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Development of a Just-in-Time Adaptive Intervention for Smoking Cessation Among Korean American Emerging Adults

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Abstract

Purpose—Cigarette smoking is a preventable risk factor that contributes to unnecessary lung cancer burden among Korean Americans and there is limited research on effective smoking cessation strategies for this population. Smartphone-based smoking cessation apps that leverage just-in-time adaptive interventions (JITAI) hold promise for smokers attempting to quit. However, little is known about how to develop and tailor a smoking cessation JITAI for Korean American emerging adult (KAEA) smokers.

Method—This paper documents the development process of MyQuit USC according to design guidelines for JITAI. Our development process builds on findings from a prior ecological momentary assessment study by using qualitative research methods. Semi-structured interviews and a focus group were conducted to inform which intervention options to offer and the decision rules that dictate their delivery.

Results—Qualitative findings highlighted that (1) smoking episodes are highly context-driven and that (2) KAEA smokers believe they need personalized cessation strategies tailored to different contexts. Thus, MyQuit USC operates via decision rules that guide the delivery of personalized implementation intentions, which are contingent on dynamic factors, to be delivered “just in time” at user-scheduled, high-risk smoking situations.

Conclusion—Through an iterative design process, informed by quantitative and qualitative formative research, we developed a smoking cessation JITAI tailored specifically for KAEA smokers. Further testing is under way to optimize future versions of the app with the most effective intervention strategies and decision rules. MyQuit USC has the potential to provide cessation support in real-world settings, when KAEAs need them the most.

Compliance with Ethical Standards

Research Involving Human Participants and/or Animals All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Disclosure of Potential Conflicts of Interest The authors Cerrada, Dzubur, Blackman, Mays, Shoptaw, and Huh declare that they have no conflict of interest.

Keywords

Smoking cessation; Just-in-time adaptive intervention; Mobile health

Tobacco Use Among Korean Americans

Cigarette smoking is a preventable behavioral risk factor that contributes to unnecessary lung cancer burden among Korean Americans (KAs) [1, 2]. National smoking prevalence estimates for KA men are among the highest (30.0–36.7%) relative to other Asian American subgroups (14.6–32.4%) and national rates (16.8%) [3–5]. In addition to excessive exposure to smoking and pro-smoking norms within the KA community [6], focus group data suggests that social pressure to conform and the role of smoking in social settings make quitting difficult [7]. KA emerging adult (KAEA; aged 18–25) smokers may experience additional challenges to cessation, as emerging adulthood is a developmental period associated with high rates of substance use [8] thought to be driven by identity exploration [9]. Further, KAEAs describe the importance of smoking when socializing with other KAs [10] and tend to severely overestimate smoking prevalence among KAs [11]. To the extent that smoking is perceived to be a component of their cultural identity [7] (even among KAEAs with low Korean acculturation) [10], young KA smokers face unique sociocultural pressures to continue smoking. Thus, it is critical to design cessation interventions suitable for KAEAs early in their smoking career before nicotine dependence poses additional challenges [12].

Existing cessation interventions culturally tailored to KAs have focused primarily on older smokers (e.g., aged 35–50) with low levels of acculturation towards American culture [13–16]. Cultural adaptation strategies included face-to-face counseling with Korean counselors, Korean language quit-lines, and enlisting family support. In contrast, KAEA smokers report preference for cessation methods that exclude nicotine replacement therapy or consultation with health professionals, as these aids are perceived to represent “weak will” [10]. One known cessation intervention targeting adolescent smokers in Korea used group lessons delivered by instructors, which resulted in abstinence among 25% of the participants [17]. Authors cited intention to quit, smoking fewer cigarettes per day, and fathers who never smoked as predictors of cessation. Given the dearth of information on this topic, additional research is needed to elucidate strategies that are acceptable and effective among younger KA smokers.

Smoking Cessation Using Mobile Applications

A growing number of mobile cessation applications (apps) are being developed and may be useful for private, non-pharmacologic quit attempts, given high rates of smartphone use in the USA [18]. Despite this, few evaluations have identified the most effective apps, especially among ethnic minorities. A recent analysis categorized the most popular iPhone and Android apps ($n = 98$) based on their primary approach to cessation: calculator, calendar/tracker, rationing, hypnosis, informational, lung health tester, tracking, and gaming [19]. Apps were further assessed for adherence to several evidence-based guidelines for

cessation [20]. Overall, the reviewed apps demonstrated low adherence to clinical guidelines, with few offering advice for managing roadblocks (15%), recommendations for medication (4%), or connection to a quitline (0%). Even quit-smoking texts, which have been proven to be effective for cessation [21], were only used by 12% of the apps. Research on effective development and delivery of mobile cessation apps is warranted.

