A smartphone app to communicate child passenger safety: an application of theory to practice

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Abstract

Child passenger safety remains an important public health problem because motor vehicle crashes are the leading cause of death for children, and the majority of children ride improperly restrained. Using a mobile app to communicate with parents about injury prevention offers promise but little information is available on how to create such a tool. The purpose of this article is to illustrate a theory-based approach to developing a tailored, smartphone app for communicating child passenger safety information to parents. The theoretical basis for the tailoring is the elaboration likelihood model, and we utilized the precaution adoption process model (PAPM) to reflect the stage-based nature of behavior change. We created assessment items (written at 6th grade reading level) to determine the child’s proper type of car seat, the parent’s PAPM stage and beliefs on selected constructs designed to facilitate stage movement according to the theory. A message library and template were created to provide a uniform structure for the tailored feedback. We demonstrate how messages derived in this way can be delivered through new m-health technology and conclude with recommendations for the utility of the methods used here for other m-health, patient education interventions.

Introduction

As the leading cause of death for children in the United States, motor vehicle crashes pose the single greatest health risk to children [1]. Child restraint devices (CRDs) are the best protection for infant and child motor vehicle occupants. However, to provide maximum protection, the CRD must be the correct seat for the child’s age, weight and size, and it must be used properly and consistently.

According to a 2008 study, children under age two are 75% less likely to be killed or suffer severe injuries in a crash if they are riding in a rear-facing restraint rather than a forward facing one; in fact, for children 1–2 years of age, riding rear facing is five times safer [2]. Convertible seats available today allow children to remain riding rear facing until they weigh 30–45 pounds. Forward-facing safety seats, appropriate for children who are over the age of two years and at least 40 pounds, can accommodate children up to 65 pounds and are known to reduce fatal injury by 54% [3]. Belt-positioning booster seats, for children who have outgrown their forward-facing seat have been extremely effective in reducing crash-related injuries, decreasing risk by as much as 59% [4–6].

Use and misuse of CRDs

Usage rates for CRDs vary by the age of the child. In 2008, 21% of US children under 1 or <20 pounds
were not restrained in a rear-facing safety seat [3]. In a 2008 NHTSA study, 40% of children weighing 20–40 pounds were not restrained properly [3]. Most studies show that appropriate use of booster seats in the US hovers between 20–40% [7–11].

Not only do many children continue to ride unrestrained or restrained in the wrong device for their age and size but many of the correct devices are being used improperly, greatly compromising their protective benefits [12–16]. One US study across six states found an 84% misuse rate among rear-facing seats [17]. Misuse is also common among those using forward-facing seats—81%—usually due to loosely or improperly secured harnesses or seat belts [17].

Because of the prevalence and pervasiveness of car seat installation errors and other types of misuse, many families now use the services of a child passenger safety technician (CPST). CPSTs are individuals who have completed a 4-day course, successfully passed a written exam, completed a supervised car seat check, and have maintained their certification by earning continuing education credits on CPS issues periodically [18]. CPSTs, who can be found in all 50 states and US territories, provide installation and seat check services, typically at community events or through hospital- and fire department-based programs.

**Increasing the correct use of CRDs**

Despite decades of research on promoting car safety seats, the gaps in proper and consistent use described earlier demonstrate the critical need for innovative ways to reach parents with potentially life-saving information. A systematic review [19] found that the effectiveness of education-only programs has yet to be demonstrated and called for research to identify the ‘amount and quality of content necessary to change knowledge, attitudes and behaviors’. Although the American Academy of Pediatrics recommends that car seat education be included in anticipatory guidance [20], such counseling is done infrequently [21, 22]. Moreover, clinicians may not be equipped (either in terms of time or skills) to address the new complexities of proper use across the range of available products. It has been well established that child passenger safety laws (now in all 50 states) and education coupled with access to loaner or low-cost seats is effective in increasing overall use rates [19]. However, how best to communicate with parents in ways that will provide the information necessary to increase proper and consistent use remains to be determined.

**Use of communication tailoring**

Health communication research has demonstrated the superiority of tailored over generic messages for health behavior change programs and the importance of behavioral theory in achieving success [23]. Tailored communication is intended to reach a specific individual with information that is based on characteristics unique to that person, related to the outcome of interest and derived from individual assessment [24]. The theoretical basis for tailoring comes from the elaboration likelihood model, (ELM) [25], which states that people are more likely to actively process information if they perceive it to be personally relevant [26–29]. Tailored messages are more likely than generic messages to be read and remembered, perceived as interesting and personally relevant, saved, discussed with others and acted upon [30–34]. Tailored interventions have been used with promising results in a number of pediatric injury prevention studies, including work conducted by members of the current study team in community and pediatric emergency department settings [35–41].

