



Qualitative Study Protocol: Augmented Reality Technology to Deliver Asthma Inhaler Technique Training for Children and Adolescents With Asthma

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Abstract

Asthma is a chronic inflammatory condition of the airways with a heterogeneous symptom profile. When symptoms are poorly controlled and frequent, asthma sufferers are impacted regularly, with limitations on physical activities and sleep disturbances, significantly impairing quality of life. Asthma is highly prevalent and the leading cause of disease burden in young people. Those aged 0–14 contribute to over half of the asthma hospitalisations within Australia. Asthma education and self-management remains a key component of care; however, challenges remain in the paediatric population with difficulties of engagement. Augmented reality (AR) may provide a novel and effective solution with its ability to superimpose virtual objects into a real-world setting. Using a smartphone or tablet to deliver AR makes this modality accessible to much of the population. AR is a growing field in technology and has already established uses in education and training. The ability to increase motivation, enhance enjoyment and encourage faster concept understanding in the educational setting is encouraging and supports our proposal that AR technology can provide a generation appropriate education delivery modality for young people with asthma. To ensure successful implementation of an AR asthma educational resource on a large scale, the usability, acceptability, barriers and enablers of its use must be investigated. Using an iterative co-design process, an asthma resource utilising AR to deliver education on inhaler technique will be created. Qualitative research will be undertaken using semi-structured interviews with moderator guides to obtain mixed-method data on the AR resource. Participants will be key members of the asthma community including children and adolescents with asthma (8–17 years old), caregivers of children and adolescents with asthma, and health professionals. Understanding the usability, acceptability, barriers and enablers of the AR resource will enable us to improve our alpha version and test an optimal version in a planned feasibility study.

Keywords

augmented reality, asthma, education, inhaler, qualitative

Background/Study Justification

Asthma

Asthma has been defined as chronic inflammation of the airways which can result in bronchial hyper-responsiveness and limitation in airflow (Braman, 2006). It is a heterogeneous disease, with varying symptoms including coughing, wheezing, shortness of breath and chest tightness in susceptible individuals (Braman, 2006; Mims, 2015). Symptoms can range in severity from mild to life threatening

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(Licari et al., 2018). The airway hyper-responsiveness and variable airflow limitation is usually reversible, either with pharmacological intervention or spontaneously, and may be triggered by a variety of stimuli such as pollen, temperature changes, exercise and viral respiratory tract infections (Mims, 2015). The main aim for management of asthma is to control the inflammation and symptoms, as well as reduce the risk of exacerbations (Global Initiative for Asthma, 2020; James & Lyttle, 2016). Those who have poor symptom control suffer frequent symptoms and/or require frequent use of a reliever, have activity which is limited by their asthma and can experience nocturnal waking due to their symptoms. Asthma is defined as ‘uncontrolled’ when there is either poor symptom control and/or frequent exacerbations (two or more per year) which requires oral corticosteroids or having a serious exacerbation more than once or more per year, which requires hospitalisation (Global Initiative for Asthma, 2020; Papaioannou et al., 2015). Those who have uncontrolled or poorly controlled asthma with frequent symptomatology may be impacted on a daily basis, including having limitations in their physical activities and sleep disturbances (Papaioannou et al., 2015). They suffer from impaired quality of life, including poorer health and mental well-being, heightened psychological distress and increased symptoms of anxiety and depression (Drapeau et al., 2012; Goldney et al., 2003; Janson et al., 1994; Vollmer et al., 1999; Welfare, 2013; Yonas et al., 2013).

Impact of Asthma

Asthma is a highly prevalent disease, estimated to affect over 330 million people worldwide (Braman, 2006). This is especially true in the paediatric population, in which asthma is the most common chronic condition globally (Braman, 2006; Poulos et al., 2005; Woolcock et al., 2001). There is increasing knowledge surrounding the disease and its pathogenesis, as well as growing evidence-based treatment options. Despite this, prevalence is increasing with an estimation of over 100 million more people to be diagnosed with asthma by 2024, and there are still approximately 180,000 deaths which are related to asthma per year worldwide (Masoli et al., 2004; Nunes et al., 2017).

