointments, corresponding to cost savings of £9,483 to £20,991 per GP practice per annum. Net savings for the Islington Primary Care Trust, which manages a large number of practices in inner London, were estimated to be £471,158 per annum.

The annual direct cost of missed hospital appointments in England is estimated to be £575 million each year. Pilot studies using SMS-based reminders have demonstrated 33% to 50% reductions in the number of appointments missed. Hence, if the reduction in the number of missed appointments in the text reminder schemes studied were applied to England as a whole, it would translate into annual primary care savings ranging from £55.6 million to £83.5 million a year. The potential savings to the NHS in England from reducing the number of missed hospital appointments are even more substantial.

If such declines were generally achieved in English hospitals, this would translate to annual cost savings ranging from approximately £200 million to £280 million. In the context of an estimated budget deficit of about £600m for the NHS in 2005-06, these potential savings are significant.

SMS reminders potentially offer significant increases in health service efficiency.

1. Efficiency gains in the delivery of health services

Turning to the first area covered by the systematic review, the use of text messages to deliver health services more efficiently, the potential benefits fall into four categories:

- Appointment reminders
- Safety of healthcare workers
- Management of human resources in health services
- Administration of health financing organisations

Appointment Reminders

Missed appointments are a substantial cost for many health systems but particularly for the National Health Service (NHS) in England. There are direct costs involved in arranging the appointment, which are therefore wasted, and the opportunity cost of the missed appointments.

The scale of the costs associated with missed appointments is substantial. A survey of 683 general practice (GP) surgeries indicated that in 2005 over 10 million GP and nearly 5 million practice-nurse appointments were missed and that the number of missed appointments had been increasing year by year. In 84% of the practices surveyed, missed appointments were seen to be a problem: they lengthened waiting times for GP appointments and adversely affected the ability of the practice to reach its performance targets. A large majority of the GPs believed that patients missed appointments because they had forgotten it. Not surprisingly, almost all (98%) felt that missed appointments wasted NHS resources; while 87% felt the phenomenon adversely affected the efficient running of the NHS. Such was the strength of feeling that 71% of the GPs responding said they would consider deregistering patients who repeatedly missed appointments. A significant majority (66%) thought that the introduction of charges for missed appointments might help address this problem.[2]

The estimated cost of a GP appointment is £18, while that for nurse is £7.[3] Therefore the annual direct cost of missed appointments to the NHS in England is £180 million for GP appointments and £34 million for practice nurse appointments. The figure for hospitals is even higher. The direct cost of missed hospital appointments, estimated to number 4.5 million to 6 million each year[4] (or up to one in ten appointments), is estimated to be £575 million annually.[5] Hence missed appointments in England cost the NHS about £789 million a year. It is not surprising, therefore, that to try to reduce the extent of the problem, the Department of Health (DOH) has issued Missed Appointment Guidance, which identifies ways in which GP surgeries can improve attendance rates for hospital and GP appointments.[6]

Sending text messages to remind patients to attend their appointments is one potential means of tackling the problem. A number of pilot schemes using SMS to remind patients to attend their NHS appointments have been launched in England since 2003.[7] Concerns about patient confidentiality have been addressed through an 'opt-out' scheme, based on an 'implied consent model': patients were sent a leaflet informing them about the scheme and giving them the opportunity to opt out.[8] In another pilot, patients were given an information leaflet – with a tear-off section that captured the date and time of the appointment and the mobile telephone number, but without any other information which would identify the patient – which acted as the consent mechanism.[9]

Another concern has been the possibility of an adverse impact on equity in the use of mobile phones for communicating with patients.[10] However, as discussed in the previous article, this seems unlikely given that mobile phones are widely accessible to all socio-economic groups in the UK.

SMS-based reminders are now used in appointments in imaging diagnostics[11], paediatrics[12], sexually transmitted illnesses[13], antenatal clinics[14], adolescent health (for example for the morning after pill)[15], mental health[16], dental services[17], rheumatology (to remind patients to attend urine and blood tests for drug monitoring)[18] and blood transfusions.[19]

Some studies have focussed on the organisational factors which either facilitate or hinder the uptake and diffusion of the SMS-based reminders. For example, service uptake is negatively influenced by a lack of administrative staff time to 'sell the benefits' of SMS reminders to patients and to fill in the forms. Take up can be enhanced when clinicians are involved in signing up patients to the scheme.[20] The additional time required to administer the scheme, the perceived risk of human error, and systems which prevent the access of temporary staff all hinder uptake of SMS reminder initiatives.[21] Staff commitment, automation, multilingual-texting facility and the training of the personnel involved in the scheme by the vendor all improve acceptance.[22]

Patients who receive SMS reminders have tended to ignore subsequent paper-based communications, including those which included instructions to prepare for diagnostic investigations or therapeutic interventions.[23]

Some of the pilot schemes have already reported success in reducing the number of appointments missed, but these results were not based on rigorous studies specifically designed to evaluate the impact of SMS reminders.[24] In London, a scheme which used SMS text messaging for imaging diagnostics appointments reported positive patient experience and a reduction in the number of patients who did not attend (DNA) appointments. However, the rate of decline was not quantified.[25] In a pilot study in Cambridge, SMS reminders to patients with dermatology clinic appointments led to a 50% decline in the number of DNAs[26]. A pilot scheme in Leeds achieved a 33% reduction in the number of DNAs to a hospital-based sexual health clinic.[27] Other pilots have reported up to 40% reductions in DNAs for hospital outpatient appointments.[28] In primary care rather than hospital settings, similar successes have been reported. A trial which involved two GP practices in London, reported 26% and 39% declines in the number of DNAs, with respective savings of £9,483 and £20,991 per annum.[29] Net savings for the Islington Primary Care Trust, which manages a large number of practices in inner London, were estimated to be £471,158 per annum.

There have also been schemes trialled in other countries. In the US, the rate of non-attendance for hospital outpatient appointments has been reported to be around 8% of the total, but outpatient clinics which use SMS-based appointment reminder systems report up to 30% reductions in DNA rates – even when the uptake SMS reminder service was as low as 20% of the patients.[30] In Norway, a hospital-based SMS reminder system, integrated with the clinical administration systems of the GP practices, reduced hospital outpatient DNA rates by 14%.[31] Swedish experience of SMS reminder use in private dental and chiropractic clinics suggests that the number of DNAs can be reduced by up to 50%.[32]

A peer-reviewed clinical research study reported a randomised control trial undertaken in an orthodontic clinic in the Netherlands which compared the effect on attendance rates of a reminder sent one day before the appointment using telephone, mail or text message with a control group which was not sent any reminder. The study found that reminders had no effect on attendance or cancellation rates, and in fact the patients who were sent a reminder reacted negatively, feeling the reminder was inappropriate use of resources.[33] However, it is difficult to extrapolate the findings from this study to other countries as the DNA rates at 4% were already very low as compared with levels in Northern Ireland (13.6%)[34] and England (23.3%).[35]

The Safety of Healthcare Workers

Health service workers often face threats to their personal safety. These can be due to the abusive behaviour of patients, to contact with biological hazards, or to natural disasters or accidents. In the NHS in England, over 95,000 instances of violent or abusive behaviour towards NHS staff were reported in 2002-03.[36]

One interesting SMS application developed in England allows midwives visiting patients' homes by themselves to use their mobile phone to notify a computer system of their location details at start of a visit. If there is no update within a certain time limit, the computer will generate an SMS text message to confirm the safety of the midwife. If there is no response to the message, team leaders, managers or the police are contacted.[37] Following the introduction of the system a large majority of the midwives said that they felt safer when working alone in the community.[38]

Human resource management in the health service

The two key areas of human resource management which emerged from the survey as offering the potential for efficiency gains from the use of text messages were communication between health care workers, and managing temporary staff requirements.

Communication problems between health care professionals commonly lead to errors which adversely affect patient well-being.[39] Much of the clinical information used by doctors come from peers, personal notes on patients or diagnostic tests.[40] Doctors prefer to seek the opinion of experts rather than consult guidelines, manuals or computer-aided decision systems.[41] For many health professionals, face-to-face communication or other interruptive methods (such as mail or telephone) are the preferred modes of information exchange.[42]

Text messaging is now used to enhance communication between healthcare workers. For example, in England, the NHS E-mail and Directory Service offers e-mail and SMS text messaging for NHS employees.[43] Similarly, the Food

Standards Agency's SMS text-based scheme alerts Food Enforcement Officers working away from the office to new food warnings – highlighting the urgency of the warning, the product name, and the action to be taken by local authorities.[44] Text messaging has been identified as a useful communication tool between surgeons, enhancing the coordination of patient care, improving the efficiency of administrative activities, increasing the accuracy of messages, and even increasing the speed of response to urgent cases.[45]

The second area in which text messaging schemes appear useful is in meeting temporary human resource needs. In England, the NHS spends up to £1 billion a year employing temporary staff to meet staffing needs. Agencies which provide temporary staff to the NHS have established systems which match NHS needs with available health workers, and automatically send text messages to check on the availability of suitable temporary staff on their register.[46] The SMS schemes improve the accessibility of staff and the speed with which they can meet the requirements of the health service, often at short notice. The schemes also reduce costs for the employment agencies and health service employers.[47]

Administrative efficiency of health financing organisations

SMS applications are being used to increase administrative efficiency in healthcare financing organisations. For example, in the Philippines – where almost 40 in every 100 people have a mobile phone – the government Health Insurance Corporation has began to use SMS to inform its 64 million beneficiaries, including those who work abroad, of their status and entitlements.[48] In India a health insurance company, which launched an SMS facility for enquiries and alerts on claims, has reported cost savings and a reduction in claim processing time from 23 to seven days.[49]

2. Benefits to patients

A more efficient health service offers indirect benefits to patients through releasing funds which were formerly tied up in administrative costs. However, the research literature and other sources indicate that SMS applications also offer much more direct benefits to groups of patients. Two of these are covered in more detail in later sections of this report (see pages 29 and 40). Here, we summarise the range of potential benefits to patients discovered in our systematic review. These include areas where communication between medical staff and patients is critical:

- improving the extent to which patients stick to their medications and treatment;
- monitoring patients' conditions;
- providing psychological support to patients;
- communicating test results;
- other areas including queue management .

