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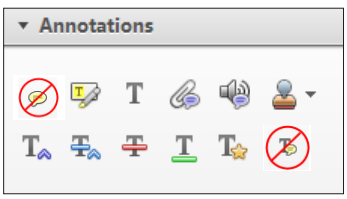

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eHealth and the use of individually tailored information: A systematic review

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Abstract

Background: Tailored messages are those that specifically target individuals following an assessment of their unique characteristics. This systematic review assesses the evidence regarding the effectiveness of tailoring within eHealth interventions aimed at chronic disease management.[AQ: 2]

Methods: OVID Medline/Embase databases were searched for randomised control trials, controlled clinical trials, before–after studies, and time series analyses from inception – May 2014. Objectively measured clinical processes/outcomes were considered.

Results: Totally, 22 papers were eligible: 6/22 used fully tailored messaging and 16/22 used partially tailored messages. Two studies isolated tailoring as the active component. The remainder compared intervention with standard care. In all, 12/16 studies measuring clinical processes and 2/6 studies reporting clinical outcomes showed improvements, regardless of target group. Study quality was low and design did not allow for identification of interventions' active component. Heterogeneity precluded meta-analysis.

Conclusion: This review has demonstrated that there is a lack of evidence to suggest that tailoring within an eHealth context confers benefit over non-tailored eHealth interventions.

Keywords

clinical decision-making, decision-support systems, eHealth, evidence-based practice, information and knowledge management

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Background

Long-term conditions affect one in five people, yet account for 80 per cent of general practice consultations.[1] More than half of all clinical decisions fail to take account of the best-available evidence.[2] In addition, evidence-based guidelines often do not accommodate co-morbidities and multiple medications.[3–5] There is a recognised need to find innovative ways of integrating knowledge into clinical workflow, to contextualise and personalise care, and to manage the complex care needs and human factors which contribute to unwanted variation in practice.[6]

Clinical decision support systems (CDSSs) utilise algorithms of varying complexity that are applied to existing eHealth systems. Typically, a CDSS within an electronic health record (EHR) will present the user of the EHR with a series of messages designed to improve clinical care, for example, identification of possible drug interactions or prompts to consider clinical investigations. The use of such automated reminders via CDSS has been shown to be one of the most consistently successful approaches to encourage clinicians to adopt evidence-based practice.[7] In terms of efficacy, a 2005 systematic review concluded that while a number of studies showed an improvement in clinical processes (e.g. adherence to guidelines), there was a lack of evidence demonstrating improved clinical outcomes.[8] In the same year, a separate systematic review found that CDSSs, which incorporated contemporaneous recommendations (as opposed to simple summaries of data) and were available within the normal work stream, were more likely to result in improved clinical outcomes − 90 per cent (30/32) of interventions which included these features demonstrated improved outcomes.[9]

Communicating with messages that are specifically tailored to an individual has been found to be more effective than generic messages at changing behaviour.[10] The theory underpinning the use of such methods draws heavily on a number of behaviour change theories, including the Health Belief Model,[11] Prochaska and DiClemente's[12] Stages of Change, and Bandura's[13] Social Cognitive Theory. The tailoring of messages to specific individuals is viewed as the most sophisticated form of automated communication that can be used to deliver health education and material aimed at health promotion.[14] Tailoring has been defined as 'any combination of strategies and information intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and derived from an individual assessment'.[15] This assessment is dependent on the type of intervention and the target audience, but could be based on routinely collected data (e.g. professional role, socioeconomic status, health records or clinical parameters) or data collected from the individual with the specific intention of formulating a tailored message (e.g. health literacy, self-efficacy or pre-existing attitudes and knowledge). Interventions that utilise tailored messages tend to involve the distribution of printed material aimed at primary health promotion, for example, dietary advice,[16–18] smoking cessation,[19,20] or uptake of screening.[21]

There is a lack of literature concerning the use of tailored messages aimed at changing healthcare practitioner (HCP) behaviour. There is also a lack of evidence to inform the design and modality of tailored messaging, and whether the effectiveness of existing eHealth technologies (e.g. CDSS) can be improved were they to incorporate tailored messaging.

