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Research Article

Air Quality Measurment App For Children With Asthma

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Abstract

The harmful substances present in the atmosphere that cause damage to humans and other living beings' health, is known as air pollution. examples of air pollutants Particulates and biological molecules. Air pollution will cause allergies many diseases and death. It may be harmful to the animals and natural environment Indoor air pollution is a wellknown risk factor that triggers and exacerbates asthma, the most common pediatric chronic disease. Using a mobile app to monitor indoor air quality could be promising in engaging children in keeping their indoor air quality clean and healthy as the basis of environmental secondary prevention for asthma management. No app is available, however, to allow children to monitor, assess, and improve their indoor air quality.

Keywords: *Air Pollution, Indoor Air Quality, Mobile app*

Introduction

Asthma is the commonly seen pediatric chronic disease, characterized by recurrent attacks of breathlessness and wheezing. More than 340 million people had asthma globally[1] and 6% of children in the India suffered from asthma in 2018[2] . While asthma cannot currently be cured, it can be controlled through improved healthcare and avoiding or reducing asthma triggers from environmental factors. Among various environmental factors that contribute to the excessive asthma morbidity, exposures to air pollutants are found to be important contributors to worsening the symptoms[5,6,7] Especially, the relationship between fine particulate matter (PM2.5) and asthma morbidity is well established[8]. Because children spend the majority of their time indoors, indoor environments dominate exposures to many air pollutants and thus it is important to monitor indoor air quality (IAQ) for asthma management[10]. Childhood asthma management is challenging, however, because it requires understanding causes of triggers and avoiding them, triggering both multi-factorial

and unique to each individual[11]. Moreover, it is difficult for doctors and caregivers to monitor the health of children with asthma simultaneously with the environmental triggers.
Smartphones are ubiquitous, sensors have become prominently used in mobile health, and mobile apps[12,13] offer new opportunities for access to care, monitoring, and management of a chronic disease. A plethora of mHealth apps are available offering various features to facilitate asthma management, including medication reminders, symptom monitoring, prompt communication with a provider, and access to tailored education, information, and resources[14,15,16]. Because asthma is a chronic condition, it is crucial to educate affected children how to live with it, and mobile apps have potential to meet such needs. However, few apps offer ways to monitor air pollutants indoors, which are some of the most frequent triggers for asthma attacks, and even fewer apps are specifically designed for children. For mobile apps to be successful to manage chronic diseases, designers must be committed to user-centered, evidence-based design in order to best meet user needs. Beyond the requirements of good design and development, the central question of designing mobile apps for children with asthma is how to accommodate the perspectives and needs of children and engage children in digital interactions that foster positive outcomes for asthma management.

Lıterature Survey

Recruitment Children 8 to 12 years old with moderate asthma were eligible to participate in the study. We chose the 8 to 12 age range because children around the age of 8 Thus, children in this age range can use digital devices with complex and abstract languages for autonomous tasks Children were not eligible if they could not read or speak English or if their involvement was deemed inappropriate by the pediatrician because of their mental and physical conditions[18]. After obtaining the institutional review board's approvalResearchers approached by telephone caregivers of children with asthma who regularly visit the hospital. A total of 12 caregivers who met the inclusion criteria were contacted. After obtaining by phone their temporary consent to participate in the study, caregivers and children with asthma provided consent electronically during the interview. Data Collection].. We followed the user-centered design process to design and iteratively refine a child-friendly IAQ monitoring app for asthma management. Due to COVID-19, all data collections from participants were done through virtual interviews using video-conferencing software of a participants' choice (e.g., Skype, Zoom, Google Duo). While all the interview questions were to be asked to children, we also encouraged a participant's parent to join the interview and share their thoughts when they wanted.

Exsıstıng System

(1) Review existing apps

We reviewed of mobile applications available in the market that offer functionalities pertaining to IAQ monitoring and/or asthma management for children. The purpose of this step was to establish baseline concepts and functionalities for our app. While we conducted an extensive review of existing apps available on both app stores , we did not find any app that offered functionalities for IAQ monitoring associated with asthma management nor IAQ monitoring for children. Thus, we selected instead two IAQ monitoring apps, AirNow and AirVisual, and three asthma management apps designed for children: Wheezo, a digital

stethoscope that records breathing sounds to detect signs of asthma; AsthMe, an information repository for asthma management; and AsthmaActionHero, a mobile diary to record asthma conditions and take actions for asthma management, based on the number of downloads, reviews, and average user ratings. Based on a review of existing apps, we created two sets of low-fidelity sketch prototypes for our app (See Figure 2).