Improving adherence to health advice and medication

Adherence is the term for the extent to which patients follow the advice given by their doctor or nurse. Non-adherence to prescribed treatment is estimated to be around 50% on average, but it is higher for long-term conditions which require daily medication.[50] This leads to adverse health consequences for the patient, causes substantial costs to the health system, and can have an adverse effect on public health: as patients who do not adhere to their treatment are often hospitalised due to the relapse of their condition, and interruption of treatment for infections leads to the emergence of resistant strains. Many individual and therapy-related factors influence adherence, but a discussion of these is beyond the scope of this paper.

SMS reminders can be used to prompt patients to take medication at the correct time and to encourage them to continue and complete treatment regimens for a wide range of conditions, such as acne[51], asthma[52], diabetes[53], tuberculosis[54], and HIV/AIDS[55]. They can be used as well to remind teenagers to take their contraceptive medication[56] or to remind patients to fill repeat prescriptions.[57] For patients with long-term conditions who have to take medication regularly, text reminders need to be designed to retain user interest and avoid desensitisation. The explanation of the benefits at start of a scheme that uses reminders, personalised messages[58], different text messages each day[59], mixing reminders with alerts, jokes, and provision of lifestyle tips[60] can all help retain interest in the reminder and improve adherence.

One example of the kind of text message reminders being used is an innovative scheme in England using coded messages to ensure confidentiality when reminding teenagers to take their prescribed oral contraceptive pill.[61]

In South Africa, SMS reminders have been used to enhance adherence to treatment in patients with tuberculosis[62] and AIDS[63], and also in the latter case to monitor treatment adherence levels.

A study in South Africa which used Cell Phone Prompted Self Administered Therapy (PSAT) to improve adherence in tuberculosis patients treated according to the World Health Organisation-recommended protocol reported that the scheme had reduced staff workload without an adverse effect on cure rates. The scheme was welcomed by staff and the local health authority officials.[64]

A study in Scotland of a cohort of 32 young adult asthma patients used SMS text messages written in 'txtspk' from a fictitious friend 'Max' (e.g. "yo dude, it's max reminding U2 take ur inhaler"), accompanied by a stream of celebrity gossip and horoscope messages. It was reported to be successful, with participants describing the service as acceptable, and even saying that they had developed a rapport with the fictitious character Max.[65]

There have also been peer-reviewed clinical studies of SMS applications designed to improved adherence. A double-blind randomised clinical trial in Spain, involving 26 primary health care centres, analysed the effect of providing printed information followed by two text messages (either lifestyle reminders or to reminders to take medication) on adherence and lifestyle changes in patients with hypertension. Outcomes in the intervention group were compared with those in the control group who were not sent text messages. Statistically, there was no difference in rate of non-adherence in both groups, which was around 15%. However, the intervention group achieved better control of blood pressure and a reduction in body weight.[66]

A case control study from Spain of patients given Hepatitis A and B vaccines compared adherence to immunisation schedules in patients who received a text reminder for their follow-up vaccination with the control group who were not sent a reminder. The adherence level in the intervention group was higher than that in the control group and this difference was statistically significant.[67]

In Australia, a randomised control trial involving HIV positive individuals receiving antiretroviral therapy compared adherence levels before and after an intervention which combined one-to-one individualised patient education and regimen analysis with a choice of a variety of aids to improve adherence to medication including a dosette box, text messaging at each scheduled dose and a programmable medication alarm. The results show that after the intervention there was a statistically significant decline in the number of missed doses as compared with the pre- intervention experience.[68]

Monitoring Illness and Medical Interventions

The effective monitoring of medical conditions, especially chronic illness, improves health outcomes and reduces health care costs.[69] SMS applications are being used in a variety of settings to enable monitoring of acute and chronic conditions as well as monitoring the effect of medical interventions.

For example a rheumatologist in England has implemented a reporting system that uses SMS messages where patients who have had corticosteroid injections to inflamed joints of soft tissue can report by text whether the injections have been beneficial (for example in alleviating pain or improving movement). This has enabled remote monitoring and reduced the need for follow up outpatient appointments, thereby reducing costs.[70]

SMS applications have also been used in South Africa to monitor HIV positive individuals receiving anti-retroviral drugs, where side effects are reported directly by patients sending text messages to health workers.[71]

In Italy, SMS applications have enabled cancer patients to report their symptoms systematically to doctors from home, thereby reducing their need to be hospitalised for monitoring.[72]

In England, France and Thailand, SMS messaging has enabled improved self-monitoring by diabetic patients and more regular reporting to clinicians.[73]

A novel application linked to the monitoring of patients in intensive care involves nurses sending alerts to clinicians via SMS when certain changes are detected in the physiological status of the patient. The clinician is informed about status of critical patients more rapidly this way than with the use of pagers, thereby enabling a faster response.[74]

A cohort study in Denmark evaluated the feasibility and impact of using SMS messages to enhance self-care of asthma by reminding patients to take medication, note their symptoms, measure the peak expiratory flow rate and complete an SMS-based asthma diary to send to their doctors. The study found that patients were not only able to use the SMS diary, but were also enthusiastic about it, as it gave them a greater sense of control over their condition.[75]

Similar results have been reported in the peer-reviewed clinical research literature. A randomised control trial in Croatia which compared an intervention group of patients who were asked to regularly monitor their asthma and send their peak flow results to their clinician on a daily basis via SMS with a matched control group who were advised to monitor their asthma but not send a text message, found that the symptom profile in the intervention group was significantly better than that in the control group. The intervention was found to be acceptable to patients.[76]

A prospective intervention study in Finland compared health outcomes in diabetic patients given a mobile phone to send a text message on their daily glucose level to a database (receiving once-weekly advice from clinicians) with matched controls who had received standard management (i.e. routine outpatient visit once every three months). This study was not able to demonstrate a statistically significant difference in outcomes, but in a subgroup of patients who most actively used SMS, there was a small statistically significant improvement. This result suggests that motivation to self-care is critical for the improvement of glycaemic control.[77]

In contrast, a prospective cohort study in Korea, which trained diabetic patients to report their blood glucose levels via either a web-based system or text messages, receiving instructions on adjustment of the medication dosage via the web, showed that diabetes control (as measured by HbA_{1c} level) had improved following the intervention as compared with levels at start of the study. This improvement was statistically significant.[78]

Another cohort study of diabetes management by SMS in Spain reported that overall user satisfaction and acceptance was very good, and additional costs were not high.[79]

Diagnosis

SMS applications in this area include the communication of diagnoses to patients, and remote diagnosis. Traditional approaches used to communicate test results are time-consuming and inefficient. They often require the patients to go and collect their results in person. Using text messages is likely to speed the communication of results and save money and time.

Text messages have been used in more developed countries to communicate results of in-vitro diagnostic tests (such as blood or microbiology tests)[80] and radiological imaging such as breast cancer screening[81] or screening for sexually-transmitted infections.[82] In less developed countries, where there are still greater access barriers to individual ownership of mobile phones, SMS has been used to send results more efficiently to clinics in rural areas.[83] SMS has also been used to expedite the communication of occupational health examination results on foreign workers to their employers.[84]

Although the reported benefits of using mobile phones and SMS test messaging to communicate results of diagnostic tests include reduced waiting times to inform patients,[85] reduced costs in communicating normal results,[86] increased convenience for patients and providers with improved access and expansion in service use[87], we could not identify any well-designed clinical studies reporting these benefits.

Experience with remote diagnostics using SMS applications is limited but SMS has been used in combination with a well-established monitoring system to estimate the severity of stutter in children living in rural Australia.[88]

Provision of Psychological Support

The management of certain conditions, such as bulimia, can be improved if there is continuity and immediacy of support from health professionals. In other conditions where interaction between the patient and the outside world is restricted (for example in immuno-suppressed patients or those with an infection that requires isolation), support and interaction with other sufferers, family, friends and peers can have a beneficial therapeutic effect. Text messaging may be beneficial in such circumstances, especially for communicating with young people who are high users of text messaging as discussed in the previous article.

For example, SMS texting have been used to encourage young people to access counsellors to seek support on a range of issues, such as bulimia[89], chronic illness[90], managing stress during end-of-year exams[91], and to receive advice on health[92] or relationship problems.[93]

A randomised controlled trial in Scotland described elsewhere in this report (see page 40) used text messaging to support young people with diabetes between their clinic visits using a system called 'Sweet Talk'. This sets a series of goals to influence health behaviour, to help patients set self-management goals and to improve glycaemic control. The study results show a statistically significant improvement in diabetes control (as measured by metabolic control and self-efficacy) in the intervention group of patients using Sweet Talk, as compared with those who received standard care.[94]

Another clinical study, which focused on bulimia nervosa sufferers in Germany, employed observational methods and explored the acceptability and feasibility of SMS-based psychological support. The results suggest SMS intervention is an appropriate intervention for providing aftercare following discharge from hospital.[95]

Contacting Blood Donors

Text messages are being used to invite teenagers to donate blood, and to collect information on the blood groups of individuals to develop a database so that donors can be contacted in emergencies when blood (particularly of rare groups) is needed.[96]

In India, when a Blood Centre texted a request to potential donors for blood to help a young patient with leukemia, 150 calls were received offering donations within an hour.[97]

Enhancing access to health services for disabled people

People with certain disabilities, such as those who are deaf or mute, can benefit from SMS-based applications to contact emergency services.[98] Text messaging services for contact with the emergency and health services have been launched in England[99], Northern Ireland[100] and Hong Kong.[101]

Managing Queues

Long waiting times and queuing lead to customer dissatisfaction. The sense of dissatisfaction has probably increased as people have come to value their time more highly over the years (a phenomenon due to rising levels of pay increasing the opportunity cost of time spent unproductively). Hence efficient queue management is critical to improving service quality and user satisfaction.[102]

There is scope for the use of text messages to manage queues and reduce waiting time in health services.

In the systematic review we found one example: Queen Elizabeth Hospital in England, which has introduced a system whereby patients who are waiting to collect their dispensed drugs are sent an SMS message to inform them when their prescription is ready for collection.[103] This has provided much greater flexibility to the patients who do not have to waste time waiting for a prescription as they can return any time during the day to collect their medication.

3. Public health benefits

The third major area of potential benefits from SMS applications lie in the field of public health. They can cover the need to contact specific individuals, such as those thought to have been exposed to a communicable disease, or to everyone in a particular population group or geographic area, for example when there is concern about an epidemic such as SARS. Text messages have also been used in public health campaigns such as anti-smoking campaigns.