Objective

This systematic review aimed to assess the published evidence regarding the effectiveness of eHealth interventions designed to improve the management of chronic diseases by providing information or advice that has been tailored to the recipients, that is, HCPs or patients.

The research question was as follows: Does the cumulative published research evidence support the hypothesis that a system that incorporates messages specifically tailored to an individual

(HCP or patient) results in improved clinical processes or outcomes in the management of long-term conditions?

Method

Types of studies

Randomised controlled trials (RCTs), controlled clinical trials (CCTs), controlled before and after studies, and interrupted time series (ITS) analyses were considered for inclusion in the review. Studies published in any language were considered.

Types of recipients

Studies that involved patients with a specified long-term condition receiving healthcare (any setting), and/or HCPs responsible for the care of those with long-term conditions (any setting), were considered.

Types of interventions

We considered interventions that used eHealth technologies to deliver tailored information to patients or HCPs within the care setting. The search strategy, therefore, included a combination of terms relating to eHealth, health records, and communication strategies (including tailoring of information).

Types of outcomes

Any outcome was considered where a comparison was drawn between the intervention and no intervention and/or existing practice with regards to objectively measured professional performance, clinical outcome, or patient behaviour. The study's stated primary outcome was our main outcome of interest, with consideration also given to any stated secondary outcomes or post hoc analyses. Patient and professional satisfaction was also recorded, but studies were not included if this was the sole outcome.

Search strategy

A search strategy was devised to include keywords and text words relating to the following terms: chronic disease, methodology, eHealth, health records, communication, and user groups (available on request). Text words were appropriately truncated to maximise returns. Terms were combined using Boolean logic. There was no keyword identified for tailored messaging, and so we adopted a broad search strategy. As well as including variations of tailored messaging as text words, we included an exploded search of other communication-related keywords in an effort to capture studies that utilised tailored messages but did not refer to it as such. The search was run against both Ovid Medline (1946–present) and Embase (1974–present), with no restrictions placed on language.

Eligibility criteria for inclusion

Studies that were RCTs or CCTs were deemed eligible if the other criteria mentioned above were met. Additional methodologies (controlled before–after studies and interrupted time series

analyses) were considered if they met quality criteria specified by the Cochrane Effective Practice and Organisation of Care Group (EPOC) data collection checklist.[22] In accordance with the EPOC criteria, the quality criteria for inclusion of both types of studies were as follows:

- Controlled before–after studies were only eligible if the control site was deemed suitable; there was evidence of contemporaneous data collection, and there were ⩾2 intervention and ⩾2 control sites.
- Interrupted time series analyses were included if there was a clearly recorded point in time when the intervention began and where there were ⩾3 data points recorded both before and after the intervention commenced. Given the potential heterogeneity of the studies relevant to the review, study inclusion was not based on a minimum cut-off for methodological quality.

Data collection and analysis

Titles and abstracts were initially reviewed by a single reviewer (N.T.C.) and discarded if deemed not to be relevant to the research question. A shortlist was then compiled for which full-text articles were sought. These were independently reviewed by two reviewers (N.T.C. and C.W.). Any discrepancies were resolved by consensus. An online data abstraction form (modified from the EPOC data collection checklist[22]) was used for data collection.[23] An overall quality rating was assigned to RCTs based on the following criteria: allocation concealment, blinded or objective assessment of primary outcome(s), completeness of follow-up, reliable primary outcome, and protection against bias. In accordance with previously published EPOC systematic reviews,[24,25] studies were rated as being of high quality if the first three criteria were met with no additional concerns. Studies were of moderate quality if ⩽2 criteria were 'not done' or 'not clear' and of low quality if this applied to >2 criteria.

Assessing tailoring

Kreuter et al.[15] judged that an intervention incorporated tailored messaging if the intervention included both the following:

1. An assessment of individual patient characteristics;
2. Communication that was specifically targeted at that individual.

