S-PC: An e-treatment application for management of smoke-quitting patients

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The main objective of this paper is to present a new program that facilitates the management of people who want to quit smoking, implemented through an e-treatment software called S-PC (Smoker Patient Control). S-PC is a web-based application that manages groups of patients, provides a bidirectional communication through mobile text messages and e-mails between patients and clinicians and offers advice and control to keep track of the patients and their status.

A total of 229 patients were enrolled in the study, randomly divided into two groups, although some variables were tested to ensure that there were no significant differences between the groups that could have an impact on the outcome of the treatment. There were no significant differences between the two groups regarding the ratio/number of males/females, tobacco dependence, co-oximetry, average cigarette consumption, current age and age when smoking started. The first group was made up of 104 patients (45.4% of the total) and followed a treatment that incorporated the S-PC tool, while the second one had 125 patients without the S-PC tool. S-PC was evaluated for its effectiveness at assisting the patients to give up smoking, and its effect on clinician time management.

74% of the S-PC group completed the treatment without relapses and remained abstinent three months after the completion of the treatment, understanding abstinence as being continuous (with no relapses allowed and co-oximetry below 1 ppm) from the day of stopping. In contrast only 45.6% of the No S-PC group completed the treatment without relapses and remained abstinent three months after completion of the treatment. The rate of admiss-tance to the program has doubled in one year and patients went from having to wait for 3 months to be immediately admitted into the program.
This therapeutic e-health program aims at maximizing the number of patients that a professional can effectively help to quit smoking. In addition, the system also detects patients who are not progressing appropriately, allowing the professional to improve their treatment parameters dynamically.

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1. Introduction

Tobacco smoking is a major risk factor for active and passive smokers in certain respiratory [1] and circulatory diseases [2] as well as in some types of cancer [3,4] and infections [5], among other diseases [6–10]. Because of this, both public and private medical institutions in an increasing number of countries provide services for people that want to quit the habit of smoking.

NRT (Nicotine Replacement Therapy), in the form of nicotine patches and/or nicotine gum, is effective to treat the short-term nicotine withdrawal. Depending on the treatment and replacement, the chances that patients succeed in quitting smoking are increased between 50% and 70% upon NRT [11]. However, NRT alone becomes ineffective after about 8 weeks of starting the treatment and its effect in maintaining a smoke-free patient over a longer period of time (years) appears to be quite modest, as demonstrated by meta-analysis of different studies [12,13]. In light of this, some countries, such as the USA [14], the UK [15] and Australia [16], have published evidence-based guidelines to recommend effective tobacco cessation interventions ranging from brief instructions for quitting to extensive counseling combined with pharmaceutical adjuncts [17].

Because of the social context of tobacco smoking and extension of tobacco addiction in the population, it is not feasible to provide general cessation programs where patients are interned and only return to the streets upon completion of the program. A major issue in the treatment of addictions, and in smoking cessation, is the high relapse rates. There can be several reasons: decrease of the initial motivation, carelessness, yielding to peer pressure in certain situations (parties, dinners, situations of anxiety or relaxation), a conscious decision by the patient to start smoking again, craving, among others. A factor that can help in these situations is to develop a strong therapeutic link between the patient and the medical service. Constantly reminding them about the decision taken (to stop smoking), and making them feel closely connected to the professional team can minimize the chances of relapse. Strategies that favor this situation may have a positive impact on the obtained results regarding the long-term tobacco abstinence.

Therefore, many cessation programs combine pharmacological treatment with a simultaneous psychological treatment to control the progress and reinforce the motivation of the patient. This following can be done on an individual basis [18], in the context of group therapy [19], or via long distance support through phone calls [20]. The increasing number of people taking advantage of public and private cessation programs overloads these programs and decreases their efficacy. This is so because the psychological part of the treatment is often as important as the pharmacological treatment in order for a patient to quit smoking. A previous study proved that individual counseling, combined with telephone counseling were associated with higher 52-week abstinence rates than telephone counseling alone [21]. Previous studies have shown that social support was associated with cessation and with short-term maintenance of abstinence [22]. Therefore, there is the need to develop efficient e-health tools in order to optimize both the time spent by the clinicians that follow a patient and the efficacy of their service, minimizing the probability of relapse by the patient. In consequence, tools are needed to allow professionals follow patients without making such following too long time consuming.