In addition to easy accessibility offered by apps, the timing and context of intervention delivery may also be an important component of an effective and efficient cessation app. An emerging mobile phone intervention design, just-in-time adaptive interventions (JITAI), allows for flexible, real-time delivery of interventions [22]. “Just-in-time” (JIT) refers to the delivery of specific types and levels of support at the right time only when needed, while “adaptive” refers to the provision of dynamic, personalized support tailored to the individual in a given context [22].

Two studies have assessed cessation JITAI using text messages [21, 23]. In both study designs, participants set a quit date and received automated messages that encouraged them to remain quit and offered tips for managing craving. Content was adapted to smokers’ stage of change according to the transtheoretical model [23, 24] and baseline cessation concerns, e.g., gaining weight [21]. Riley and colleagues additionally delivered messages during times users indicated as high-risk for lapse and adapted messages accordingly [23]. For example, if participants reported cigarette cravings after breakfast, a text during breakfast time encouraged “getting up from the table and taking a walk” [24]. Both JITAI designs allowed users to request interventions when experiencing withdrawal, at which point they received distraction/coping support messages. Only one study assessed a proximal outcome (number of cigarettes smoked/day) [23], although it was not assessed as a function of JITAI components.

Researchers who develop JITAI must attend to several design principles in addition to behavioral theory and empirical evidence [22]. First, the number and timing of “decision points,” i.e., *when* interventions should be delivered, must be planned to align with “proximal outcomes.” Proximal outcomes represent mediating pathways that lead up to distal outcomes [22]. In our case, avoiding smoking lapse would be a proximal outcome for long-term abstinence, the distal outcome. Next, decisions regarding which specific “intervention option” to deliver at each decision point must be considered with respect to “tailoring variables.” Tailoring variables represent factors that potentially moderate the effect of intervention options on proximal outcomes and inform which option is optimal for whom or for which context(s) [25]. These may include stable factors (e.g., age, gender) and dynamic factors (e.g., location, availability of cigarettes). Finally, “decision rules” systematically link intervention options with tailoring variables to guide whether an intervention component should be delivered at a decision point, and if so, which one [22].

In designing a cessation JITAI tailored to KAEA smokers, we needed to determine the decision points, intervention options, and tailoring variables most relevant to this population. Of particular interest was designing a JITAI that could provide support when KAEA socialize with Korean friends, a commonly described smoking situation [6]. Thus, our JITAI must be able to identify when this and other smoking situations occur and provide

appropriate support. The current study delineates the development of a lapse prevention JITAI that is adapted to tailoring variables *relevant to KAEA smokers' own unique immediate contexts* (e.g., alone vs. with friends) and delivers specific, *situation-appropriate* intervention options (e.g., use vape pen vs. practice cigarette refusal) during decision points (e.g., craving moments) when KAEAs need it the most.

Prior Quantitative Research

Findings from our prior ecological momentary assessment (EMA) study provide insight into *when* KAEAs would benefit most from intervention, e.g., common smoking situations [26]. Participants were KAEA daily smokers ($N = 78$) who had been smoking for at least 2 years. Information about their immediate contexts were collected when (1) participants were “lighting up” their cigarettes (i.e., $n = 2614$ smoking EMAs) and (2) during randomly scheduled times (five maximum) throughout the day (i.e., $n = 2136$ non-smoking EMAs) for 7 days using a mobile app. On average, participants responded to 3.91 non-smoking EMAs and 4.79 smoking EMAs each day [26].

We identified a range of dynamic factors, e.g., locations, social contexts, activities, and psychological states, associated with smoking that were informative for developing an app prototype. Briefly, KAEAs were more likely to smoke when outside relative to all other locations and in the presence of Korean friends relative to all other social contexts. Activities associated with smoking included socializing (OR = 1.6, 95% CI = 1.3, 1.8), commuting (OR = 1.5, 95% CI = 1.2, 1.9), drinking alcohol (OR = 1.8, 95% CI = 1.4, 2.3), and eating (OR = 1.2, 95% CI = 1.1, 1.4). With regard to psychological antecedents, greater cigarette craving (OR = 1.7, 95% CI = 1.5, 2.0) and stress (OR = 1.2, 95% CI = 1.1, 1.4), relative to one's own average levels, were associated with smoking [26]. Altogether, our EMA data helped us to identify situations during which JIT support could be delivered.