Contact Tracing and Partner Notification for communicable diseases

Sexually transmitted infections (STIs) are a major public health problem in both industrialised and developing countries, as the incidence and prevalence of STIs are both increasing. Partner notification (also termed partner management or contact tracing) is an important public health activity to control STIs, as the sexual partners of people with an STI are likely to be infected but asymptomatic and therefore not seeking care.[104] SMS applications are being used to notify the partners of individuals with STI.[105] They are also being used in the effort to control major global public health problems such as tuberculosis, HIV and SARS. One such example, TB, is covered in more detail elsewhere in this report (see page 29).

A text alert service named "SARS Contact Tracing SMS" was launched by StarHub and the Singapore Tourism Board, to trace people in case of future SARS outbreaks in Singapore.[106]

Clients attending an STI clinic in Melbourne found calls or text messages to mobile phones an acceptable and efficient means to contact their recent sexual partners, especially if the contacts were provided with details of a web site which had information on the STI to which he/she had been potentially exposed.[107] Alternatively, the SMS message can be sent by the clinic to the client (or the index case) for them to forward to their partner(s), thereby maintaining the anonymity of the partner.[108]

A case report in 2001 described how SMS text messaging was used in London to reach very rapidly the partner of a client who had earlier attended the STI clinic and was diagnosed with an infection. Although the partner was not aware of the reason why his girlfriend had attended an STI clinic, the text message he received from her contained details of the diagnosis code, which was then used to initiate appropriate treatment for him. Thus SMS may be considered as an adjunct to contact slips for contact tracing in genito-urinary clinics.[109]

Communicating Health Information to the Public

Text messages are particularly useful for the rapid communication of health information to the general public, for example in public health emergencies such as an outbreak of a communicable disease such as meningitis, or to reach particular client groups such as when a large group of people are inadvertently exposed to an infectious agent (such as hepatitis B, or HIV). It is also a very useful tool when large numbers of people need to be reached to recall rapidly harmful food products or pharmaceuticals.[110]

It is a measure of the usefulness of text messages that there are so many examples to be found of public health and awareness campaigns – and particularly in developing countries where there may be fewer alternative means of communicating with the public than in developed countries. In 2005, the Ministry of Health in Indonesia launched a hotline to enable the general public to report disease outbreaks, to lodge personal complaints about health services and also to register to receive and disseminate information on epidemics, such as SARS and avian flu[111] (or natural disasters, such as tsunamis[112]). Similarly, SMS is being used in Malaysia, South Korea and the UK to alert the public to natural disasters[113] or to warn on food safety.[114] It is being used in Spain to inform people of extreme weather conditions[115], and in Dubai to send health information to citizens.[116] Text messages have been used in public awareness campaigns in India to inform and educate the public on the WHO tuberculosis control strategy.[117] In Kenya, Nigeria and Mali there have been text-based campaigns to inform the public on HIV and malaria control programmes.[118] In Iraq SMS has been used to support a polio vaccination campaign targeting nearly 5 million children across the country.[119] During the SARS crisis a mobile operator in Hong Kong sent messages to citizens, informing them of precautions which helped reduce risk of exposure to SARS virus.[120]

SMS-based mass messaging can also be used to target particular geographic areas or population segments. In the UK, NHS Direct Interactive uses text messaging to provide health promotion advice and information to people with long-term conditions such as asthma and diabetes.[121] Similarly, other UK health organisations use text messaging to target people in rural areas[122]; to provide health promotion information to students[123]; confidential health information to school children[124] and teenagers[125]; sexual health

advice[126] and anti-smoking education to adolescents[127]; mental health promotion to young people aged 15 to 25 years[128]; information on pollen count to asthmatics[129] or hayfever sufferers[130]; alerts on high levels of smog and air pollution to high risk groups.[131] SMS text applications are also being used to provide health education and promotion advice to people with obesity.[132]

Other countries have also used both free and paid-for SMS applications to target specific groups. For example, following floods people in Mumbai exposed to the flood waters were sent an SMS test message which advised them to take prophylactically 200 mg of the antibiotic Doxycycline to prevent leptospirosis infection.[133] A wireless sex education campaign was launched in Singapore over a ten day period: young people could text questions to a panel of international doctors and pay a charge of $3 per question answered.[134] In China, specialists from Shanghai University provide, for a fee, information on acupressure for various conditions.[135] In Korea, there are paid-for services which provide information to young people on women's health.[136] In Kenya, free information on questions related to HIV/AIDS is provided by an NGO to subscribers.[137] In Singapore, the National Kidney Foundation uses SMS to encourage uptake of screening services for kidney diseases by the general population.[138]

Effective use of SMS in peer-to-peer communication of public health information, especially where there is inadequate information provided by the government, was illustrated during the SARS epidemic in China when the first case was discovered in Guangdong province and the epidemic quickly spread in the province. While the government and news agencies remained silent on the outbreak the news of the epidemic were transmitted instantly throughout the country via mobile phones, in particular via text.[139] This helped inform the international community and the WHO on the extent of the epidemic. It also put effective pressure on the government to act more decisively to combat SARS.[140]

Use of SMS in Smoking Cessation Programmes

Over 1,300 million people in the world smoke tobacco.[141] Four-fifths of these live in low- or middle-income countries. The WHO estimates that tobacco smoking killed around five million people in 2003 and if unchecked, will kill one billion people in the 21st century.[142] The World Bank estimates that if adult tobacco consumption declined by 50% between now and 2020, approximately 180 million tobacco-related deaths could be avoided. The need to reduce smoking is clear.[143] However, only a small percentage of cigarette smokers (1-3%) achieve lasting abstinence (at least 12 months) using their willpower alone.[144] Thus public health policies and interventions which encourage the cessation of smoking bring major health and economic benefits.

Text messaging has been used in Australia[145], New Zealand[146], Spain[147] and the UK[148] to provide health education, to campaign against smoking and to assist people who are trying to quit to change their behaviour.

Turning to the clinical research, a randomised control trial in New Zealand which assessed the effectiveness of text messaging in smoking cessation programmes found that the number of people who stopped smoking was significantly higher in the intervention group than in the control group which did not receive SMS text message based support.[149] A follow-up study by the same team, found that this intervention was as effective for Maori as non-Maori participants.[149]

A cohort study in the US, which assessed smoking cessation among college students using a Web and text-messaging programme, reported comparable or superior cessation rates to those achieved in minimal-contact or self-help smoking-cessation interventions.[150]

Conclusion

A large number of studies from both the grey literature and clinical studies published in peer reviewed journals demonstrate the wide use of SMS-based applications in health services. Many report efficiency gains, benefits to patients and public health benefits, depending on the context. The studies also show that SMS-based healthcare applications are acceptable to patients, suggesting text messaging can be used to develop new service delivery models in future.

The wide scope of the examples we found in the peer-reviewed and grey literature is indicative of the potential to introduce SMS applications in a wide range of areas to deliver both efficiency savings and improvements in the health of individuals and public health. However, many of the uses of SMS have not yet been subjected to clinical trials, as they have been so recently developed. There is now a clear need to undertake well designed randomised clinical trials with economic evaluation alongside these to confirm clinical and economic benefits and to inform policy to develop novel service delivery methods which utilise SMS-based applications. What's more, despite the number and range of the individual applications revealed by a thorough review, none of them appears to have been extended systematically or on a large scale throughout health services. Given the potential improvement in health outcomes and economic benefits indicated by the evidence available so far, the policy assessment should include consideration of how to introduce promising SMS applications at scale and in a systematic way, in order to ensure that their fullest potential is realised.

For a full list of the 150 references in the systematic review, please visit http://www.imperial.ac.uk/healthmanagement/mobiles

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The potential of SMS applications for the control of tuberculosis

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Foreword – Professor Catherine Peckham CBE

Tuberculosis and the associated problem of drug resistance is a serious and growing international problem placing an increasing burden on health services including the NHS. An important aspect of strategies to combat tuberculosis is adherence by patients to protracted treatment and the avoidance of poor compliance linked to the appearance of resistance.

In an original and unusual approach to infectious disease control, the study reported here examines the potential contribution of the Short Messaging Service (SMS) feature on mobile phones and the role of text messages as a means of encouraging patients to complete prescribed courses of treatment. The results of the modelling study suggest that SMS has the potential to improve tuberculosis control contributing to reduced non-compliance and better health outcomes while at the same time securing economic benefits.

On the basis of these encouraging conclusions the effectiveness of SMS in the treatment of tuberculosis now warrants testing in well-designed clinical studies associated with appropriate economic evaluation. Professor Peckham is Professor of Paediatric Epidemiology and Biostatistics at the Institute of Child Health.

1. The global health burden of tuberculosis

Tuberculosis is the world's most common cause of death from a single infectious disease. A third of the world's population is believed to be infected by the bacterium Mycobacterium tuberculosis, although the majority of these infections are latent, not active.

The incidence of the disease has been increasing. In 1997 an estimated 7.96 million new tuberculosis cases developed each year, with an average fatality rate of around 23%, leading to nearly 2 million deaths. In the same year the prevalence (the number of existing cases of the disease) was estimated to be 16.2 million.[1] By 2003, the incidence of tuberculosis (the number of new cases) had increased to 8.8 million, with an estimated 1.7 million deaths.

The World Health Organisation (WHO) 2005 report on Global Tuberculosis Control estimates that, despite international control efforts, the incidence rate of tuberculosis is increasing by 1% a year.[2] The incidence is increasing in both the developing and developed countries alike, with the rate of increase being faster in Africa and Eastern Europe than in the rest of the world.

What's more, a third of the 42 million people infected with HIV are also infected with tuberculosis, which is also a leading cause of death in people with HIV.[3] The damage that HIV inflicts on the immune system means it is a major factor increasing the risk that a latent tuberculosis (TB) infection will progress to the active disease. Hence people living with HIV and AIDS (PLWHA) are at much greater risk than other people of developing active tuberculosis.[4]

Many societies and health systems around the world are therefore facing both the major human catastrophe of the growing HIV epidemic and increasing incidence of TB. The collision of these two epidemics creates new challenges.[5] Of particular concern is the increased incidence of the more virulent type of tuberculosis (known as miliary TB), combined with drug resistance and co-infection with HIV. This phenomenon is partly due to poor control of the disease in South East Asia, Sub-Saharan Africa and Eastern Europe.[6]

As a result, five TB control targets are incorporated in the Millennium Development Goals, (MDGs), the eight over-arching targets set by the United Nations for reducing poverty by 2015.[7] The component TB targets are:

1 achieve a 70% case detection rate of new smear-positive tuberculosis cases
2 achieve an 85% cure rate
3 have halted and begun to reverse incidence
4 halve TB prevalence compared with 1999
5 halve death rates compared with 1990.