Preliminary work using mobile phones showed that this type of patient was twice as likely to successfully quit smoking as patients that did not have such support [23]. A more recent study [24] confirmed that proactive telephone counseling is effective in short term reduction of cigarette consumption and in increasing the percentage of smokers that attempts to quit by more than 5%, when compared to that of people without phone counseling. Another study [25] of the same group suggests that text messaging can double the likelihood of smoking cessation when compared to patients that have neither continuous contact with their caregivers nor personalized follow-up. Such contact and follow-up are very important psychological aspects of the process of quitting smoking, because they provide support and help maintain patient motivation [26,27]. Another study [28], that aimed at determining whether mobile phone-based interventions are effective in stopping smoking, concluded that mobile phone-based text messaging smoking cessation interventions have a positive effect on long-term outcomes. Another study [29] evaluated the effectiveness of the telemedicine interventions, comparing their applications at home and in the consulting room or hospital. It showed evidence for the efficacy of household applications in clinical outcomes for chronic disease management, as for example hypertension and AIDS. In hospital applications, it was found that telemedicine was comparable to face-to-face care in emergency medicine. Therefore, psychological following appears to be an essential part in the quitting of the smoking process, as it is the case for other cessation programs.

Given that such following requires a large time investment by health professionals, it is important to have tools that automate this part of the treatment as much as possible, while maintaining or increasing the efficiency of the professionals.

Taking the facts described in the previous paragraphs into account, it was our objective to develop and benchmark the effectiveness of an e-health tool that would: (a) be generally applicable in smoking cessation treatment programs, (b) automate much of the work that needs to be done by the clinicians, (c) allow professionals to more effectively maintain a personalized support and follow-up of patients, (d) give patients the
psychological support that they require for successfully quitting smoking, and (e) decrease the time needed by clinicians to manage the patients and reduce average length of waiting lists. This tool was named S-PC (Smoker-Patient Control). An additional objective was to understand to what extent patients were satisfied with being treated using the tool.

S-PC is an e-medicine service based on a computer program that manages a central database of information on patient progression. It was benchmarked in the smoking cessation program being run at the public hospital Santa Maria in Lleida, Spain. In this paper we present the tool and its functionality, as well as the results of the benchmark and studies on patients' satisfaction. Those studies suggest that S-PC meets the objectives of its development. This tool can be freely downloaded from Hesoft Group web page.1

2. Background and significance

Most reported studies of mobile phone technology used for smoking cessation follow patients by at most 6 months [23–26]. This is at odds with the current study, which has followed patients for a year.

Nevertheless, the effect of S-PC on the likelihood of smoking cessation by patients appears to be comparable to that found in other studies that measure the effect of SMS on smoking cessation in the short term [23–26,34]. All such studies present likelihoods of smoking cessation that are approximately twice as high using mobile phone technology as in control groups. In some of these studies that likelihood decreases at 6 months while in others it remains at about 2 months, as is the case with ours. Studies that followed the patients for longer periods usually also considered the effect of Internet messages on improving the outcome of smoking cessation interventions.

In the “Free C” study [23], the response rate at 6 months was 92%. In “Tzelepis F” [24], the results showed that telephone-counseling participants were more likely than the controls to have attempted to stop (48.6% vs. 42.9%, p = 0.01) and they reduced their cigarette consumption (16.9% vs. 9.0%, p = 0.0002). In the “Free C” [25], continuous abstinence at 6 months increased significantly in the intervention group compared to the control group (10.7% intervention vs. 4.9% control, RR 2.20, 95% CI, 1.80–2.68, p < 0.0001). The “Whittaker R” [28] six-months studies concluded that mobile phone interventions increased rate long-term of stopping (p = 0.049). However, none of these studies lasted more than six months, while the present study was conducted over a one-year period.

What is new about the current study is the evaluation of the effect of the tool on clinician and patient's time management, waiting list reduction, and the patient satisfaction with the mobile texting intervention. As far as we know none of the other studies have performed such evaluation.

