Research Paper ∎

Review of Computer-generated Outpatient Health Behavior Interventions:

Clinical Encounters "in Absentia"

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A b s t r a c t   **Objective:** To evaluate evidence of the effectiveness of computer-generated health behavior interventions—clinical encounters "in absentia"—as extensions of face-to-face patient care in an ambulatory setting.

Data Sources: Systematic electronic database and manual searches of multiple sources (1996–1999) plus search for gray literature were conducted to identify clinical trials using computer-generated health behavior interventions to motivate individuals to adopt treatment regimens, focusing on patient-interactive interventions and use of health behavior models.

Study Selection: Eligibility criteria included randomized controlled studies with some evidence of instrument reliability and validity; use of at least one patient-interactive targeted or tailored feedback, reminder, or educational intervention intended to influence or improve a stated health behavior; and an association between one intervention variable and a health behavior.

Data Extraction: Studies were described by delivery device (print, automated telephone, computer, and mobile communication) and intervention type (personalized, targeted, and tailored). We employed qualitative methods to analyze the retrieval set and explore the issue of patient-interactive computer-generated behavioral intervention systems.

Data Synthesis: Studies varied widely in methodology, quality, subject number, and characteristics, measurement of effects and health behavior focus. Of 37 eligible trials, 34 (91.9 percent) reported either statistically significant or improved outcomes. Fourteen studies used targeted interventions; 23 used tailored. Of the 14 targeted intervention studies, 13 (92.9 percent) reported improved outcomes. Of the 23 tailored intervention studies, 21 (91.3 percent) reported improved outcomes.

Conclusions: The literature indicates that computer-generated health behavior interventions are effective. While there is evidence that tailored interventions can more positively affect health behavior change than can targeted, personalized or generic interventions, there is little research comparing different tailoring protocols with one another. Only those studies using print and telephone devices reported a theoretic basis for their methodology. Future studies need to identify which models are best suited to which health behavior, whether certain delivery devices are more appropriate for different health behaviors, and how ambulatory care can benefit from patients' use of portable devices.

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The number of controlled trials, reviews, and reports in the literature and popular media suggests that interest in using technology to augment patient–physician interactions has increased in the last decade. Recently, a *JAMIA* article recommended that telemedical services and information systems address behavior change, individual risk factors, and patient education, and further predicted that "the

Table 1 ∎

Summary of Reviews and Analyses of Personalized, Targeted, and Tailored Interventions

Author	Intervention Focus	Method	Delivery Device
Skinner et al., 1993[71]	Patient education	Overview, 31 articles and reviews	Computer-assisted instruction, telephone
Alemi and Stephens, 1996[72]	Preventive care, ambulatory setting; patient education	Overview, 4 projects	Telephone, print materials
Shea et al., 1996[73]	Preventive care, ambulatory setting	Meta-analysis, 16 trials	Computer-generated reminders
Balas et al., 1997[23]	Distance medicine technology	Literature review, 61 trials	Computer systems, telephone
Piette, 1997[74]	Diabetes management	Literature review, 33 studies	Telephone using AVM (automated voice messaging)
Balas et al.,1998[75]	Diabetes management	Literature review, 15 studies	Computer systems, print materials
Marcus et al.,1998[76]	Physical exercise	Literature review, 28 studies	Mass media-based interventions
Wagner, 1998[77]	Mammography screening	Meta-analysis, 16 articles	Print materials
Bental et al., 1999[19]	Patient information systems	Overview, 15 projects	Computer systems, print materials
Brug et al., 1999[18]	Nutrition	Overview, 8 studies	Print materials
Kristal et al., 1999[78]	Nutrition	Review, 10 studies	Print materials
McBride and Rimer, 1999[79]	Telephone-delivery	Literature review, 74 trials	Telephone
Strecher, 1999[22]	Smoking cessation	Literature review, 10 studies	Print materials

trend is toward delivery of care in an ambulatory setting or by interaction with a patient directly at home, and telemedicine services and information systems provide the necessary communication links."[1]

The purpose of this study is to report the current state of the peer-reviewed evidence for patient-interactive computer-generated health behavior interventions—clinical encounters "in absentia"—as extensions of face-to-face patient care. We were interested in two specific areas: the health behavior models used in these interventions and the devices used for patient education, counseling, and reminder systems aimed at improving patient health behaviors.

Background

Other Reviews

Other reviews have focused on a specific delivery method (e.g., telephone-delivered interventions) or a particular health behavior focus (e.g., smoking cessation). To our knowledge, this is the first review to summarize findings across all interventions that involve devices that communicate or interact directly with the patient, regardless of technology, health behaviors, or medical conditions. Intervention types are also defined more narrowly and more consistently than in previous literature reviews (as discussed under Methods). While other reviews describe the growing

role of telecommunication in health care, this review specifically examines the state of computer-generated or computer-operated therapeutic communications. Table 1 summarizes previous review papers.

Theoretic Models

Patients are increasingly involved in managing their health care,[2] and health care providers are challenged to motivate, educate, and help people adhere to healthy behaviors and medication regimens in the ambulatory setting.[3] Understanding why people behave the way they do and identifying the factors underlying behavioral change help in the development and evaluation of effective health behavior interventions.[4] Although a review of theories is outside the scope of this paper, we mention the four cognitive-behavioral models used most frequently in the studies reviewed.