Owing to the limited number of published studies that the search strategy returned, we accepted interventions that included either of these criteria, as agreed by the two reviewers.

Protocol

A review protocol has not been published but is available from the corresponding author on enquiry.

Results

Search results

The search strategy was run twice – September 2013 and again in May 2014. The final yield from both searches was 1074 returns, of which 89 were duplicates. Of the remaining 985 studies, 818 were initially rejected based on title alone, with a further 112 discarded after review of the abstract

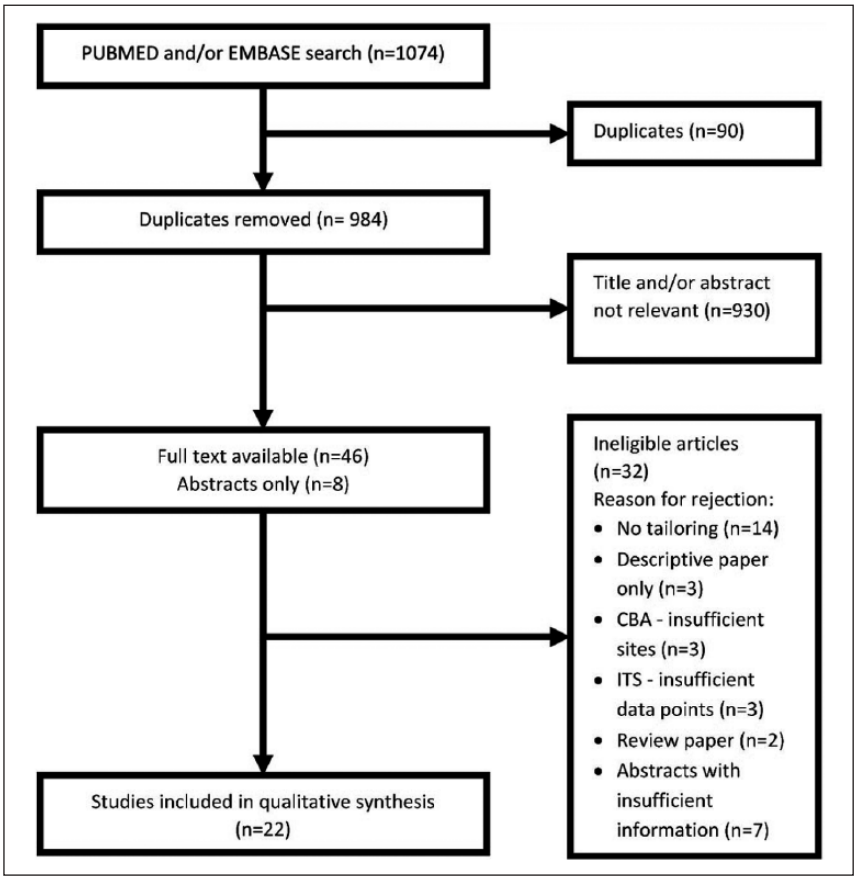

Figure 1. PRISMA diagram of literature search.

(see Figure 1). Full-text papers were sought for the provisional shortlist of 55 studies and were available for 45 of these. The abstracts of the remaining 10 studies were assessed and included if there was sufficient information to meet the inclusion criteria. Owing to the absence of any tailoring component in the intervention, 15 papers were rejected. The remaining 40 papers were then reviewed by the two reviewers. Furthermore, 18 papers were then rejected as they failed to meet (or had insufficient detail to satisfy) the eligibility criteria, leaving 22 papers to be considered in the review.

These 22 studies are shown in Table 1 (sorted by first author). All of the studies were published since 2002 and most were conducted in North America.[26–41] The majority were RCTs.[26,28,30–34,36,37,39–45] The clinical problem addressed by the various interventions varied, but the most common applications were diabetes,[26,27,35,36,39,44] cardiovascular disease,[32,35,39,43] and the prescribing of medication.[30,31,37,46]

Setting and characteristics of the studies

Most studies were undertaken in either an outpatient or community-based setting and involved physicians (see Table 2). Other professional groups included nurses and pharmacists. The studies

Table 1. Studies eligible for inclusion in the review.

