Implementations of Health Information Technologies with Consumers as Users: Findings from a Systematic Review

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Abstract

Background: A systematic review of evaluations of innovative eHealth implementations was funded by the New Zealand Ministry of Health to inform information strategy. A key trend of interest to the Ministry was person-centered healthcare, including systems where health consumers use health information technology (IT) directly. Herein we report, analyze and reflect on the review findings with respect to such systems.

Objectives: To review the nature and extent of known successes of health IT with consumers as users.

Methods: Queries for evaluations of innovative eHealth implementations were submitted to MEDLINE, EMBASE, PsycINFO, CINAHL and Business Source Premier for articles appearing between 2003 and early 2009 and filtered on inclusion criteria of reporting actual implementations (i.e., use), innovativeness, evaluation (interpreted generously) and scaleability. Substitutions were made where more recent superior studies of the same or closely related projects could be found.

Results: 100 of 1413 retrieved articles met the inclusion criteria; 47 of these involved consumers as users of a component of the evaluated system. Systems that provided messaging between the patient and their regular care provider met with satisfaction and good uptake. There were improved chronic disease outcomes in 11 of 15 education / self-management systems and 2 of 3 home telemonitoring systems where measurement of such outcomes was reported; a further 3 systems targeting the family members of individuals with chronic conditions as principal users all showed positive well-being outcomes for the caregivers.

Conclusions: There have been a number of demonstrated instances of clear successes in both uptake and outcome for health IT interventions involving consumers as users, particularly for chronic condition management. However, compelling demonstrations (in terms of methods and sample size) remain isolated. More study is needed to assess the transferability of the demonstrated successes to greater scale, diverse contexts of deployment and to other conditions. Better keywords and more systematic reporting, particularly with respect to implementation and evaluation status, would aid similar reviews in the future.

KEYWORDS: Computerized patient medical records; Consumer health information; Consumer participation; Internet; Self care

1. Introduction

New Zealand has a sophisticated eHealth environment. It is recognized as in the top tier of nations with respect to IT use in General Practice medicine [1], where computer-based prescribing is ubiquitous, receipt of laboratory and hospital discharge data electronically is the norm, and electronic referral and online decision support are increasingly
commonplace. Problems common to the Developed World – rising healthcare costs, increasing rates of chronic conditions and an ageing population – however, mitigate against complacency.

The New Zealand Ministry of Health (MoH) commissioned a systematic literature review to inform information strategy. The key question was: What IT innovations have been demonstrated to provide benefits in health care? Of particular interest was innovative eHealth that supported a transformation of care in ways that may be more person-centered, involve the social context of patients (e.g. family and community), improved integration of service delivery and/or provided better chronic disease management. An important class of such eHealth systems are those where health consumers use health IT directly (in this case taking ‘consumers’ as patients or other interested parties, particularly those engaged in the day-to-day care of another, such as a spouse, child or parent with a chronic condition).

Oh et al [2] conducted a systematic review of definitions of eHealth and found that there is a wide range of descriptions and assumptions about what it encompasses. They found that eHealth is associated with health improvement, benefits, efficiency, effectiveness and enhancement, and that these aspects of health as a process are enabled by technology. It is with respect to this broad sense of eHealth that the literature review of health IT benefits was conducted with evaluations of innovative eHealth implementations as the key items of interest.

Herein we report the methods and findings of the review focusing on the results involving health IT with consumers as users. The original MoH report, on which the present paper is based, is available [3]; any differences in interpretation of the results owe to the authors of the present paper, and are not necessarily the views of MoH.

### Table 1. Inclusion criteria.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Description</th>
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<tbody>
<tr>
<td>Evaluation of a specific implementation</td>
<td>Opinion, proposal or theory not related to any clearly reported implementation is excluded. Other literature reviews are excluded as data points but inform the discussion. Relevant methods articles not reporting on evaluation of a specific implementation are also excluded, but informed review of evaluation frameworks (a work component beyond the scope of the present paper).</td>
</tr>
<tr>
<td>eHealth</td>
<td>Paper must report on a health related innovation that is dependent on IT</td>
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<tr>
<td>Innovative</td>
<td>System must have a ‘boundary-crossing’ impact (i.e., transform roles in health delivery). Telemedicine connection of two traditional provider settings (such as specialist consult to remote clinic) was not considered to be sufficiently innovative for inclusion.</td>
</tr>
<tr>
<td>Clear evaluation methodology</td>
<td>Studies with no clearly defined evaluation method were excluded</td>
</tr>
<tr>
<td>Developed world</td>
<td>Studies with a primary thematic emphasis on the developing world and associated issues were excluded</td>
</tr>
<tr>
<td>Evidence of scaleability to 100,000 patients</td>
<td>As a guide, papers showing a positive outcome with 100+ patients in the treatment group or that report continued production use of the system</td>
</tr>
<tr>
<td>Not duplicating another included paper</td>
<td>Include only the most recent (or most extensive) paper reporting on a particular eHealth implementation</td>
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2. Methods

We identified inclusion criteria as listed in table 1. To deliver a review servicing the objectives, the query to literature databases has a conceptual structure as illustrated in Figure 1. The concept of ‘innovativeness’ was embodied in the query by searching for terms related to particular objectives deemed innovative to support (notably, self-care, person-centered care, integrated care and consumer/provider co-production of care were of interest to MoH).

Recognizing that there would not be a great wealth of rigorous evaluations available for implemented, innovative eHealth systems, the requirement for measurement was realized through a range of terms intended to match any sort of systematic pursuit of evaluation data. The publication range was restricted to 2003-2009 (with the queries run in late January 2009). The rationale for the restrictive date range was that projects that had published evaluations only in 2002 or earlier were unlikely to represent sustained successes with modern architectures of direct relevance for current New Zealand health sector planning; moreover, earlier successes should have been picked up by the review of impact of health IT done by Chaudhry et al [4].

The following databases were queried to identify candidate papers for the systematic review: MEDLINE® In-process and other non-indexed citations and MEDLINE; CINAHL; PsycINFO; EMBASE; and EBSCOhost Business Source Premier (BSP). The full MEDLINE query (then replicated for CINAHL, PsycINFO and EMBASE) is provided in Appendix 1. Note that the MEDLINE query also includes restrictions on article type (to exclude editorials – deemed a likely source of ‘noise’) and to research on human subjects (e.g., serving to exclude veterinary applications). The query required considerable reformulation to fit the BSP query interface; the BSP query is provided in Appendix 2.

Analysts assessed each candidate paper retrieved by the database queries against the inclusion criteria to provide a human check on the intended effect of the database query – seeking reports of eHealth that are innovative, implemented and evaluated, scalable, and thematically concerned with health IT in the developed world. Review and methodology articles were ‘set aside’ (excluded from the direct analysis of implementations, but used to inform discussion of results).

In general two analysts independently assessed each candidate paper for inclusion, with a third analyst casting the deciding vote in case of disagreement, and a final review by the lead analyst (JW). The process varied for the BSP query results, which proved to have a much lower rate of relevance. These were first scanned by an analyst with an Information Systems background (KD), with only those identified for inclusion by this first analyst being further screened by a second analyst.

During this assessment stage, the article may have been updated to a newer and/or more comprehensive evaluation of the same technology if such an article could be identified.

In the report to MoH, it was noted that a large proportion of the included studies (about half) reported types of health IT classed as ‘consumer’ or ‘crossing consumer-provider divide,’ as well as there being some telemedicine applications with high levels of consumer involvement (in contrast to ‘provider’ systems aimed at professional users, such as computerized physician order entry [CPOE] and clinical decision support applications). For the present paper, we have re-analyzed the types of health IT in the included articles and report the new analysis with respect to those systems where the consumer is a direct user of the technology.
3. Results

1413 articles were retrieved by the database queries, 100 of which met the inclusion criteria (see Figure 1). Of these, 41 involved consumers as direct end users. We also found six borderline cases for which careful reading was required to decide that the consumer’s role as IT user was in fact minimal or nil, but which we deemed sufficiently instructive to discuss herein.

Examining the functionality reported for the systems described in the 47 remaining articles, we clustered the articles by application type with a focus on the role of the consumer as user. Table 2 gives brief descriptions of these applications with ‘borderline’ as the last category.

Appendix 3 shows the authors, aims, participants, methods and results/conclusions for the 47 articles grouped by their dominant application type. The majority of the articles were from US based implementations (n=30). Other implementations were in the UK (n=3), Germany (n=2) the Netherlands (n=2), or other European countries (n=5); two of those implementations were in multiple European countries. The remainder of the implementations were in Canada (n=3), Australia (n=1), and Columbia (n=1).