Cognitive-behavioral theories focus on the individual level and use two key concepts—behavior (as mediated through cognitions) and knowledge (which is necessary but not sufficient to produce behavior change). These theories focus on intrapersonal factors such as an individual's knowledge, beliefs, motivation, attitudes, developmental history, experience, skills, self-concept, and behavior. Models using an intrapersonal approach are the stages of change, or transtheoretic, model (TM), the health belief model (HBM),

Table 2 ■

Models and Concepts for Health Behavior Change

Concept	Definition	Application
Health Belief Model:		
Perceived susceptibility	One's opinion of chances of getting a condition	Personalize risk based on a person's features or behavior.
Perceived severity	One's opinion of how serious a condition and its consequences are	Specify consequences of the risk and the condition.
Perceived benefits	One's opinion of the efficacy of the advised action to reduce risk or seriousness of impact	Define action to take; how, where, when; clarify the positive effects to be expected.
Perceived barriers	One's opinion of the tangible and psychological costs of the action	Identify and reduce barriers through reassurance, incentives, assistance.
Cues to action	Strategies to activate "readiness"	Provide how-to information, promote awareness, provide reminders.
Self-efficacy	Confidence in one's ability to take action	Provide training, guidance in performing action.
Stages-of-Change Model:		
Pre-contemplation	Unaware of problem, hasn't thought about changes	Increase awareness of need for change, personalize information on risks and benefits.
Contemplation	Thinking about change, in the near future.	Motivate, encourage to make specific plans.
Preparation	Making a plan to change	Assist in developing concrete action plans, setting gradual goals.
Action	Implementation of specific action plans	Assist with feedback, problem solving, social support, reinforcement.
Maintenance	Continuation of desirable actions, or repeating periodic recommended step(s)	Assist in coping, reminders, finding alternatives, avoiding slips/relapses (as applicable).
Theory of Planned Behavior and Theory of Reasoned Action:		
Behavioral intention	Perceived likelihood of performing the behavior; prerequisite for action	Define action; identify how much effort one is planning to exert to reach goal.
Attitude	One's favorable or unfavorable evaluation of the behavior	Identify outcomes of action.
Behavioral belief	Belief that behavioral performance is associated with certain attributes or outcomes	Provide information about outcomes; clarify positive effects to be expected.
Normative belief	Subjective belief regarding approval or disapproval of the behavior	Identify barriers and advantages of behavior.
Subjective norm	Influence of perceived social pressure; weighted by one's motivation to comply with perceived expectations	Identify specific groups or individuals of influence; identify how much their approval or disapproval affects action.
Perceived behavioral control (Theory of Reasoned Action only)	One's perception of how easy or difficult it will be to act	Incorporate information about likely results of action in advice.
Social Cognitive Theory:		
Reciprocal determinism	Behavior changes result from interaction between individual and environment	Work to change environment.
Behavioral capability	Knowledge and skills to influence behavior	Provide information and training about action.
Expectations	Beliefs about likely results of action	Incorporate information about likely results of action into advice.
Self-efficacy	Confidence in ability to take action and persist in action	Point out strengths; use persuasion and encouragement; approach behavior change in small steps.
Observational learning	Beliefs based on observing others	Point out others' experience; identify role models.
Reinforcement	Responses to a person's behavior that increase or decrease chances of recurrence	Provide incentives, rewards, praise; encourage self-reward.

SOURCES: Bandura,[8] Glanz et al.,[4] Prochaska et al.,[7,41] Rhodes et al.,[5] and Skinner and Kreuter.[6]

and the theory of reasoned action/theory of planned behavior (TRA).[5,6] The TM is concerned with an individual's readiness to change.[6,7] The HBM focuses on an individual's perception of the threat of a health problem.[4] The TRA focuses on an individual's intention to perform a behavior.[6] Social-cognitive theory incorporates intrapersonal and interpersonal factors; as in the HBM and TRA, the benefits of a behavior must outweigh the costs; also, a person must have a sense of self-efficacy or personal agency about the behavior.[8,9] Personal empowerment, an individual's ability to cope with situations and perceived sense of control over them, is emphasized.[8,10] Table 2 summarizes the concepts of each theory.

An appropriate theoretic framework applied to development of health behavior messages can greatly enhance a patient's motivation to comply with an intervention.[5] Further enhancement can be achieved using patient characteristics in conjunction with computer production capabilities to approximate a face-to-face clinical encounter.[6]

Another enhancement feature may be achieved by using mobile devices rather than delivery methods that tether ambulatory patients to a computer, telephone, or mailbox. Mobile devices such as cell phones or pagers are particularly suitable for outpatient interventions, since patients can carry them easily. These devices have received considerable popular media and commercial attention,[11–13] so we made an effort to find papers that described their use. The price of mobile communication devices has dropped dramatically in the last decade, so the increasing power and decreasing cost of communication may provide opportunities for therapeutic interventions that were not feasible before. In addition, their portability and convenience seem to create an attachment or synergy between the user and the device, which can bond the user to the intervention protocol.[14]

Methods

The literature that describes this area of investigation is not indexed in a single database. We therefore designed a search strategy that involved searching across multiple databases using both free text and appropriate specialized terminology.