(2) Understand needs

An important step in user-centered design is to establish basic understanding of practices and needs of end-users to guide ideation and design of an app. To that end, we created a set of open-ended interview questions with three themes: (1) exploring how children with asthma manage and live with their conditions, (2) investigating the experiences of using mobile apps in general and for asthma management in particular, and (3) learning about current understanding of IAQ and its relationship to asthma. In addition, we collected participants' demographic information age, gender, and asthma severity from their guardians. Lastly, we displayed our low-fidelity sketch prototypes on a shared screen, explained the key concepts of each sketch, and asked for children's feedback. Each interview lasted about 30 minutes.

(3)Iterative design and evaluation

Based on the collected requirements and feedback of our prototype sketches in the previous steps, we iteratively created a set of wireframes which were then developed into high-fidelity prototypes for the final design of our app Then, we conducted an interview with the same group of participants to receive feedback on the prototypes. In the interview, we first introduced our app to participants as "a mobile app that allows you to monitor air qualities in your home and outside, record your asthma conditions, and find information about actions to take for asthma management". We then displayed our prototypes on a shared screen and asked participants to think aloud and express their thoughts and feelings while freely exploring the prototypes as much as they wanted. Our original plan was to conduct participatory design workshops and in-person interviews in which a participant would directly engage in idea exploration and interact with an interactive high-fidelity prototype on a mobile phone. However, due to the CDC recommendations for social distancing during COVID-19, we cancelled the workshops and instead conducted all interviews virtually. During the interview, a participant verbally commanded their intended interactions with a prototype cased on a shared screen, and an interviewer executed the user's interaction commands as a form of the Wizard of Oz study. Then, when participants had no more ideas to share, we asked three questions about each screen based on the cognitive walkthrough method, including (1). Each interview lasted up to 60 minutes. After completing this interview, parents of participants were sent an electronic gift card for their child's time and effort[20]

Design conceptualization based on the review of existing apps:

From the review of the existing apps, four trends emerged that were prevalent or in common across apps. First, all apps used vivid colors and simple graphical components for information visualization (See Figure 1a). For instance, the apps for air quality monitoring used colored graphical components ranging from speedometers, emojis, and bar graphs with color scales to indicate the level of air quality (See Figure 1b), while the apps for asthma management allowed users to pick different emojis and other colored graphical components

to indicate the user's condition (See Figure 1c). Second, all apps used graphical characters and personified graphical components to make information more engaging and fun

Fig 1a and 1b: Review of already existing apps

Third, all apps provided the features to track the history or the trend of the monitored information. For instance, graphs were used for the apps for air quality monitoring to keep track of the changes in air quality indoors and outdoors over time, and the apps for asthma management offered the features to record and keep track of asthma symptoms and conditions. Lastly, all apps offered the informational content that can encourage users to make beneficial, real-life changes. For instance, the apps for air quality monitoring provided information about how users should respond to poor air quality indoors, and the app

Proposed System

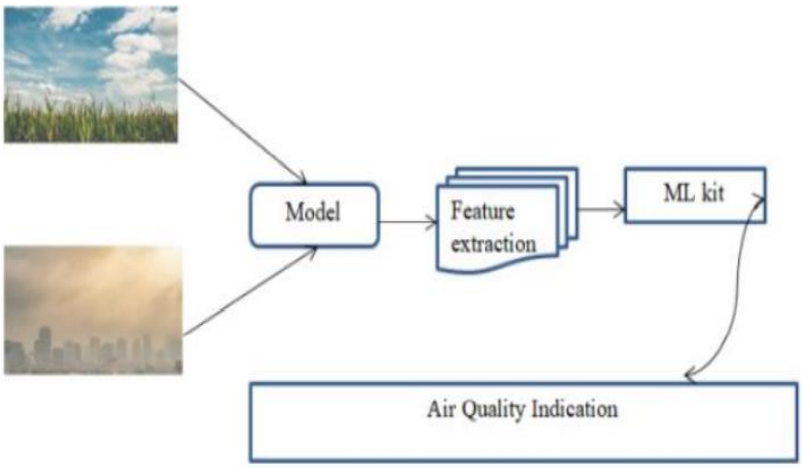

Fig 2 : Proposed Model

ADVANTAGES

- Efficient working.
- It is safe and ecofriendly application.
- User friendly approach
- Medication remainders
- Both indoor and outdoor air quality at one page

SYSTEM SPECIFICATIONS:

H/W CONFIGURATION:

- Processor - I3/Intel Processor
- RAM - 4GB (min)
- Hard Disk - 128 GB
- Key Board - Standard Windows Keyboard
- Mouse - Two or Three Button Mouse
- Monitor - Any

S/W CONFIGURATION:

- Operating System : Windows 7+
- Server-side Script : PHP
- IDE : Android Studio
- Libraries Used : Volley, Recycler view and

Fig 3a and 3b : Design of app

Fig 4 : Mockup design for the app

The second wireframe was created using a gamification theme of egg hatching, which we named AirPet .Through several design iterations and discussions within the research team, we developed the wireframe into a high-fidelity prototype that shows a virtual egg for which hatching speed is determined by the level of air quality indoors and daily spirometer data entry .To promote engagement, this prototype uses the level of IAQ and whether or not daily spirometer data is recorded as factors to affect the speed of egg hatching, which progress is displayed on a progress bar underneath the egg. Maintaining good IAQ and recording daily spirometer data will hatch approximately one egg a week. In addition, air quality outdoors and weather information are displayed on top of the screen.

Final Design and İmplementation

Based on the feedback we received from participants, we again iteratively revised the prototypes through in-depth discussions within the research team, and then developed them into a working system. In what follows, we explain two versions of our final app and how we addressed the issues identified from user feedback in the final designs. The final design of AirQ The biggest concern with the AirQ prototype was that the interface was too simple to convey IAQ information effectively because it relied solely on the shape and color of an icon. To address this issue, we separated a house icon from a cloud icon and located a horizontal AQI color strip underneath the house icon to indicate where the current IAQ is within the range. We also added text to display a label and a numerical level of IAQ next to the house icon When a user clicks anywhere in the IAQ information pane on a home screen, the app moves to an IAQ detail page where a bar graph of the recent IAQ trends is located. We moved the bar graph to a subpage so that the app can still benefit from the target users' familiarity with a bar graph to convey the IAQ trend information but reduce its influence on the overall and initial perception of the app . Next, we grouped a cloud icon with other weather conditions to conceptualize outdoor air quality as part of outdoor/weather information. Underneath the weather pane is a button to log daily spirometer data. Clicking this button brings up a subpage where a user can enter spirometer readings and review the daily log of previous data entry Clicking the house icon at the bottom left corner of a

navigation bar will bring up a chatting page where a user can interact with Airic, a chatbot, both verbally and via typing to ask any question relating to IAQ and asthma management. Lastly, we provided a list of action items that the user can perform to improve IAQ.

Fig 5a, 5b, 5c and 5d : Final design of the app

Limitations

we conducted all interviews virtually due to the pandemic, which might have influenced the participants' experience with our prototypes differently from how they would experience when directly interacting with them. We are hopeful that we can conduct in-person interviews in a system deployment study planned as a next step of this project.

Summary

Indoor air pollution is a known risk factor that contributes significantly to the adverse respiratory health in children [23]. Thus, keeping IAQ clean and healthy is the basis of environmental secondary prevention for asthma management [24]. However, our study showed that the affected children had little or no knowledge about what indoor air pollution is or how it affects their asthma symptoms [25]. While parents are and should be the main source of information for their children's asthma management, it is important for the affected children to have a method for self-management of asthma. This suggests that there is a need for an easy yet effective mechanism that helps to ensure children's engagement with IAQ as part of asthma management. In this study, we conducted a series of interviews to involve the end users, children with asthma, throughout the process of designing an app that promotes their engagement in monitoring and improving IAQ and tracking daily asthma conditions through a user-centered design approach. Through this process, we iteratively revised and improved the prototypes to assure that children can use our app easily, effectively, and reliably. This process has revealed two crucial aspects that require deeper consideration when creating a child-friendly app, including balancing brevity and expressivity and the longitudinal effects of gamification.

Conclusion

This work completes the foundational stages of concept generation, iterative design, and implementation in the user-centered design process. These stages are fundamental to the

subsequent evaluation and deployment of the app to support children with asthma to monitor and improve IAQ. The next phase is to conduct usability testing of a working system with end users to evaluate its effectiveness for children's use before public deployment. Our iterative design process demonstrated that it is critical to engage intended users as early as the concept generation phase and throughout the iterative design stages to assure that the final app meets user needs and functions as intended.. As a next step, we plan to conduct a longitudinal deployment study with children with asthma to evaluate the real-world effects of our apps regarding how different approaches – a conventional form of concrete information presentation and an abstract gamification – influence the affected children's engagement with IAQ, as well as how the increased awareness to IAQ influences the level of IAQ and asthma conditions..

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