The most important applications that perform a function similar to that of S-PC are STOMP [32], PMC [33] and TXT2STOP [23,25]. Table 1 presents a comparison of the functionality of

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these tools with respect to that of S-PC. S-PC is the application with the more complete set of functionalities. The physical medium used by each of the applications varies. PMC uses e-mail to exchange messages and information with the patients. STOMP and test2stop use mobile text messaging for the same effect. S-PC was set-up in this study to use mobile text messaging. Nevertheless, it can also use e-mail if that is required by the clinicians. Only S-PC and PMC create customized lists of patients, and graphically represent clinical history and treatment progression. In addition, S-PC sends warning messages to clinicians when a patient at risk is identified by the program. It also permits customizing messages at will. These two features are exclusive to S-PC.

3. Materials and methods

3.1. Smoking cessation program at University of Lleida/Santa Maria Hospital

The smoking cessation program of the detoxification unit at the University of Lleida/Santa Maria Hospital has been active for 6 years. Currently, the applied smoking cessation protocol has three goals for the patients. The first two, nicotine detoxification and smoking cessation, are easily achieved with appropriate pharmacological treatment. The third goal is that the patient suffers the least possible anxiety during the process, in order not to relapse when the treatment is over. This goal is currently where the clinician focuses most of his/her efforts.

Over the years, the types of patients treated in this unit have changed. Ten years ago, 90% of the patients were referred to the service via medical recommendations and due to pressing health problems. Currently, 90% of the patients seek treatment because they want to lead healthier lives and spend less money. In fact, economic reasons led to a sharp increase in the number of patients wanting to quit smoking with the unit’s help in the last couple of years. Given budget restrictions that make it impossible for more personnel to be hired, patients had a three-month waiting period before being admitted to the program. In addition, many of the patients are from neighboring villages, which leads to an increase in their transportation expenses. If the reasons for quitting smoking are economic, this could threaten the continuity of the patient in the smoking cessation program. This situation made it necessary to develop an e-health tool to improve the efficiency of the staff and decrease the overall cost of treatment for the patients.

The S-PC tool was designed with these considerations in mind and benchmarked for a year in a small scale clinical study performed in the smoking cessation program of Santa Maria Hospital. Ethics approval for the study was obtained from CEIC (in catalan: Comitè Étic d’Investigació Clínica), the Ethics Committee for the Health Region of the province of Lleida (Spain), where the participants were recruited and human experimentation was conducted. All participants signed an informed and written consent before engaging in the study.

The definition of abstinence used in the smoking cessation program of the detoxification unit at the University of Lleida/Santa Maria Hospital is understood as continuous abstinence from the last day of stopping with no relapses allowed. Self-reported abstinence is verified through the co-oximetry levels with the Fagerström test [30]. Although some tobacco guides define non-smokers from 0 to up to 10 ppm in the co-oximetry test [44], in this case and due to the low contamination levels in the city of Lleida, patients were considered to be non-smokers when the test result was below 1. Various Fagerström tests are done throughout the treatment. When patients first arrive to the unit, one test is done. Then, seven days after, the day to stop is set and a second test is performed. A week after the stopping day a third test is done, the result of which should be below 1. Finally, a last test is done at the end of the treatment.

3.2. Patient selection

The Tobacco Unit of the Santa Maria Hospital, where S-PC was implemented, provides service to a town of approximately 150,000 inhabitants. For this reason, the absolute numbers of patients that try to quit smoking is small. In order to be able to perform this study with sufficient statistical power, all 229 patients that required the services of the Unit after implementation of S-PC were enrolled in the study, after giving their informed consent.

The patients were divided into two groups with randomly selected patients. The first group, the intervention arm, made up of 104 patients (45.4% of the total, SMS group) followed a treatment that incorporated S-PC. The only requirement to be part of this group was to own a mobile phone and know how to use it. The second group, the control arm, formed by 125 patients (54.6% of the total, No SMS group) followed a treatment that did not include S-PC. Both groups were then tested to ensure that the following variables, which may have significant impact on the outcome of the treatment, were not significantly different between them: mean cigarette consumption (P-value, P = 0.1), age at which cigarette consumption started (P = 0.8), current age (P = 0.16), tobacco dependence [as measured by the Fagerström test [27]] (P = 0.86) and co-oximetry [level of CO exhaled] (P = 0.39). There are also no significant differences between the two groups regarding the “number of males/number of females” ratio (P = 0.14). Both groups are not significantly different regarding these variables (P > 0.05). These are important controls to avoid that results of the study are biased by possible confounding factors.