First author (ref)	Year	Design	Country	Clinical speciality	Clinical problem
Avery[46]	2012	RCT	UK	General/family practice	Medication prescribing
Boukhors[26]	2003	RCT	Canada	General/family practice	Diabetes
Cafazzo[27]	2012	ITS	Canada	Paediatrics	Diabetes
Carroll[28]	2012	RCT	USA	Psychiatry	Maternal depression
Cruz-Correia[42]	2007	RCT	Portugal	Other	Asthma
Epstein[29]	2011	RCT	USA	Paediatrics	ADHD
Field[30]	2009	RCT	Canada	General/family practice	Medication prescribing
Fossum[47]	2011	CCT	Norway	Other	Pressure ulcers
Gurwitz[31]	2008	RCT	USA/Canada	Other	Medication prescribing
Jones[48]	2011	ITS	UK	General medicine	Acute medicine
Kinn[32]	2002	RCT	USA	Other	Hypertension
Mcdonald[33]	2005	RCT	USA	Paediatrics	Preventative service
Nagykaldi[34]	2012	RCT	USA	General/family practice	Preventative care
Persell[35]	2010	ITS	USA	General medicine	CVD, diabetes, and cancer
Persell[43]	2013	RCT	USA	General/family practice	CVD
Pinnock[45]	2013	RCT	UK	General medicine	COPD
Quinn[36]	2008	RCT	USA	Other	Diabetes
Raebel[37]	2007	RCT	USA	Obstetrics and gynaecology	Medication prescribing
Ross[44]	2006	RCT	USA	General medicine	Diabetes
Sequist[39]	2005	RCT	USA	General medicine	CVD and diabetes
Tierney[40]	2005	RCT	USA	General medicine	Asthma
Vollmer[41]	2011	RCT	USA	Not clear	Asthma

RCT: randomised controlled trial; ITS: interrupted time series; ADHD: attention-deficit hyperactivity disorder; CCT: controlled clinical trial; CVD: cardiovascular disease; COPD: chronic obstructive pulmonary disease.
*Denotes abstract only.

were undertaken in both academic and non-academic settings. There was a general lack of information describing the experience or qualifications of the various professional user groups. Totally, 13 of the studies directed the intervention at HCPs.[28–32,35,37,39,40,45–48] The remainder directed the intervention at patients,[27,33,34,41–44] or at both HCPs and patients.[36] Study quality is noted in Table 4. Further details on individual study characteristics are available on request.

Influence of tailoring component on intervention design

All of the studies included in the review incorporated some degree of individual patient assessment. This assessment was made via automated data queries of routinely collected clinical datasets or via additional data entry completed by patient and/or HCP (see Table 3).

The use of individually tailored communication was only evident in a minority of studies.[27,33,34,41,43,44] All of these studies delivered messages to individual patients based on data specific to that patient, for example, risk of illness/injury and how this might be modified for the individual;[33,34,43] individualised educational content;[41,44] or individualised clinical results.[27] For the remainder of studies, the content of communication was dictated by automated algorithms based on the individual assessment rather than the specific circumstances of the end-user. For example, it was common that automated CDSS aimed at HCPs would provide prompts based on

Table 2. Clinical setting and characteristics of providers.