Data Sources

Databases searched included MEDLINE (1966–99), HealthSTAR (1981–99), CINAHL (1982–99), *Current Contents* (1997–99), EMBASE (1990-1999), INSPEC (1969–1999), PsycINFO (1967–1999), and *Sociological*

Table 3 ■

Key Words Used in Literature Review

Key Words	Additional Terms
Compliance	Adherence Motivation
Patient education	Education Decision making Empowerment
Preventive health services	Self-help Health behavior Ambulatory care
Reminder systems	Drug monitoring Intervention Patient reminder Tailored reminder Targeted reminder Tailored intervention Targeted intervention
Computer	Computer communication networks Computer systems
Telephone	Telephone systems
Pager	Paging technology
Print communication	Letter Postcard
Communication	Counseling Self-assessment

Abstracts (1986–1999). We also searched the Cochrane Collaboration and Web of Science (*Science Citation Index Expanded* and *Social Sciences Index*) databases. To account for gray literature, we searched CRISP (Computer Retrieval of Information on Scientific Projects) and *Dissertation Abstracts*, contacted authors, and conducted targeted Internet searches. We also searched LEXIS-NEXIS for more popular literature on this subject.

Searches were limited to publications in English. A summary of key terms and phrases is given in Table 3.

Study Selection

Eligibility for inclusion in the final set included:

- Controlled clinical trials and quasi-experimental studies with some evidence of instrument reliability and validity

- At least one patient-interactive feedback, reminder, or educational intervention intended to influence or improve a stated health behavior

- An association between one intervention variable and a health behavior

Table 4 ◼

Rating System

Factor	Description	Possible Points
Randomization	Assignment to different interventions by chance	2
Control group	Comparison made to group of subjects not given the health behavior intervention	2
Theory or model used	Theoretic basis for intervention design Rationale for using chosen model and rejecting other options	1
Sampling	Sampling method described Sample composition clearly described Sample of adequate size Number and ratio of withdrawals described	3
Analysis of main effect variables	Clear definition for each variable Clear description of methods and results Numeric table presented for each effect variable	1
Content	Intervention clearly described and replicable Discussion of withdrawals Discussion of study limitations	1

Eligible trials were evaluated using the rating system described in Table 4. Ratings were based on recommendations from the literature.[15,16] Articles received a score from 1 to 10; sampling and randomization aspects and presence of a control group were weighted most heavily (totaling 7 points). The minimum score was set at 5 for inclusion.

The initial cross-database search yielded 1,404 publications; this was reduced to 519 after elimination of duplicates. Review of the title and abstract of each publication yielded 97 publications potentially meeting eligibility criteria. After review of these articles, 49 publications were eliminated because they did not meet the eligibility criteria (the primary cause was a focus on physician reminders). Manual searches of the bibliographies of remaining articles, reviews, key journals in the appropriate fields, and key individuals yielded another 6 articles, for a total of 55; multiple reports of studies were collapsed to yield a final total of 46 studies in this review. Nine of these are feasibility or quasi-experimental studies included because they describe promising approaches. Figure 1 illustrates our selection process.

Data Extraction and Definitions

Each item was scored using the rating system described in Table 1. Items were classified by intervention type, delivery device, and use of synchronous vs. asynchronous interaction.

We defined three intervention types according to features accepted in the literature: personalized, targeted, and tailored. *Personalized messages* have the person's name on the information he or she receives. The message content is not adapted to the individual's diagnostic, behavioral or motivational characteristics.[17] Personalized intervention studies were eliminated unless a higher level intervention (i.e., targeted or tailored, or both) was also a condition in the study.

Targeted message content is customized to reach a specific subgroup of the general population, based on the principles of market segmentation. Content is
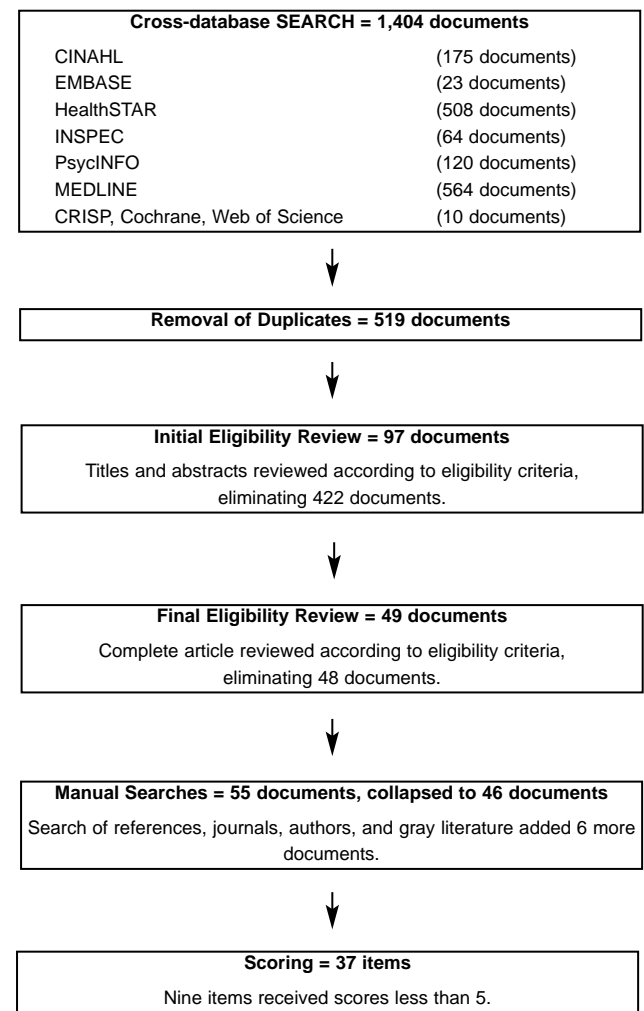

Figure 1 Search and selection process.

