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Asthma Academy: Developing Educational Technology to Improve Asthma Medication Adherence and Intervention Efficiency

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Abstract

Asthma is a leading chronic disorder among children and adolescents. Although some children outgrow asthma while transitioning into adulthood, there are others who continue to suffer from life-threatening asthmatic exacerbations. Teenagers tend to have certain misconceptions about their asthmatic condition and treatment which are rarely recognized or addressed in regular clinical consultations. After reviewing the literature in this field, we have identified that improving patient knowledge can be effective in augmenting engagement, and considerably improving their clinical outcomes. It is necessary to develop an effective educational intervention that can help Asthma patients change their perception about self-efficacy and ultimately reduce the total health care costs incurred. Hence, a sound transfer of knowledge during the transition from childcare to adult care is highly recommended. On these very lines, Georgia Institute of Technology designed an interactive educational application called Asthma Academy in conjunction with Children's Healthcare of Atlanta. This website resides in the public cloud and uses a novel animation video-based curriculum to deliver essential healthcare education to asthmatic adolescents in an interactive manner. What distinguishes it from similar initiatives is the use of a cost-effective technique to simulate caregiver-patient interactions and the ability to cater to a wide range of socio-economic statuses and educational levels. A group-based study with twenty asthma adolescents was conducted to evaluate the user acceptance and performance of Asthma Academy supplemented by regular check-ups over a period of eight to ten weeks. Observations recorded post the study clearly indicate higher levels of engagement and the systematic dissemination of information offered by Asthma Academy.

I. INTRODUCTION

Asthma is one of the most common chronic diseases and the third leading cause of hospitalization among adolescents [1]. It is a medical condition that causes coughing, wheezing, and difficulty in breathing. During the period from 2008–2010, the prevalence of Asthma was higher among children than adults. According to the Center for Disease Control, it affects 7.1 million (1:11) children and its rampancy has increased by 15% in the last decade [1]. Records obtained from the Center for Disease Control and Prevention also indicate that in 2013, about 21% of high school students (grades 9-12) had asthma [1]. Asthma demands a great deal of health care utilization and entails a lot of missed days of school and work. Asthma also greatly reduces quality of life, and is associated with direct and indirect costs totaling to 14 billion dollars per year [2].

Asthma educational programs can help reduce burden and improve the quality of life [3,4,5,6,7]. In fact, the Expert Panel Report 3 (EPR 3) Guidelines for Diagnosing and Managing Asthma states that educational programs that teach selfmanagement are a vital part of asthma care [7]. Improving asthma control reduces health care utilization along with the direct and indirect costs. The transfer from pediatric to adult healthcare and subsequent changes in life-style during adolescence are of extreme importance in this connection. However, the influence of these factors on young adults with Asthma is vastly unknown. Educational intervention is a powerful technique to inform teenagers about their health conditions. There is little information regarding educational programs in adolescent asthmatics [6], especially severe persistent uncontrolled asthmatics. Avatar-based videos have been used in a wide array of clinical settings to improve patient knowledge and self-management [8,9].

Pediatric Asthma care necessitates the need for an efficient channel for adolescents to report to their care providers, who, in turn, can monitor their gradual progress [10]. Currently, there are a few initiatives being undertaken across the country to address the issues of adolescents affected by Asthma [11]. Collectively, these include summer camps, teenage support groups, and short-term coalition-building programs. Although such initiatives have proven to be effective, they do not promise prolonged and positive after-effects due to the absence of follow-up assessments [12]. Studies have highlighted the importance of technological intervention in healthcare education [13]. Asthma and patient engagement are specifically mentioned in 3 of the top 100 national priorities for Comparative Effectiveness Research (CER). However, educating adolescents about their health and related consequences is time-consuming and not all individuals respond to the same style of education, which makes it all the more challenging for care providers [14,15]. In this paper, we propose the concept of Asthma Academy, a web based interactive educational application, in order to improve access and lower the cost of effective asthma education for individuals with severe and persistent but poorly-controlled asthma. Asthma Academy features animated avatars and voices that appeal to adolescents based on the current media consumption trends, as shown in Fig. 1[16]. Our videos are more cost effective to produce per minute than standard liveaction videos. The incremental cost of altering the videos to improve engagement or incorporate new knowledge is dramatically lower, thereby allowing the videos to appeal to a wider population.