Fig. 1 illustrates the procedure of the study, with the two groups of patients involved, the type of treatment they followed and the types of communication between them and the clinician. Both groups made regular visits to the clinician. The clinician monitored the Control Group manually, whereas, for the SMS Group the clinician monitored the patients with the assistance of the S-PC tool. Additionally, the SMS Group had an additional form of communication through mobile text messages as positive reinforcement and test questions.

All patients that belonged to the SMS group and had an were sent and answered the satisfaction questionnaire about the use of S-PC during their treatment. 69 patients answered this survey. This group was statistically tested to ensure that it was representative of the larger SMS-group.
3.2.1. Statistical testing

Mainly we compare patients treated using the S-PC protocol (SMS group) with patients treated using the classical protocol (No SMS group). SPSS [31] was used for statistical analysis. A $\chi^2$ test was used to determine the degree of statistical significance of the differences between patient and control groups with regard to non-numerical variables. For example, comparing how significantly different is the percentage of patients that quit smoking in each group, or how different two groups are with regard to their percent sex composition is done through this test. A Student-t test was used to determine the degree of statistical significance of the differences between patient and control groups with regard to numerical variables. For example, differences in co-oximetry, number of cigarettes, ages, etc. The significance level or p-value ($P$) was set to 0.05. In our case, this measures the probability that two sets of patients being compared with respect to a given variable are similar. Table 2 describes the statistical differences between the two groups.

### Table 2 – Patient characterization. Statistical differences between the two groups.

<table>
<thead>
<tr>
<th></th>
<th>SMS group</th>
<th>No SMS group</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption</td>
<td>25.26 ± 11.07</td>
<td>27.98 ± 14.22</td>
<td>0.11</td>
</tr>
<tr>
<td>Fagerström Test</td>
<td>5.38 ± 1.95</td>
<td>5.41 ± 2.07</td>
<td>0.86</td>
</tr>
<tr>
<td>Co-oximetry</td>
<td>21.36 ± 11.55</td>
<td>20.60 ± 11.70</td>
<td>0.39</td>
</tr>
<tr>
<td>Current age</td>
<td>43.04 ± 9.2</td>
<td>44.7 ± 9.5</td>
<td>0.16</td>
</tr>
<tr>
<td>Start smoking age</td>
<td>16.16 ± 2.9</td>
<td>16.29 ± 3.5</td>
<td>0.81</td>
</tr>
</tbody>
</table>

3.3. S-PC design

The design of S-PC was made following stringent usability and user-friendliness criteria, after an exhaustive analysis of (a) other applications with partial functional overlap (Table 1), and (b) the clinical requirements of the medical staff that uses S-PC.

There are five criteria that determine usability and user-friendliness [38,39]. First, a usable program must allow users to accomplish basic tasks the first time they use it (Learnability). Second, users that are familiar with the program should be able to quickly perform the tasks for which the program is required (Efficiency). Third, users should quickly re-learn how to use the program after some time without using it (Memorability). Fourth, users should not be able to make serious mistakes by using the program, and recovery from any error ought to be easy (Error rate). Fifth and final, the user should be satisfied with using the program (Emotional Response).

### 3.4. Implementation details for S-PC

S-PC is a multiplatform, multi-language, application with a user-friendly graphical user interface (GUI) that enables easy access and utilization of all its functions by the clinician, implemented by using Javascript, CSS, JSP and XHTML. English, Spanish and Catalan languages are currently available. Additional languages can be easily added upon request.

An intuitive help menu is also available, as well as a user manual. S-PC can run on any computer, operating system (Windows, Symbian, Leopard, Linux, etc.), and on any of the major web-browsers (Firefox, Explorer, Chrome, Opera, Safari, etc.).

The implementation reported in this paper runs on an Intel Xeon X3430 (2.4 GHz, 8 Mbytes of cache), Main Memory of 4 GBytes, 1333 MHz and with 3 Mbits bandwidth for Internet access. It is implemented by using cloud technology, which diverts the calculations from the core of the computer where the application runs to virtual machines. This ensures greater service quality and decreases maintenance and upgrade costs.