By 2003, the case detection rate was 45% while treatment success had reached 82%, but these rates varied significantly by region and country.[8] In 2003, the global cost of TB control was estimated to be US$1.32 billion, 49% higher than in 2002.[9]

Although in the past international concern has focussed on developing countries with the highest incidence of TB, more recently attention has turned to tuberculosis control in eastern Europe and developed countries of western Europe. This is because of the relatively high proportion in these countries of drug resistant cases, particularly multiple drug resistant tuberculosis (MDRTB), that is, strains resistant to at least two first line drugs (isoniazid and rifampicin).

Furthermore, the increasing labour mobility is creating new challenges. Immigration to developed countries has played an important role in spreading TB to some communities, such as immigrants in inner cities. In western Europe, Canada and the USA over half of the active newly diagnosed cases of TB originate in migrants, often two to five years after their arrival.[10]

Tuberculosis control programmes

The WHO recommends a public health strategy known as DOTS (Directly Observed Therapy – Short course) for controlling TB. This involves six months of treatment with a recommended drug regimen. The treatment has a two month intensive phase and a four month continuations phase. The patients who are on DOTS recommended regimens are observed by a trained clinician, health worker or sometimes a member of the community to confirm that the drugs are taken each day. There is evidence to show that DOTS is more cost-effective and treatment outcomes are better when compared with regimens involving self-administered therapy.[11]

Efforts to control TB globally are hindered by a number of problems including:

- shortage of funding for national TB programmes;
- the scarcity of qualified health workers;
- weaknesses in health systems such as inadequate organisational structures and poor infrastructure;
- inadequate social support;
- a lack of transport to take patients to healthcare providers; and
- resistance to change amongst stakeholders.[12]

Taken together, these mean accessibility to services and adherence to treatment are poor and the consequence of

poor adherence is an increase in acquired multi-drug resistant TB (MDRTB) and the further spread of primary MDRTB infection within the population. (See Box 1)

Box 1: The consequences of poor adherence

Empirical evidence shows that poor adherence leads to increased drug resistance.[13] If a patient with tuberculosis takes treatment once a week rather than the prescribed regimen of twice a week for the duration of the treatment, the risk of a positive culture at 12 months is five times greater. (The risk of developing isoniazid resistant disease is nearly 3 times greater).[14] An unfavourable response to treatment (positive cultures, relapse or death) was shown to be twice as likely in patients who did not comply with the continuation phase of their treatment even if the intensive phase of treatment had been adequately completed.[15]

Multiple drug resistant TB (MDRTB) is more difficult and expensive to treat while treatment periods are long and resource intensive.

Current internationally recommended treatment regimens for TB last a long time and involve a combination of different medications. Globally, adherence to these treatments is sub optimal. This has led to low cure rates and an upsurge of multi-drug resistant TB with consequent public health risks and economic consequences.[16] The magnitude of the world's MDRTB problem remains unclear. However, given the limited data available, it is estimated that the global annual incidence of MDRTB in 2000 was about 3.2% of new TB cases (between 273,000 to 414,000 each year). The cost in both human and financial terms is high. Even at the lowest discount prices negotiated for second-line drugs through the WHO Green Light Committee[17] the annual global cost of treating MDRTB may be greater than the global cost of around $1 billion needed to treat all the drug sensitive cases.[18]

Use of mobile applications to enhance tuberculosis control programmes

The scale of the problem makes it all the more urgent to find ways of improving tuberculosis control. Successful TB control programmes require high-quality coordinated services for diagnosis, treatment and continuing care; processes which are user focused; and services which meet the needs of individual patients.

Mobile communications, and especially the Short Messaging Service (SMS) feature, can be used in conjunction with other initiatives to establish and maintain contact between the patient and the TB service over the entire course of treatment to ensure greater adherence to treatment. The characteristics of SMS, as discussed earlier, make it particularly suitable for incorporation in tuberculosis control programmes.

For example, mobile phones and text messages can be used;

- To improve attendance of patients at TB clinics;
- To facilitate the dispensing of drugs by community pharmacies;
- For regular follow up of treatment and progress; and
- To remind patients who self-administer medications to regularly take their drugs.

This may be especially valuable where there are geographic or social barriers to other forms of contact.

There are a few studies describing the use of mobiles and SMS in tuberculosis control. A pilot project involving ExactMobile (a South African software application developer), Eastern Cape Department of Health (which manages healthcare clinics) and National Health Laboratories (which manages laboratories) used SMS technology to deliver test results to six clinics in the region and to speed up treatment times.[19] (See Box 2)

Box 2: Use of SMS to deliver test results in remote areas

The pilot project was in Transkei, an impoverished rural area in the Eastern Cape. In the regions around 15,000 cases of tuberculosis are treated each month, with a cure rate of about 50%. The cure rate was estimated to be lower in Transkei, where the time between testing and the start of treatment typically took several weeks.

In the pilot project, motorcycles were used to deliver sputum samples daily. These trips took one to four hours, depending on the quality of the roads. The samples were tested rapidly and results entered into the computer software application which automatically sent the results via SMS to a mobile phone carried by a doctor or nurse in the rural clinic. This combination of motorcycles and wireless delivery reduced the time to receive laboratory results from weeks to as little as few hours.

In the first three months the number of samples referred for TB testing by six clinics increased by 333%, as compared with the three-month period before the project started. As the clinics now can get results faster, they can treat more people. This has led to more patients and clinic staff requesting tests for tuberculosis.

Charges for use of mobile applications were low, quoted to be about 2.85 rand ($0.35) per minute for voice and 0.68 rand ($0.08) per SMS message. ExactMobile, which donated its services, spent only about $1,250 on software development.

SMS has also been used in a pilot project in South Africa to remind patients to take their medications during TB treatment and monitoring.[20] The pilot involved a system to enable Cell Phone Prompted Self-Administering Therapy (PSAT), which enabled the patients to be released from direct observation. These patients were prompted daily to take their medication through an SMS. In the first pilot study, it was reported that 71% of the TB patient population had access to a mobile phone. The monthly cost of the SMS service to the local health authority was US$ 1.30 per patient. In the initial pilot study there was only one failure to complete the treatment amongst the 138 patients involved in the study. (See Box 3)

Box 3: SMS reminders to take medication

South Africa is one of the 22 WHO-designated high burden countries. Treatment costs are one of the highest per completed treatment case.[21] The incidence of TB in South Africa is estimated to be 300,000 new cases each year with a death rate of around 10%, a figure that is likely to increase given that the country faces one of the worst HIV epidemics in the world.[22]

In the project a personalised database was created with the information on all the TB patients. The computer sent out daily personal SMS reminders to all patients. The health professionals involved in the project claim that, despite organisational challenges they faced in setting it up, the approach is cost-effective and is a useful adjunct to DOTS programme.[23] But, as a significant number of patients failed to use the service as instructed, the cure and completion rates were reported to be similar to the clinic-based DOTS, but the cost of service delivery was lower.[24]

The programme has since expanded with further pilot studies in the use of SMS in TB and HIV control in South Africa. The World Health Organisation has cited the project as an international example of best practice, although some concerns have been expressed on privacy, data protection and security of information.[25]

2. The TB problem in England

In England the incidence of TB has increased by 25% during the past 10 years to reach a rate of 13 per 100 000 population. This is higher than in most other western European countries. Compared with 1987, when incidence of TB in England was at its lowest, over 1700 additional cases are now being diagnosed each year and the incidence rate is still rising.

The incidence of TB follows patterns of migration. In 2002, around 67% of the people with TB were members of an ethnic minority population and were born abroad (up from 63% in 2001). In 2002, the rate was 22 times higher in the foreign born population (a rate 90 per 100,000 population) than in the UK-born population (4.1 per 100,000).[26] Most TB cases in England occur in inner cities. Two out of every five cases are in London which also has the highest incidence (to 40.6 cases per 100,000 population), and where in the last ten years the incidence of the disease has doubled. In some London boroughs the rate is now comparable to that prevailing in some developing countries.

People with untreated tuberculosis and those diagnosed with tuberculosis who do not complete their prescribed treatment regimen pose major public health risks to the general population. This is a widespread problem: about 10-20% of newly identified patients have a high risk of non-adherence to their treatment. Some factors known to have an adverse effect on adherence to the course of treatment include:

- homelessness
- history of imprisonment
- drug and alcohol abuse
- immigrant status
- mental health problems

Broadly speaking, measures to improve adherence amongst these risk groups have three aims: first, to help the patients address their social problems which hinder them from following their treatment consistently; second, to enhance their contact with health professionals working in TB service; and, third, to strengthen communication between the health professionals and the patient over the duration of the course of treatment.

The alarming trends prompted the Chief Medical Officer to launch (in October 2004) the National Action Plan for TB which sets out the steps needed to tackle the growing challenge of tuberculosis in England.[27] Tackling the disease is now a priority for the National Health Service (NHS).

We report findings of a modelling study which builds on and extends an earlier study commissioned by the Department of Health on tuberculosis care in England and undertaken by Dr Rifat Atun and Mr Yevgeniy Samyshkin (Imperial College London), Prof Martin McKee and Dr Lucy Thomas (London School of Hygiene and Tropical Medicine), and Dr Richard Pitman (Health Protection Agency).

3. Modelling the impact of SMS use in tuberculosis control in England

In the context of this growing public health problem, our aim was to assess the potential impact of using SMS applications in tuberculosis control programmes in England. We look at both health outcomes and the economic impact of introducing SMS interventions.