The precaution adoption process model (PAPM) is well suited for making messages personally relevant because it reflects the stage-based nature of behavior change [42, 43], which allows messages to be tailored on a person’s readiness to change as well as on the constructs that are thought to move someone from one stage to the next. The PAPM distinguishes among people who are at different stages of awareness and readiness to act—unaware, unengaged, undecided, decided not to, planning, acting and maintenance—and identifies theory-based constructs to facilitate stage movement. The PAPM has been successfully used to understand a
range of behaviors [44–46], including our earlier work on child passenger safety [37, 47].

Use of mobile technology
Paralleling the recognition of tailoring as an effective health communication approach has been an explosion of interest in e-health [19, 20, 48, 49] and m-health [50]. According to the World Health Organization (WHO), there are now more than 5 billion wireless subscribers, and commercial wireless signals cover more than 85% of the world’s population, making the use of mobile and wireless technologies a credible and potentially very valuable tool for promoting health. In the United States, an estimated 58% of all adults and 83% of those ages 18–29 have smartphones [51]. In a pediatric emergency department setting that serves an urban and predominantly lower income population, which was one of the settings for the study reported here, we found that 95% reported owning a cell phone, and among these, 88% were smartphones (W. C. Shields et al. unpublished data).

Our search for computer applications in injury prevention, found four studies that successfully used kiosk-based, tailored health communication for child injury prevention [37, 38, 47, 52]. Four additional studies successfully used internet-based programs for an array of injury topics and audiences [53–56], only one of which [53] used communication tailoring. These studies provide little detail on the process of developing the intervention content, and no studies using smartphone applications were found. There is a clear need for more research on using m-health technologies for teaching parents about child injury prevention.

Aims
The purpose of this article is to illustrate a theory-based approach to developing a tailored, smartphone app for communicating child passenger safety information. The article describes how we utilized the PAPM to (i) reflect the stage-based nature of behavior change related to the use of CRDs and (ii) tailor messages based on PAPM stage to inform and persuade parents to use the proper CRD consistently. We demonstrate how messages derived in this way can be delivered through new m-health technology and discuss recommendations for the utility of the methods used here for other m-health, patient education interventions. Next steps in evaluating the PAPM-derived m-health intervention through a randomized, controlled trial are also described.

Methods
This work is part of a multisite intervention trial to increase the proper and consistent use of car safety seats, including booster seats, among children in Baltimore, MD and Little Rock, AR. The intervention is being designed for parents or guardians of children from birth through age eight who will be recruited from waiting rooms within the pediatric emergency departments in two hospitals. The intervention is a mobile application for use on iPhone and Android smartphones. The intervention builds on a previous Safety in Seconds kiosk-based program [37, 47]. Parents will download the app and use it to answer a series of assessment items about their knowledge, beliefs and car seat behavior for any age-eligible children in the family. The app will provide feedback in real-time and parents will be able to return to it any time to review the information and can reassess a child after responding to recommended changes. The app will also provide a link to a parent portal, where additional child passenger safety information will be available through links to online resources. Throughout the process of developing the app, parents were involved through a focus group, survey and two rounds of pilot testing; results from these data collection activities and an evaluation of the app will be separately reported elsewhere. Here, we focus on the application of theory to creating the app.

Defining the behavior
Correct and consistent car seat use is the behavioral goal of our app. This complex behavior is in reality made up of numerous component behaviors, including characteristics specific to the vehicle, the child and the type of restraint. Based on our assessment of
the literature, experience in running child passenger safety programs and with input from CPSTs on staff, we selected four component behaviors that are critical to child passenger safety behavior and that can be accurately assessed by self-report, a key feature of computer-tailored applications. The four component behaviors to be addressed in the app were (i) correct type of child restraint for child’s age and weight; (ii) correct location of child restraint in vehicle; (iii) use of child restraint for all rides and (iv) use of CPST to install or check the seat.

Applying the PAPM

The PAPM provides the theoretical basis for understanding the adoption of the car safety seat behaviors of interest [42]. An important utility of applying PAPM is that it recommends specific persuasive message concepts at each stage [42, 43]. For instance, in the earliest stages, a person needs messages that increase awareness and personalization of the hazard and the precaution. After becoming aware of a threat and how to reduce it, individuals need to feel capable of performing the behavior, and that it is consistent with social norms and what significant others want them to do. Once someone has begun performing the behavior, they need to experience a reward or positive reinforcement to maintain the behavior.