First Author (ref)	Location of care	Academic status	Profession involved	Level of training	Mean age (year)	Years in practice
Avery[46]	Community-based care	–	Physicians, pharmacists	–	–	–
Boukhors[26]	Outpatient care	–	Physicians	–	–	–
Cafazzo[27]	Outpatient care	–	Physicians	–	–	–
Carroll[28]	Outpatient care	University/teaching setting	Physicians	–	–	–
Cruz-Correia[42]	Outpatient care	–	Physicians	–	–	–
Epstein[29]	Community-based care	–	Physicians	Accredited and/or licensed	47	–
Field[30]	Community-based care	Non-teaching setting	Physicians	–	–	–
Fossum[47]	Nursing home	Non-teaching setting	Nurses	Accredited and/or licensed	–	–
Gurwitz[31]	Inpatient care	University/teaching setting	Physicians, nurses	–	–	–
Jones[48]	Inpatient care	University/teaching setting	Physicians, nurses	–	–	–
Kinn[32]	Outpatient care	–	Physicians	Accredited and/or licensed	–	–
Mcdonald[33]	Outpatient care	University/teaching setting	Physicians	Accredited and/or licensed	–	Post-graduate level 1–3
Nagykaldi[34]	Community-based care	Non-teaching setting	Physicians, Nurses	–	–	–
Persell[35]	Community-based care	University/teaching setting	Physicians	–	–	–
Persell[43]	Inpatient care	University/teaching setting	Physicians	In training	–	–
Pinnock[45]	Outpatient care	–	Physicians	–	–	–
Quinn[36]	Outpatient care	–	Physicians	–	–	–
Raebel[37]	Pharmacy	Non-teaching setting	Pharmacists	–	–	–
Ross[44]	Outpatient care	–	–	–	–	–
Sequist[39]	Outpatient care	University/teaching setting	Physicians	Mixed	40	–
Tierney[40]	Outpatient care	Non-teaching setting	Physicians, pharmacists	Mixed	–	–
Vollmer[41]	Community-based care	–	–	–	–	–

Table 3. Role of tailoring in the interventions. 'Tailored assessment' relates to the assessment of individual patient characteristics and how that data was collated. 'Tailored communication' describes whether or not communication was specifically targeted to an individual.

First Author (ref)	Tailored assessment	Tailored communication	Recipient of communication	Tailored communication detail
Avery[46]	Automated data query	None	Healthcare practitioner (HCP)	Message contents dependent on data
Boukhors[26]	Data from patient	None	Patient	Message contents dependent on data
Cafazzo[27]	Data from patient	Tailored to user	Patient	Message contents dependent on data and tailored to user requirements (trend wizard)
Carroll[28]	Data from parent and HCP	None	HCP	Message contents dependent on data
Cruz-Correia[42]	Data from patient and HCP	None	Patient	Message contents dependent on data
Epstein[29]	Data from patient and HCP	None	HCP	Message contents dependent on data
Field[30]	Automated data query	None	HCP	Message contents dependent on data
Fossum[47]	Automated data query	None	HCP	Message contents dependent on data
Gurwitz[31]	Automated data query	None	HCP	Message contents dependent on data
Jones[48]	Automated data query	None	HCP	Message contents dependent on data
Kinn[32]	Automated data query	None	HCP	Message contents dependent on data
Mcdonald[33]	Data from patient	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Nagykaldi[34]	Data from patient and HCP	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Persell[35]	Automated data query	None	HCP	Message contents dependent on data
Persell[43]	Automated data query	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Pinnock[45]	Data from patient	None	HCP	Message contents dependent on data
Quinn[36]	Data from patient and HCP	None	Patient and HCP	Message contents dependent on data
Raebel[37]	Automated data query	None	HCP	Message contents dependent on data
Ross[44]	Automated data query	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances
Sequist[39]	Automated data query	None	HCP	Message contents dependent on data
Tierney[40]	Automated data query	None	HCP	Message contents dependent on data
Vollmer[41]	Automated data query	Tailored to user	Patient	Message contents dependent on individual data taking into account the individual circumstances

Table 4. Reported outcomes and main results from studies included in the review. Study quality score compiled for RCTs only (see 'Methods').