We reviewed the articles within each application type to identify successes, negative outcomes, and qualitative findings. The remainder of this section describes the applications within each type and their evaluation outcomes.
### Table 2. Application types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>Messaging</td>
<td>The consumer user communicates with their regular face-to-face practice for administrative matters and to clarify issues</td>
</tr>
<tr>
<td>Teleconsult</td>
<td>The consumer communicates to clinical service providers with no pre-existing face-to-face relationship</td>
</tr>
<tr>
<td>Education / Self-management</td>
<td>Focus on the consumer user learning and doing for themselves</td>
</tr>
<tr>
<td>Family</td>
<td>The consumer user is a person supporting the ill person</td>
</tr>
<tr>
<td>Telemedicine</td>
<td>The consumer is remotely monitored with various, but non-trivial, degrees of participation by self and/or family</td>
</tr>
<tr>
<td>Borderline</td>
<td>Cases that illustrate the boundary; consumer is close to the system, but in some sense less than a full-fledged end user</td>
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### 3.1. Messaging

Eight of the articles involved messaging systems for communication between the patient and their regular practice [5, 6, 7, 8, 9, 10, 11, 12]. These systems typically provided patient access to components of their medical record, online appointment scheduling and requests for refills and referrals, as well as a facility for email communication with practice staff.

It should be noted that Houston et al [7] is on the boundary of our inclusion criteria in that it is a survey of experiences with patient-physician email for participants recruited through consumer health information websites, and thus refers to a technical function but not just one specific implementation of that function. Also, Sole et al [10] is on the boundary of our description of Messaging systems; it involves a service that automatically triages college students, with the option of referring them to face-to-face contact. This is included under the Messaging category on the rationale that the college health service is in a sense the students’ regular provider, whether or not the particular student user has seen that service previously.

Patients reported enthusiasm for and satisfaction with these systems in all five cases where measured [5, 6, 7, 8, 9]. Increasing [5, 6] or high [10] use was explicitly reported in some cases, and in no case did the service appear to be lacking in uptake. Fung et al [5] reported the largest user cohort with registered members rising from 20,617 (0.7% of all members) in the first quarter of 1999 to 270,987 (8.6%) in the third quarter 2002. Users of Messaging services reported convenience and a sense of empowerment [6], preference over telephone [9] and positive factors such as being able to save and review written correspondence and increased comfort with asking questions by email rather than in person [7]. In addition, Hess et al [6] found that patients identified missing lab results that physicians had not manually released, as well as identifying inaccurate information and slow response from the physician or nurse.

Providers expressed initial concerns about the patient email features of their system [8, 9]. They worried that patients would use email inappropriately and that decreased productivity might result from the need to reply to large numbers of email queries. However, non-physician clinic staff were more enthusiastic post-implementation [8]; and clinicians were not inundated with messages and there was no detrimental effect on productivity [9]. Zhou et al [12] found that office visit rates decreased more than the control group, and telephone contact rates increased less than the control group; alternatively, Hess et al. [6] found there was an increase in messages through their system, but no correlated decrease in other modes of contact (i.e. office visits or telephone contacts).

On the downside, Houston et al [7] found 21% of patients reported inappropriate use of email for serious, urgent medical issues; and 41% of patients expressed concerns about confidentiality or privacy. Also, Staroselsky et al [11] found that modifications to the medication list (e.g. additional medications) pointed out by patients reviewing the content online records were generally not corrected by their physicians.
3.2. Teleconsult

Two articles looked at Internet-based “Ask the Doctor” services where there was no prior relationship between the user and the responding clinicians [13, 14]. Convenience for the user was cited as a major benefit, and the ability to re-read and reflect on provider responses was also mentioned. Perhaps surprisingly, one of these studies, from Colombia, found that most users were from large cities, not from rural areas where a physical visit to the doctor might be expected to pose more practical difficulties.

In a somewhat similar vein (patient comfort with Internet as a way to interface with the health system), one study [15] looked at Chlamydia testing using Internet-ordered and self-administered vaginal swabs. The large majority of users preferred online ordering of the test kits for mailing over picking them up at community locations. The screening was effective, with 10% of patients testing positive and most of those being confirmed as seeking treatment. This screening approach seemed to reach populations who were not otherwise accessing traditional health care, at least for this problem (e.g., only 29% reported receiving a pelvic exam in the prior year).

3.3. Education / Self-management

The largest category of consumer systems was those aiming to improve consumer knowledge and self-management. These targeted various medical conditions, including asthma [16, 17, 18], diabetes [19, 20, 21], cancer [22, 23], arthritis [24], amyotrophic lateral sclerosis [25], panic disorder [26], anxiety and depression [27, 28], and schizophrenia [29]. Others aimed to improve users’ physical fitness [30, 31] or weight management [32] or promote smoking cessation [33, 34].

Eleven of 15 articles (73%) found at least one positive outcome where the studies were designed to test outcomes (an additional five articles were qualitative only). The 11 positive outcomes factored into:

- Objectively measured biological outcomes, with quality of life and/or social support outcomes, in chronic disease (Anhøj et al [16] augmented by trial results [35]: asthma symptoms, quality of life, lung function and airway responsiveness, for an asthma diary with provider access; D-Net [20] tailored information for diabetes: lipids, dietary behavior and perceived social support);
- Mental health outcomes by validated instruments (Beck Depression Inventory-II and Beck Anxiety Inventory for programmed therapy of anxiety and depression patients at a specialist clinic [27]);
- Self-reported chronic disease management outcomes (fewer symptom-days, symptom-nights, school days missed, restricted-activity days, and hospitalizations for asthma for tailored information and multimedia to urban youth [18]; self-reported panic attack frequency and severity [but 99% attrition] [26]);
- Self-reported psycho-social/self-efficacy outcomes (quality of life, healthcare competence and social support for CHESS service combining information, communication and decision aids for breast cancer patients [23]; rural/remote patients more confident and more likely to call an ambulance for asthma after a multimedia education package [17]);
- Self-reported healthy action (self-reported 10-week abstinence at 12-week follow-up after tailored behavioral support [34]; talking more to family [but not physicians] about smoking [33]; reduced bodyweight [measured by researchers] and, for completers, waist circumference, fat intake and physical activity [but with phone marginally more effective than Internet] in counseling service for working adults [32]; school related, but not leisure, physical activity level after tailored feedback [31]).

It is notable that the successful systems frequently made use of information tailoring [20, 23, 31, 33, 19, 34] or programmed instruction [26, 27]. Some involved an aspect of communication with providers [16, 23, 32] (thus overlapping with Messaging or Teleconsult systems) or a forum for consumers to share experiences [23]. The smoking cessation systems are notable for innovative recruitment strategies (from Google Ads [33] and upon purchase of nicotine patches [34]).

Of the four reported failures, two were in the domain of diabetes. A multimedia physician waiting room application failed to show biological, knowledge or self-reported efficacy changes, but showed users to perceive themselves more susceptible to complications [19]. A trial of a patient portal with diabetes management functions (modeled on an effective kiosk-based intervention, not retrieved in the present study [36]) showed no association with improved self-care behaviors [21]. The third case was an interactive voice response system for antidepressant adherence promotion, which, although prescribing clinicians liked the adherence data it provided to them, encountered low uptake and high dropout rates with respect to patients making the calls to the system [28]. A borderline case with respect to ‘failure’
was an Internet-based physical activity intervention for rheumatoid arthritis patients, which cited financial issues (lack of full reimbursement for required equipment and unwillingness to stop, as required by insurer, concurrent therapy) as a basis not to pursue broader implementation due to negative patient feedback [24]. Interestingly, this physical activity intervention proved effective in an earlier trial that was not retrieved in the present study [37].

Of the five papers that were qualitative-only with respect to evaluation, two focused on user feedback to inform the development of interactive applications (one in cancer [22] and one in schizophrenia [29]). These articles were borderline with respect to the original inclusion criteria of evaluation of ‘implementations.’ The cancer application was designed to aid patient-provider communication, and the user study validated the relevance of ‘patient testimonials’ and 70% reported the skills helped in talking with physicians. The schizophrenia user study found that information needs included illness treatment, well-being, daily activities and patients’ rights. Farzanfar et al [30] evaluated the established Telephone-Linked Care (TLC) system that employed automated telephone calls for behavioral change and chronic disease management. They found a range of both user-related and system-related issues that impeded or prevented system utilization. Nicholas et al [38] found that health information on digital television was used and rated favorably. There was some evidence that the information might be used as a substitute for doctor visits; however, responders rated information from their GP or practice nurse as more important. The final article [25] reported analysis of online comments in the distinctive PatientsLikeMe forum where people with amyotrophic lateral sclerosis (ALS) post their personal health data. Members were found to reference such data to locate others with relevant experience to answer questions, to offer advice based on personal experience and to solidify relationships based on shared concerns.