The PAPM as used in this study is illustrated in the following example. An individual parent could be at different stages of readiness for each of the four behavioral components. For instance, a parent who always places her 5-year-old buckled up in a seat belt in the back seat may be unaware of the superior protection provided by a belt-positioning booster seat, or she may have decided not to use a booster seat because she thinks her child won’t like it, and she may have never thought about getting advice from a car seat expert. This parent is in a more advanced stage for using a device all the time and putting her child in the back seat but she is in an early stage with regard to booster seat use (correct seat type) and going to a CPST. This illustrates the complexity of defining the behavioral outcomes and the need for different (i.e. tailored) messages to address each component of the behavior. In this example, the parent should be acknowledged for correctly placing the child in the back and being consistent about buckling up but she needs to be fully informed and persuaded that a booster seat is a better choice and that a car seat expert can be a useful resource for her and her family.

Creating tailored messages

We created assessment items (written at ≤6th grade reading level) to determine: (i) what type of CRD would be correct for the child’s age and weight, (ii) the parent’s PAPM stage for each component behavior and (iii) participant’s beliefs on selected constructs designed to facilitate stage movement according to the PAPM: perceived risk of a crash, self-efficacy for avoiding a crash, barriers to each of the component behaviors and social influence for keeping the child safe (see Table I). A message library was created to provide educational messages (written at ≤6th grade reading levels) in response to each of these tailoring variables. Individuals’ answers to the assessment questions are stored in a database and processed by a computer program that uses predetermined decision rules to link each answer to a specific message. Messages are combined for each behavioral outcome and delivered via screens on the app that the parent can scroll through as well as print out.

Results

Tailored feedback

To provide a uniform structure for the feedback, we created a template that includes the elements of the message that will be delivered to individuals at each of the stages, along with the theoretical concepts to be addressed. Table II provides an example for the first component of car seat behavior, which is whether the child is in the correct seat for his or her age and weight.

The first message element is an introduction that feeds back the information the parent input, which is a way of framing the entire message, emphasizing that the accuracy of the feedback is dependent upon the information the parent provided, personalizing it
and giving the parent an opportunity to correct any misinformation.

The second and third elements are intertwined. The second element is the stage-specific link, which is intended to directly respond to the parent’s stage of readiness (e.g., ‘there are many reasons to change your mind…’ for those in Stage 4). This is designed to link to the messages that are tailored on risk perception, self-efficacy, barriers and social influence, which is the third element of the message. Here, there is some overlap across the stages; for instance, people in Stages 3–5 should all respond to a message tailored on their self-efficacy. But, for those who are in Stage 3, appealing to social influences may enhance the self-efficacy appeal. Those in Stages 4 and 5 will have already identified reasons why they are not doing the behavior, and their message will need to include a direct response to these perceived barriers. We expect that this messaging not only makes the information more personally relevant but also enhances the potential impact on behavior of the factual information about CRDs.

The fourth element is the factual information that provides the rationale for the specific behavioral component, which we believe is a necessary aspect of our persuasive appeal. Individuals need to understand why they are being asked to perform a specific behavior. In this example, we are encouraging parents to use the correct car seat, so the underlying rationale has to do with how a car seat, booster seat or seat belt provides protection depending on the size of the child occupant. A brief message explaining the facts will be provided to parents and will be framed to reflect their child’s age and whether they are using the correct or incorrect seat.

Finally, all communication messages need to have a specific call to action so that the receivers understand what is being asked of them. This call to action is prefaced by a heading titled ‘What You Can Do’ to make it clear that parents are able to take action to prevent injury. As shown in Table II, we will provide a stage-specific call to action, and all parents will receive referral information on where they can purchase a car seat or receive a loaner seat. Additionally, harnessing the power of mobile technology, the smartphone app can send ongoing reinforcement via automated reminders about the information learned in the tailored feedback.

<table>
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<tr>
<th>Table I. Assessment variables and items</th>
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<tr>
<td>Variables</td>
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<td>Personalizing variables</td>
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<td>Behavioral components</td>
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<tr>
<td>o Use of correct device</td>
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<td>o Use of device in back seat</td>
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<td>o Use of device all the time</td>
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<td>o Car seat inspection</td>
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<td>Perceived risk of a crash</td>
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<td>Self-efficacy for avoiding a crash</td>
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<td>Perceived barriers</td>
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<td>o you haven’t started using a [correct seat type] for [child’s name]?</td>
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<td>o [child’s name] does not ride in the back seat all the time?</td>
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<tr>
<td>o [child’s name] does not travel in a [child’s seat type] all the time?</td>
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<td>o you have not had [child’s name] seat installed or looked at by a car seat expert yet?</td>
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<td>Social influence</td>
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<td>Message elements</td>
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| Stage-specific link | The safest way to ride for children of [child’s name]’s age and size is in a [correct seat type]. | There are many reasons to decide to have child ride in [correct seat type]. | There are many reasons to change your mind and use a [correct seat] for [child’s name]. | It’s great that you’re planning to use [correct seat]. | Way to go! That’s the best seat for [child’s name]’s age and size. |