customized to "target" broad psychographic (i.e., activities, interests, and opinions) and sociodemographic groups. Targeted interventions do not account for personal differences in intervention needs among individuals in the target population, but they may be personalized.[18]

Tailored interventions are messages or a series of messages based on a specific individual's characteristics, as determined through historical records, replies to questions, or replies to previous messages. Tailored messages are generally based on published theoretic models, and message content is specific to one individual at one point in time. One of the goals of a tailored intervention is for patients to perceive the information as applying only to them.[17,19,20] An example of a tailored intervention is delivering messages or information contingent on a patient's "stage of change," a model postulating that patients will respond to and better remember messages presented on cue. For instance, patients who have just quit smoking will respond better to messages pitched to the "action" phase than the "precontemplative" phase.[21,22] The actual messages are picked from a large pool of potential responses either manually by a therapist or through a largely automated process designed by a therapist.

The primary distinction between targeted and tailored interventions is that tailoring adapts content or the way content is presented according to the needs of the individual. Material is not fixed and feedback is based on individual, not subgroup, characteristics. Devices used for feedback range from the most simplistic, such as tailored letters, to expert systems incorporating behavior change models into an interactive messaging system.

Interventions can be distinguished along a continuum, from generic (or "one-size-fits-all") to highly individualized, tailored approaches as seen in Figure 2. Confusion between targeted and tailored interventions is compounded by researchers' inconsistent use of the terminology.[22]

We grouped intervention delivery devices into categories adapted from Balas et al.[23]: 1) mobile communication systems (use of a pager, mobile telephone, or other wireless system for delivery), 2) computerized communication systems (use of a computer, modem, touch-sensitive screen, or other interfacing equipment for delivery), 3) automated telephone communication (usually computer-generated messages using a regular telephone line and telephone), and 4) print communication (use of a letter, bulletin, fax transmission, newsletter, postcard, or manual deliv-

F i g u r e 2 Intervention types continuum.

ery).

We also distinguished between synchronous and asynchronous communication. Synchronous communication is like communication by telephone—dialog occurs in real time. Asynchronous communication is like e-mail—two parties carry on a dialog by leaving messages, but do not usually communicate in real time.

Results

Of the 46 studies meeting our inclusion criteria, 9 received scores below 5. These studies were excluded from analysis but are included in Table 5 because they illustrate promising approaches and merit discussion.

Lack of homogeneity among the remaining 37 studies precluded pooling of data; our findings, therefore, form a descriptive literature review. Studies varied by recruitment method, subject characteristics, study design, time frame, setting, measurement of effects, and health behavior focus. Many studies reported multiple outcomes; several used targeted or tailored interventions in conjunction with personalized or generic interventions; some used more than one targeted or tailored intervention.

Of 37 studies, 33 (89.2 percent) reported improved outcomes and 20 of these (60.6 percent) were statistically significant. Fourteen studies used targeted interventions; 23 used tailoring. Eleven of the targeted intervention studies (78.6 percent) reported improved outcomes; 6 of these (54.5 percent) were statistically significant. Of the 23 tailored intervention studies, 22 (95.7 percent) reported improved outcomes; 15 of these (68.2 percent) were statistically significant. Table 5 lists the studies by delivery device.

No Intervention Benefits

Four studies[50,66–68] did not report statistically significant or improved outcomes. Lack of effect was explained by use of a limited, non-intensive one-time feedback with no inclusion of psychosocial factors[66]

Table 5 ■

Summary of Targeted and Tailored Interventions, Categorized by Delivery Device

Author[s]	Methods	Health Behavior	N	Results	Score
Mobile Communications:					
Facchinetti & Korman, 1996,[62]1998[63]	Quasi-experimental controlled trial Reminder system vs. control Targeted, asynchronous (PRN: Prescription Reminder Network)	Medication adherence: reduce drug holidays	24	Text pager improved adherence, reduced number of "drug holidays" and total number of days without therapy.	4
Milch et al.,1996[64]	Quasi-experimental Medication use before (control period) and during pager use Targeted, asynchronous (Neuropage)	Medication adherence: increase compliance	6	Mean compliance rose from 56% to 96% during pager use.	1
Dunbar et al., 2000[65]	Quasi-experimental Interactive reminder system Targeted, synchronous (CareWave)	Medication adherence: increase compliance	26	Patients on HIV medications reported high acceptance of paging system.	2
Computer Systems:					
Shultz et al.,1992[57]	RCT: Transmission of glucometer results via modem once a week vs. standard diary results Targeted, synchronous	Diabetes: reduce blood glucose levels	20	Significant improvement in reduced blood glucose levels in modem intervention group over traditional diary group.	6
Turnin, 1992[58]	RCT: Diabeto use (computer-aided instruction) vs. no Diabeto use Tailored, synchronous (Diabeto)	Diabetes: increase dietetic knowledge and improved diabetes self-care	105	Diabeto use associated with significant improvement in dietetic knowledge, some decrease in caloric excess in overeaters, decrease in fat intake in over-consumers, increase in carbohydrate intake in under-consumers; no impact on caloric deficit.	9
Buchanan et al., 1993,[59] 1995[60]	Quasi-experimental Interactive explanation system Tailored, synchronous (Migraine)	Migraine: improve understanding of migraines	16	Presentation of information based on individual patient's medical record, concerns, questions, and physician input. System "accepted by patients."	1
Carenini et al., 1994[61]	Quasi-experimental Interactive explanation system Tailored, synchronous (Migraneur)	Migraine: improve understanding of migraines	16	Presentation of information based on individual patient's medical record, concerns, questions, and physician input. Patients "found system useful."	1