3.4. Family

Three systems targeted the family members of patients as principal users: families of children with traumatic brain injury (TBI) [39], caregivers of older adults with progressive dementia [40], and parents of premature infants in neonatal intensive care [41]. All of these systems had some positive outcomes with respect to well-being of the caregivers. The TBI system combined online education and synchronous video teleconferencing with a therapist to build the parents’ skills. The intervention resulted in significantly greater improvements in depression and anxiety for users with greater prior experience with technology; it was effective overall in improving caregiver functioning. The progressive dementia system included online information (including on-demand video) and a caregiver online forum. Preliminary results indicated that the online cognitive-behavioral intervention (Positive Caregiving classes) may lead to substantial reductions in negative caregiver appraisals of burden and increased perceived self-efficacy. Baby CareLink [41] allows families telepresence to their baby in the neonatal intensive care unit (NICU) in terms of monitoring their baby from home, scheduling visits and data (daily reports, doctor’s notes and growth chart). It is reported that user parents made a median of 17 sessions from outside the hospital, resulting in greater comfort and confidence on the parents’ part, and also yielding a 75% reduction in reports of quality-of-care problems.

3.5. Telemedicine

There can be considerable overlap among the seven applications we class as Telemedicine systems and those we class as Messaging systems, Education/Self-management and, in some cases, Family systems. However, we consider Telemedicine to be the dominant characteristic where the raison d’être of the system is to allow clinical user(s) to remotely monitor a patient and the consumer user is still significant (or it would be outside the scope of this paper) but secondary to the clinical user.

Two articles demonstrated health outcome benefits. First, Carelink, an Internet-based insulin pump monitoring system, applied to rural and urban children showed HbA1c reduction versus non-users [42]. Users uploaded data weekly to monthly (depending on the child’s clinical status) and were instructed to email their diabetes care provider to review the Carelink data when an upload was complete; this was almost always done by a parent, and on occasion by a teenage patient. Second, a home monitoring trial evaluated patients with symptomatic heart failure or angina with a 3-month intervention of nurse videoconferencing, daily transmission of weight and blood pressure, and periodic transmission of electrocardiogram (ECG) [43]. The home monitoring significantly reduced readmission rates and length of stay for angina patients and improved quality of life and functional status of patients with angina and with heart failure. Patients found the technology easy to use and expressed high levels of satisfaction.

Another study [44] documents a lack of positive outcome in getting patients with established coronary artery disease to contact a call center and transmit an ECG whenever they had symptoms. Although patients considered the system helpful, only 23% of calls were made in the first hour after onset of symptoms. A related article on the same study [45] found that equipping patients with the ECG system did not decrease risk for the composite endpoint of re-
hospitalization, re-vascularization, subsequent myocardial infarction and/or death. The authors concluded that patients needed further encouragement to use ECG transmission at an early stage.

The remaining four articles reported qualitative evaluations and/or report components of the care process that may contribute to health outcomes. Rubel et al [46] report on an ECG monitoring technology with embedded intelligence and linkage to multiple levels of computed alerts. Patients find the tools easy to use; and for 50 patients take readings in a self-care scenario, 97% of tracings were judged to be of professional quality. Lamothe et al [47] applied qualitative methods to home telecare of elderly people with severe pathology in at least one of chronic obstructive pulmonary disease, cardiac insufficiency or unstable diabetes. The participants performed daily self-administered of a range of physiological observations and a nurse was appointed at the central monitor to respond to alerts. The majority of patients were satisfied and perceived advantages, including a sense of security. The authors noted the organizational challenge of adopting processes from pre-established interventions to ad hoc responses to patient needs. Kirsch et al [48] report highly positive consumer feedback with wireless remote monitoring of blood pressure and weight for pediatric nephrology cases in the context of dialysis and post-transplantation recovery. It must be noted that while the technology appears highly scalable, the results reported are based on very small samples (12 patient interviews). Lewis et al [49] report formative evaluation on a tele-rehabilitation application that allows therapists to communicate with remote patients conducting Virtual Reality driven therapies. This study is borderline for evidence use or scalability, with the reported study pre-dating deployment to the field.

3.6. Borderline Systems

Six articles report applications that illustrate the boundary of ‘consumer as user’ wherein IT is touching upon the consumer and the shape of their healthcare experience more so than with a ‘traditional’ application such as CPOE, but the consumer role is somewhat limited. Chen et al [50] report an automated interview that assesses the readiness for sexual behavior change of HIV-positive men; the system then recommends change messages delivered by providers at regular visits. The majority of patients and providers said the quality of messages was good, and providers felt more confident in delivering HIV prevention counseling and did more counseling. In a similar vein, Flocke et al [51] describe a community health promotion resource for physicians that includes a Web-based database of community programs and patient education material, and a health behavior prescription pad. While higher rates of discussion of health promotion were observed, uptake by practices was limited and no change in patient attitudes was observed. Collins et al [52] describe a remote pharmacy application where a remotely operated machine dispenses medication, overseen by a technician trainee, and the patient has the ability to ask questions of the pharmacist via a remote video link. 778 prescriptions were dispensed, but licensing issues were a threat to continued operation. Chima et al [53] report provider tracking of referral and outcomes for a self-management program for diabetes using a centralized electronic medical record. Use of an automated alert for referral to self-management (based on HbA1c) has shown a 40% increase in referrals. Kinny et al [54] found marginal improvement in client satisfaction for computer-assisted assessment of client needs and a client feedback system in the context of quality improvement for public community-based long-term care, including assessment via client and case manager agreeing on scoring for whether services were delivered and needs met. Finally, seizure patients participating in an epilepsy self-management study conducted a computer-based reading test to assess intellectual ability [55]; the test was found to have high reliability and strong association with other accepted tests.

4. Discussion

4.1. Successes

A range of successes document the promise of IT solutions where the health consumer is an active end user of the system. These successes include:

• Messaging systems allowing a patient to review components of their medical record, schedule appointments and ask questions of their regular care provider, which meet with consumer satisfaction and uptake;
• Teleconsult systems where consumers can submit information to a remote healthcare provider in the absence of a prior face-to-face relationship;
• Education / self-management systems, which have shown a range of health outcome benefits with respect to chronic condition management;
• Family systems, which have shown improvement in the well-being of caregivers of individuals with chronic conditions; and
• Telemedicine systems, supporting home telemonitoring by health providers of consumers with significant chronic conditions, which have shown improved health outcomes.

We have also found instances of IT that support chronic condition management and self-management through helping physicians to identify cases for referral to self-management training [53] and through reliable patient assessment [55].

The Messaging and Teleconsult systems can be seen in light of broader societal trends toward online services such as Internet banking and shopping online. They have not yet demonstrated health improvements, although there is the basis for saying they are promising in this regard (e.g., patients identifying medication errors from their online record [11]; high rates of pursuit of treatment after remote submission of a vaginal swab for Chlamydia testing [15]). Productivity impacts were mixed between positive [12] and neutral [6, 9]. The proportion of the overall client base that registers for a Messaging service is reported at 8.6% by Fung et al [5], which is consistent with ‘early adopters’ in Rogers’ model of innovation diffusion [56]. It is worth saying that this proportion was measured in 2002, and this was up from 0.7% in 1999. The uptake level aligns with a 2008 report of 600,000 users of the US Veterans Administration (VA) My HealtheVet Personal Health Record [57], which would also place it in the early adopter stage in light of some 8 million veterans enrolled in the VA. The possibility for such a service to advance to become the norm is obvious but not yet demonstrated.

A range of systems were found to have demonstrated benefits to the health and/or well-being of their users; in all cases these benefits were relating to chronic conditions. There were improved chronic disease outcomes in 11 of 15 Education / Self-management systems and two of three Telemedicine systems (in each case involving home telemonitoring) where measurement of such outcomes was reported; a further three Family systems showed positive well-being outcomes for the caregivers. Objectively measured improvement in physiological measures was demonstrated in two of the Education / Self-management systems and one of the two Telemedicine systems with positive results (in asthma [16]; diabetes [20]; Carelink insulin pump monitoring system [42]). Moreover, the other Telemedicine system with positive results showed outcomes in effectiveness (reduced readmissions and length of stay with ECG monitoring [43]), and there were self-reported asthma management outcomes in one further Education / Self-management system (Puff City [18]). The remainder of the positive outcomes were limited to those related to well-being of patients or their caregivers (in one case, anxiety and depression outcomes by validated instruments [27], and otherwise self-efficacy, confidence and quality of life, as well as healthy action related to smoking, diet and physical activity).

4.2. Comparison with other reviews

These findings with respect to Education / Self-management systems compare with those of Austin Boren et al [58] who conducted a meta-analysis over 112 outcome measures assessed in 19 studies of computer-assisted diabetes education from 1985-2005. 82% of trials had at least one measured outcome significantly improved, with 42% of the total measured outcomes significantly improved. They found educational and behavioral measures significantly improved in 50% of the occasions where there were measures; whereas clinical measures significantly improved only 38% of the time and health status 22% of the time. Not restricted to diabetes, and also in concurrence with our findings, an 11754 participant meta-analysis of Web-based versus non-Web-based behavioural change interventions by Wantland et al [59] found improved outcomes with respect to knowledge and/or behaviour change, including increased exercise time, increased knowledge of nutritional status, asthma treatment, and weight loss maintenance.