In Australia, asthma is the leading cause of disease burden in young people aged 5–14 years (AIHW, 2018; Braman, 2006). It is one of the most common hospital emergency department presentations, and half of the asthma hospitalisations in Australia are in young people aged 0–14 years old (AIHW, 2018; Poulos et al., 2005). For children, poorly controlled asthma has a significant impact on daily living for the child themselves, as well as the whole family unit, with sleep disturbances due to symptoms, missed schooling and restrictions on activities compared to their healthy peers all contributing (Gustafsson et al., 2006; Poulos et al., 2005).

Asthma also significantly affects healthcare systems and governments, with direct costs (those related to asthma

management, investigations, and treatments) and indirect costs (losses related to not being at work and school resulting in reduced productivity). In recent years, this has been estimated to cost the Australian economy \$AUD 24.7 billion in 2015 and the US economy \$USD 56 billion in 2011 (Deloitte, 2015; Nunes et al., 2017).

Asthma Self-Management Education

Asthma education and guidance on self-management remains an essential part of care and is recognised as an important aspect of treatment in asthma management guidelines (Global Initiative for Asthma, 2020; National Asthma Council Australia, 2020). A systematic review by Gibson et al. (2003) reviewed 36 trials and compared self-management programmes with usual care and found that self-management education was effective in reducing hospitalisations, emergency department visits, days off work or school, symptoms and also improved quality of life. A systematic review looking specifically at the paediatric population and the efficacy of asthma self-management on health outcomes also found that asthma self-management programmes in children reduced missed school days, emergency department visits and symptoms (Wolf et al., 2003).

Despite recognition of education as important, studies show that limited health literacy resulting in low treatment adherence, poor asthma knowledge and limited engagement in self-management contribute to many Australians still having poor asthma control (Holley et al., 2017; Mackey et al., 2016; O’Connor et al., 2015). Children and adolescents are an especially vulnerable population in which engagement may be challenging; however, having increased knowledge about asthma and asthma medications has been associated with higher medication adherence rates (Koster et al., 2015; Mosnaim et al., 2014).

Health professionals are expected to provide adequate information for asthmatic patients; however, in a recent 2018 systematic review, overall, the inhaler technique was correct in only 15% of over 6000 healthcare professionals (Plaza et al., 2018). This is reflective of data suggesting that 10–30% of people with asthma use their inhalers correctly, and over the last 40 years, there has been no significant improvement in technique (Basheti et al., 2008; Sanchis et al., 2016).

New Interventions Required for Asthma Self-Management Education

In 2015, Blanchard et al. reported on the ‘National Young People and Asthma Survey’ to provide a current picture on asthma control and evaluate the national asthma strategy currently in place in Australia which aims to improve asthma self-management. This survey identified that majority of young people aged 12–25 had poorly controlled asthma and a key recommendation was made that new interventions for education were required, especially surrounding the use of preventative medications (Blanchard et al., 2014).

In Australia, approximately 92% of the population has access to a smartphone, and over 80% of young people with asthma use a smartphone daily, making education delivered via this modality accessible (Blanchard et al., 2014; Corbett et al., 2020). Asthma smartphone self-management apps have been studied in meta-analysis and shown to be effective in improved adherence with medications compared to standard treatment, improved asthma control and the potential for improving quality of life; however, this has been predominantly in adult based populations (Farzandipour et al., 2017; Hui et al., 2017; Miller et al., 2017). It is also still unclear as to which specific features are associated with the engagement and adoption of self-management apps, and studies considering the education delivery to children specifically are lacking (Hui et al., 2017; Iio et al., 2020; Miller et al., 2017).

Augmented Reality in Educational Settings and for Behaviour Change

Augmented reality (AR) can be delivered by a smartphone or tablet device and has been defined as technology able to superimpose virtual objects into a real-world setting so that the virtual objects seems to co-exist in the same space in real time (Akcayir & Akcayir, 2017). AR allows information to be delivered via videos, animations and graphics which can be a generation appropriate modality for children and adolescents.

AR has already been applied to educational and training settings as well as in the business world (Lee, 2012). In the healthcare clinical setting, it has been predominantly applied to allow medical practitioners the ability for surgical planning and is used for both treatment and training purposes (Eckert et al., 2019). In the educational sphere, there is evidence that AR can increase self-learning opportunities (Akcayir & Akcayir, 2017), increases motivation (Bacca et al., 2018), has the ability to encourage faster concept understanding in children with disabilities (Hrishikesh & Nair, 2016) and also can enhance collaborative learning (Phon & Halim, 2014). There is also evidence it enhances enjoyment (Ibáñez et al., 2014), provides a positive attitude (Rafał Wojciechowski, 2013) and enables users to receive information quickly (Chiang et al., 2014). Previous research has also shown that AR can assist in memorisation when digital information is presented within a real-world environment (Fujimoto et al., 2013). This may be reflected in the findings of a meta-analysis in which the performance of students who used AR based approaches had an improvement of a moderate effect size compared to those who used non-AR based approaches (Santos et al., 2014).