| Tailored comments | Stages 1, 2 | High perceived risk for an accident: car crashes are leading cause of death Low perceived risk for an accident: accidents can happen any time; chances of injury greater in [current incorrect seat type]; [correct seat] is best protection | Stages 3–5 | Low self-efficacy for avoiding an accident: can’t always control when an accident will happen; [correct seat] is best protection High self-efficacy for avoiding an accident: accidents can happen to good drivers; crashes leading cause of death; [correct seat] best protection | Stages 6, 7 | Knowing that [he/she] is in the right type of car seat should make you and [social influence] feel good about keeping [child’s name] safe in the car. |

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<tr>
<th>Underlying rationale</th>
<th>Stages 3–7</th>
<th>Mechanics of how [correct seat] provides protection (brief description)</th>
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<tr>
<td>Call to action</td>
<td>Stages 1–7</td>
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<td>Think about getting a [correct seat] at [store or safety center] today</td>
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<td>Decide today to get a [correct seat] at [store or safety center]</td>
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<td>It’s not too late to make a safer decision and commit to getting a [correct seat] at [store or safety center] today</td>
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<td></td>
<td>Put your planning into action and get a [correct seat] at [store or safety center] today</td>
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<tr>
<td></td>
<td></td>
<td>Great job keeping [child] safe. Check in with a car seat technician when you think [child’s name] is ready for a [next seat type]</td>
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Link to resources Link to resources Link to resources Link to resources Link to resources
This same template is used for each of the remaining three behavioral components, with information specific to the behavior being addressed (data not shown; available upon request).

**Safety in seconds app**

Displaying the feedback is critically important to the potential impact of these carefully constructed messages. A template for this purpose was also created. Several screen shots from the app illustrate how our assessment items and tailored feedback are communicated (Figures 1–3). In addition to the visual appeal elements of the layout, the actual app is also colorful although the figures are shown in black and white here.

**Discussion**

This work offers new information on at least two important health communication challenges. First, how best to educate parents about proper and consistent CRD use has remained elusive. Our app is grounded in two well-established behavior change theories, ELM and PAPM, which should increase the likelihood of success. The use of computer tailoring made it feasible to disentangle the specific behavioral components of ‘proper and consistent’ CRD use and provide specific messages efficiently. The success of other tailored programs bodes well for this one. Second, although the steps in creating tailored communication have been well described [23], our article describes how a specific theory was used to systematically construct tailored messages. Creators of tailored communication interventions must spend substantial time determining both informational content and persuasive appeals, and they must be sensitive to issues of literacy. The template we created and the work we described here helped systematize this process, and should be...
useful to others interested in creating theory-based, tailored messages.

With increased interest in m-health, it is important to consider the rationale for using a smartphone app to address any given health problem. In our case, the rationale was multifaceted. The interactive nature of such a program allows for repeated contact with participants and the delivery of multiple tailored messages. The greater effects of multiple tailored interactions as compared with single tailored or untailored interactions have been demonstrated in other behavioral interventions [57, 58]. The portability of the app makes it ideal for repeated interaction and reinforcement of information and behavioral changes. When introduced in a clinical setting, smartphone apps (as well as other computer-based programs) can address identified barriers to the delivery of patient education. They minimize the patient education burden on clinical staff by replacing or supplementing the clinician’s counseling. With electronic health records, the information shared by the patient on the app can efficiently be sent to the health record for access by the clinician, who can then provide reinforcement of the app’s messages. Apps also provide a constructive activity for patients during wait time, and once the infrastructure is in place, operational costs likely decline.

There are some limitations to consider in the work described here. In the absence of the intervention trial, which is now underway, we do not know the app’s efficacy. Second, we needed to create a package of information that was comprehensive but not exhaustive. To be efficient and effective, we limited our assessment and our content to the most important and most changeable aspects of proper and consistent car seat use. The app encourages visiting a CPST who can identify and correct other important use/misuse challenges not included in our app. In addition, we also created a ‘parent portal’ that directs parents to additional information on CRD’s. The technical expertise and other resources needed to fully develop and pilot test a complicated app such as ours may be prohibitive for other programs. Finally, resources are also required to ensure that the app is updated with any changes in best practices over time. Therefore, a long-term perspective and dynamic approach to program operation is key. Although the efficacy of this smartphone app will not be known until completion of our ongoing randomized controlled trial, there is great potential for similar intervention development approaches to be applied in other populations and to address other important public health problems with complicated educational messages and behavioral goals.

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Conflict of interest statement

None declared.

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