Also consistent with the present findings, Murray et al [60] conducted a meta-analysis of 24 randomized controlled trials (RCTs) of Interactive Health Communication Applications (IHCAs) between 1990 and end-2003 (defining IHCAs as computer-based, usually web-based, information packages for patients that combine health information with at least one of social support, decision support, or behaviour change support). They found a significant positive effect on knowledge, social support, continuous behavioral outcomes and clinical outcomes; however, the lower bound of 95% confidence interval (CI) of clinical outcomes was just barely positive, and the effect on binary behavioral outcomes was positive but not significant, prompting the authors to conclude “[users] may have improved behavioural and clinical outcomes compared to non-users.” There was also a positive effect on self-efficacy with the lower bound of the CI just at 0.00.

The area of home telemonitoring for patients with chronic conditions is evolving rapidly. Paré et al [61] reported that the effects on patients’ conditions (pulmonary conditions, diabetes, hypertension, and cardiovascular diseases) were inconclusive based on 65 studies between 1990 and 2006. Within the limited scope of our present review, which has the focus on consumers as users, our results appear to be more positive for outcome, but this is based on a single study [42]. The results concur with our own with respect to clinical effectiveness outcomes (e.g., decrease in the emergency visits, hospital admissions, average hospital length of stay), which Paré et al report as “more consistent in pulmonary and cardiac studies than diabetes and hypertension.” Conversely, an RCT of 1,665 older and underserved patients with diabetes mellitus recently reported net benefits over five years for physiological outcomes (Hb1Ac, cholesterol and
blood pressure) for home telemedicine; notably, the intervention kit was multifaceted and included videoconferencing to a nurse, personal data access and online learning, as well as telemonitoring [62]. Moreover, a review of remote health monitoring by Litan [63], reveals several relevant studies not captured in the present review, including: either home telemonitoring or nurse telephone support showed a reduction in mean admission duration and one-year mortality over usual care for high-risk heart failure patients [64]; home telemonitoring showed a range of benefits including reduced HbA1c for chronic/complex diabetic patients [65]; Dimmick et al [66] find reduced hospitalization for congestive heart failure patients with home telemonitoring supporting a net cost savings; the Health Buddy symptom surveillance and education device showed reduction in hospital admissions and exacerbations for chronic obstructive pulmonary disease patients [67]; and the Blue Angel for Asthma Kids Internet-based interactive asthma educational and monitoring program showed a range of asthma outcomes [68].

Two studies looking at health IT more broadly paint a mixed picture on consumers as users. In reviewing 109 articles about health IT for chronic conditions, Dorr et al [69] found 26% of systems involved patients and caregivers among the users, but gave no more positive endorsement for consumers as users than to indicate that patient support / patient portals were modestly associated with success. A more detailed picture is painted by a recent Rand report [70] which, in the context of a review of costs and benefits of health IT generally, placed 28 studies under the theme of rising health IT applications involving consumers as users, including 18 studies of technologies designed to be used by patients in settings other than where doctors work. The report identified a number of the same technologies as the present study, including the CHESS system for women with a recent breast cancer diagnosis [23], the Kaiser Northern California e-health system usage study [5], and Beating the Blues cognitive behavioral therapy (CBT) programme [27]. They also identified several successes missed by the present review, including two diabetes home telemonitoring studies that showed modest-but-significant physiological effects [71,72], and two RCTs of technologies to enhance subsequent doctor-patient interaction [73,74].

We find a mixed message with respect to consumer acceptance for applications where they are end users. Paré et al [61] are entirely positive, and conclude that patients with chronic conditions comply to home telemonitoring interventions irrespective of age or socioeconomic status and across nationalities. Conversely, a recent systematic review of acceptance of consumer health IT [75] cites failure of users to accept technology – for reasons including poor usability, lack of computer skills and low self-efficacy – as common reasons for project failure. Moreover, this study finds that measurement of potential acceptance factors to be highly variable, to largely omit social and task factors, and to be in need of greater guidance by technology acceptance theories. The results of the present review lend some credence to this. For example, Farvolden et al [26] report extreme drop-out (only 1% completing) for an Internet based CBT for panic disorders and agoraphobia; Anhøj et al [16] find decreasing use for an Internet based asthma diary; and the D-Net diabetes self-management program also saw decreasing use over 10 months [20], although it did show some significant physiological outcomes. From the use of the TLC system for physical activity promotion comes the observation that users are more likely to re-contact the system if they have complied with previous advice than if they have not [30]. Giving some insight into differential outcomes, if not acceptance per se, Carey et al [39] found greater positive effects from their web-based intervention for patients with prior experience of computer use. Not among the retrieved papers, but based on a Web based smoking cessation intervention that was retrieved, Strecher et al [76] suggest engagement with the program as a mechanism underlying impact, and that engagement appears to be influenced by source of the message, degree of message tailoring and timing of exposure; tailoring was significantly associated with self-reported continuous abstinence in the retrieved study [34].

4.3. Challenges and Limitations

The results can be seen as presenting a two-fold challenge for more widespread benefit from health IT with consumers as end users:

- Transferring what appears to work. Cases such as D-Net [20], Puff City [18] and Carelink [42] have demonstrated improved management of widespread chronic conditions. The challenge is to learn to transfer reliably these benefits to other contexts beyond their initial trial sites. This requires identification of the essential elements in their success and, conversely, the key barriers that were avoided.

- Support for benefits outside of current immediate performance criteria of health providers and the systems in which they work. Many of the demonstrated benefits (e.g., consumer self-efficacy) may be viewed as ‘softer’ than widely accepted indicators of chronic disease progression such as HbA1c, and thus could be more difficult to establish as the basis for sustained investment.

The latter issue is well illustrated by the case of an activity promotion intervention, already demonstrated to be effective, which failed to find a pathway to scalability due to entanglements with the insurance scheme and lack of funding source for a required equipment component (a bicycle ergometer) [24]. More subtle was the finding that
physicians failed to update the medication record with respect to changes reported by patients [11] (albeit, reported indirectly by the researchers as compared to email direct from the patients). Further illustrating the notion that the case for action on the part of providers can be the weak link was the observation by Flocke et al [51] that their community health promotion resource was not appreciably implemented in six of the seven intervention practices.

The chief limitation of the present study is with respect to completeness of retrieval of relevant studies. We note having encountered a number of studies not retrieved by the database queries (e.g., with respect to evaluations cited in the articles retrieved, and those identified by other reviews). We chose not to utilize disease-specific search keywords (e.g., ‘diabetes’) in the interest of not pre-supposing the domains of success, which may account for some of the shortfall in recall. Moreover, we felt that the studies retrieved lacked sufficient uniformity to give meaning to any formal meta-analysis. The ability to balance precision and recall with respect to terms for the Activity (implementation) and Measurement (systematic evaluation) dimensions of our query (Figure 1) was particularly unsatisfactory. Among our test cases for the MEDLINE query was a mobile phone based smoking cessation intervention known to the authors to fit the substantive inclusion criteria [77]. We were unable to find, however, search terms that would include this test case without bloating the retrieved articles to beyond 10,000 (and thus beyond our project resources for manual review). The BSP interface was poorly suited to our query strategy and required resorting to relatively ad hoc strategies to manage the lack of precision. Beyond the challenges associate with database queries, the presentation of the articles themselves often made it time-consuming to determine if implementation or evaluation had indeed taken place, and at times failed to meaningfully describe the nature of the health IT intervention. The inclusion criterion of ‘scalability’ was difficult to put into practice when screening articles, in part due to a general lack of mention as to whether reported technologies were seeing ongoing use. The rapidly-growing field of home telemonitoring appears to be particularly underrepresented in our results. With respect to this it is notable that the US Library of Medicine Medical Subject Headings (MeSH) currently provide ‘telemedicine’ and ‘patient monitoring’ but do not include the terms ‘telemonitoring’ or ‘home telemedicine.’ The impact of reporting bias is unknown, but the national bias (i.e., preponderance of articles with US as the setting) suggests that the incentive and/or ability of innovators to report their findings varies significantly by country.

We have to re-emphasize the time-sensitivity of our findings. Beyond the limitations of our methods per se, our results reflect what was available through the databases accessed as of January 2009. This is an active area. At any time, new more successful formulations of health IT for consumers, and additional studies that better establish the impact of existing technology, may significantly alter the evidence base and the conclusions that are appropriate to draw from it.

The identified evidence for consumers-as-users systems is still limited to a relatively small set of studies that are compelling with respect to size and methodology; only six studies were retrieved that reported RCTs with greater than 100 individuals in the invention group (five >100 [20, 31, 18, 28, 44], and one >1000 [34]) and these were mixed with respect to success. Telemedicine / telemonitoring applications that demonstrate success, such as CareLink [42] and the Ottawa telemonitoring intervention for heart failure and angina patients [43], require the commitment of clinical staff to online communications activities, and thus will face the barriers of creating convincing arguments for overall cost-effectiveness and of changing clinical roles. Perhaps easier to roll out, successful Web based education interventions such as Puff City [18] appear to require the service of a referral coordinator as the only per-user provider cost.