Study	Intervention	N	Results	
Gustafson et al., 1994,[55] 1999[56]	RCT: CHESS use vs. no CHESS use. Tailored, synchronous (CHESS: Comprehensive Health Enhancement Support System)	Information and support: improve social support, mood, and quality of life	204	CHESS users reported improved cognitive functioning, sense of social support, and more active life; reported more participation in health care and decreased levels of negative emotions. No significant differences between groups for depression, physical functioning or reported level of energy.	9
Binsted et al., 1995[80]	Quasi-experimental. Interactive explanation system. Tailored, synchronous (PIGLET: Personalized Intelligent Generator of Little Explanatory Texts)	Diabetes: improve diabetes self-care	10	Generation of diabetes information collected through medical record; includes personalized reminders. Patients and medical staff found system helpful and easy to use.	1
McRoy et al., 1998[83]	Quasi-experimental. Generation of customized educational materials and medical explanations. User satisfaction questionnaires completed online. Tailored, synchronous (LEAF: Layman Education and Activation Form)	Medical history taking; increase understanding of medical conditions and treatment	35	User satisfaction measured via online questionnaire: 87% of users completed evaluations; 87% prefer online system to paper. Other findings: users like having medical information tailored to their interests; 71% found definitions somewhat or very helpful; 58% found dialog sections helpful.	1
Jones et al., 1996,[81] 1999[82]	RCT: Personalized cancer information (P) vs. general cancer information output via "computer consultation" (G) vs. cancer booklet (B) information group. Tailored, synchronous	Information and support: increase understanding of cancer information	525	P reported higher satisfaction with information, thought information was relevant, and learned something new. B more likely to feel overwhelmed by information than P or G. P and G thought information was limited. Printed information use at home: 83% B; 57% G; 70% P. P and G groups also sent printouts of information viewed; P more likely to use this information than G.	9
Rolnick et al., 1999[54]	RCT: CHESS use vs. no CHESS use (included receiving a book related to either HIV or breast cancer) Targeted, synchronous (CHESS)	Information and support: improve social support, mood and quality of life	107	*HIV group:* discussion service used more often (time and number of uses). *Breast cancer group:* discussions were "disease-based."	9

Table 5 ■

Summary of Targeted and Tailored Interventions, Categorized by Delivery Device (*continued*)

Author[s]	Methods	Health Behavior	N	Results	Score
Automated Telephone Communications:					
Ahring et al., 1992[51]	RCT: Transmission of glucometer results via telephone once a week vs. standard diary results every 6 weeks Targeted, asynchronous	Diabetes: reduced blood glucose levels	42	Significant difference in blood glucose levels between 6-week and 12-week experimental groups. Approximately two thirds of experimental group expressed increased understanding of blood-glucose control, motivation for self-management and general knowledge about diabetes.	6
Stehr-Green 1993[49]	RCT: Computer-generated telephoned immunization reminders vs. control Targeted, asynchronous.	Preventive health: increase immunization rate	222	11.6% improvement in immunization rates in intervention group. On-time immunizations: 52.9% intervention, 41.3% control.	9
Friedman et al., 1996,[44] 1997[45]	RCT: TLC use vs. no TLC use (control) Tailored, synchronous (TLC: Telephone-linked Care) Model: social cognitive theory	Hypertension: increase medication compliance and lower blood pressure	267	*Medication adherence:* improved 17.7%–18% in TLC, 11.7%–12% in control. If nonadherent at baseline: 36% improvement TLC, 26% control. *Blood pressure:* mean systolic and diastolic blood pressure decreased in both groups.	10
Hyman et al., 1996[50]	RCT: Computer-interactive phone call re: total cholesterol and weight vs. no call (control) Targeted, synchronous	Preventive health: decrease cholesterol level and body weight	115	Subjects recruited from those who completed a 4-week cholesterol behavioral and diet program. No significant difference between experimentals and controls.	9
Baer and Geist, 1997[84]	Quasi-experimental Computer-administered behavior therapy program (BT STEPS) using interactive voice response (IVR) Tailored, synchronous Model: "behavioral theory"	Mental health: increase adherence to behavior therapy program	65	Patients who completed two or more phone sessions were "greatly improved."	2
Jarvis et al., 1997[47]	RCT: TLC vs. control Tailored, synchronous Model: stages of change	Physical exercise: increase activity	52	Increase in stage of change: TLC 88%, control 62%.	7