Present Study

The goals of our present formative research were to supplement findings from the aforementioned EMA study regarding common smoking situations by using qualitative methods and to report on the process of building a culturally- and developmentally-appropriate, tailored, mobile JITAI prototype (“MyQuit USC”). Thus, our development process was grounded in both quantitative and qualitative data pertinent to KAEA smokers. With respect to developing a JITAI, our EMA data provided insight into *when* interventions should be delivered (decision points, tailoring variables) while the qualitative data allowed us to determine *which* approaches (intervention options) are most preferred in an app. The Institutional Review Board at University of Southern California approved all study procedures.

Qualitative Methods

Semi-structured interviews were conducted with KAEA smokers to elicit perceptions of common cessation strategies identified from literature reviews and brainstorming sessions held by the research team. Interviews also probed for suggestions regarding the development

of an app tailored for this population. A follow-up focus group with additional participants was conducted to further explore these strategies.

Interview participants consisted of a subsample of five male and three female KAEAs ($M_{\text{age}} = 22$, $SD = 2.1$) who participated in the EMA study. Seven identified as a regular/daily smoker and one identified as a light smoker ($M_{\text{cigarettes per day}} = 6.5$, $SD = 2.3$). Three reported attempting to quit in the past 12 months. The focus group consisted of two male and two female KAEA smokers ($M_{\text{age}} = 24$, $SD = 1.4$). We recruited participants who were interested in quitting or thought about quitting in the past.

Interviews were conducted using methods suggested by Seidman [27] and the focus group was conducted using methods by Kreuger and Casey [28]. Eight interviews (~30 min each) and one focus group ($n = 4$; 60 min) were conducted. Trained graduate students conducted interviews using a semi-structured script in either English or Korean, depending on participants' language preference. The focus group was conducted in English and led by CJC and JH using a discussion guide. The script probed about common cessation strategies (e.g., distraction, cigarette substitution, social support, informational messages, goal setting) and preference for app features (e.g., personalization). Follow-up probes were asked based on interviewee responses. Qualitative data were analyzed through an iterative process. Themes and categories were derived from meaning units (MU), non-overlapping statements about participants' experiences [29]. Data were independently reviewed and coded for recurrent patterns by CJC and KCAB. They met to resolve any discrepancies and reviewed findings with JH.

Interview Data Results

Across all themes ($n = 259$ MU), the most prominent was participants' perceptions of cessation strategies ($n = 129$ MU), which was further divided into categories reflecting each strategy. Distraction/cigarette substitution constituted the largest category ($n = 54$ MU), e.g., eating/drinking, engaging in physical activity, and working. Another category pertained to seeking social support for cessation ($n = 44$ MU). A majority of participants agreed that some form of social support, such as encouragement, would be helpful ($N = 6$), but would be contingent on whether the person providing support was a family member, friend, or significant other and their smoking status. One participant mentioned that enlisting family support would not be feasible because many KAEA keep their smoking hidden from their family. Three participants indicated social support would not work because quitting was a personal issue and should not involve others.

“My parents don't know that I smoke because I don't live at home. I live away from my parents. I think for the most part most Korean Americans, their parents don't know.”—Female participant

“Those around you could help, but I think this is an issue that the individual needs to take care of on his own.”—Male participant

Other cessation strategies discussed were receiving informational messages ($n = 13$ MU), goal setting ($n = 15$ MU), and practicing refusal skills ($n = 3$ MU). Participants differed in preference for informational and fear-inducing messages; some agreed that receiving either

factual or dramatic information about the negative health effects of smoking would deter them from smoking ($N=3$), while all others claimed the opposite. Tracking and gradual reduction of cigarettes were perceived to be helpful by most participants ($N=6$), so long as goals were realistic. Although practicing refusal skills was rarely mentioned, two participants found these strategies to be helpful when suggested by the interviewer.

Suggestions for app features constituted a second theme. Participants discussed tracking and statistics about their smoking behavior ($n=6$ MU), reminders from friends/family ($n=7$ MU), and facilitating a social network among users ($n=3$ MU). Another category highlighted how varied individual preferences were with respect to receptivity and perceived effectiveness of specific strategies. Specifically, participants emphasized the role of both stable and dynamic factors ($n=9$ MU), such as personality, location, social context, and personal availability. For instance, one participant would be willing to do “push-ups to distract” themselves from craving symptoms only when alone at work but not in public. Another participant explained that they would do push-ups regardless of who was there. More broadly, multiple respondents emphasized that the success of the intervention depended on motivation to quit ($N=4$).