The efficacy of AR for behaviour change has also been explored over recent years, especially in relation to nutrition and dietary habits as well as in the retail sector for consumer behaviours (Lavoye et al., 2021; McGuirt et al., 2020; Suzuki et al., 2015). With the ability of AR for immediate delivery of visual feedback and the ability for 'in the moment' behavioural reminders or recommendations, this has been shown to increase self-motivation and action and highlights the ability

of AR as a behaviour change intervention for the future (Khan et al., 2019).

Augmented Reality as a Delivery Modality for Asthma Self-Management Education

AR may provide an exciting, effective new modality for delivering asthma education for young people. It also may be an effective strategy for education delivery to parents with low literacy levels, which is a particularly important area to address as this is known to be associated with poorer asthma control and lower adherence to asthma treatment (Koster et al., 2011; Lasmar et al., 2009).

AR has already established itself as a growing field in technology with rapid growth patterns in areas such as media, entertainment and marketing. This is expected to contribute to the estimated market value in 2025 to be greater than US \$140 billion (ABI Research-Augmented Reality Total Market Value Will Surpass US\$140 Billion in 2025, 2021). It has been described as a 'disruptive' technology, as it displaces already well-established practices by its growth and uptake by users (Siddhpura et al., 2020).

To our knowledge, there has been only one other educational resource for children which utilised AR for asthma self-management education via gamification (Suha et al., 2021). Promisingly, there was increased engagement in the educational programmes and improved inhaler technique in those randomised to using the AR application, compared with children using a video or leaflet. This study, however, did not have participants with a diagnosis of asthma and did not assess asthma related health outcomes, nor conduct any qualitative investigation for the acceptability and usability of the resource to users.

Aims

This article outlines the protocol for a qualitative study, which aims to evaluate the acceptability, usability, barriers and enablers of an AR educational resource for inhaler technique, using an iterative co-design process to create an optimal tool for future feasibility studies. This will occur over two stages:

1. Development of an AR resource which can be delivered via a smartphone or tablet as an educational tool for children and adolescents with asthma
2. Determine the acceptability and usability of the developed resource and identify the barriers and enablers in delivering self-management education to children and adolescents, their caregivers and relevant health professionals

Explanation and Justification of Method

As AR technology is a novel concept for delivering asthma self-management education for young people with asthma, the

acceptability and usability of the resource is crucial for successful implementation. This research will determine the acceptability and usability using semi-structured interviews with moderator guides to obtain mixed method data. Deductive thematic analysis using the domains of the Theoretical Domains Framework (TDF) and the Theoretical Framework of Acceptability (TFA) will inform both the semi-structured moderator guide and coding for analysis, and the System Usability Scale will also be integrated to ensure acceptability, usability and barriers and enablers of the resource are all analysed (Sekhon et al., 2017).

The TDF has been validated in its use for research involving behavioural change and implementation problems (Cane et al., 2012). It provides an understanding of behaviour change and forms a basis for exploring implementation problems allowing for our intervention design and application in the real world to be successful (Atkins et al., 2017).

Acceptability has been defined as a ‘multi-faceted construct that reflects the extent to which people delivering or receiving a healthcare intervention consider it to be appropriate, based on anticipated or experienced cognitive and emotional responses to the intervention’ (Sekhon et al., 2017). The TFA has seven constructs of which can be used as a guide to both prospectively and retrospectively assess the acceptability of an intervention (Sekhon et al., 2017).

Usability testing is important in intervention development prior to examining its efficacy in the real-world clinical setting, so the effectiveness, efficiency and satisfaction of its goals from users can be optimised (Susan Alexander and Haley, 2019). The System Usability Scale has been validated as a versatile and reliable scale for products and systems and will also be used to determine usability of our resource (Bangor et al., 2008).

Phase 1 – Augmented Reality Resource Development

The development of the AR resource will be underpinned by current resources which have used similar technology including the Lung Foundation Australia ‘Stepwise Management of Stable COPD’ reference guide (Lung Foundation, 2020) and in conjunction with input from health professionals. The application will function via pattern recognition of a paper-based poster, to trigger educational videos to be activated and initiate the paper-based poster to come to life on either a smartphone or tablet.