Basic elements (see Fig. 2) are the computer, a modem, mobile text messages, mobile phones and the web server. The computer stores patients’ information in a MySQL database and runs S-PC. S-PC sends text messages to the mobile phones of patients and receives their responses. The modem connects S-PC (located at the server) with the mobile phone network. Fig. 2 shows the communication flow chart between the patients and the clinicians. The patient interface with S-PC via SMS messages received in and sent from their mobile phones. Clinicians interface with SP-C via a computer and use it to communicate with the patients via SMS messaging.
Therefore, the implementation, as shown in Fig. 3, and to analyze patient progression in the treatment program. Patient–Clinician communication is described in more detail in Fig. 2.

S-PC has a client–server architecture (see Fig. 3). In its implementation, different technologies were applied. The presentation layer is implemented using Java Server Pages (JSP) for the structure and CSS (Cascading Style Sheets) is used in the presentation. JavaScript is ideal for verifying web forms. Therefore, we use it for validation of submitted information to the server. Java Servlets have been used in the controller layer and Java in the model layer. CSS has been used for defining the presentation of a web document (HTML, XHTML, etc.). JDBC (Java Database Connectivity) allows the connection to the database. The database is implemented in MySQL because of its performance and wide range of Application Programming Interfaces (APIs) available for it. The database stores information about clinical history of patients of each center, messages and messaging, treatments and clinicians, etc.

3.5. Patient–clinician communication

S-PC enables clinicians to pre-define, edit, adapt, and send three types of SMS messages to the patients, following guidelines that were established to improve impact of messaging [27]:

1. The same Test question is sent once a week to follow each patient’s progress through the treatment: How is the treatment going? A mandatory text messaging reply is required. Possible replies are 0 (Bad), 1 (Not too Bad), 2 (Good) and 3 (Very Good). This format facilitates automated processing, storage, graphing, and analysis of the answers by the server. Missing replies and “0” answers are flagged as risk patients and forwarded to the clinicians for personalized follow-up. The system relies on the honesty of the patient’s answers. Having a single question repeated weekly avoids patient’s confusion. Given that the information is organized in the database, a clinician can access the list of patients at risk, and of patients that are not following the treatment appropriately, enabling a personalized treatment of each type of profile. Patients at risk are the patients who answered Bad or Not too Bad to the test question. Once the weekly test response from the patients is received, messages are processed in the following way. We recommend contacting directly with the patients at risk via mobile text message or a phone call (method used in section “An evaluation of S-PC in the context of the smoking cessation program”) inviting them to visit the health center. However, as the S-PC allows any configuration, the final decision is up to the clinician.

2. Positive Reinforcement messages that support the patients and reinforce their resolution to quit smoking, assuring

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**Fig. 2 – S-PC flow chart.** This Figure shows both, the basic elements of the S-PC program and the flow of information between them. Basic elements are the computer, a GSM 3SIG modem, mobile text messages, mobile phones and the web server. The computer stores patient information in a MySQL database and runs S-PC. The GSM 3SIG modem connects S-PC to the mobile phone network. S-PC sends text messages to the mobile phones of patients and receives their responses. Clinicians interact with SP-C via web browser and use it to communicate with the patients via mobile text messaging and to analyze patient progression in the treatment program.

**Fig. 3 – S-PC Architecture.** Main technology and their relationship. All the used software is free.
the patient that he/she is thoroughly followed. A variety of messages can be defined and used, in order to avoid that the patient feels that he/she is being routinely attended by a machine, which would have a negative effect on the treatment. These messages were written by the clinicians, based on previous consultation with patients regarding the positive reinforcement they would like to hear during their treatment. This approach comes from the group of expert patients as a therapeutic strategy, which has been successfully used [43], and which consists of a small group of patients who succeeded in giving up smoking and want to help other patients to do the same. Table 3 shows the 14 first messages used for positive reinforcement.

3. Alert messages that notify risk patients that they are close to relapse (by observing a worsening of the patient’s responses to the Test messages), with the purpose of correcting the patient’s behavior. Clinicians contact patients with this kind of message in order to have them come to the hospital for consultation.