“Well if you find ways to help you then yeah. I think that would work. But it has to fit you. It’s just some ways that help certain people and other ways that help someone else.”—Male participant

“That’s important to me, who you’re with, location, things like that. Character, personality, of course, plays a role...”—Male participant

Focus Group Data Results

A focus group, which included current smokers who have attempted to quit in the past, was conducted to elicit additional cessation strategies, generating a total of $n=85$ MU. The only strategy mentioned in the focus group and not the interviews was medication, e.g., patch, although the single participant who tried it cited side effects as reasons for not currently using them. When discussing suggestions for developing an app, participants focused on contextual information regarding smoking situations. Specifically, participants’ responses ($n=15$ MU) suggested that they were generally aware of contexts in which they were likely to smoke such as in the morning, while driving, while on break, after work, and just before going to sleep, which represent ideal contexts during which participants could be more receptive to JIT intervention.

“(Craving) comes based on like where I am walking and what’s happening and like the time of the day.”—Male participant

“But I always have to smoke after work, right after work.”—Female participant

When asked about what features should be included in the app, participants discussed similar cessation strategies mentioned in the interviews, i.e., reminders from friends/family ($n=3$ MU) and facilitating a social network among users ($n=3$ MU).

Summary of Formative Research

Together, our quantitative and qualitative findings provided guidance on developing a prototype JITAI cessation app for KAEA smokers. EMA findings showed that overall, common smoking contexts identified for older, non-Korean smokers, are also relevant to KAEAs, e.g., eating, commuting, and drinking alcohol [30]. Despite these similarities, our JITAI design accommodates cultural factors specific to this group identified from our data, namely, the role of KA friends (vs. non-Korean friends) in significantly cuing smoking [26], the emphasis on personal will and motivation for quitting (without reliance on NRT or social support), and the ability to keep quit attempts private from family members.

Our qualitative research additionally highlighted that (1) KAEA smoking episodes are highly context-driven and that (2) KAEA smokers believe they need personalized cessation strategies in different contexts. Table 1 summarizes the lapse prevention strategies we considered and how our formative research influenced selection of individual JITAI components. With regard to developing decision rules for JITAI, we identified a range of possible intervention options that KAEAs would be willing to receive in an app. However, given the heterogeneity in individual preference for these strategies, it became clear that a single approach for managing craving, e.g., distraction, is unlikely to be effective for all KAEA smokers in all situations *even within the same individual over time*. In other words, our findings suggest that users may need the flexibility to self-specify how and when to address each craving situation, e.g., socializing with friends, a feature not available in the aforementioned cessation JITAIs [21, 23]. Further, this feature must be combined in an app that facilitates self-motivated, non-pharmacologic quit attempts.

Implementation Intentions

In response to our findings that smoking is highly context driven and that smokers may need personalized cessation strategies, we elected implementation intentions (IIs) as the primary intervention component to be deployed at user-specified times and contexts. IIs are if-then statements that specify when, where, and how an individual will respond to situations in which a specific behavior is likely to occur in order to reach a goal [31]. When forming an II, individuals must identify a situation in which to act (e.g., going to a bar with friends) and an appropriate response (e.g., give cigarette pack to non-smoking friend), thereby creating a strong mental link between situation and intention [31]. In this case, KAEA smokers' goals would be to resist lapses in a variety of high-risk smoking situations (HRSS) by setting self-specified cessation strategies. By repeatedly associating specific strategies with particular situations, resisting lapse is expected to be automatized and less dependent on conscious intent [31].

A number of studies have been conducted with smokers randomized to a minimal intensity II intervention, where smokers select 3 to 4 IIs at baseline [32–34]. Across all studies, smokers randomized to the II intervention group demonstrated either reduced smoking or greater abstinence rates compared to those in the control group. Relevant moderators of the effect of II included habit strength (e.g., nicotine dependence) and motivation to quit [32–34]. We note, however, that it is not clear if any of the aforementioned studies evaluated

whether IIs were actually enacted in real time, limiting specific inference on how IIs help prevent lapses.