This project will use an iterative co-design process with likely end-users, for the development of the AR educational resource. Iterative co-design is an important process in the implementation of any intervention as it places the user at the centre of the design process (Susan Alexander and Haley, 2019). The design process involves identification of users with a specific context for use of the resource initially, an understanding of the requirements of the user, production of a design, then evaluation of this with users and stakeholder involvement (Alwashmi et al., 2019). The process is repeated

with improvement of the resource over time. This enables the intervention designed to be best suited for the likely end-users and increases likelihood of successful uptake (Alwashmi et al., 2019).

Phase 2 – Determine the Acceptability, Usability, Barriers and Enablers for the AR Resource to Deliver Asthma Self-Management Education to Young People

One-on-one interviews will be conducted to identify acceptability, usability, barriers and enablers for the use of the AR resource by children and adolescents with asthma aged 8–17 years old, their caregivers, as well as health professionals, including paediatric respiratory physicians, general paediatricians, nursing staff, general practitioners, pharmacists and asthma educators.

The interviews will be of approximately 45–60 minutes in duration per participant. During the session, participants will receive a demonstration of the resource from a study investigator and be asked to trial the use of it themselves as a one-off.

Semi-structured moderator guides will be used to assist in collecting the qualitative data which will specifically address the research aims. The moderator guides will form the basis of the interviews which have been developed specifically for each of the three participant groups described previously and will be framed by the TDF and TFA.

Interviews will take place in the respiratory department of the major tertiary paediatric hospital in Adelaide, South Australia (S.A.).

Interviews will be recorded and transcribed by an automated transcription service, with participants being contacted at a later date to validate the content if required.

Sampling/Recruitment

Three groups of likely end users will be recruited to allow for wider generalisation of data (Cote & Turgeon, 2005). Health professionals, children and adolescents with asthma, and caregivers of children and adolescents with asthma will be chosen based on their identification as information-rich cases. To cover the varying opinions of the asthma community, this study will interview participants from two categorised groups: children and adolescents with asthma, and parents of children and adolescents with asthma. We identified six different health professions that cover asthma treatment, management and education: respiratory specialists, paediatric general medicine specialists, general practitioners, nurses, pharmacists and asthma educators.

Asthma Community

Purposive sampling will be used through recruitment flyers inviting potential participants of the asthma community to join the study. These flyers will be displayed in wards and

offices of the tertiary paediatric hospital the study will be undertaken in, where there is a high exposure to our target sample. Potential participants will contact researchers via email or the telephone number provided on the recruitment flyer. Asthma patients may also be recruited through existing contacts throughout the Respiratory Department at The Women's and Children's Hospital, S.A., via the respiratory specialists and asthma educators during clinical appointments, with a letter of invitation for the study provided to the family.

Potential participants will be screened to ensure they meet inclusion criteria, and if screening is successful, they will then be invited to participate in an interview. A Participant Information Sheet and Consent Form will be emailed or posted to the potential participant, and they will be given an opportunity to read through and ask any questions either through the provided contact details or at the beginning of the interview. They will be asked to bring the Consent Form to the interview to have it signed and witnessed by a member of the research team.

Qualitative data will be obtained through interviews with participants from the following categories:

- i. Children and adolescents with a clinical diagnosis of asthma – aged 8–17
- ii. Parent/guardians of asthmatic children and adolescents aged 8–17

Non-English speaking participants have been excluded due to logistical difficulties around the need for interpreters as well as the cost and delays this may present. Those unable to consent have also been excluded.

Health Professionals

Purposive sampling will be used through a recruitment email inviting potential participants to participate in the study. These will be distributed by email via relevant managers at the tertiary paediatric hospital where the study will be undertaken. Health professionals may also be recruited through existing contacts of the Respiratory Department of this hospital.

Initial contact with potential participants will be via email and the telephone number provided on the recruitment email. Potential participants will be screened to ensure they meet inclusion criteria and, if screening is successful, they will then be invited to an interview at a suitable time and date. A Participant Information Sheet and Consent Form will be emailed or posted to the potential participant, and they will be given an opportunity to read through and ask any questions either through the provided contact details or at the beginning of the interview. They will be asked to bring the Consent Form to the interview to have it signed and witnessed by a member of the research team.