Nearly all of the reported systems can be seen as promoting self-management and supporting components of Wagner’s Chronic Care Model (CCM) [78]. The technologies particularly relate to the CCM precept that interactions are more likely to be productive if patients are active, informed participants in their care. That said, it was surprising that none of the studies reported thoroughgoing ‘care planning’ tools where the user participated in formulation of, or even accessed online, a comprehensive plan for their individualized chronic condition management. Rather, care planning as an activity was most evident is some of the Borderline systems where the system was used to implement referral to self-management education and track progress [53], or was used to assess needs [54].

In conclusion, there have been a number of demonstrated instances of clear successes in both uptake and outcome for health IT interventions involving consumers as users, particularly for chronic condition management, and including interventions addressing important gaps in the traditional healthcare system, such as the well-being of caregivers. However, compelling demonstrations (in terms of methods and sample size) remain isolated. More study is needed to assess the transferability of the demonstrated successes, simply to increase the scale of benefits, and to extend to more diverse contexts of deployment and to other conditions. It must be acknowledged that many of the interventions with measured health benefits to consumers involve commitment of professional staff (for monitoring, to answer queries and for patient education) for which the business case to sustain such services has not yet been demonstrated. Greater attention to factors relating to consumer acceptance of the technology may contribute to better understanding of the variability in outcomes in the literature. In addition, better keywords and more systematic reporting, particularly with respect to implementation and evaluation status of consumer health IT projects, would aid similar reviews in the future.
5. Acknowledgements
This work was supported by a project grant from the New Zealand Ministry of Health and the Partnerships for Excellence programme of the New Zealand Tertiary Education Commission. We acknowledge the input of staff of the National Institute for Health Innovation – Malcolm Pollock, Dr Martin Orr and Steve Wood – the guidance of Dr Andrew Holmes, and feedback from Dr Shane Reti.

6. Conflicts of Interest
None declared.

7. References
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Appendix 1. MEDLINE query

1. Informatics/ or Medical Informatics/ or Nursing Informatics/ or Public Health Informatics/ or Medical Informatics Applications/ or Medical Informatics Computing/ or Decision Making, Computer-Assisted/ or Diagnosis, Computer-Assisted/ or Medical Informatics Computing/ or Radiographic Image Interpretation, Computer-Assisted/ or Therapy, Computer-Assisted/ or Drug Therapy, Computer-Assisted/ or Radiotherapy, Computer-Assisted/ or Radiotherapy Planning, Computer-Assisted/ or Surgery, Computer-Assisted/ or Information Storage/ or Retrieval/ or Information Systems/ or Clinical Laboratory Information Systems/ or Community Networks/ or Decision Support Systems, Clinical/ or Geographic Information Systems/ or Hospital Information Systems/ or Medical Order Entry Systems/ or Integrated Advanced Information Management Systems/ or Knowledge Bases/ or Management Information Systems/ or Ambulatory Care Information Systems/ or Clinical Laboratory Information Systems/ or Clinical Pharmacy Information Systems/ or Database Management Systems/ or Decision Support Systems, Management/ or Radiology Information Systems/ or Medical Records Systems, Computerised/ or Online Systems/ or Reminder Systems/ or Computing Methodologies/ or Artificial Intelligence/ or Automatic Data Processing/ or Computer Systems/ or Software/ or Speech Recognition Software/ or User-Computer Interface/ or Computer Communication Networks/ or Internet/ or Computers/ or Microcomputers/ or Computers, Handheld/ or Man-Machine Systems/ or Computer Security/ or Point of Care Systems/ or Electronic Mail/ or Decision Support Techniques/ or Patient Identification Systems/ or Natural Language Processing/ or Fuzzy Logic/ or Expert Systems/ or Telemedicine/ or Remote Consultation/ or Telepathology/ or Teleradiology/

2. (e-Health or e health or eHealth or Electronic Health or Health Informatics or Nursing Informatics or Computer-assisted or Computer-aided or Informatics or Medical informatics or Electronic health record$ or EHR or Electronic medical record$ or Computerised patient record$ or Computerised patient record$ or CPR or Personal health record$ or PHR or Computerised Decision Support or Computerised Decision Support System$ or Computerised Decision Support or Computerised Decision Support System$ or CDSS or Clinical Decision Support or Computerised Physician Order Entry or CPOE or Computerised Physician Order Entry or Medical Order Entry or Electronic order entry or Electronic discharg$ or Electronic patient discharg$ or Electronic mail or e-mail or email or Electronic prescription or e-prescription or e-lab$ or elab$ or Electronic transmission of Prescriptions or "Picture Archiving and Communication System" or PACS or e-referral or e-referral or electronic referral or Patient portal or Information Systems).mp. [mp=title, original title, abstract, name of substance word, subject heading word]

3. Self Care/ or Self Administration/ or Self Medication/ or Interprofessional Relations/ or Interdisciplinary Communication/ or Physician-Nurse Relations/ or Professional-Family Relations/ or Professional-Patient Relations/ or Nurse-Patient Relations/ or Physician-Patient Relations/ or Interdisciplinary Relations/ or Delivery of Health Care, Integrated/ or Patient Care Management/ or Critical Pathways/ or Patient Care Planning/ or Advance Care Planning/ or Case Management/ or Progressive Patient Care/ or Continuity of Patient Care/ or Managed Care Programs/ or Patient-Centered Care/ or Public Health/ or Delivery of Health Care/ or Health Services Accessibility/ or Healthcare Disparities/

4. (Citizen-centric care or Person-centered care or Patient-centric care or Patient-centred care or Continuity of care or Integration of primary care or Support for self-care or Supported care plan$ or Remote delivery or Remote collaboration or Interdisciplinary collaboration or Population health or Selfcare or Self care or Self management or Interoperability or Coproduction or Co-production).mp. [mp=title, original title, abstract, name of substance word, subject heading word]

5. (Implementation or Installation or Deployment or Users).mp. [mp=title, original title, abstract, name of substance word, subject heading word]

6. Healthcare Reform/ or Quality of Health Care/ or "Outcome and Process Assessment (Health Care)"/ or Peer Review, Health Care/ or Program Evaluation/ or Benchmarking/ or Clinical Audit/ or Medical Audit/ or Total Quality Management/ or Quality Assurance, Health Care/ or Quality Indicators, Health Care/ or Risk Adjustment/ or Utilisation Review/ or Concurrent Review/ or "Health Care Quality, Access, and Evaluation"/ or Health Care Costs/ or Direct Service Costs/ or Hospital Costs/ or Health care Reform/ or Health Expenditures/ or Health Resources/ or Quality of Health Care/ or Technology Assessment, Biomedical/ or "Costs and Cost
7. (Benefits or Quantified Benefits or Costs or Cost-Benefit or Health systems evaluation or Quality improvement or Error reduction or Adverse outcomes or Adverse events or Workflow or Work flow or Risk management or efficiency or change or Evidence or Service improvement or Adherence or Compliance or Convergence or Utilisation or Utilisation or Usability or Evaluation or Outcomes).mp. [mp=title, original title, abstract, name of substance word, subject heading word]

8. (1 or 2) and (3 or 4) and 5 and (6 or 7)

9. limit 8 to (humans and yr="2003 - 2009" and (comparative study or "corrected and republished article" or journal article or meta analysis or multicenter study or randomised controlled trial or "review" or validation studies))
Appendix 2. BSP query

(Informatics or (Medical Informatics) or (Nursing Informatics) or (Public Health Informatics) or (Medical Informatics Applications) or (Medical Informatics Computing) or (Computer-Assisted Decision Making) or (Computer-Assisted Diagnosis) or (Medical Informatics Computing) or (Computer-Assisted Radiographic Image Interpretation) or (Computer-Assisted Therapy) or (Computer-Assisted Drug Therapy) or (Computer-Assisted Radiotherapy) or (Computer-Assisted Radiotherapy Planning) or (Computer-Assisted Surgery) or (Information Storage) or (Retrieval or (Information Systems) or (Clinical Laboratory Information Systems) or (Community Networks) or (Clinical Decision Support Systems) or (Geographic Information Systems) or (Hospital Information Systems) or (Medical Order Entry Systems) or (Integrated Advanced Information Management Systems) or (Knowledge Bases) or (Management Information Systems) or (Ambulatory Care Information Systems) or (Clinical Laboratory Information Systems) or (Clinical Pharmacy Information Systems) or (Database Management Systems) or (management Decision Support Systems) or (Radiology Information Systems) or (Computerized Medical Records Systems) or (Online Systems) or (Reminder Systems) or (Computing Methodologies) or (Artificial Intelligence) or (Automatic Data Processing) or (Computer Systems) or Software or (Speech Recognition Software) or (User-Computer Interface) or (Computer Communication Networks) or Internet or Computers or Microcomputers or (handheld Computers) or (Man-Machine Systems) or (Computer Security) or (Point of Care Systems) or (Electronic Mail) or (Decision Support Techniques) or (Patient Identification Systems) or (Natural Language Processing) or (Fuzzy Logic) or (Expert Systems) or Telemedicine or (Remote Consultation) or Telepathology or Teleradiology) OR (e?Health or (Health IT) or (Electronic Health) or (Health Informatics) or (Nursing Informatics) or (Computer-assisted) or (Computer-aided) or (Informatics) or (Medical informatics) or (Electronic health record*) or (EHR) or (Electronic medical record*) or (Computerized patient record*) or (CPR) or (Personal health record*) or (PHR) or (Computerized Decision Support) or (Computer?ed Decision Support System*) or (CDSS) or (Clinical Decision Support) or (Computer?ed Physician) or (CPOE) or (Computerized physician) or (Decision Support) or (Medical) or (Decision Support) or (Electronic refer*) or (Electronic hospital refer*) or (Electronic discharge*) or (Electronic patient discharge*) or (Electronic mail) or (email) or (Electronic prescri*) or (e-prescription) or (eprescription) or (elab*) or (Electronic transmission of Prescriptions) or (Picture Archiving and Communication System*) or (PACS) or (e?referral) or (electronic referral) or (Patient portal) or (Information Systems))