A Patient–Clinician communication example can be seen in Fig. 4, which describes the communication flow between the two parts. Over the course of a week, various messages are sent from the clinician (S-PC) to the patient. In this example, two reinforcement messages are sent on days 2 and 4 respectively. One test question is sent on day 7 and answered by the patient with one of a range of possible options.

All messages can be defined or modified at any time in the database of S-PC. By default S-PC automatically sends messages on predefined days and schedules. Test and Positive Reinforcement messages are typically sent this way. Alternatively, a clinician can manually send a message to a patient through the system. Alert messages are typically sent this way. No patients were told that S-PC could automatically send the messages at predefined schedules.

3.6. Treatment protocol

We are now able to explain the e-treatment implemented by S-PC in which patient and clinician interchange SMS in a predefined protocol. The first message (Positive Reinforcement) welcomes the patient into the program, notifying that SMS monitoring will start. When and how many Positive Reinforcement SMS are sent to each patient is a decision of the professional that follows that patient. The frequency of the messages can be fully automated. However, the clinician must consider that a constant frequency could cause a negative psychological effect on the patient, derived from routine. To avoid this, a protocol that varies the number of Positive Reinforcement messages that are sent to the patients over time was developed and implemented (Table 4). Test messages are sent

![Fig. 4 – Information flow diagram between S-PC and a patient.](image-url)
once a week. As was said before, sending an Alert message depends on the progress of each patient.

The number of SMS depends on the therapy duration. To begin with, the psychologist of the team ascertained that 2 Positive Reinforcement messages per week were sufficient to support the patient’s progression. If progression of the treatment is favorable, message frequency will decrease to avoid saturation. For stronger psychological effect, it is important that test and Positive Reinforcement messages arrive to the patients at unexpected times (for example Sunday at lunch). This leads to further discussion of the treatment between the patient and his/her local support system, increasing motivation. However, care is taken so that messages are not delivered at inconvenient times (for example at work or at night, while patients are sleeping), because such delivery could contribute to treatment rejection. This strategy is designed to reinforce the sensation that the professional is following the patient at all times with great interest.

Cost of SMS messaging must also be taken into account. The scheduling for positive reinforcement shown in Table 4 takes this factor into account and was decided upon by the clinicians of the Santa Maria Hospital after some testing. The duration of the whole program is 1 year.

<table>
<thead>
<tr>
<th>Month</th>
<th>Week</th>
<th>#SMS</th>
<th>Month</th>
<th>Week</th>
<th>#SMS</th>
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<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>13</td>
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</tr>
<tr>
<td>2</td>
<td>2</td>
<td>14</td>
<td>0</td>
<td>26</td>
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<td>1</td>
<td>27</td>
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<tr>
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<tr>
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<td>1</td>
<td>24</td>
<td>0</td>
<td>36</td>
<td>1</td>
</tr>
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</table>

Table 4 – Scheduling of the positive reinforcement SMS messages. Positive reinforcement messages are delivered according to schedule shown in this table. The number of delivered positive reinforcement SMS messages sent to a patient during each week of the treatment is shown here.

4. S-PC operation

S-PC can be accessed through the web-browser, using a secure login window. It is available from anywhere in the world, as long as an active Internet connection is available. The user (clinician) logs in by entering its username and password, choosing the language in which s/he wishes to work (Catalan, Spanish and English). Fig. 5 shows the access screen of the application.

Next, the user (clinician) accesses the main screen (Fig. 6), where s/he can search for the status of patients, append notes to clinical histories (yellow) or registered new patients. The main S-PC functionalities are (1) registering a new patient, (2) identification and management of lists of different types of patients, (3) create/modifying the templates of “test” and “positive reinforcement” messages, (4) deliver “alert” messages to the mobile phone of patients, (5) change user properties (as password), (6) exit, (7) return to the login screen, (8) show patient status, (9) save private clinician notes, and (10) send user feedback to improve the application. Next, mainly windows are presented.

Patient responses of the “test” messages can be visualized in pie charts (Fig. 7) and progress charts (Fig. 8). Answers are codified as follows: 0 Bad, 1 Regular, 2, Good and 3 Very Good. These charts facilitate identifying patients at risk that need personal attention.

Fig. 5 – S-PC Login. This is the authentication window. Catalan, Spanish or English languages can be chosen.
1. Patients State (Fig. 7). It shows the general graphical percentiles of the current status of patients. The individual status of each patient is also displayed.