Study	Study quality	Outcome(s)	Main results of the outcome(s)
Avery[46]	Moderate	Number of potential drug AE*	Intervention group significantly less likely to have been prescribed contraindicated medication (all three measures)
Boukhors[26]	Low	Number of hypoglycaemic events*	No significant difference in incidence of hypoglycaemia
Cafazzo[27]	ITS	Number of blood glucose tests and glycaemic control (HbA1c)*	Number of blood glucose tests increased with intervention. No difference in secondary outcomes – incidence of hyperglycaemia and glycaemic control
Carroll[28]	Low	Number of mothers identified as having depressive symptoms and number of mothers referred for psychiatric assessment	Intervention groups more likely to have depression detected and more likely to be referred to specialist
Cruz-Correia[42]	Low	Patient satisfaction and patient adherence to recommended monitoring	Patients were satisfied with system Patients adherence was not altered with electronic system – if anything adherence improved with paper system
Epstein[29]	Low	Proportion using recommended diagnostic tools at follow-up*	Significant increase in use of diagnostic questionnaires
Field[30]	Moderate	Alert rate*, Type of alert* – incorrect dose, incorrect frequency, drug should be avoided, incomplete clinical information (creatinine)	Overall, no difference in rate of alerts between groups.
Fossum[47]	Low	Proportion with malnourishment, proportion at risk of malnourishment and pressure ulcer	No change in risk of PU No change in prevalence of PU No change in prevalence of malnourishment
Gurwitz[31]	Low	Number of drug-related AE*	No significant difference in AE's between intervention and control
Jones[48]	ITS	Length of stay (LoS)*, accuracy of early warning score (EWS), adherence to protocol, clinical response to EWS alert, rate of cardiac arrests, number of critical care bed days, and mortality rate	Significant decrease in LoS during intervention period
Kinn[32]	Low	Likelihood of being diagnosed with hypertension, likelihood of receiving ≥1 antihypertensives, number of antihypertensives per patient, and use of combination therapy, BP	Significantly more patients receiving appropriate diagnosis in intervention group Intervention group significantly more likely to be on antihypertensive. Intervention group had significantly less antihypertensive agents prescribed.

(Continued)

Table 4. (Continued)

Study	Study quality	Outcome(s)	Main results of the outcome(s)
Mcdonald[33]	Low	Parent safety knowledge, prevention beliefs, and safety behaviours	Improved safety knowledge at follow-up.
Nagykaldi[34]	Low	Provision of preventative services, number of log ins to portal, and patient centredness	Minimal use of portal Patient centredness score improved in intervention group
Persell[35]	Low	LDL cholesterol*, change in BP, smoking cessation, prescription of a statin, and number of office visits	No significant difference in rate of lowered LDL No significant difference in attendance at clinic Significantly more statins prescribed in intervention group
Persell[43]	ITS	16 quality performance indicators (QPIs) – prescribing for chronic disease and screening procedures*	Performance measures improved
Pinnock[45]	High	Time to admission to hospital with exacerbation of COPD*, time to admission, number and duration of admissions, deaths, QoL, and number of patient contacts	No significant difference in admission rate or QoL in those receiving intervention.
Quinn[36]	Low	Physician satisfaction, diabetes self-care, and glycaemic control	Physicians satisfied Glycaemic control improved Patients self-care improved
Raebel[37]	Low	Proportion of pregnant women dispensed a contraindicated medication*	Intervention group were significantly less likely to be prescribed a contraindicated medication
Ross[44]	Low	System usage	Intervention group had greater usage of system
Sequist[39]	Low	Receipt of recommended care* and HCP perceptions surrounding guideline adherence	Patients in intervention group significantly more likely than control patients to receive recommended diabetes care and CAD care
Tierney[40]	Low	Percentage adherence to management recommendations*	No significant differences in adherence to guideline between groups
Vollmer[41]	Low	Patient adherence to medication*, patient QoL, reliever medication use, asthma control, and healthcare utilisation	Small but significant increase in adherence

AE: adverse event; HbA1c: glycated haemoglobin; LoS: length of stay; EWS: early warning score; LDL: low-density lipoprotein; QPI: quality performance indicators; COPD: chronic obstructive pulmonary disease; QoL: quality of life; BP: blood pressure; IQR: interquartile range; SD: standard deviation; ITS: interrupted time series; CAD: coronary artery disease; PU: peptic ulcer; HCP: healthcare practitioner.
*Denotes primary outcome(s) where stated

an assessment of a patient's data, but the prompt provided by the system was generic to the system and not tailored to the HCP's job-description or clinical context.