Qualitative data will be obtained through one-on-one interviews from health professionals in the following categories:

- i. Nursing Staff
- ii. Paediatric General Medicine Doctors
- iii. General Practitioners
- iv. Respiratory Specialists
- v. Pharmacists
- vi. Asthma Educators

Inclusion criteria for the above participants include having worked in their profession in S.A. and having treated asthma patients regularly for >12 months in the last 5 years. They will be excluded if they are aged <18 years old, unable to consent or are non-English speaking.

Qualitative research requires sample sizes which are both large enough to ensure broad views and depth, however, also small enough for intensive meaningful analysis, and there are no prespecified criteria in determining sample size (Cleary et al., 2014). An approximate total sample size of 15–20 has been determined in being helpful in exploring the potential use of AR technology as an education tool for this study, allowing documentation of diversity and understanding variation among participants (Patton, 2002). This also is in line with experts who advocate for there to be less than five users per round of iterative design, as 85% of usability problems with the resource is detected within the five users, with more users not being cost or time effective (Susan Alexander and Haley, 2019).

Data Handling/Analysis

Deductive thematic analysis will be used as the coding method to categorise participant responses from interviews into the domains of the theoretical domains framework. The analysis of the data will be coded by two independent researchers to improve inter-rater reliability. Disagreements will be resolved with discussion. Coded data will be entered and analysed using NVivo software. A kappa co-efficient will be calculated to examine the degree of inter-rater reliability between the two coders (NVivo, 2020).

All research documentation will be treated as confidential and will be securely stored. Hard copy documents and audio recordings will be stored in a secure office. Audio recordings which will be taken from the interview sessions will be kept for 30 years after transcription. All transcriptions will be de-identified. Electronic data will only be accessible to study investigators on hospital network servers in secure folders.

Ethics

Anonymity and Confidentiality: All audio recordings which are taken from interview sessions and transcribed will be de-identified. Storage of hard copy data will be secure and stored securely in an area with only staff access within the tertiary hospital. Electronic data will be stored on hospital servers in secure folders which will only be accessible to study investigators. We will ensure all data is de-identified.

Research within a vulnerable population group: As this research involves participants aged 8–17 years old, all investigators and research assistants involved have a current Working with Children Check or a Child-Related Employment Screen clearance which has been issued through the S.A. government. As this research is purely seeking opinions from participants, we anticipate this to be low risk in terms of causing any negative impact on children and young people safety, emotional and psychological security. Moderator guides have been designed specifically for this age group to minimise confusion or distress from a lack of comprehension.

Informed consent: Participation will be voluntary. Potential participants will contact researchers via email or the telephone number provided on the recruitment flyer and will be screened to ensure they meet inclusion criteria. A Participant Information Sheet and Consent Form will be emailed or posted to the potential participants, and they will be given an opportunity to read through and ask any questions either through the provided contact details or at the beginning of the interview. The Consent Form will need to be signed and witnessed by a member of the research team. A specific Participant Information Sheet for children and adolescents has been developed to ensure information is conveyed in an age-appropriate manner. For children under 18, consent will need to be provided from their parent/guardian. To ensure communication is effective in the consent process, the exclusion criteria for this study also include being non-English speaking.

Beneficence: If asthma community participants (i.e., children and adolescents with asthma or their caregivers) choose to withdraw from the study, there will be no implications to their clinical care. This is made clear to them as part of the consent process.

This study will also be conducted with the principles of the ‘Declaration of Helsinki’, Good Clinical Practice, the National Statement on Ethical Conduct in Human Research ([National Statement on Ethical Conduct in Human Research, 2007](#)). It will also comply fully with the Australian Code for the Responsible Conduct of Research (2007) and within the laws and regulations of Australia.

This study has been reviewed by Human Research Ethics Committee of The Women’s and Children’s Hospital Network in Adelaide, S.A., and been approved (approval number HREC/20/WCHN/74).

Rigour

Rigour will be ensured during all steps of this research.

Participants will be enrolled from key stakeholders in the asthma community (being children and adolescents with asthma, their caregivers, and health professionals) to ensure transferability. We will use purposive sampling of members of the asthma community to be able to optimise participants able to answer our research question.

Using semi-structured interviews with moderator guides, we will increase dependability, credibility and conformability.

As they will be audio-recorded, we will undergo member checking to also increase both credibility and confirmability with the participant being able to validate the interview. