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An expert system intervention for smoking cessation

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Abstract

The Pathways to Change system (PTC) is an expert system intervention for smoking cessation. Assessments are performed either by mail or by a telephone interview and each smoker receives a three- to four-page report that provides individualized recommendations matched to the individual's needs and readiness-to-change. The Transtheoretical Model of Change provides the theoretical basis for the expert system. Four different studies have demonstrated the efficacy of this intervention in a general population, with cessation rates of 22 to 26%. Furthermore, the difference between the groups was larger at each follow-up assessment point, indicating that the effects of the treatment increased long after the end of treatment. The studies involved two proactively recruited samples, demonstrating that a large proportion (85.3% and 82.5%) of the population of smokers could be successfully recruited into a smoking cessation program. Expert system interventions have the potential to have an extremely high impact on a total population of smokers.

Keywords: Expert system; Smoking cessation; Stages of change; Transtheoretical Model

1. Introduction

Of the people alive in the world today, 500 000 000 are predicted to die from the use of tobacco with an average loss of ten years of life [1]. Consequently, five billion years of human life will be lost to one behavior. Even a modest breakthrough in developing an intervention with greater impact on populations of smokers could prevent millions of premature deaths and billions of lost years of life. This paper describes a computer-based expert system intervention that has the potential to increase our impact on a population of smokers.

Clinic-based interventions have been known to produce the largest amount of abstinence at long-term follow-up. Smoking cessation clinics, for example, typically result in 25 to 30% abstinence at 12-month follow-ups [2,3]. This is the case even when behavior change programs include nicotine replacement therapies such as nicotine gum (an average of 28% abstinence) or the patch (an average of 28% abstinence) [4]. While such clinical interventions produce the highest abstinence rates, they also produce the lowest participation rates. State of the science cessation clinics offered for free by HMOs typically result in about 1% participation of eligible

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measures, including the target behaviors, the Decisional Balance scales and the Temptation scales.

The five *Stages of Change* that characterize a patient's readiness to participate in preventive care are Precontemplation, Contemplation, Preparation, Action and Maintenance. In the Precontemplation stage, patients are not intending to take action in the foreseeable future. In the Contemplation stage, patients are intending to change their behavior within six months. In the Preparation stage, patients have recently made some changes in their behavior and plan to attempt take action again in the next month. Patients are in the Action stage for the first six months after quitting. Patients are in the Maintenance stage when they have taken action and maintained that change for six months or more. Regression occurs when patients revert to an earlier stage of change. Relapse is regression from Action or Maintenance to an earlier stage.

The *Processes of Change* are ten cognitive and behavior activities that facilitate change [28]. The cognitive processes are critical in the early stages and the behavioral processes are critical in the later changes.

The *Decisional Balance* scales [29,30] involve weighting the Pros and Cons of continuing to smoke. In Precontemplation, the pros of smoking far outweigh the cons of smoking. In Contemplation, these two scales are more equal. In the advanced stages, the cons outweigh the pros. The pros and the cons capture some of the cognitive changes that are required for progress in the early stages of change.

The *Situational Temptation* scale [31] involves an assessment of how tempted a smoker would be to smoke in a variety of situations. These include social situations, negative affect situations and situations involving physical cravings. This scale is particularly sensitive to the changes that are involved in progress in the later stages and predicting relapse.

The Transtheoretical Model also involves a specification of the relationship between the Stages of Change and the dependent measures (behavior, pros, cons, situational temptations), between the Stages of Change and the independent measures (Processes of Change), and between the dependent and independent measures. A complete description of this aspect of the model is beyond the scope of this paper and can be found elsewhere [32–38].

3. Pathways to Change expert system

3.1. Overview

Expert systems interventions may be broadly classified as *batch*, *interactive* or *distributed* systems. A *batch* system derives its name from the era when mainframe computers were the dominant approach to computing. Materials were submitted to a central processor and, after a delay, the results were returned. It is a distal system, involving no direct contact with the computer. For the smoking cessation expert system, information is gathered from the smoker either via mail or telephone and intervention materials are communicated, after a delay, in the same way. A batch system has the advantage that it requires only a single central computer and database to serve all smokers and that it can contact smokers at home. The disadvantage is that a complete assessment is required, followed by an interval before the intervention materials are communicated. The intervention materials are also limited to written materials. Fig. 1 uses a communication model to illustrate some of the alternative methods of implementing a batch system.