Of the six studies that fulfilled both criteria for having used tailored communication (as dictated by Kreuter et al.[15]), the primary outcomes (where stated) were patient self-care (improved),[27] serum lipids (no difference),[43] and medication adherence (better than control but reduced overall).[41] The remainder of studies did not state the primary outcome, but reported on service uptake (improved in intervention group),[44] patient knowledge (improved in intervention group, but multiple comparisons made),[33] and patient centredness (improved in intervention group).[34]

Comparison – tailored intervention versus non-tailored intervention

Two studies compared an intervention which utilised tailoring with an intervention that included untargeted activity.[33,44] Neither study specified the primary outcome of interest in the methods. Both studies provided tailored educational material to patients and compared outcomes with patients who had received non-tailored material. For example in one study,[33] parents completed a questionnaire designed to assess previous injuries sustained by their child as well as parental perceptions of their child's current risk of injury. The educational material then incorporated the events previously described as well as addressing any misconceptions in injury risk identified from parental responses. Tailoring resulted in an increase in patient service uptake in one study,[44] with multiple comparisons being made in the other, introducing the possibility of a type 1 error.[33]

Comparison – intervention versus no intervention

The primary outcome was not overtly stated in eight of the studies. Of the 22 studies included in the review, the main outcome of interest was related to clinical processes and performance in 14, with the remainder concerned with clinical outcomes (see Table 4).

Studies where the stated primary outcome related to clinical processes included HCP adherence to existing guidelines,[29,35,39,40] avoidance of adverse drug events,[30,31,37,46] patient adherence to medication,[41] and patients' frequency of clinical testing.[27] Of the six studies which failed to stipulate the primary outcome, one measured HCP adherence to an existing guideline aimed at improving diagnosis rates.[36]

A total of 12 among the 16 studies concerned with clinical processes reported a favourable outcome. For those studies aiming to assess HCP adherence to guidelines, most reported an improvement;[28,29,32,35,39] however, one of these studies also noted a pre-intervention improvement in the ITS analysis, introducing the possibility that secular change was responsible for the observed improvement.[35] The rate of potential adverse drug events was significantly reduced in half of the relevant studies.[37,46] When compared with controls, patient medication adherence was said to be higher; however, the actual difference was small and both groups' overall adherence fell during the study period.[41] The other measures of patient-driven clinical processes also improved (blood sugar testing[27] and service uptake[44]).

Two of the six studies concerned with clinical outcomes reported positive findings. Four studies measured clinical parameters as the primary outcome which included glycaemic control (unchanged),[26] length of hospital stay (improved),[48] change in serum lipids (unchanged),[43] and time to admission to hospital (unchanged).[45] Clinical parameters were also measured in two further studies and included glycaemic control (improved)[36] and presence of malnourishment and/or pressure ulcers (unchanged).[47]

Comparing patient-orientated interventions with HCP-orientated interventions

Eight of the studies targeted patients with the intervention,[26,27,33,34,41–44] one study involved an intervention aimed at both HCPs and patients,[36] and the remainder focussed solely on HCPs (see Table 3).

For the eight studies where the intervention targeted patients, five (63%) reported that the intervention produced a positive effect. This included increased patient satisfaction,[42] monitoring of blood glucose,[27] adherence to medication,[41] system usage,[44] and knowledge[33] (see Table 4).

For the 14 studies where the intervention was targeted at HCPs, a similar proportion reported positive findings (8/14, 57%). These included improved adherence to guidelines,[29,35,39] detection of morbidity,[28,32] decreased adverse drug events,[37,46] and length of hospital stay[48] (see Table 4).