There were three stages to our study:

1. We modelled the care pathway for tuberculosis control in London;

2. We estimated the costs and outcomes of SMS-interventions for a cohort of tuberculosis patients; and

3. We used epidemiological modelling to explore the impact of SMS in control programmes on the general population.

Stage 1: Modelling the care pathway for tuberculosis control in London

We undertook a systematic review of SMS-based applications for health care services and for tuberculosis control, described in more detail on pages 18-28, and available in full at http://www.imperial.ac.uk/healthmanagement/mobiles

The review identified SMS-based applications in health care provision, in addition to some cases where SMS was used in tuberculosis control. After focus group discussions with public health experts, clinicians and tuberculosis nurses from North Middlesex NHS Trust, we applied the SMS applications we had discovered in the systematic review to the TB care pathway.

We also used results of the largest study of tuberculosis patients in London involving 2,010 patients from all of the 33 centres treating TB cases.[28] This study provided us with evidence on the factors influencing adherence to treatment as well as:

- the incidence of TB in London;

- the social and demographic characteristics of the population with tuberculosis;

- the actors affecting the start of treatment, and adherence, relapse and completion rates;

- the risk factors for MDRTB.

We held a facilitated focus group session held with the tuberculosis team at North Middlesex Hospital comprising of the TB Consultant, the lead TB Nurse and TB Nurse to:

(1) test the feasibility and acceptability of the interventions in clinical care;

(2) determine the characteristics of TB patients in the locality covered by the North Middlesex Hospital and see whether these differed from the rest of London; and

(3) to explore how the TB Service at North Middlesex Hospital dealt with non-adherence.

The interventions we tested with the experts and the issues discussed included SMS reminders for:

(1) TB clinic visits for non-compliant (DOT) patients;

(2) appointments at community pharmacist for DOT patients;

(3) appointments for compliant (non-DOT) patients;

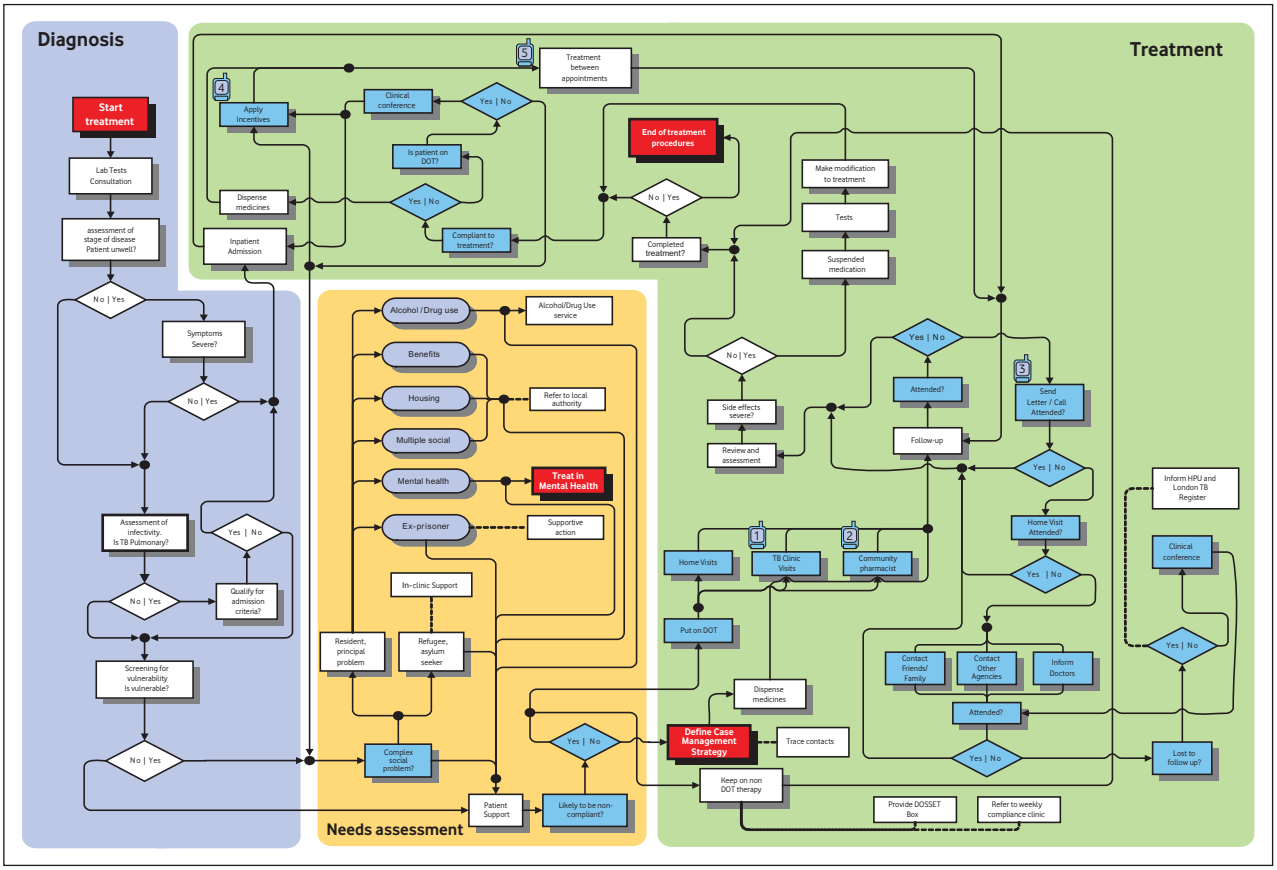
(4) reminding patients to take medication between appointments.

We learned that mobile phones and text messages were already being used, albeit unsystematically, by the TB Service at North Middlesex Hospital. On the basis of the focus group results, we identified a 'Refined Set of SMS-based Interventions' which could be applied in tuberculosis control throughout London and applied these to develop the care pathway model (shown in Figure 1). The focus group was also used to generate probabilities on the likely effects of using SMS on adherence to treatment, relapse, completion rates and outcomes in tuberculosis patients who were non-compliant (about a fifth of the total).

Stage 2: Economic modelling

The second stage of the study involved estimating the benefits of the SMS-based interventions. We developed an economic model to estimate the additional, or incremental, benefits of the interventions using mobile technologies (other things equal) in relation to additional, or incremental, resources or costs involved in the implementation of the intervention. We modelled the treatment progression and care outcomes for a cohort of 1000 newly diagnosed

Figure 1: Tuberculosis care pathway and SMS-based interventions



Key:

The SMS Intervention-based Policy (numbers are references to The Care Pathway for Tuberculosis Treatment in the UK, Showing the Policy)	
1	Mobile phones and SMS reminders to be used to remind the patients who are on DOT to attend the TB clinic
2	To attend the local pharmacist to receive TB drugs for DOT
3	To remind the patient to attend the clinic for regular check-up and evaluation
4	Mobile phones themselves can be used as an incentive for the patient in the settings where mobile phones can be highly valued
5	SMS reminders can be used for the patient to keep him/her to the TB drug diary.

tuberculosis patients and estimated the costs and outcomes over a period of time.

To ascertain whether SMS could improve adherence, and explore the impact of the interventions identified in the model, we subdivided our cohort of patients into the two broad categories:

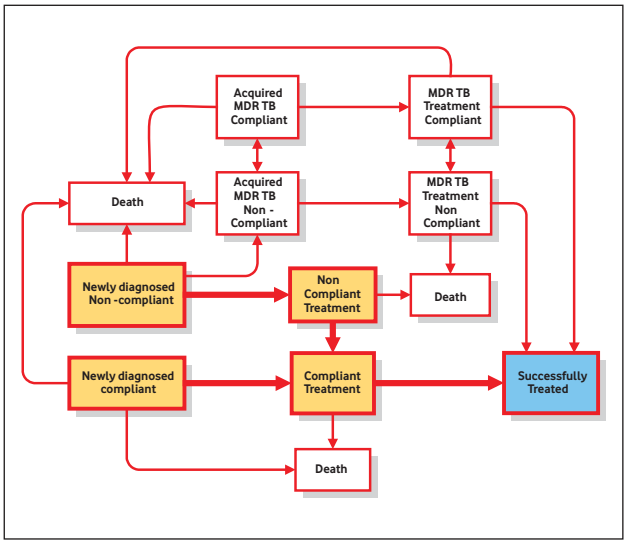
(i) patients who were likely to follow the treatment regimen; and

(ii) patients with known risk factors who will have higher risk of non-adherence to treatment

In terms of outcomes we looked at treatment completion, death (from tuberculosis and non-TB causes), failure of treatment, transfer-out from service, non-adherence, loss of follow-up, and the development of MDR tuberculosis.

We used a procedure known as Markov modelling, where the cohort of patients is completely described by a number of states and by the (constant-probability) transitions between these states (See Figure 2).

Figure 2: Cohort with compliant and non-compliant sub-groups



In the cohort of TB patients at the beginning of treatment we considered only two states:

(i) newly-diagnosed compliant patients and

(ii) newly-diagnosed non-compliant patients.

As the treatment progresses, the patients' conditions can improve, patients can develop drug resistance, die from TB or from other causes, or be treated successfully. States in the diagram which have only incoming arrows leading to them are called 'terminal states': in our model these are death and successfully treated cases. Once a patient is successfully treated he/she leaves the cohort. Interventions to improve outcomes are aimed at reducing the probability of non-compliance and diminishing the drug resistant forms of disease. The optimal care pathway is shown in bold on the diagram.

Stage 3: Epidemiological modelling

To assess the potential benefits on a wider scale, the transmission dynamics of tuberculosis in the general population need to be taken into consideration. We estimate the cost effectiveness of the SMS interventions over a time horizon of 10 years, taking into account service utilisation and unit cost, and applying an epidemiological model. The marginal cost and marginal benefits are estimated using discount rates to capture the present value of future costs, and also to reflect the time preference for evaluating the outcomes of care (i.e. the sooner the better).

The epidemiological model we developed is described in full at http://www.imperial.ac.uk/healthmanagement/mobiles

We estimated the costs of tuberculosis care using published studies from the UK, NHS tariffs and expert opinion.[29]

Health economists use an incremental cost-effectiveness approach to compare alternative health policies. Marginal improvements in health outcomes (the additional health benefits) are compared with marginal changes in the cost of programmes (the additional costs of providing the improved service). The new policies are compared to current best practice or current patterns of service organisation and provision.

In our analysis we use incremental cost-effectiveness approach to compare cost and benefits of current tuberculosis control programme with a new programme that incorporates SMS-based interventions.

4. Results

We simulated a range of scenarios using SMS-based interventions, and compared these with the current situation where the non-compliance rate is 20%. We simulated improvements in compliance rates ranging from 5% (in the non-compliant group) to the extreme case of a 100% improvement in the response rate in the non-compliant group.