Our proposed intervention also improves access to educational programs as compared to in-person consultation since patients are not required to travel to the clinic. Adolescent patients are likely to be more engaged because the video production technology allows for more variety in characters and storylines that deliver the key messages, increasing the chances that patients will identify with a character. Also, adolescents may perceive animation technology as friendlier than traditional asthma educational videos or in-person consultation. We aim to study whether this format can lead to better outcomes for adolescents. The ultimate objective is to equip adolescent patients with the necessary skills to self-reliably manage their health condition. Asthma Academy has been designed with a user-centric design and it provides information-based intervention in a user-friendly manner.

II. HYPOTHESIS AND SPECIFIC AIMS

As stated above, the primary objective of the proposed work is to improve the attitudes of adolescents towards asthma and improve self-reported medication adherence. Therefore, we hypothesize that a web-application based educational interface will prove instrumental in improving knowledge and will boost patient engagement. Secondary aims include:

4. Adolescents with severe asthma who receive avatar based educational video modules will be more actively engaged in the clinical care model as compared to those who are provided with standard web links.
5. These patients will have the knowledge and skills efficient health management as compared to those who are provided with standard educational information.

III. ASTHMA ACADEMY: SYSTEM DESIGN

The home page of Asthma Academy is concise with an ordered list of videos, as shown in Fig. 2. Children are known to respond very favorably to collaborative communication media like blogs, wikis, videos (Web 2.0 applications) [17]. These can effectively address the challenge of patient education and engagement in health care systems. The application has been designed to target adolescent users and to continuously encourage them to learn new healthcare based concepts. It can be used in two separate modes: (a) Individual user mode and (b) Coach mode. The chapter-wise quizzes form a custom Knowledge Map for the users to track their progress throughout the study, as shown in Fig. 2(b).

The Coach mode is a super user mode that offers an additional set of capabilities to care providers. It helps them track the progress of their patients in terms of (a) Videos completed (b) Quizzes attempted and (c) Timeline of activity. They can collectively view and compare the performance and progress of their patients. Caregivers can utilize this information to decide the next mode of treatment or the next step in the sequence of medical care.

IV. IMPLEMENTATION: SOFTWARE ARCHITECTURE

Asthma Academy is an educational web application based on the web services offered by Google as shown in Fig. 2(a). The application is designed within the Python sandboxed environment offered by the Google App Engine (GAE). The cloud-based Platform as a Service (PaaS) handles automatic scaling depending on the amount of incoming requests

[18]. The GAE allows for easy integration with other cloud-based services that are a part of the Google Cloud Platform and comes endowed with a rich set of APIs. The translational potential of this novel animation character-based video education program is high. It can be easily implemented in a busy clinical care setting with minimal involvement by the clinic staff as shown in Fig. 3.

V. FEATURES OF THE APPLICATION

The following section describes the key features offered by the application which distinguish it from the existing and available solutions.

A. Customized User Profile

Asthma Academy offers login capabilities and a custom profile to every user. This profile is used by the care providers to monitor the progress of their respective patients.

B. Animated Video Lessons

Producing engaging animation-based videos has become much more cost-effective in the recent years due to the improvement of text-to-speech technology, best exemplified by the software GoAnimate [19]. A \$40/month subscription plan allows access to a library of over 40 tracks, unlimited videos and exports. Videos can be of any length and can include multiple characters. Each character has a diverse range of distinct voices, postures and unlimited vocabulary (difficult words sometimes require phonetic spelling in the script) to choose from. The home screen consists of six lessons presented chapter-wise using animated videos as shown in Fig. 2(a) and Table I. The videos are based on thorough scripts written by experienced medical personnel. The videos are instructional in nature and every lesson covers multiple aspects of Asthma, right from proper medication to what measures can be taken for self management of the condition.

C. Session wise Quizzes

Every other lesson is followed by a quiz which comprises of elementary questions based on the video. Every lesson is a part of the patient's individual Knowledge Map, as shown in Fig. 2(b).

D. Interaction with Social Media

The individual can view and share the results by posting updates to social networking sites like Twitter etc. Caregivers and users can either use their Google account credentials or create a user account using the Google App Engine's backend service platform and protect it with a strong password. These set of credentials are securely encrypted to form a random token, whose value is archived in a password protected server version of the cloud [20].