((Self Care) or (Self Administration) or (Self Medication) or (Interprofessional Relations) or (Interdisciplinary Communication) or (Physician?Nurse Relations) or (Professional?Family Relations) or (Professional?Patient Relations) or (Nurse?Patient Relations) or (Physician?Patient Relations) or (Interdisciplinary Relations) or (integrated Delivery of Health Care) or (Patient Care Management) or (Critical Pathways) or (Patient Care Planning) or (Advance Care Planning) or (Case Management) or (Progressive Patient Care) or (Continuity of Patient Care) or (Managed Care Programs) or (Patient Cent?red Care) or (Public Health) or (Delivery of Health Care) or (Health Services Accessibility) or (Healthcare Disparities)) OR ((Citizen?centric care) or (Person?centred care or (Patient?centric care) or (Patient?centred care) or (Continuity of care) or (Integrat* primary care) or (Support* self?care) or (Supported care plan*) or (Remote delivery) or (Remote collaboration) or (Interdisciplinary collaboration) or (Population health) or (Self?care) or (Self management) or Interoperability or Co?production)

Implementation or Installation or Deployment or Users

((Healthcare Reform) or (Health?care) or (Quality ? Health Care) or (Outcome and Process Assessment) or (Peer Review) or (Program Evaluation) or Benchmarking or (Clinical Audit) or (Medical Audit) or (Total Quality Management) or (Quality Assurance) or (Quality Indicators) or (Risk Adjustment) or (Utilization Review) or (Concurrent Review) or (Quality Access) or (Quality evaluation) or (Health Care Costs) or (Direct Service Costs) or (Hospital Costs) or (Health?care reform) or (Health Expenditures) or (Health Resources) or (Health?care Quality) or (Biomedical Technology Assessment) or ("Costs and Cost Analysis") or (Cost?Benefit Analysis) or (Innovation Diffusion) or (Technology Transfer) or (Entrepreneurship or (Organization* Innovation)) OR (Benefits or (Quantified Benefits) or Costs or (Cost?Benefit) or (Health system* evaluation) or (Quality improvement) or (Error reduce*) or (Adverse outcome*) or (Adverse event*) or Work?flow or (Risk management) or efficien* or chang* or Evidence or (Service improvement) or Adherence or Compliance or Convergence or Util?ation or Usability or Evaluation or Outcome*)
NOT (financial or medicare or insurance or power or (develop* country) or policy or nigeria or korea or india or africa or georgia or china or brazil or peru or mexico or (middle east) or merchant).
## Appendix 3. Articles included in present review (grouped by category)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Aim</th>
<th>Participants</th>
<th>Methods</th>
<th>Results/conclusions</th>
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<tr>
<td><strong>MESSAGING</strong></td>
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<tr>
<td>Fung et al (2006) [5]</td>
<td>Examine trends in usage of 4 e-health services (online drug refills, appointment scheduling, medical advice and prescription drug advice) through a web-based secured portal</td>
<td>270,987 users registered for access - actual usage varies by service</td>
<td>Descriptive study of number of users of each service</td>
<td>Usage grew rapidly. Transactional services (appointment scheduling and online drug refills) were used more frequently than care-related services. Patients with higher clinical need and better ties to the health system were more likely to use all services.</td>
</tr>
<tr>
<td>Hess et al (2007) [6]</td>
<td>Describe the implementation and initial patient reaction to a patient portal for diabetes self-management, which provides access to the PHR and tools to supplement the current self-management efforts.</td>
<td>3 primary care practices in the UPMC health system</td>
<td>Descriptive study plus pre- and post-implementation focus groups (n=21 and 18 respectively)</td>
<td>Patients felt a sense of empowerment from access to medical records such as lab tests, and found electronic appointment scheduling convenient. Electronic message volumes increased over time.</td>
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<tr>
<td>Houston et al (2004) [7]</td>
<td>Explore the experiences of patients who were early adopters of email communication with their physicians</td>
<td>internet-based survey of 1881 individuals, of whom 311 used email with their physicians</td>
<td>Internet survey plus follow-up interviews with 56 individuals</td>
<td>Patients found email efficient, appreciated the ability to save the correspondence, and felt more emboldened to ask questions. 21% used email inappropriately for urgent or sensitive matters.</td>
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<td>Kittler et al (2004) [8]</td>
<td>Investigate opinions of non-physician clinic staff concerning email communications with patients, before and after implementation of a gateway application supporting general emails, appointment scheduling, prescription renewals, referral requests, and access to components of the electronic medical record.</td>
<td>22 responders at 3 sites for post-use survey (of whom 10 were regular users). 67 staff at 10 sites for pre-use survey.</td>
<td>Descriptive study from pre- and post-use surveys</td>
<td>Before system implementation, many staff felt increasing email usage with patients could improve the quality of their care. Staff reported high satisfaction with the system and felt more enthusiastic about increasing patient email use after using it.</td>
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<td>Liederman &amp; Morefield (2003) [9]</td>
<td>Evaluate use of a web-based provider-patient communication services to provide electronic messaging, non-urgent asynchronous consultations, appointments, medication refills, and preventive care reminders via Internet browser.</td>
<td>8 clinicians (7 physicians and 1 nurse), 9 medical assistants, and 4 clerical front office staff + 645 patients</td>
<td>Descriptive study from system logs, staff interviews, and emailed patient satisfaction surveys.</td>
<td>Providers and patients preferred web messaging over phone calls for non-urgent problems. Most users reported satisfaction and ease of use. System did not have a negative impact on provider productivity.</td>
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<td>Sole et al (2006) [10]</td>
<td>Describe the implementation and usage of a web-based triage system in a college health setting. The software enables students to input specific conditions and symptoms, get an assessment of urgency for treatment, learn about specific diseases and conditions, and request an appointment by e-mail</td>
<td>1 college, 1290 encounters</td>
<td>Descriptive study of system usage information, plus comparison with medical records for 59 encounters where appointments were requested by email.</td>
<td>There was strong agreement between the system classification and provider diagnosis upon presentation. The system advised users to seek care within 24 hours for the majority of encounters but recommended self-management for 22%.</td>
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<td>Staroselsky et al (2008) [11]</td>
<td>Evaluate effectiveness of a secure web-based patient portal in providing more accurate medication lists in the electronic health record. The portal enabled users to view components of their records and send messages to providers.</td>
<td>84 patients</td>
<td>Descriptive study comparing medication information from pre-populated patient surveys with information in the medical record.</td>
<td>Medication lists were frequently inaccurate. Users of the patient portal had as many errors in their medication list as non-users, and notifying physicians of discrepancies by email did not result in them correcting the medical record.</td>
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<td>Zhou et al (2007) [12]</td>
<td>Determine whether patient access to secure patient-physician messaging affects annual adult primary care office visit and documented telephone contact rates</td>
<td>4686 patients who had used the service and 3201 matched-control patients</td>
<td>Retrospective cohort and matched-control studies with pre-post analysis</td>
<td>Use of the secure messaging features reduces office visit rates and slows growth of rate of telephone calls compared to the control group.</td>
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<td><strong>TELECONSULT</strong></td>
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<td>Gaydos et al (2006) [15]</td>
<td>Evaluate an internet-based program for women to request and use self-collected vaginal swab kits to test for chlamydia. Users could pick up kits at various community locations or request them to be mailed to their homes.</td>
<td>400 kits were sent in for testing</td>
<td>Descriptive study of testing results and questionnaires submitted with samples</td>
<td>10% of kits sent in were positive for chlamydia, and treatment was confirmed for most of those individuals. Most kits were mailed to users. This screening approach was popular and reached many women not accessing traditional health care for screening</td>
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<tr>
<td>Umefjord et al (2006) [13]</td>
<td>Investigate usage and acceptance of an internet based “Ask the Doctor” service, which enables users to ask questions to be answered by family physicians who have no prior relationship with the enquirer.</td>
<td>Available to the general public. 3622 questions submitted during the study period. 1223 survey responses received.</td>
<td>Descriptive study based on survey responses</td>
<td>Internet consultations meet with high satisfaction and 43% said they wouldn't pursue the matter further. Users found the service convenient and flexible and appreciated being able to reread and reflect on the written response.</td>
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<td>Valenzuela et al (2007) [14]</td>
<td>Report experience with a web-based Doctor Chat teleconsultation application</td>
<td>Available to the general public. 270 teleconsultation sessions over approximately the first 6 months of operation.</td>
<td>Descriptive analysis of the types of queries submitted. 19 of the 270 users also completed a survey which was analyzed</td>
<td>The queries were categorised by user demographics, health specialty, etc. Most queries were from major cities, not remote areas which might have been expected to benefit most. Most survey responders expressed satisfaction.</td>