Study	Description	Target/Goal	N	Results	Score
Piette and Mah, 1997[53]	Feasibility study. Automated voice message (AVM) calls vs. no calls. Targeted, synchronous	Diabetes: improve diabetic self-care	65	98% reported no difficulty understanding and responding to AVM queries. AVM system could identify potentially serious health problems. 71% were willing to listen to preventive care messages.	2
Friedman, 1998[46]	RCT: Report of three TLC studies: hypertension medication adherence (MA); dietary modification (DietAid); exercise (ACT). TLC use vs. no TLC use (control). Tailored, synchronous. Models: social cognitive theory, stages of change	Hypertension: increase medication adherence and lower blood pressure. Physical exercise: increase activity	267	MA: 18% mean adherence improvement in TLC users vs. 12% control. TLC diastolic blood pressure reduction 5.2 mm Hg vs. 0.8 mm Hg in control. DietAid: TLC reduced mean total cholesterol vs. no change in control. ACT: TLC increased walking to 121 min/week vs. 40 min/week in control.	10
Lieu et al., 1998[48]	Randomized trial: Automated telephone call (TC) vs. letter only (L) vs. TC followed by L (TC+L) vs. L followed by TC (L+TC). Targeted, asynchronous. Model: health belief	Preventive heath: increase immunization rate	648	TC+L and L+TC led to significantly higher immunization rates than L or TC.	8
Meneghini et al., 1998[52]	Controlled trial. Daily report of self-measured glucose levels or hypoglycemic symptoms via voice-interactive phone system vs. no ECM use. Targeted, synchronous (ECM: Electronic Case Manager)	Diabetes: lower diabetes or hypoglycemic crises and emergency room visits	107	58% of clinic patients used ECM. Three-fold decrease of diabetes-related crises or hypoglycemia in ECM group. Two-fold decrease in clinic visits of complex diabetes management issues.	5
Print Communications:					
Prochaska et al., 1993[41]	Randomized assignment via stage of change. Standardized self-help manual (ALA+) vs. manual matched to stage (TTT) vs. interactive computer report plus individualized manual (ITT) vs. four counselor calls plus stage manual plus report (PITT). Tailored, asynchronous. Model: stages of change	Smoking cessation: abstinence from smoking tobacco	756	ITT outperformed other conditions at each f/u point and demonstrated higher prolonged abstinence rates than other groups.	8

Table 5 ■

Summary of Targeted and Tailored Interventions, Categorized by Delivery Device (*continued*)

Author[s]	Methods	Health Behavior	N	Results	Score
Campbell et al., 1994[26]	RCT: Well-child appointment letter vs. postcard vs. control Targeted, asynchronous Model: health belief model	Preventive health: increase immunization rate	558	Letter and postcard rates significantly higher than control rates (75.0%, 73.7%, and 67.5%, respectively). No difference between letter and postcard groups.	10
Campbell et al., 1994[31]	RCT: Multicenter study. Tailored nutrition information packet vs. non-tailored packet vs. control Tailored, asynchronous Models: health belief model; stages of change	Nutrition: lower fat intake	558	Tailored group was more than twice as likely as non-tailored group to remember receiving information. Tailored group significantly reduced total fat and saturated fat intakes compared with control.	10
Osman et al., 1994[89]	RCT: Computer-generated tailored asthma education booklet (BI) vs. standard oral education (control) Tailored, asynchronous	Asthma: decrease hospital admissions	801	BI associated with reduction in hospital admissions for patients judged most vulnerable on study entry.	9
Rimer and Orleans, 1994[86]	Controlled trial Tailored guide and counselor calls (GC) vs. standard guide (G) vs. control (CO) Tailored, asynchronous	Smoking cessation: abstinence from smoking tobacco	901	GC used Clear Horizons Guide tailored to older adult population. 20% of GC reported not smoking 12 months after intervention vs. 12% of G. Higher proportion of both GC and G used quitting techniques, were more likely to set a quit date and use nicotine reductiontechniques than controls.	8
Skinner et al., 1994[29]	RCT: Individualized mammogram recommendation letters vs. standard letter Tailored, asynchronous Model: stages of change	Preventive health: increase mammogram rate	435	Individualized letter recipients were more highly associated with mammogram follow-up if income <$26,000 or if African-American. Overall, individualized letters were better remembered and more thoroughly read than standard letters Higher-educated women less likely to report interest in content.	10
Strecher et al., 1994[43]	RCT: Tailored letter vs. generic letter vs. control Tailored, asynchronous Models: health belief, stages of change	Smoking cessation: abstinence from smoking tobacco	51 & 197	Younger smokers more likely to quit Significant effects of tailored letters only for moderate to light smokers.	10

Study	Intervention	Topic	N	Results	Score
Brug et al., 1996,[32] 1998,[33] 1999a,[34] 1999b[35]	RCT: Tailored vs. non-tailored / 1996 and 1999b: Tailored vs. general nutrition information / 1998: Tailored letter and iterative feedback (TI) vs. tailored letter (TL) vs. general letter (CO) / 1999a: Tailored feedback vs. tailored feedback and psychosocial information letter / Tailored, asynchronous / Models: social cognitive theory, theory of planned behavior	Nutrition: lower fat intake, increase fruit and vegetable intake	1996, 1999b: 347 1998: 762 1999a: 315	1996: Significant short-term effect of tailored messages on fat intake and opinions about vegetable and fruit intake. No significant effect on fruit and vegetable intake. 1998: TI and TL lower mean fat scores than CO. TI and TL higher mean vegetable scores than CO. No significant differences between TI and TL groups. 1999a: Significant reduction in mean fat score. Mean fruit intake increase. No vegetable change. 1999b: Personalized dietary and psychosocial feedback more likely to be read, seen as personally relevant and motivating to reduce fat intake.	10
Kreuter and Strecher, 1996[88]	RCT: Enhanced health risk assessment (HRA) vs. standard HRA vs. control / Tailored, asynchronous / Models: health belief, stages of change	Preventive health: decrease fat intake and cholesterol and increase activity	1,317	Each behavior analyzed separately. Enhanced HRA led to statistically or nearly statistically significant effects for cholesterol test, fat reduction, and exercise.	10
Campbell et al., 1997[67]	RCT: Risk result feedback vs. control / Targeted, asynchronous	Preventive health: increase Pap test rate	411	No statistical difference between groups. Women 50 to 70 years old who received results were "more likely" to have a Pap test in the next 6 months.	9
Baker et al., 1998[25]	RCT: Personalized targeted reminder letter from physician vs. personalized postcard from physician vs. generic postcard vs. control / Targeted, asynchronous	Preventive health: increase influenza immunization rate	24,743	64% of targeted letter group remembered reminders vs. 39% combined postcard groups. Targeted letter more effective than either postcard intervention.	9
Dijkstra et al., 1998[39,42]	RCT: Information on outcomes of quitting (O); self-efficacy-enhancing information (SE); O + SE; or no information (CO) / Tailored, asynchronous / Model: stages of change	Smoking cessation: abstinence from smoking tobacco	752	Subjects considering change benefited most from O + SE intervention; those planning to quit benefited most from SE intervention. Significantly more smokers in O, SE, and O + SE interventions attempted 24-hour quits.	10