2. Patients Evolution (Fig. 8). This table shows the responses of individual patients to test questions over their treatment. In this case the number of weeks are twenty. Users can modify the number of weeks to be represented.

Many listings can be created, as for example patients at risk (see Fig. 9).

Creating and modifying templates for all kind of messages (test, positive reinforcement and alert) can be done as shown in Fig. 10.

The system also allows the clinician to select a group of patients to whom a given alert message must be send (Fig. 11).

5. Results

5.1. S-PC effectiveness

The effectiveness of S-PC was evaluated with respect to (a) its effect in assisting the patients to quit smoking, and (b) its effect on clinician time management, as measured by the time that patients spend in the waiting list before being admitted in the program and by the number of personal visits each patient requires.

Table 5 summarizes the results and the differences between the SMS and the No-SMS group. 74% of the SMS group completed the treatment without relapses and remained abstinent three months after the completion of the treatment. In contrast only 45.6% of the No-SMS group complete the treatment without relapses and remained abstinent three month after completion of the treatment. The groups were significantly different with respect to this issue and the treatment
Table 5 - Contingency table comparing relapses between patients of different groups. Patients in the SMS group more strictly adhered to NRT and had significantly less relapses than those in the No SMS group ($\chi^2$ test shows significance of $P<0.001$ in both cases). NRT differences are seen by comparing the first five rows of the table, while relapsing differences can be seen by comparing rows 6–9. There was no significant difference in the relapsing frequency with respect to sex, where $P=0.1$, (see rows 10–13). This can be seen by analyzing the last four rows of the table.

<table>
<thead>
<tr>
<th>Patient types</th>
<th>SMS</th>
<th>No SMS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strictly following NRT</td>
<td>52</td>
<td>48</td>
<td>100</td>
</tr>
<tr>
<td>Following NRT</td>
<td>34</td>
<td>21</td>
<td>55</td>
</tr>
<tr>
<td>Left NRT</td>
<td>18</td>
<td>56</td>
<td>74</td>
</tr>
<tr>
<td>Total</td>
<td>104</td>
<td>125</td>
<td>229</td>
</tr>
<tr>
<td>Strictly follow treatment</td>
<td>77</td>
<td>57</td>
<td>134</td>
</tr>
<tr>
<td>Smoking relapses during treatment</td>
<td>27</td>
<td>68</td>
<td>95</td>
</tr>
<tr>
<td>Total</td>
<td>104</td>
<td>125</td>
<td>229</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strictly follow treatment</td>
<td>63</td>
<td>71</td>
<td>134</td>
</tr>
<tr>
<td>Smoking relapses during treatment</td>
<td>55</td>
<td>40</td>
<td>95</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td>111</td>
<td>229</td>
</tr>
</tbody>
</table>

is significantly more successful in the SMS group than in the No-SMS group ($P<0.001$). We found no significant influence of sex on treatment success in either of the groups ($P=0.1$), discounting sex as a confounding factor for the effect of S-PC in the treatment of patients that are quitting tobacco.

We also note that S-PC has positive effects on the first two goals of treatment (nicotine detoxification and smoking cessation). Records of adherence by the SMS and No SMS group to Nicotine Replacement Therapy (NRT), as reported by the patients, were kept and analyzed. Comparing the SMS and the No SMS group shows that adherence to NRT was significantly greater in the former than in the latter ($P<0.001$).

To evaluate the effect of S-PC on the time management of clinicians, we compared clinician patient load before and after S-PC implementation. We also compared the time that patients spent in the waiting list and the average number of visits per patient before and after S-PC was implemented. The effect of S-PC on clinician time management was strong. 100 new patients per clinician were enrolled in the program during 2010 without S-PC. In comparison, S-PC allowed 200 new patients per clinician to be enrolled and treated during 2011. Before using S-PC, each patient attended 10 visits/year. S-PC

allowed this number to decrease to an average of only 7 visits/year per patient. In addition, more time is now spent with the new patients (the ones that require more attention) and significantly less clinician time is dedicated to already enrolled patients, which are effectively accompanied through S-PC. Even though the rate of admittance to the program has doubled in one year, patients went from having to wait for 3 month to be admitted in the program to immediate admittance.