Interactive versions of the PTC intervention have been developed and are being evaluated [21,22]. Interactive systems have several clear advantages, including the use of different types of media for communication and tailoring the assessment and presentation to the needs of the individual. The interactive system also operates in real time, pro-

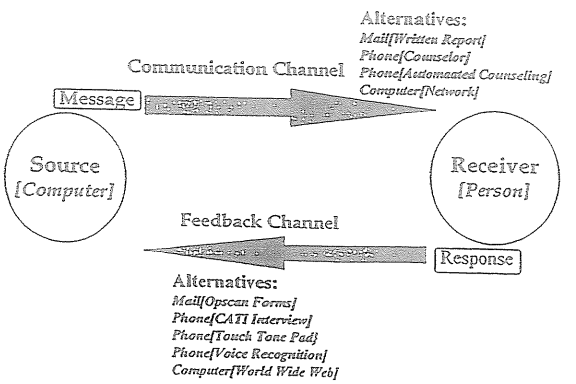

Fig. 1. Alternative communication and feedback channels for a batch expert system (from Velicer et al., 1998).

individual reports are assembled from a large number of available paragraphs on the basis of a complex set of decision rules. These rules are derived from prior longitudinal studies of how smokers change.

The first report is based on a comparison of the responses of the smoker to a large comparative sample of successful and unsuccessful quitters. This report relies only on *normative* comparisons. The norms differ by stages. The initial norms were derived from a naturalistic sample of smokers. Evaluation trials of the expert system provide updated norms at periodic intervals. The second and all subsequent reports compare the smoker to both the normative group and to their own previous responses and provide both *ipsative*, i.e., self-comparisons, and normative comparisons. The ipsative comparisons involve access to the database for the results of the previous contact. On the basis of these comparisons, a three- to four-page report is generated that makes individualized recommendations for change. The PTC system can generate almost 20 000 unique reports.

3.4. Feedback report

The three- to four-page feedback report is divided into four sections:

(a) Stage and Decisional Balance. This section contains a description of the subject's current stage of change and their pros and cons of quitting. The feedback describes the interpretation of their stage, how their decisional balance compares to others and how they compare ipsatively with their last assessment.

(b) Processes of Change. This section provides feedback on the subject's use of up to six change processes, how they compare normatively on each process with self-changers who were most successful in progressing to their next stage and how they compare ipsatively with their previous assessment.

(c) Tempting Situations. This section describes the tempting situations that are the most dangerous for the individual and provides feedback on how to successfully avoid or control those situations.

(d) Strategies. This section describes strategies for taking small steps to progress to the next stage. The strategy section is based only on stage. An example of a strategy for the contemplation stage is to delay the first cigarette of the day by an extra 30 min. The feedback report also refers participants to sections of the stage-matched self-help manuals.

4. Outcome studies

4.1. Overview

Four studies based on three different samples have been performed to evaluate the efficacy of the PTC expert system for smoking cessation. In this paper, we will provide only a brief summary of some of the results of these studies. A more detailed description is available from the primary sources.

The following is a brief overview of the methodology common to all the studies. The outcome reported here is point prevalence abstinence. Other outcome measures, including two sustained abstinence measures, are reported in the original sources. All outcome measures produced a similar pattern of results. All the results reported here were statistically significant. All results reported here are based on a complete case analysis. Details of attrition are reported in the original sources and alternative methods of handling missing data had no impact on the conclusions about the effectiveness of the intervention. Eligibility requirements were very general and included a self-report that subjects were currently smoking, had no serious illness, were between the ages of 18 and 75, and were competent in English. No monetary compensation was provided to participants. The stage distributions for the last three studies matched that found in other representative samples [20]. The first study involved a volunteer sample. Subjects were randomly assigned to condition and there were no differences between the groups at baseline in any of the studies with respect to either demographics or smoking history variables.

In each study, unless otherwise noted, the expert system intervention employed involved three contacts (baseline, three months, and six months) as described in the previous section. In each study, the expert system intervention also included a series of stage-matched manuals and the expert system report referred the smoker to these manuals for additional materials [24]. In each study, all groups were assessed at six-month intervals.

presents the point prevalence abstinence outcome data for two of the four groups involved in the study. The expert system condition is compared to the action-oriented manual group, the two groups relevant to this overview.

4.3. Study 2

The second, third and fourth studies employed *proactive recruitment* in an attempt to provide an intervention to the entire population. Reactively recruited samples typically involve no more than 5% of the available population and tend to be disproportionally female, highly educated and in the later stages of change [40]. In contrast, proactive procedures attempt to reach a larger proportion and a more representative sample of the at risk population. Proactively delivered expert system interventions can provide a unique combination of materials that are individualized to help to an entire population of smokers.

In the second study [41], a random-digit dial phone survey was employed to recruit a representative sample of smokers. Of the identified smokers, 82.5% were enrolled in the study and assigned to either an expert system intervention condition or an assessment only condition. The expert system intervention included the three reports and related manuals. The study design was a 2 (group) × 5 (occasion) design. At the 24-month follow-up, the point prevalence abstinence rate was 26% for the expert system intervention compared to 20% for the assessment only condition. The difference between the two groups was larger at each assessment point than the previous assessment point, indicating that the effects of the treatment continued long after the end of treatment (six months). Fig. 3 illustrates the results of this study.