Table 5 ■

Summary of Targeted and Tailored Interventions, Categorized by Delivery Device (*continued*)

Author[s]	Methods	Health Behavior	N	Results	Score
Dijkstra et al., 1998[38]	RCT: 3 tailored letters and self-help guide (3TS) vs. 3 tailored letters only (3T) vs. 1 tailored letter and self-help guide (TS) vs. 1 tailored letter only (T) vs. non-tailored intervention (CO) Tailored, asynchronous Model: stages of change	Smoking cessation: abstinence from smoking tobacco	752	3TS and 3T: more stage transition; higher intention to quit than CO; higher impact than TS or T. TS led to more quitting behavior than CO. No difference between T and CO. In heavy smokers, tailored messages did not lead to more quitting than TS, T, or CO.	10
Greene and Rossi, 1998[36]	RCT: 1 dietary feedback report and educational materials vs. control. Fat intake and stage-of-change assessments at 0, 6, 12, and 18 months Targeted, asynchronous Model: stages of change	Nutrition: lower fat intake	296	Rate of progression to action stage by 18 months was found in 9%–12% of subjects in precontemplation or contemplation stage; 24% preparation stage subjects; 40% unclassified subjects.	10
Marcus et al., 1998[85]	RCT: Individual motivationally-tailored reports (IT) VS. standard self-help booklets (ST) Targeted, asynchronous Models: stages of change, health belief	Physical exercise: increase activity	194	IT: significant increase in physical activity each week and self-reported time exercising; more likely to reach action stage of motivational readiness for physical activity adoption.	10
Bastani et al., 1999[27]	Randomized 2-group design Educational booklet and personalized health risk letter Tailored, asynchronous	Preventive health: increase mammogram screening	901	8% increase in mammography after intervention. No intervention effect in women under 50 years of age.	10
Bull et al., 1999[68]	Clinical controlled trial Tailored pamphlet vs. standard pamphlet vs. control Tailored, asynchronous Model: stages of change	Physical exercise: increase activity	763	No significant differences between groups.	10
Campbell et al., 1999[87]	RCT: Multi-level, multi-component intervention Bulletin-orientations: expert (EXP) vs. spiritual and pastor-oriented (SPIR) vs. standard Tailored, asynchronous Model: stages of change	Nutrition: lower fat intake, increase fruit and vegetable intake	459	*Recall receiving bulletin:* 72.9% SPIR, 64.6% EXP, 38.2% control. *High trustworthiness:* 63.5% SPIR, 53.6% EXP, 48.6% control. *High credibility:* 45% SPIR, 31% EXP, 33% control. *Fruit/vegetable intake:* SPIR did not differ significantly from EXP. SPIR and EXP mean consumption significantly	10

Study	Method	Target behavior	N	Results	
Dijkstra et al., 1999 [40]	RCT: Multiple tailored (MT) vs. single tailored (ST) letters vs. standard self-help guide (SHG) vs. control (CO). Tailored, asynchronous. Model: stages of change	Smoking cessation: abstinence from smoking tobacco	843	higher than control. *High impact of pamphlets: 58% SPIR, 45% EXP.* MT had more effect than SHG or ST. ST had more effect than CO.	10
Lutz et al., 1999 [37]	RCT: Tailored newsletter with tailored goal-setting component (TG) vs. tailored newsletter without goal-setting component (T) vs. non-tailored newsletter (NT) vs. control (CO). Tailored, asynchronous. Models: social cognitive theory, stages of change	Nutrition: increase fruit and vegetable intake compared with control	710	Daily fruit and vegetable intake was higher for all 3 newsletter groups. Differences from baseline to post-intervention were greatest in TG; next was T, then NT. No statistically significant differences among tailored newsletter groups.	10
Myers et al., 1999 [30]	RCT: Minimal intervention (MI) vs. enhanced intervention (EI). Tailored, asynchronous. Model: preventive health, a combination of health belief model, theory of reasoned action, and social cognitive theory	Preventive health: increase prostate cancer screening rate	413	Age of 50 years or older positively associated with adherence. Married men more likely to adhere. Belief in having an early detection exam in the absence of symptoms predicted adherence.	10
Raats et al., 1999 [66]	Clinical trial. Tailored feedback vs. no feedback. Tailored, asynchronous. Model: theory of planned behavior	Nutrition: lower fat intake	171	No real difference between groups.	8
Rimer et al., 1999 [28]	Randomized trial. Provider prompting alone (PI) vs. provider prompting and tailored print materials (TPC) vs. provider prompting and tailored print materials and tailored phone counseling (TPC+TTC). Tailored, asynchronous. Model: stages of change	Preventive health: increase Pap and mammogram screening rates	1,318	TPC+TTC did not perform better than PI. TPC+TTC: 35%–40% increase for Pap tests and overall cancer screening. *Subgroup findings:* TPC+TTC most effective on Pap among women who worked for pay and those who viewed interventions as "meant for them." TPC+TTC most effective for mammography among married women.	8
Velicer and Prochaska, 1999 [90]	Report of 4 studies. Computer-generated (Pathways to Change expert system intervention) tailored report. Tailored, asynchronous. Model: stages of change	Smoking cessation: abstinence from smoking tobacco	756 to 4,144	Cessation rates: 22%–26%	8