Risk of bias in included studies

There was a high risk of bias for all studies included in the review, with the exception of one high-quality study[45] (see Table 4). Three studies were assessed as having concealed allocation adequately.[37,40,45] The remaining studies either failed to do so or did not provide sufficient information. Four studies reported that the assessors were sufficiently blinded to allocation group.[30,31,40,45] Of the remainder, 10 studies derived outcome data from automated data queries, making assessment bias unlikely.[28,29,32,37,39–41,43,44,47] Seven studies were assessed as having adequate follow-up of professionals and/or patients.[30,32,33,41,45–47]

Three of the studies were ITS analyses.[27,35,48] All three used a reliable outcome measure. It was unclear how either of these studies protected against detection bias (in terms of either data collection or blinded assessment) or secular changes in the population being studied. One study reported on the completeness of the dataset, which was assessed as being satisfactory.[35]

Discussion

In order to assess the effectiveness of tailored messages within eHealth interventions, a comparison needs to be made between outcomes of tailored interventions and non-tailored interventions. However, based on the results of this review, the research question remains incompletely answered for a number of reasons.

First, any direct comparison between tailored and non-tailored interventions was limited to a minority of the included studies. Nearly all studies compared the intervention to a no change/standard practice control group as opposed to a non-tailored intervention. This makes it impossible to ascertain whether any improvements were secondary to the tailoring component of the intervention per se.

Second, the outcome of either of these comparisons presented a mixed picture. A number of studies concluded that there was improvement in clinical processes, for example, adherence to guidelines, avoidance of prescription errors, and increased service uptake when compared to no intervention. However, most of these studies presented methodological weaknesses meaning that these conclusions should be met with caution.

Third, only a minority of studies included in the review included an intervention that fulfilled both criteria for what is considered to be tailoring of information. All of the other studies included in the review incorporated only one of the two components that define true tailoring. The adoption of studies meeting this less strict definition increased the number of studies eligible for inclusion but made it difficult to address the research question specifically.

Last, the quality of most of the included studies was assessed as low. However, the introduction of methodological quality as an eligibility criterion for inclusion would have excluded almost all

of the studies identified. Meta-analysis was not possible owing to the heterogeneous nature of the interventions and outcomes of the studies reviewed.

It should be noted that this review is limited to describing the *effectiveness* of tailored messages within eHealth systems and has done so by adopting a quantitative approach. For those studies that demonstrate improved outcomes, no attempt has been made to assess which components of the intervention were responsible. This will no doubt vary by setting (e.g. patient-orientated versus HCP-orientated interventions) and would require alternative methodologies.

Significance

Despite these limitations, some limited conclusions can be drawn. Irrespective of the degree to which the intervention incorporated tailoring, or the degree to which tailoring was responsible for the observed outcomes, it is notable that 14 of the 22 studies included reported positive findings. These improvements were largely limited to clinical processes as opposed to clinical outcomes and were observed in interventions aimed at both patients and HCPs. It is also notable that none of the included studies reported any harm. This would suggest that personalised eHealth interventions (aimed at either patients or HCPs) can safely effect behaviour change which may in turn reduce unwanted variation in practice. To what extent tailoring of messages is responsible for this effect is unknown.

The lack of studies that combine eHealth technologies with interventions that utilise tailoring of information is surprising, given the evidence that tailoring is effective when used in conjunction with traditional media, and the ease with which tailoring algorithms can be incorporated into new technologies. This may reflect the fact that both are relatively recent innovations. Given the existing evidence that tailored messages via traditional media can effect behaviour change, it would seem a logical extension to incorporate them into eHealth interventions. Clearly, there is a need for additional work in this area. Future research should delineate the role of tailoring in eHealth (e.g. by comparing it with non-tailored interventions as opposed to no intervention or standard care) as well as identifying which are the active components of such interventions (e.g. via future qualitative studies).

Conclusion

Tailoring of information to recipients has previously been shown to be an effective way of changing behaviour when used with traditional media. This review suggests that eHealth-tailored information delivery may improve clinical care, but there is currently a lack of evidence to conclude that the use of tailoring within an eHealth context confers any benefits over non-tailored eHealth interventions. This lack of evidence reflects the low number of good quality studies in this area. It is only by designing studies where the role of tailoring is isolated as the active component in the intervention, that the effectiveness of tailoring can be adequately assessed.

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