VI. STUDY DESIGN & RESULTS

The Institutional Review Boards (IRBs) from the Children's Center for Clinical Outcomes Research & Public Health (CORPH) as well as Georgia Institute of Technology approved the case control study design trial of Asthma Academy. The target population is adolescents

aged 12-18 years of age with severe Asthma as defined by American Thoracic Society criteria (i.e. on a high dose of inhaled corticosteroid and a history with 12% reversibility).

A total of twenty (n=20) children were recruited from the Emory Children's Center Allergy-Immunology clinic and the Hughes Spalding Asthma Center during routine clinical care. The participants were arbitrarily divided into intervention and control groups, each consisting of ten adolescents (total n=20) as shown in Fig. 4. After informed consent, relevant information was obtained from the clinical charts (including history/physical) of these patients. Patients were randomly chosen to receive a link to either the standard asthma education website or Asthma Academy. The tasks included: (a) Complete watching the videos (Intervention group) or reading the material (Control group) and (b) Answer questions on asthma knowledge, symptoms and adherence. The questions were uniform across both the groups. The patients then returned for a regular clinic visit, where they completed a satisfaction survey. The data collected from the trial was used to compare the effectiveness of strategies for enhancing patients' adherence to medication regimens. There were a few insights obtained post analysis which have been enumerated as follows:

The standard WordPress website contains links to informative portals like Asthma and Allergy Foundation of America, American Lung Association and so on. In other words, the information is not collated which renders it passive in nature. The average amount of time spent by patients to answer questions on the standard website was about 3.2 minutes as compared to that spent by the patients on Asthma Academy which ranged from 4-7 minutes.

One in every four questions was answered incorrectly on the standard WordPress site. The reason can be attributed to the absence of a systematic video-based educational format and the information overload disseminated via web links.

The accuracy of those using Asthma Academy was 100% as compared to those using the standard website, for whom the accuracy measure reported a mean of 20.45 and a standard deviation of 1.7.

The frequency distribution graph of answers recorded from the participants' responses as shown in Fig. 5 reveals the average response rate for questions. Data also reveals that the control group faltered while answering questions related to novel concepts like 'Use of Albuterol'.

The recorded observations suggest higher levels of engagement offered by Asthma Academy in stark contrast to the standard website. Differences in accuracy levels also indicate that systematic dissemination of information can prove instrumental in improving patient knowledge.

VII. CONCLUSION

The objective of this project was to gather evidence-based data to prove that interactive educational intervention techniques can lead to higher levels of engagement. The results of this study demonstrate that animation-video based technology is more engaging and can be used to supplement in-person consultations. Future studies should include larger groups in

order to identify cost-effectiveness measures and medication adherence post study. Given the small group, we could not conduct statistical analyses on compliance or assessments of bias. Although we will require longer periods to study the impact of Asthma Academy on clinical health outcomes, care providers can incorporate it into their current personalized care model for patients with severe persistent asthmatics. They can observe their patients' enhanced self-confidence levels and deduce information about the challenges their patients face. In the future, the idea of a similar web application can readily be tailored to manage other chronic diseases, such as diabetes or sickle cell disease. While computer-based learning programs that improve chronic disease self-management skills and personalized approaches for asthma management are being implemented, it is critical to determine whether providing healthcare knowledge in an interactive manner is an effective adaptive treatment strategy for addressing the needs of transition-based Asthma care. In the future, it can be used as a design element to optimize the intervention sequence for different groups of study participants with a given chronic disorder.

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Lesson Two: Understanding Asthma

Figure 1.
Asthma Academy: Lesson Two video

(a)

(b)

Figure 2.
(a) Asthma Academy (b) Knowledge Map

Figure 3.
System Architecture

Figure 4.
Study Design

Figure 5.
Asthma Academy: Reponse rates

TABLE I.**Asthma Academy Lessons**

Chapter Name	Video
Lesson one: Let's get started! Asthma can be controlled!	Character Introductions
Lesson Two: What is Asthma anyway?	Understanding Asthma
Lesson Three: Things that make you wheeze!	Learning about Asthma triggers
Lesson Four: Yes! I can control my Asthma!	Controlling Asthma
Lesson Five: I have a plan!	How to deal with an Asthma attack
Lesson Six: It's a brand new day!	Putting it all together!