NOTES: RCT indicates randomized controlled clinical trial.

and use of similar messages for both control and intervention protocols.[68]

Use of Models

Only 23 studies (62.2 percent) stated use of a theory to guide the health behavior intervention: 19 were print communications, 4 were telephone.

Comment on Emerging Technologies

Clinicians' use of pagers, personal digital assistants, PalmPilots, and laptop computers as portable information resource devices is a subject of numerous studies.[69] Just as clinicians have found that these devices provide a greater sense of control, mastery, and personal empowerment in the work setting, perhaps patients may also find such devices advantageous when managing their treatment regimens in the outpatient setting. Portability of "always ready" devices in combination with the messaging interventions can create a synergistic feedback loop between patient and device as evidenced by Milch's finding[64] that "several of the patients allowed that the pager became a trusted friend" and Dunbar's report[65] of high patient engagement with a pager system.

Mobile systems may have clear advantages over computer, telephone, or print communication systems for delivery of tailored health behavior interventions, because they offer the benefits of constancy—"anytime, anywhere" messaging and communication capability[14]; physical freedom—because the system is wireless and mobile, the patient is not restricted to one physical environment to receive messages[14]; privacy—messages can be modified so that others cannot observe or interact with them[14]; and temporal flexibility—users can interact with the content when available or postpone interaction if desired.[24]

Yet a portable system is not without limitations and disadvantages. Potential problems include acceptance—studies reporting general acceptance of computerized and mobile delivery systems have had small numbers of subjects, so we do not know whether a selection bias or novelty variable is involved in this outcome; intrusiveness—the "anytime, anywhere" feature may be too intrusive for long-term use; and economic consequences—we do not know how a portable system may economically

affect a patient, a practitioner, or the health care system. Only 13 studies in this review* considered cost as a factor of a system's feasibility or success.

Conclusion

Our review indicates that many studies demonstrate the effectiveness of "clinical encounters in absentia," but few good studies incorporate leading edge communication technologies. The studies reviewed here represent the best available evidence to date of the effectiveness of targeted and tailored health behavior interventions across health behaviors.

An overwhelming majority (91.3 percent) of tailored intervention studies reported improved outcomes, as did 92.9 percent of those studies that used targeting; however, little research compared tailored to targeted interventions. We therefore cannot conclude that tailoring is more effective than targeting. One notable exception is Prochaska et al.[41] Using the stages of change model to characterize readiness to quit smoking, they compared two tailored interventions to a targeted condition and general smoking cessation materials. At the 18-month follow-up period, tailored interventions outperformed both targeted and generic conditions and were associated with higher prolonged abstinence rates than other conditions. This study offers evidence that tailored interventions can more positively influence health behavior change than targeted, personalized, or generic interventions, but more studies like this need to be conducted.

There has also been little research comparing different tailoring protocols to one another. One group of smoking cessation studies compared three types of tailored interventions matched to stage of change to controls,[39,42] four types of tailored interventions to a nontailored intervention,[38] and two types of tailored interventions to generic material and controls.[36] Two patterns emerged: there was more forward stage transition in the tailored groups compared with controls, and multiple interventions were more effective than single tailored interventions. Studies of this kind must be conducted for health behaviors other than smoking.

It is notable that only those studies using print and telephone devices reported a theoretical basis for their methodology. Future studies need to identify which models are best suited to which health behaviors and whether certain delivery devices are more appropriate for different health behaviors. While "it is not inconceivable to view computer technology for health promotion and the delivery of services as a form of

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medical intervention with patient satisfaction, compliance, and improved health status as the goals,"[3] we need to know to what extent such interventions can beneficially replace interpersonal health behavior recommendations. In addition, usability studies could elucidate the complex process of human interaction with technology—the interplay between interface design and human cognition. The current research shows that isolated paper, telephone, and computer-delivered communications can cause health-enhancing behavior change. The communication of these behavior change models over an integrated Internet linked array of delivery devices, pagers, cell phones, interactive television, and computers with portable devices is technically feasible today.

Friedman et al.[45] have stated that "in the future there will be devices in general use that will incorporate features of the current telephone, television, video, and computer as well as wireless devices that people will be able to carry with them." That future is currently possible through the use of tetherless devices such as pagers and personal digital assistants, but research on these devices currently lags far behind research on print, telephone, and computerized communications.

In 1997, Balas et al.[70] predicted that, "in the future, application of distance technology may strengthen the continuity of care between patient and clinician by improving access and supporting the coordination of health care activities from a single source."[23] Technology has finally reached the point that health behavior models can be integrated with computer-generated interventions to provide consistent, continuous interactive ambulatory care. What is missing is comprehensive measurement of the effectiveness of these systems, which has the potential to not only inform the organization and delivery of health care but help move the science of medical informatics toward the goal of achieving the status of a "mature science."

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