4.4. Study 3

The third and fourth studies shared the same sample [41,42]. The entire population of a Health Maintenance Organization (HMO; a large defined group of patients who pre-pay a fee to an organized group of medical providers) was contacted to identify eligible smokers. 85% of the smokers agreed to participate in the study and were randomly assigned to treatment. In the first study [42], the study design was a 2 group (expert system vs. manual only) × 4 contacts (1, 2, 3 or 6 contacts) × 4 occasions design which evaluated both the impact of interactive interventions versus non-interactive interventions and the impact of different numbers of contacts. At 18 months, there was no clear dose response relationship. However, at each follow-up, the interactive (expert system plus manuals) intervention was more effective than the non-interactive (manual only) intervention. At the 18 months follow-up, the point prevalence abstinence rate was 22% for the four expert system intervention conditions compared to 16% for the four manual only conditions. Fig. 3 illustrates this result for the comparison of expert system and manuals collapsed across the four levels of number of contacts.

4.5. Study 4

In the fourth study [43], which shared the HMO sample with the third study, the standard expert system intervention condition and the assessment only condition were two of the four groups included. The expert system intervention included the three reports and related manuals. The overall study design was a 4 (group) × 4 (occasion) design. At the 18-month follow-up, the point prevalence abstinence rate was 23% for the expert system intervention compared to 17% for the assessment only condition. Fig. 3 illustrates the results for these two groups.

5. Discussion

Several consistent findings emerge across the four empirical studies. First, the expert system intervention produces a point prevalence smoking cessation rate of 22 to 26% at the end of the study. Fig. 4 summarizes the results for the expert system condition from the four studies. This rate is only slightly less than the rate achieved by intensive clinic-based intervention. This is impressive for two reasons. It was achieved with a total population in the last three studies and the intervention was of low intensity, delivered at home. Many smoking cessation interventions have been applied primarily to a self-selected subsample of smokers. This involves primarily smokers in the preparation stage, i.e., those prepared

18 or 24 months). One explanation is that an action criterion is being employed but the intervention is designed for smokers in all stages. Smokers in the early stages require more time to reach the action criterion compared to smokers in the later stages. Therefore, it is only at the extended follow-up that the early stage smokers reach the action criterion.

Expert system interventions represent an emerging technology that can incorporate prevention into the health care information system. Expert systems have the potential to play the same role in behavioral medicine that pharmacological interventions play in biological medicine. They help to overcome a number of the barriers that prevent the adoption of behavioral programs for health promotion and disease prevention and possess a number of advantages. Some of the advantages include: *Complete assessment*. Computer-based systems can conduct a comprehensive assessment, covering the whole range of behaviors. *Integration into existing interventions*. Expert systems can be modified to be synergistic with other interventions and to be complementary to the clinical encounter. A summary of the expert system report can be provided to the health care provider. *Appropriate for a whole population*. Expert system interventions are ideal for population based approaches. First, they can provide an efficient means of screening. Interactive systems can immediately branch to an in-depth assessment when a problem area exists. Second, expert systems can include a large array of interventions that can be matched to the individual. Expert systems can incorporate a wide variety of different intervention materials. Intervention approaches can range from motivational materials for patients in early stages and detailed advice and support for those patients who are in the later stages. As the patient progresses (or regresses) different intervention materials are available. *Complete data*. Expert systems provide an automated recording device so that even small amounts of progress can be detected and reinforced. These automated gathering of data provides an extensive empirical data base that can be used to both serve the patient and provide an evaluation of the effectiveness of the system. *Cost*. Prevention can be very expensive in term of the resources required to provide the services to all patients. Expert systems represent a potentially less costly alternative.

Expert system technology is still in its infancy and a number of other barriers exist that must be overcome before expert systems become widely available. However, the promise of this technology for modifying problem behaviors is outstanding. Advances in expert system technology will be driven both by advances in technology and by advances in our understanding of human behavior. Interactive versions of the PTC expert system interventions are already being tested at the University of Rhode Island and other research centers and distributed systems involving both the World Wide Web and telecommunications are being developed. The availability of a variety of different communication mediums (sound, pictures, graphics and animation) as well as the ability to interact in real time has the potential to greatly increase the effectiveness of the interventions. As information systems technology improves and access to computers becomes more general, many of the current barriers to dissemination will disappear. Expert system interventions are being developed for a variety of other risk factors and parallel developments to those described for smoking cessation are occurring. Combining interventions in a multiple risk factor approach to improve health represents a promising alternative to the type of single risk factor interventions described here. Combining expert system technology with other interventions represents another promising avenue of investigation. The studies reported here have only investigated a very limited number of variations on the timing of the expert system contacts and the number of expert system contacts. Both the optimal number and the optimal timing for intervention contacts may differ by stage. Research discoveries from basic research on how to modify human behavior can guide the improvement of future generations of expert systems. Technology-based interventions have the clear promise of facilitating disease prevention and health promotion in the general population.

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