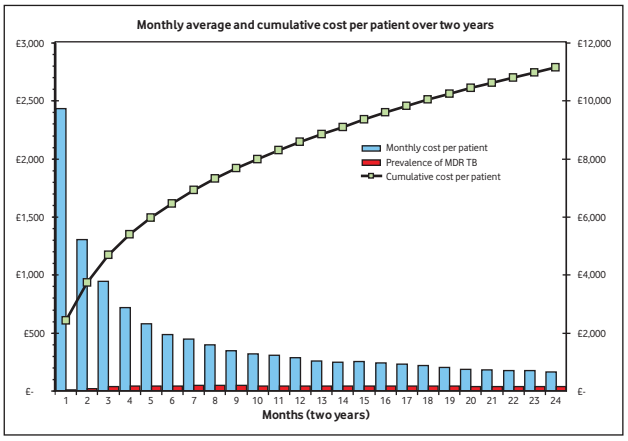
The simulation results show that for a cohort of 1,000 patients the potential cost savings from using SMS interventions range from £117,000 (if the compliance rate in the non-compliant group improved by 5%) up to over £3.8 million in the extreme case of a 100% improvement in compliance. The results are shown in table 1 and figure 3.

Table 1: Potential benefits of improved compliance

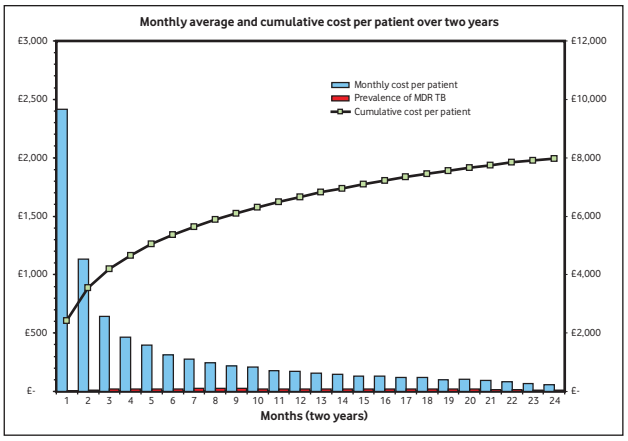
Responsiveness of the high risk group to compliance - improving policies	Proportion of the total number in cohort affected by the policy	Estimated mean cost of treating a cohort of 1000 patients	Difference in cost compared to the 'current' patterns of compliance, (as a % of the cost of 'current practice')	Number of life years saved as compared with 'current' pattern of compliance
Hospitalisation policies: 20% of all new DS cases and 50% of all MDR cases hospitalised				
0% (current pattern of compliance)		£7,728,000	-	
5% (of 20%)	1%	£7,612,000	- £117,000 (-1.51%)	27
12.5% (of 20%)	2.5%	£7,409,000	-£320,000 (-4.13%)	70
25% (of 20%)	5%	£7,063,000	-£666,000 (-8.6%)	142
50% (of 20%)	10%	£6,155,000	-£1,573,000 (-20.4%)	309
75% (of 20%)	15%	£5,015,000	-£2,713,000 (-35%)	498
100% (of 20%)	20%	£3,927,000	-£3,801,000 (-49%)	661

Figure 3: Economic benefits of SMS interventions on tuberculosis care

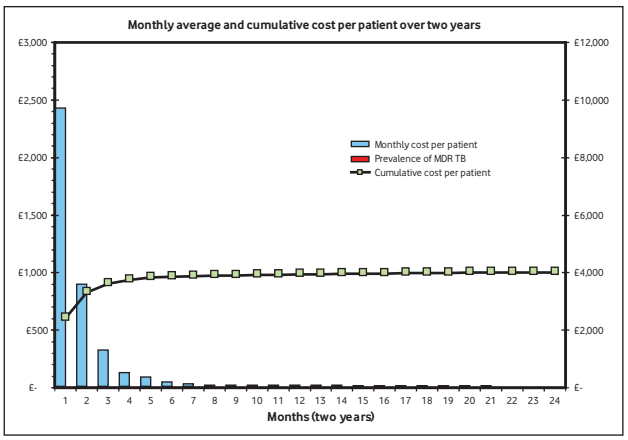
"Current" practice, 20% non-compliance ("risk group")



50% response to compliance policy in the risk group



100% response to compliance policy in the "risk group"



The scenario modelling shows that:

- SMS-based interventions improve health outcomes;
- The number of TB patients who are non-compliant decreases;
- The number of MDRTB cases declines substantially.
- There is an increase in the number of patients who are cured and a decline in the number of deaths.
- The potential number of MDR cases under treatment is considerably lower in the SMS scenarios.
- The number of successfully treated cases increases and the number of deaths falls due to reduction of the infectious phase of the disease, and particularly of MDR cases. (See Figures 4 and 5.)

Figure 4: Outcomes without SMS-based interventions

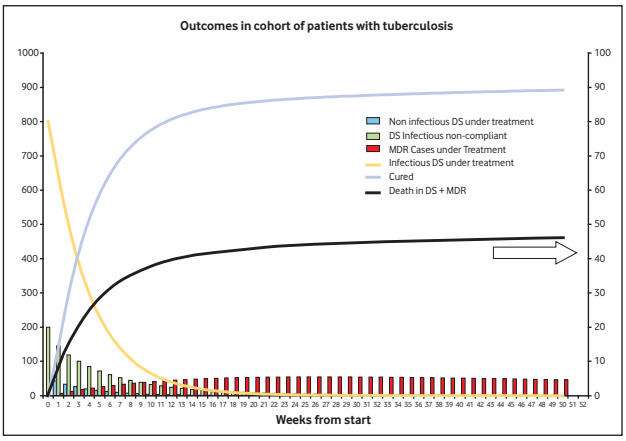
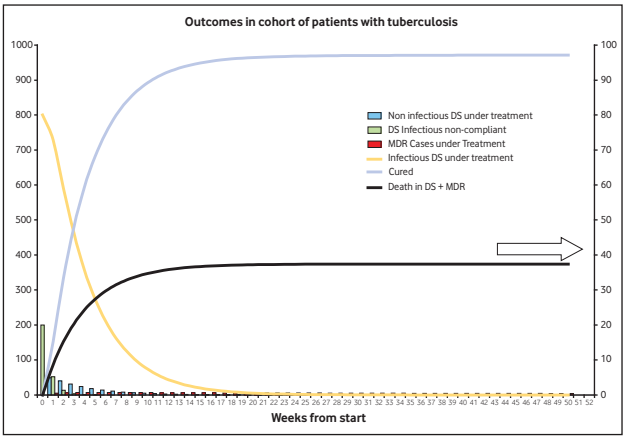


Figure 5: Outcomes with SMS-based interventions



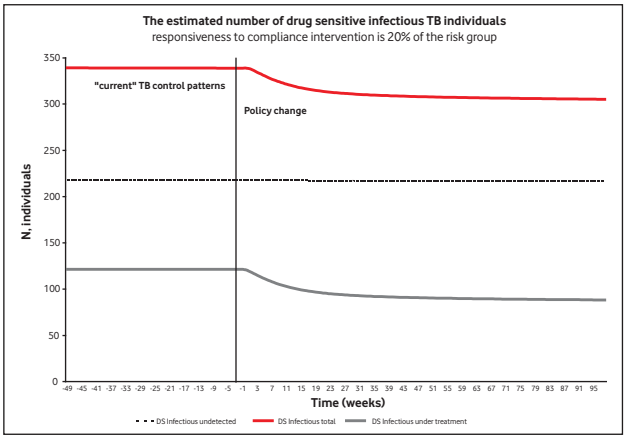
The scenario modelling demonstrates potentially large economic and health benefits of SMS applications in TB control. As TB is an infectious disease, reducing the number of people with TB and the duration of infection bring reduce transmission and consequently will bring public health benefits.

We therefore incorporated our model of a cohort of patients into a population model of 1 million adults to explore whether we could estimate the public health benefits of a reduced number of infections. In this epidemiological model we included parameters for the prevalence and incidence of TB which are affected by, amongst other things, the success of the health system at identifying and treating new cases.

Although this complexity means we cannot make precise estimates of the benefits from reducing non-compliance in the population, the modelling can nevertheless identify trends in the population in response to the introduction of policies to improve compliance with treatment. Our simulations estimate how policies using SMS applications affect the successful treatment of patients, including those with MDRTB, and consequently the epidemiology of the diseases.

The simulations show that SMS applications will benefit patients with DSTB and MDRTB, improving adherence and completion levels. In turn, this will lead to a reduction in the number of cases with DSTB and MDRTB. (Figure 6)

Figure 6: Public health impact of compliance policies for drug sensitive and MDR individuals



Our epidemiological model, which has been developed to illustrate trends for a simulated population, inevitably has some limitations. In particular, it assumes a static age structure, whereas as cohorts of patients age the transmission dynamics of TB infection will change. Nor does the model incorporate any changes in the pattern of migration.

5. Conclusions

Our scenario modelling shows that SMS applications can enhance tuberculosis care in England, improving health outcomes and at the same time delivering economic benefits. The proposed interventions are likely to improve the adherence of patients to treatment, particularly in areas such as inner cities with a high incidence and prevalence of tuberculosis among ethnic minority groups, and a higher proportion of TB patients at risk of failing to comply with the course of treatment provided by their local TB service.

SMS applications which enhance adherence can play an important role in control of other infectious diseases, such as HIV/AIDS, where adherence is of critical importance to improve patient survival but also to reduce drug resistance.

Even in England, which has a well-functioning tuberculosis control system and where the national guidelines are applied, we demonstrate the potential offered by SMS applications for an improvement in patients' compliance with treatment. The mobile technologies are likely to improve compliance by a proportion of the non-compliant patients. Mobile technologies are likely to be more effective if they are applied in combination with other interventions to improve compliance by addressing social needs of vulnerable patients and immigrants.

Mobile technologies are likely to offer opportunities to improve tuberculosis services, with major health and economic benefits, in developing countries. They can be especially effective where the communications between patients and health clinics are difficult and access to services is poor due to a weak infrastructure and geography barriers. The potential of mobile should be explored by international and national agencies through well-designed clinical studies incorporating an economic evaluation.