5.2. Patient satisfaction

To further evaluate the role of S-PC during the treatment, we prepared an electronic satisfaction survey that was answered by all patients of the SMS group that used The questions were designed to evaluate the opinion of patients on the appropriateness and effectiveness of using S-PC in their treatment. The group contains representative proportions of age, sex and physical condition with respect to the complete treatment group.

95% of all patients used the application throughout the full duration of their treatment. 92% of the patients were either satisfied or completely satisfied with the support given by S-PC. However, 20% felt that they would still have managed without the system. Thus, 70% of the patients strongly agreed that the S-PC system helped them remain smoke-free, 10% had no opinion about this issue and 20% disagreed or strongly disagreed that S-PC helped them remain smoke-free. 60% of the patients agree that S-PC decreases the number of medical appointments needed during the treatment, with 25% of the patients disagreeing with this statement. When comparing S-PC to other methods used in the smoking cessation program, 70% of the patients are satisfied with this method, 25% are unsure about the comparison and less than 5% considers S-PC is not a good methodology. 96% of all patients feel that S-PC is either an adequate or a perfectly adequate tool to aid them quit smoking. Less than 10% of the users reported problems receiving or sending messages. Approximately 70% of all patients do not consider S-PC usage monotonous, with 8% having no opinion on the subject. Less than 5% of the patients felt harassed by the messaging generated by S-PC. 95% of all patients using the system felt that the clinician who took care

Fig. 11 – Sending Alerts. This window shows the mean for sending SMS messages to patients at risk.
of them was permanently following them and taking notice of their messages and answers. Finally, 98% would accept similar systems in other health treatments.

6. Discussion

6.1. Main findings

S-PC is effective, useful and perceived as an added value to treatment by patients and by clinicians. Its use increases compliance to NRT to levels of 95%, reduces the probability of relapsing and smoking during treatment by more than half. In addition, more than 90% of patients regard S-PC as having added value in the treatment and see possibilities for applying similar tools in other health treatments.

The time management of clinicians was also significantly improved. The same number of clinicians is now processing, treating and following twice as many patients. The waiting list was reduced from three months to 2 days, which is the time it takes to process and enter patient information into the S-PC central database. In addition, the time dedicated to personalized clinical attention to patients that are at risk and require closer follow-up, has been significantly increased and clinicians more effectively schedule and manage that time. S-PC also avoids unnecessary travel while allowing patients to feel closely followed up by the clinician.

These results are encouraging and complement the results found in earlier studies. Abstinence levels were 14.3% higher in the SMS group than in the control group over a twelve-month period. Previous studies reached similar positive outcomes, although none of them lasted so long and the usual treatment period was six months. Abstinence rates tend to decay over time, and a longer study implies higher levels of relapse among patients. However, our trial had some limitations regarding the number of patients involved in the study. Some of the previous studies had larger participant samples, thus reducing the margin of error. Further larger studies should be performed to verify the current results.

Our findings reassert that the use of mobile phone interventions may be effective in increasing the long-term abstinence rates in smoking patients, and that positive reinforcements messages and the usage of technology-based interventions can be an effective complements to the current smoking cessation programs.

6.2. Perspectives

We believe that S-PC could also be successfully adapted to other chronic diseases, such as hypertension. We are working on such an application for following high blood pressure patients in the cardiology service of Hospital Santa Maria. The rationale for doing so is two-fold. Firstly, given that hypertensive patients are on the rise there is a possibility that the service will be overwhelmed and unable to provide appropriate care for all of its patients. Secondly, home blood pressure (HBP) monitoring “should become a routine component” of blood pressure measurement in the majority of patients with known or suspected hypertension [35,36], given that such readings may be better predictors of cardiovascular and renal outcomes than office readings [37].

7. Conclusion

The results indicate that S-PC was successfully designed, implemented and used in the context of the quit smoking treatment. They also support the usefulness of text messaging in improving (a) the outcome likelihood of smoking cessation interventions, (b) the management of time and patients by clinicians, and thus the optimization of health care resources and the reduction of waiting lists, and (c) the patient’s perception of constant psychological support by the clinician.

Conflicts of interest

The authors claim no conflicts of interest.

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