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<td><strong>EDUCATION / SELF-MANAGEMENT</strong></td>
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<td>Anhoj &amp; Nielsen (2004) [16]</td>
<td>Review usage and perceptions of a web-based asthma management diary</td>
<td>7653 users</td>
<td>Descriptive study of site statistics, online survey (85 responses), questionnaire to providers (131 completed), and interviews (10 patients and 5 providers)</td>
<td>Users expressed satisfaction with the system but usage decreased over time. Recommendations were made for system redesign to improve ongoing usage.</td>
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<td>Authors</td>
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<td>Boyd &amp; Archer (2007) [17]</td>
<td>Trial usage in rural towns of a multimedia education package aimed at educating health professionals and people with asthma regarding when, why and how to call an ambulance for asthma.</td>
<td>approx. 180 patients</td>
<td>Questionnaire and focus groups</td>
<td>Participants felt more confident in their asthma knowledge and reported they were more likely to call an ambulance for their asthma. Community involvement in development of the package was important.</td>
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<td>Farvolden et al. (2005) [26]</td>
<td>Evaluate use and effectiveness of a freely available educational website for panic disorder and agoraphobia, which incorporates a validated screening test, a moderated support group, and a Web-based cognitive behavioural therapy program</td>
<td>99695 site users, 1161 CBT registered users</td>
<td>Descriptive study from site usage logs, screening tests, and surveys of CBT participants</td>
<td>The website is popular and well utilized. Attrition from the CBT component was extremely high (only 12 of 1161 completed all 12 sessions). Nonetheless, the CBT reduced self-reported attack frequency and severity, even after just a few sessions.</td>
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<td>Farzanfar et al. (2005) [30]</td>
<td>Explore the experiences of users of a totally automated telephone-based physical activity promotion application, with a focus on understanding factors that affected patterns of use.</td>
<td>84 healthy adult volunteers participated, 45 were interviewed</td>
<td>Interviews of participants to understand reasons for low system usage</td>
<td>Users should have control and tailored interaction. Monitoring generates anxiety for some users which must be addressed in the system design.</td>
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<tr>
<td>Fleisher et al. (2008) [22]</td>
<td>Highlight the theory-guided development of an interactive web based communication aid for cancer patients and their oncologists</td>
<td>742 patients at a cancer center</td>
<td>Usability testing. (A randomized controlled trial on the system is underway but results not reported in this paper)</td>
<td>Development of patient education interventions requires the integration of health communication best practice including user testing and feedback.</td>
</tr>
<tr>
<td>Frost &amp; Massagli (2008) [25]</td>
<td>Evaluate response to an online community where patient can choose to make their health information visible to with other patients with the same disease, to facilitate passive information sharing and active dialogue.</td>
<td>1570 patients with amyotrophic lateral sclerosis</td>
<td>Descriptive study of user communications</td>
<td>Three communication themes were common: asking for advice, offering advice and fostering relationships. Users used the posted information to identify others with similar characteristics or experiences, with whom they wished to communicate.</td>
</tr>
<tr>
<td>Gerber et al. (2005) [19]</td>
<td>Evaluate use of multimedia software for diabetes education for individuals with low health literacy levels</td>
<td>183 subjects at five urban outpatient clinics</td>
<td>Randomised controlled trial</td>
<td>Increased patient perception of susceptibility to complications, but no other measures improved.</td>
</tr>
<tr>
<td>Glasgow et al. (2003) [20]</td>
<td>Evaluation of a computer assisted diabetes self-management program to improve dietary and physical activity practices. All patients received the basic internet-based intervention with some also receiving tailored self-management training or peer support components.</td>
<td>320 patients of 16 physicians at 6 different medical offices</td>
<td>Randomised trial of the incremental effects of the additional components over the basic intervention</td>
<td>The basic intervention was successful at improving a number of physical and psychosocial measures. Incremental improvements from the additional components was not seen. Usage declined over time.</td>
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<tr>
<td>Gustafson et al (2008)</td>
<td>Evaluate the benefits of an integrated internet-based system providing information, communication and decision support services for patients with cancer, as compared to internet access and links to educational resources but without the integrated system</td>
<td>91 patients at 4 cancer centres used the integrated system (of 257 study participants overall)</td>
<td>Randomised controlled trial comparing the integrated system with basic internet resources or a non-internet control arm. Data collected by survey.</td>
<td>Subjects using the integrated system had improved scores on all 3 outcome measures (social support, quality of life, and healthcare competence), while those receiving only internet access and links to educational resources did not.</td>
</tr>
<tr>
<td>Haerens et al (2007)</td>
<td>Evaluate acceptability, feasibility and effectiveness of computer-tailored physical activity education for adolescents. Intervention was administered at schools during class time (1 hour).</td>
<td>139 students randomly selected for intervention</td>
<td>Randomised controlled trial, data collected by questionnaire</td>
<td>Intervention increased school-related physical activity but not total physical activity. Students found the program overall usable and readily understandable but less than half found the advice provided personally relevant or easy to apply.</td>
</tr>
<tr>
<td>Houston &amp; Ford (2008)</td>
<td>Evaluate a smoking-cessation website that provided tailored self-management advice to smokers, including advice on obtaining treatment and support from others to quit. In phase 2 a motivational introduction was added encouraging use of the treatment and support modules.</td>
<td>231 users (126 in phase 1, 105 in phase 2)</td>
<td>Descriptive study from review of site logs, and follow-up questionnaires</td>
<td>The motivational introduction caused more users to access support and treatment modules, leading to increased percentage discussing their smoking cessation efforts with family, and increased time spent on the site overall.</td>
</tr>
<tr>
<td>Joseph et al (2007)</td>
<td>Evaluate a multimedia web-based asthma management program targeting urban high school students.</td>
<td>314 students at 6 high schools were randomised</td>
<td>Randomised controlled trial, with the control population directed to general asthma education websites</td>
<td>Students using the system reported fewer symptom-days, symptom-nights, school days missed, restricted-activity days, and hospitalizations for asthma.</td>
</tr>
<tr>
<td>Learmonth et al (2008)</td>
<td>Evaluate the impact of a computerised cognitive behaviour therapy for management of anxiety and depression within a secondary healthcare centre. Users on a waiting list for face-to-face CBT were offered access to the computerised system.</td>
<td>655 users (of whom 71% completed the full program)</td>
<td>Descriptive study of usage information and clinical outcome data</td>
<td>Significant improvements in measures of depression and anxiety were seen in system users. Adherence was high and use of the computerised system reduced the need for face-to-face CBT.</td>
</tr>
<tr>
<td>Nicholas et al (2003)</td>
<td>Evaluate usage of and reactions to provision of health information through digital interactive television. One of the services reviewed provides a health information database and video conferencing with a live nurse. The other provides informational content and an online immunisation diary.</td>
<td>35,000 + 10,000 households have access. Approximately 1900 surveys were returned.</td>
<td>Descriptive study based on questionnaire results.</td>
<td>Health information on digital television was used and rated favorably. There was some evidence that the information might be used as a substitute for doctor visits, though responders rated information from their GP or practice nurse as more important.</td>
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<tr>
<td>Ross et al (2007)</td>
<td>Evaluate user feedback to an online patient portal for diabetes management</td>
<td>37 participants of whom 30 had used the system at least once</td>
<td>Descriptive study based on interview results</td>
<td>Users felt the system should address the differing needs of different types of users (e.g. guideline-concordant vs not); send out alerts when new information is available; and provide more oversight of user diary data</td>
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<td>Strecher et al (2006) [34]</td>
<td>Explore factors that may have moderated or mediated the effect of a smoking cessation program on abstinence at 12 weeks</td>
<td>3971 subjects enrolled, of whom 1491 responded to the 12-week follow-up survey</td>
<td>Randomised controlled trial comparing tailored web-based smoking cessation materials to non-tailored materials</td>
<td>Tailored interventions led to higher perceived relevance and higher self-reported continuous abstinence at 12-week follow-up.</td>
</tr>
<tr>
<td>Stuart et al (2003) [28]</td>
<td>Evaluate use of an IVR system, not dependent on nurse/clinician time, to enhance antidepressant medication compliance</td>
<td>647 patients at 30 primary care practices</td>
<td>Randomised controlled clinical trial comparing IVR system to just education or education and a single nurse phone call</td>
<td>IVR system was not shown to be more effective than other strategies</td>
</tr>
<tr>
<td>Valimaki et al (2008) [29]</td>
<td>Describe the design and development of a patient-centered web-based support system for patients with schizophrenia spectrum psychoses. The system provides evidenced based information, a channel for peer support, a counseling tool, and a question-answer column for interaction between client and staff</td>
<td>114 nursing staff at 2 psychiatric hospitals conducted usability testing</td>
<td>Descriptive study of development process and usability testing (data collected via questionnaire)</td>
<td>The development and usability testing process is described. Authors state that it is important to involve users in the design process.</td>
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<tr>
<td>van den Berg et al (2008) [24]</td>
<td>Investigate facilitators and barriers to implementation of an internet-based physical activity intervention previously proven effective for sedentary patients with rheumatoid arthritis (RA).</td>
<td>461 patients responded to survey of whom 76 met inclusion criteria and were interested</td>
<td>Evaluation of potential to implement intervention, using RE-AIM framework (reach, evaluation, adoption, implementation, maintenance)</td>
<td>Cost of the bicycle ergometer and interference with patient's current physical therapy were obstacles for eligible patients to actually participate</td>
</tr>
<tr>
<td>Van Wier et al (2009) [32]</td>
<td>Investigated the effectiveness of lifestyle counselling by phone or e-mail on body weight, waist circumference, and lifestyle behaviors in an overweight working population. Compared effectiveness of communication methods (phone or email)</td>
<td>1386 employees from companies</td>
<td>Randomized controlled trial with 3 groups -- phone intervention, email intervention, or control (lifestyle brochures only)</td>
<td>The internet and phone interventions led to modest significant weight loss outcomes. The phone intervention group showed greater improvement but this difference was not significant.</td>
</tr>
<tr>
<td>Carey et al (2008) [39]</td>
<td>Examine the effect of prior technology usage on response to an online problem solving intervention (utilising video cameras for consultation with a therapist) or an internet resource intervention for families of children with traumatic brain injury</td>
<td>150 individuals in 40 families, randomly assigned to one of the 2 interventions</td>
<td>Randomised controlled trial</td>
<td>The online web system with link to psychologists reduced parental anxiety in care of TBI children. Individuals with prior experience of regular technology use saw greater benefits.</td>
</tr>
<tr>
<td>Glueckauf et al (2004) [40]</td>
<td>Describe and evaluate a Web- and telephone-based education and support network for caregivers of persons with progressive dementia. A key feature of the system is a series of live, interactive, classes.</td>
<td>Several thousand new site users per month. 21 caregivers participated in the classes</td>
<td>Initial program evaluation using pre- and post-intervention questionnaires</td>
<td>The interactive classes for Alzheimer's caregivers reduced burden and improved self-efficacy. A marketing campaign was successful at improving site usage.</td>
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<td>Safran (2003) [41]</td>
<td>Evaluate a webbased system for parent education and remote collaboration concerning the care of their premature infants in the NICU</td>
<td>370 patients users across 2 hospitals. The randomised study involved 58 families</td>
<td>Descriptive study plus randomised trial</td>
<td>Randomised trial showed reduction in reports of quality-of-care problems, better communication, and children being taken home earlier. Staff report fewer return visits of newborns after discharge.</td>
</tr>
<tr>
<td>Corriveau et al (2008) [42]</td>
<td>Evaluate a system for automated monitoring of an insulin pump at home for children with type 1 diabetes</td>
<td>41 patient users</td>
<td>Descriptive study comparing patients using the automated monitoring system with those who had incompatible pumps or chose not to use the system</td>
<td>Use of the system was associated with improved glycaemic control (HbA1c levels)</td>
</tr>
<tr>
<td>Katalinic et al (2008) [44]</td>
<td>Evaluate a home telemonitoring system which enabled patients with coronary artery disease to contact a call centre, transmit an ECG, and consult a physician when experiencing symptoms at home.</td>
<td>752 patients in intervention group (748 control)</td>
<td>Randomised controlled trial</td>
<td>Cardiac patients consider a telemonitoring system helpful, but don't always use it in first hour after onset of symptoms. Quality of transmitted information was good. 23% of patients contacted the call centre at least once.</td>
</tr>
<tr>
<td>Kirsch et al (2007) [48]</td>
<td>Describe pilot study of implementation of a home telemonitoring system for children and teens performing home dialysis.</td>
<td>16 patients from one hospital's dialysis unit</td>
<td>Descriptive study based on interviews with patients and medical staff</td>
<td>The system was successfully implemented. Patients found the system easy to use and saw advantages, but some felt &quot;under observation&quot;. The majority would choose to continue use if they could.</td>
</tr>
<tr>
<td>Lamotte et al (2006) [47]</td>
<td>Investigate use of telehomecare technologies for daily monitoring at home of elderly patients suffering severe chronic conditions.</td>
<td>82 patients at 3 sites</td>
<td>Descriptive study based on interviews with patients (47) and professionals.</td>
<td>Patients expressed satisfaction with the system, including an increased sense of security and better self-monitoring. Both patients and professionals felt the system allowed for better monitoring of patients and decreased the number of emergency visits.</td>
</tr>
<tr>
<td>Lewis et al (2006) [49]</td>
<td>Evaluate a telerehabilitation application which allows therapists to remotely communicate with patients while monitoring and controlling their virtual rehabilitation exercises.</td>
<td>5 therapist participated in usability testing</td>
<td>Descriptive usability study based on videotapes of testing sessions and questionnaires</td>
<td>Various usability and technical issues were identified which will enable improvement of the system.</td>
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<tr>
<td>Rubel et al (2005) [46]</td>
<td>Evaluate use of a portable intelligent ECG monitor for early detection of cardiac ischemia and arrhythmia. The system generates alarm messages of varying severity to relevant health care providers</td>
<td>188 self-care patients, plus testing by health professionals in clinical settings</td>
<td>Descriptive study of prototype usage</td>
<td>Most recordings by patients were judged to be of professional quality. Patients and professionals found the system easy to use. Some anxious patients felt safer when monitored by the system.</td>
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<td>Woodend et al (2008) [43]</td>
<td>Test the impact of telehome monitoring in patients with heart failure or angina. The intervention consisted of 3 months of video conferencing with a nurse, daily transmission of weight and blood pressure, and periodic transmission of 12-lead electrocardiogram at least weekly.</td>
<td>124 patients randomized to intervention of 249 total</td>
<td>Randomized controlled trial.</td>
<td>Telehome monitoring significantly reduced readmission rates and length of stay for angina patients and improved quality of life and functional status of patients with angina and heart failure. Patients expressed satisfaction with the technology.</td>
</tr>
<tr>
<td>Chen et al (2008) [50]</td>
<td>Assess success of a computer based, provider-delivered HIV prevention intervention system. A computer-assisted self-interviewing assessment of individual risk behaviour and readiness to change provides input to a provider advice sheet and patient behavioural prescription.</td>
<td>234 participants, 11 physicians</td>
<td>Descriptive study of intervention outcomes</td>
<td>Patient and providers responded favourably to the risk prevention system. The intervention was successfully delivered by providers without extensive counselling training.</td>
</tr>
<tr>
<td>Chima et al (2005) [53]</td>
<td>Epic system used for tracking referrals and outcome measures of a diabetes self-management program</td>
<td>1 department</td>
<td>Descriptive study</td>
<td>Authors recommend that computerized systems should communicate with electronic medical records already present in the health care environment to minimize the manual work required to transfer data from one system to another.</td>
</tr>
<tr>
<td>Collins et al (2005) [52]</td>
<td>Describe implementation of a satellite pharmacy network, using a remote dispensing system overseen by a licensed pharmacist for difficult to serve communities and patient groups</td>
<td>2 sites, 778 prescriptions were filled</td>
<td>Descriptive study</td>
<td>Licensing and staffing issues hindered the implementation and further rollout.</td>
</tr>
<tr>
<td>Flocke et al (2006) [51]</td>
<td>Evaluate a web based health behaviour change resource for primary care practices, including a database of community programs and patient education material and a health behaviour prescription pad</td>
<td>789 patients at seven participating practices</td>
<td>Patient surveys pre- and post-intervention</td>
<td>The intervention increased the rate of discussion and referrals related to diet, exercise and weight management. Intervention was not “appreciably implemented” in 6 of 7 practices due to various barriers.</td>
</tr>
<tr>
<td>Kinney et al (2003) [54]</td>
<td>Describe and evaluate two quality improvement strategies for home-based long-term care programs</td>
<td>2222 clients</td>
<td>Randomised controlled trial</td>
<td>Small significant improvements in client satisfaction when either strategy used but not when both strategies used together.</td>
</tr>
<tr>
<td>Letz et al (2003) [55]</td>
<td>Evaluate a computer adaptive reading test for estimating premorbid general intellectual ability</td>
<td>319 outpatients of 2 epilepsy clinics</td>
<td>Descriptive study and comparison with related tests</td>
<td>Test scores exhibit high reliability and are strongly associated with an existing test for estimating general intellectual ability.</td>
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