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Use of mobile technologies to enhance control of type 1 diabetes in young people: economic evaluation

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Foreword – Professor Peter Hindmarsh

Chronic illnesses like diabetes involve many people interacting with the individual. A real difficulty has been finding a medium of communication people can relate to.

Communications are important because management of the disease doesn't just require motivating the individual, getting them to change their behaviour, but also sustaining and monitoring that behaviour over many years. Effective treatment is about how you transition people into self-management. In the past this has tended to operate on a face-to-face basis, which is costly and not all that practical.

We have to think hard about what methods of communication this population is most likely to use in day to day life and incorporate self management into the daily routine so that it becomes a normal activity and not an inconvenience. We have to explore what the preferred means of communication are and respond by designing systems that enable people to engage with the health service in their preferred manner, putting the individual in charge.

Insulin-dependent, type 1 diabetes affects about 15,000 to 20,000 young people under 18. This is not a large number compared to the number affected in adulthood by type 2 diabetes, but the paediatric condition starts that much earlier and the chances of complications are that much higher. It is a condition which is just as bad in the long-run as childhood malignancies. Diabetes will kill you in the end, and along the way it can be a miserable existence. This is a very serious health issue, and a serious cost issue.
We need to explore all the options that could enable greater control of this disease and I welcome the contribution this paper makes towards doing so. Professor Peter Hindmarsh is Professor of Paediatric Endocrinology at University College London.

Introduction

In 1995, the global prevalence of diabetes mellitus (number of people living with diabetes) was estimated to be 150 million, or 4% of world's population. By 2025, this prevalence is expected to double to reach 300 million people – representing 5.4% of the world's population[1] – and 366 million by 2030.[2]

In England and Wales, over one million people have been diagnosed with diabetes (a prevalence of 2.23 per 100 men and 1.64 per 100 women), with estimates which show that a further one million people have diabetes but have not been diagnosed. The incidence of diabetes in the UK has been estimated at 1.7 new cases per 1000 population per year, but is projected to double in the next twenty years.[3] Of those with diagnosed diabetes, about 80% have type 2 and 20% type I diabetes (insulin dependent). (Box 1)

Box 1: Diabetes Mellitus

Diabetes mellitus is caused by an excess of glucose in the blood due to a shortage of the hormone insulin or body's resistance to it. There are two types of diabetes mellitus: type 1 and type 2.

Type 1 diabetes usually begins at early age and is due to destruction of the cells in pancreas which produce insulin. Whereas, type 2 diabetes, which typically occurs in later age, is related to obesity, inadequate insulin to meet body's needs or body's resistance to the insulin produced. It is of concern that, due to rising obesity levels, type 2 diabetes is increasingly seen in children.

Type 1 diabetes is the most common metabolic disease in young people. It is characterised by a lifelong need to administer insulin. The incidence of type 1 diabetes, which is highest among children aged between ten and fourteen years[4], is increasing.[5]Genetic influences, immune defects and environmental factors influence development of diabetes[6] and account for the observed global variation in incidence.

Diabetes damages small and large blood vessels of the body, resulting in expensive-to-treat complications such as heart disease, stroke, visual impairment (as a result of new vessel formation in the retina), kidney failure, foot ulceration (which can lead to amputations) and erectile dysfunction.

If not addressed, diabetes leads to substantial ill health, with huge psychological impact on individuals and households as well as a large economic burden at societal level.[7] In 2002, in the US, direct medical and indirect costs attributable to diabetes to be $132 billion – estimated to rise to $156 billion by 2010 and to $192 billion by 2020.[8] (Box 2) In 2002, average medical expenditures for a person with diabetes amounted to $13,243, while that for persons without diabetes was $2,560. In 1999, in eight European countries, total direct medical costs of type 2 diabetes were estimated at €29 billion a year. Hospitalisations, at 55%, accounted for the greatest proportion of these costs totalling €15.9 billion. In contrast, in these countries, drug costs for managing type 2 diabetes were relatively low, accounting for only 7% of the total direct medical costs.[9] Cost of diabetes to the UK NHS is estimated to be around 9% of the NHS budget.[10]

Box 2: Cost of diabetes

Cost of diabetes relate to: (1) direct costs of diagnosis and management – such as in-patient or out-patient care in hospitals, consultations with doctors and nurses in primary care, drugs (insulin and tablets) consumables (such as syringes, other injection equipment), and investigation costs blood and urine tests; (2) direct cost of treating complications of diabetes; (3) indirect costs due missed work days, reduced productivity and diminished quality of life.

However, if successfully treated, by maintaining good control of blood glucose and blood pressure, and by leading healthy lifestyles, the risk of developing these complications and their progression is significantly reduced to levels similar to those of a person who is in good health and has no diabetes. For example, the Diabetes Control and Complications Trial (DCCT) demonstrated that, intensive treatment of type 1 diabetes which led to good glucose control, reduced the risk of diabetes-related eye problems, neurological complications and kidney disease respectively by 76%, 60% and 50%.[11] The United Kingdom Prospective Diabetes Study (UKPDS) demonstrated similar reductions in risk for these problems in persons with type 2 diabetes who were intensively treated and maintained good blood glucose control.[12,13]

Conventional treatment of Type 1 diabetes comprises 2 or 3 daily injections of short and medium acting insulin – administered by syringe and needle or pen device. Intensive insulin therapy consists of either a basal-bolus (multiple daily injection) regimen or pump therapy. Basal-bolus therapy comprises a daily injection of long acting insulin which provides the basal insulin, and boluses of rapid acting insulin calculated according to the carbohydrate count of food. Continuous subcutaneous infusion of insulin (CSII) administers rapid acting insulin via a pump. The pump is programmed to deliver a variable basal rate, and the patient

uses the pump to bolus rapid acting insulin to cover the carbohydrate count of food. Treatment with intensive insulin therapy affords greater patient flexibility and control.

In this paper we report a retrospective economic evaluation of a randomised controlled trial (RCT) in young people aged 8 to 18 with type 1 diabetes, designed and implemented by Drs Greene and Franklin at University of Dundee. The RCT compared (1) conventional treatment, (2) conventional treatment combined with SMS text-messaging and (3) intensive therapy combined with an SMS-enabled behavioural support intervention. Evidence suggests that in this age group simply intensifying insulin therapy without providing additional support to patients does not improve metabolic control.[14] Concentrating on novel therapeutic developments alone may not yield desired results. Instead, focus should be on interventions and mechanisms that make people cooperate with their diabetes and promote adherence.[15]

The study is of particular importance as it is the first RCT which has explored impact of SMS-enabled behavioural support with intensive therapy in this difficult-to-reach young age group, which generally have low adherence levels with poor glycemic control. The study used 'Sweet Talk', a proprietary complex behavioural and social intervention for young people with diabetes delivered using SMS text messaging system.[16] The system, developed at University of Dundee, is designed to promote patient self-efficacy[17] which in turn helps to improve diabetes self-management, adherence, and control of diabetes. (Box 3)

Box 3: Sweet Talk and self-efficacy

Bandura's Social Cognitive Theory suggests that health behaviours will be motivated by enhancing self-efficacy. Sweet Talk system involves "the setting and written contracting of agreed personal self-management goals during the diabetes consultation. Based on these goals and patient's profiles for age, sex and diabetes regimen, the Sweet Talk system schedules the automated delivery of a series of appropriately tailored messages, including daily messages to reinforce their personal self-management goal, and a weekly reminder of their specific goal."[18]

Self-efficacy is a person's belief in their ability to overcome the difficulties inherent in a specific task, in a particular situation.[19] Knowledge about diabetes alone is not sufficient to achieve optimal glycemic control;[20] self-efficacy is required to translate knowledge into improved diabetes self-management.[21,22] Self-efficacy, which influences diabetes self-care and metabolic control in young people[23], can be increased by empowering patients to set goals, problem-solve, improve their self-motivation and mobilise appropriate social support.[24]

As described by Dr Victoria Franklin, who led the design of the 'Sweet Talk' intervention, it involves the setting of agreed personal self-management goals during the diabetes consultation. Based on these goals and patient's profiles for age, sex and diabetes regimen, the 'Sweet Talk' system schedules the automated delivery of a series of appropriately tailored messages, including daily messages to reinforce their personal self-management goal, and a weekly reminder of their specific goal. The system draws on a database of messages created to encompass the four main diabetes self-management tasks (insulin injections, blood glucose monitoring, healthy eating and exercise). In addition patients received occasional text 'newsletters' regarding topical diabetes issues or requests for tips and suggestions about living with diabetes, and personal replies to any messages they sent in to 'Sweet Talk'.[25]

The patients are able to send text messages into the 'Sweet Talk' system – including blood glucose results. In turn, according to the profile of the patient (age, gender, treatment, treatment goals), the 'Sweet Talk' system sends to patients: (1) Daily text messages related to personal diabetes goal (2) Weekly text message reminders of personal diabetes goal (3) Pre-Clinic text message reminder (4) Sporadic text message newsletters, and (5) Personal replies to messages patients had sent to 'Sweet Talk'.

Sweet Talk provides (1) Tangible or instrumental support by providing patients with reminders about diabetes self-care activities, their personal goals and clinic visits, and can be used to request items needed for their diabetes care, (2) Informational support, by delivering regular information about diabetes and self-management tasks and patients can request information from 'Sweet Talk' by text message, (3) Companionship by developing a sense of belonging and mutuality by creating a community of young people with diabetes, and a forum for sharing feelings and experiences, and (4) Emotional support through personalised positive messages to encourage diabetes self-management and facilitating ongoing communication.

Methods

The methods for the RCT are described in detail elsewhere.[26] Briefly, the patients were randomly allocated to three study arms comprising: (1) Group 1 – a control group which continued with conventional insulin therapy (CIT) and usual medical care (which comprised clinic visits every three or four months and access to the emergency help line); (2) Group 2 – which continued with CIT and usual medical care but also received the 'Sweet Talk' Text Messaging Support intervention, and; (3) Group 3 – which received usual medical care but were also changed to intensive insulin therapy (IIT) (which included patient's own choice of multiple daily injections (MDI) or continuous subcutaneous insulin infusion (CSII) both with the 'Sweet Talk' Text Messaging Support intervention.)

SMS reminders improve patient self efficacy and management of diabetes.