Implementation Intentions in MyQuit USC

We now discuss how IIs are incorporated into the design of our prototype cessation JITAI. Detailed below are the JITAI components used in MyQuit USC (MQU) as specified by Nahum-Shani and colleagues [22]: intervention options, tailoring variables, decision rules, and decision points. Each component is embedded within specific app modules: MyPlans, MyCalendar, MyCrave, MySmoke, and MyProgress (Fig. 1), designed to address findings from our formative studies. The proximal outcome for MQU is momentary lapse, while the distal outcome is long-term abstinence. To facilitate app engagement, MQU includes “pull” components, where users request support by clicking an app icon, along with “push” components, e.g., alerts, for times when users are not aware of or motivated to resist lapses [35].

1. Intervention Options: Implementation Intentions (IIs)

Building upon previous interventions that instruct participants to select personalized IIs at baseline [32–34], we additionally “push” reminders of these IIs during HRSSs. Thus, personalized II reminders serve as our JIT intervention and each individual lapse prevention strategy reflects an intervention option. Examples of IIs include distraction, cigarette substitution, and enlisting social support. To assist participants in generating IIs for each HRSS at baseline, MQU provides default suggestions for common lapse prevention strategies applicable to different smoking contexts identified in the formative research (e.g., “I will leave my cigarettes at home” when “Going out with friends”).

2. Tailoring Variables

Tailoring variables reflect information needed to determine whether and which intervention option should be delivered. These may include relatively stable factors, such as baseline nicotine dependence, and dynamic factors that fluctuate more frequently, such as presence and type of HRSS. Based on our formative research, we identified several common HRSS. Three default situation categories are included: mood, habitual/routine contexts, and social contexts. Eating meals, for instance, was identified as an HRSS and was included as a default situation in the habitual/routine category. MQU “adapts” II reminders according to dynamic factors (whether an HRSS is present each hour and what type), which are user-specified beforehand. This information is used to determine whether an II reminder is sent and if so, which one. While we do not currently incorporate information about stable factors to adapt the delivery of II reminders, we will assess potential moderators of the effect of reminders on lapse for future JITAIs, e.g., nicotine dependence.

3. Decision rules and decision points

IIs and tailoring variables are systematically linked via decision rules in MyPlans while decision points are scheduled in MyCalendar. Our decision rule was applied hourly:

At 10 min to each hour,

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IF [HRSS PRESENT]=YES and [HRSS TYPE]=X;
THEN RANDOMIZE DELIVERY OF [II REMINDER for X];
IF [HRSS PRESENT]=NO;
THEN DO NOT DELIVER ANY [II REMINDER]"

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During app set-up and throughout the day, MyCalendar enables users to “schedule” specific times when HRSS typically occur as well as HRSS type (e.g., going to a bar with friends at 10:00 PM). To minimize burden related to inputting schedules, users also schedule a typical weekday and weekend, which auto-populates MyCalendar for the next day if not done so manually. Ten minutes prior to the hour, MQU provides JIT support by assessing whether an HRSS is present (e.g., 9:50 PM), and if so, randomizes delivery of the II reminder adapted for the given HRSS TYPE. Consider an example where X = “Going out with friends”: IF HRSS PRESENT = YES and HRSS TYPE = X, THEN DELIVER [II REMINDER for X] = “Leave cigarettes in your car”. Each value of X for HRSS TYPE and its paired II REMINDER may be unique to an individual. If no HRSS is present at a given hour, no reminder is sent.

MyCrave is designed to provide additional support when users unexpectedly experience cravings *outside* of scheduled HRSS (i.e., “unscheduled”). Users may “pull” support by tapping the MyCrave button (*I want to smoke!*) and choosing their HRSS from the list they specified during setup, after which the corresponding II reminder is presented.

Self-Monitoring of Smoking

Based on our formative research regarding suggestions for cigarette tracking, two additional components assist users with self-monitoring of their cessation progress: MySmoke and MyProgress. When a user reports a lapse by pressing the MySmoke button, a continuous count of lapses is updated in MyProgress. The MyProgress module presents a 7-day bar graph of the number of cigarettes smoked and resisted, the amount of money spent on cigarettes smoked, and the amount saved by not smoking. These values are derived from responses to EMAs that are “pushed” to the user 45 min following each scheduled HRSS and 15 min following an unscheduled HRSS.

In summary, MQU is highly personalized. Individualized schedules of HRSS paired with II messages personally adapted to each HRSS represent personalized JITAI elements. Individually tailored II message *content* provides further personalization to the II intervention itself.

MyQuit USC Study Design

Further testing is under way to determine whether receiving II reminders more effectively help KAEA smokers avoid momentary lapse compared to when not receiving reminders. To accomplish this, II reminders are pushed only during 75% of HRSS, following a microrandomization design [36]. Additionally, we will explore stable and dynamic factors that moderate this effect, e.g., nicotine dependence, quit fatigue. The effect of II reminders

and relevant moderators on momentary lapse will inform the optimization of a subsequent JITAI that can be evaluated within a randomized trial. Our target sample will consist of 60 KAEA smokers who are interested in quitting. Participants are instructed to interact with the app for 4 weeks after setting a quit date and to respond to EMAs assessing momentary lapses and contexts. In addition to momentary lapse, we also assess whether the user implemented their intention and the level of perceived helpfulness of the given II. If a user reports not smoking despite not “following through with” their specified II, they report alternative strategies used. Semi-structured interviews are also being conducted with all participants after completing the study to elicit feedback on each module and suggestions for future app versions.

Limitations

With regard to limitations in the present study, additional qualitative data might have been needed to reach data saturation. However, suggestions for intervention strategies generated in the interviews were generally repeated in the focus group and varied individualized preference for these strategies emerged as an important finding, providing support for personalized II as our primary intervention. Nonetheless, our study represents the first JITAI development process based on formative research involving both quantitative and qualitative data, to address cessation among KAEA smokers.

Conclusion

In this paper, we detailed the development of a prototype of MQU, a mobile smoking cessation JITAI. Through an iterative design process, informed by quantitative and qualitative formative research, we developed an app tailored specifically for KAEA smokers. Findings from our proposed JITAI evaluation will shed light on the most effective intervention options for given smoking situations, allowing us to optimize decision rules in future versions of the JITAI. Importantly, while the framework of our JITAI design has been tailored specifically for KAEA smokers, IIs by nature are highly personalized. Thus, MQU can easily be modified with tailoring variables and decision rules appropriate for other populations, such as more experienced smokers. Cessation JITAI apps such as MQU have the potential to deliver timely lapse prevention support privately, in real-world settings.

Acknowledgments

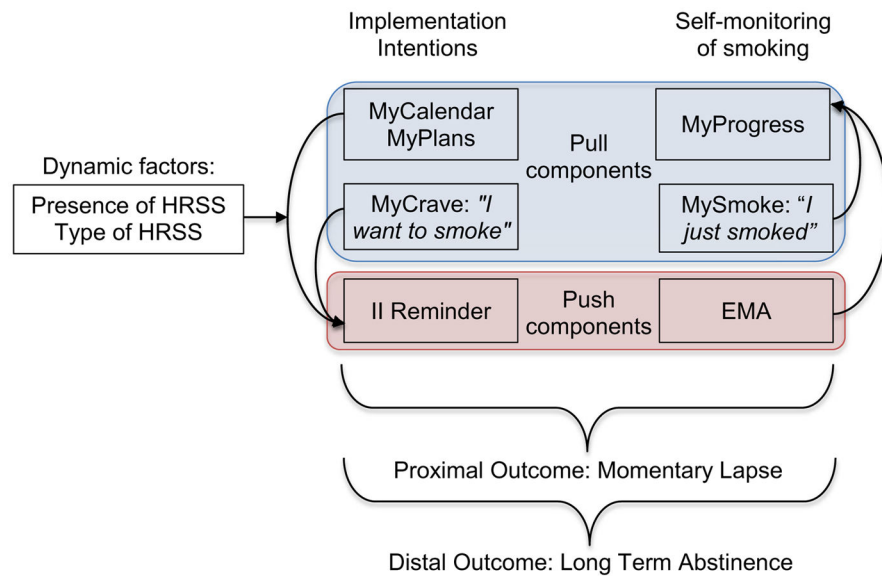
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*HRSS: High-risk smoking situation

Fig. 1.
JITAI components of MyQuit USC
*HRSS: High-risk smoking situation

Table 1

Summary of potential lapse prevention strategies

Strategy	Relevant research finding	MyQuit USC components
Distraction, Substitution	Generally supported	II reminders in MyPlans and MyCrave
Encouragement, Social Support	Depends on who offers encouragement or support	II reminders in MyPlans and MyCrave
Informational Messages	Depends on individual preference	II reminders in MyPlans and MyCrave
Refusal skills	Rarely mentioned, but supported	II reminders in MyPlans and MyCrave
Goal setting, self-monitoring	Generally supported	MyProgress, MySmoke
Anticipate smoking triggers	Identification of common smoking	MyCalendar
Medication	Medication is for those of “weak will”	Excluded
Counseling/Quitline	Emphasis on personal motivation	Excluded

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