We conducted an incremental cost-effectiveness analysis of the three arms studied in the trials, using original but anonymised trial data on service utilisation for each patient supplied by the research team at University of Dundee. For each of the three patient groups we analysed utilisation data and estimated direct costs by multiplying utilisation volume and unit costs of interventions (clinical episodes, drugs, equipment, materials, and procedures). Unit costs were estimated using published NHS National Schedule of Reference Costs and the British National Formulary. See Annex 1 for further details on the cost components included, and the unit costs used and their sources. The perspective adopted for the analysis is that of the NHS. The study was conducted over a one year period and costs and outcomes were measured within this time frame. Cost of equipment used for treatment was annualised over the period of useful lifetime of equipment.

Outcomes studied included (1), self-efficacy, using a Self-Efficacy for Diabetes scale, developed to measure adolescents' views of their competence or efficiency in managing their diabetes, which in turn leads to better glycaemic control (See box 3) and (2) haemoglobin HbA_{1c} level – a marker of blood glucose level over a three-month period and a good indicator of glycaemic control and measured as the proportion of red blood cells which are glycosylated (i.e. have glucose molecules attached to them).[27] Mean costs and outcomes were analysed using MS Excel® and SPSS®.

Results

There were 27 patients recruited to Group 1 (17 males and 10 females with a mean age of 12.86 years at start of trial), 32 to Group 2 (14 males and 18 females with mean age of 13.58 years), and 31 to Group 3 (17 males and 14 females with mean age of 13.03 years). (Table 1)

Table 1: Characteristics of patients enrolled in the trial

Groups in trial	Number of patients	Male	Female	Mean age and range (95% confidence interval)
Group 1: conventional treatment	27	17	10	12.86 (11.92 to13.80)
Group 2: conventional treatment + SMS	32	14	18	13.58 (12.74 to14.42)
Group 3: intensive treatment + SMS	31	17	14	13.03 (12.14 to13.92)

Source: Dr Stephen Green and Dr Victoria Franklin, University of Dundee

As compared with the baseline levels at the start of the study, in Group 1 (conventional treatment) and Group 2 (conventional treatment + Sweet Talk) the mean HbA_{1c} levels respectively increased (worsened) by 0.14 (95% CI 0.73 to -0.44; 2.29%) and 0.29 (95% CI 0.76 to -0.17; 4.42%). In Group 3 (intensive treatment with Sweet Talk) HbA_{1c} levels declined (improved) by 0.99 (95% CI -0.45 to -1.53; 9.32%).

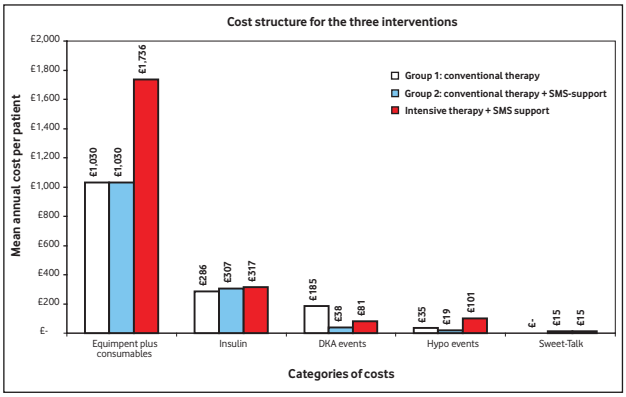
In Group 1, self-efficacy declined[28] by 9.53% (95% CI -2.1 to -16.9), whereas in Groups 2 and 3 self-efficacy increased by 3.72% (95% CI 0% to 7.4%) and 7.14% (95% CI 0.3% to 14%) respectively. Compared to Group 1, the improvements in self-efficacy in Groups 2 and 3 were statistically significant ($p<0.01$ in both cases). More explanation is needed about how the self-efficacy measure is being used here. For example, is it measured on a continuous scale? Is it a discrete scale, and the percentages reported above are the percentages reporting a given set of values? If so, what are the values, and what is the scale?

The cost of care per patient per year in Group 1 was £1,536 as compared with £1,413 for Group 2 and £2,211 for Group 3. (Table 2)

Additional annual cost per patient for Group 3 (intensive therapy with SMS) was £675 higher than Group 1 (conventional therapy) and £797.6 higher than Group 2 (conventional therapy + SMS). These differences were

statistically significant. (Table 3) The difference in costs between conventional therapy (Group 1) and conventional therapy + SMS (Group 2) was not statistically significant: as the cost of the SMS intervention was low. The cost differences between conventional treatment, conventional + Sweet Talk, and intensive + Sweet Talk show that cost of SMS is very low and the cost difference between Group 3 and 1 is largely explained by the difference in cost of the subcutaneous infusion pump, which is a key feature of intensive therapy as it provides a semi-automated delivery of insulin into the bloodstream as opposed to syringe-injections, but requires training and support when used, especially in children and adolescents. (Figure 1)

Figure 1: Cost structure for the interventions



Compared to Group 1, change in the HbA_{1c} levels in Group 2 (0.15 or 2.13%) was not statistically significant (p=0.69 and p=0.58). However, compared to Group 1, the change in HbA_{1c} levels in Group 3 (1.28 or -13.74) was statistically significant (p<0.01). (Table 2)

Sweet Talk significantly improved self-efficacy. As compared with conventional treatment (Group 1), self-efficacy in conventional treatment + Sweet Talk Group (Group 2) increased by 13.25 percentage points. This difference was statistically significant (p=0.002). Compared to conventional treatment (Group 1) intensive treatment + Sweet Talk (Group 3) resulted in a significant increase in self-efficacy by 16.67 percentage points (p=0.0019). There was no significant change in self-efficacy between intensive treatment + SMS and conventional treatment + SMS (p=0.352).

These changes are significant as a 10% improvement in HbA_{1c} is associated with a substantial reduction in complications associated with diabetes (reference DCCT). Likewise, improvement in self-efficacy improves adherence levels, which in turn improves glycaemic control.

The incremental cost-effectiveness ratios for the improvements in outcomes between the interventions compared were:

(1) £594.9 per HbA_{1c} point improvement for intensive treatment + Sweet Talk compared to conventional treatment;

(2) £620.8 per HbA_{1c} point improvement for intensive treatment + Sweet Talk compared to conventional treatment + Sweet Talk.

Incremental cost-effectiveness ratios for percentage change in HbA_{1c} level were:

(1) £58.16 per percentage point change for intensive therapy + Sweet Talk compared to conventional therapy;

(2) £58.05 per percentage point change for intensive therapy + Sweet Talk compared to conventional therapy + Sweet Talk.

The incremental cost-effectiveness ratios for self-efficacy were:

(1) £40.5 per percentage point change for intensive therapy + Sweet Talk as compared with conventional therapy; and

(2) £9.25 per percentage point change for conventional therapy + Sweet Talk compared to conventional therapy.

Discussion and conclusions

We demonstrate that mobile communication technologies, such as SMS text messaging, can be used to effectively deliver intensive treatment programmes to manage diabetes mellitus and that such a programme is acceptable even to hard-to-reach groups, such as the children and teenagers in the study, which generally have poor adherence, control and outcomes.

Our results indicate that SMS-enabled intensive treatment programmes are acceptable in management of diabetes mellitus, as shown by the young persons involved in the study, but also improve patient self-efficacy and outcomes. As compared with conventional treatment, intensive treatment + Sweet Talk results in significant improvements in outcomes as measured by HbA_{1c} and self-efficacy. Further, compared to conventional therapy, conventional therapy + Sweet Talk also leads to significant improvements in self-efficacy.

Further, our incremental cost-effectiveness analysis shows that these improvements are attained at low cost. For example, in the UK context, SMS element of the interventions are shown to be low-cost, and statistically significant improvements in self-efficacy are achieved with very small additional cost when SMS-enabled behavioural support programmes are added to conventional treatment.

Using intensive treatment + Sweet Talk compared to conventional treatment, the additional cost per-year per-patient to reduce HbA_{1c} level by one point is only £594.9.

Table 2: Cost effectiveness of conventional and SMS-ebabled iinterventions

	Cost difference	Outcome difference	ICER
Outcome measure: HbA_{1c} - absolute change			
A. (Intensive+SMS) to (Conventional)	**£ 675.0**	**1.13**	**£ 594.86**
	p-value < 0.001	p-value 0.007	
B. (Intensive+SMS) to (Conventional+SMS)	**£ 797.6**	**1.28**	**£ 620.76**
	p-value < 0.001	0.001	
C. (Conventional+SMS) to (Conventional)	**-£ 122.6**	**0.150**	**-£ 816.43**
	0.227	0.690	
Outcome measure: HbA_{1c} - % change			
A. (Intensive+SMS) to (Conventional)	**£ 675.0**	**11.61**	**£ 58.16**
	p-value < 0.001	p-value 0.003	
B. (Intensive+SMS) to (Conventional+SMS)	**£ 797.6**	**13.74**	**£ 58.05**
	p-value < 0.001	p-value 0.0005	
C. (Conventional+SMS) to (Conventional)	**-£ 122.6**	**2.13**	**-£ 57.42**
	0.227	0.580	
Outcome measure: self-efficacy			
A. (Intensive+SMS) to (Conventional)	**£ 675.0**	**16.67**	**£ 40.50**
	p-value < 0.001	p-value 0.002	
B. (Intensive+SMS) to (Conventional+SMS)	**£ 797.6**	**3.42**	**£ 233.53**
	p-value < 0.001	p-value 0.352	
C. (Conventional+SMS) to (Conventional)	**-£ 122.6**	**13.25**	**-£ 9.25**
	0.227	0.002	

Much of this cost is accounted by the cost of the subcutaneous infusion machine and not SMS enabled behavioural intervention. However, given that the average cost of a single day in hospital without treatment in UK is £313 and considering that the high human and economic costs incurred by patients with diabetes are very substantial, the additional costs to achieve improvement in HbA_{1c} levels appear very low and acceptable.

Effective management of chronic illness requires patient empowerment to enhance adherence, which in turn reduces complications of illness, prevents relapses and improves quality of life and health outcomes. SMS-enabled interventions, which are low-cost and very affordable, by enhancing self-efficacy, increases the opportunities for persons with long-term conditions to take self-control of their illness and management of their conditions. This in turn improves satisfaction, quality of life and health outcomes, which bring with it welfare and economic benefits to the individual and society.

For a breakdown of the cost analysis, please visit http://www.imperial.ac.uk/healthmanagement/mobiles

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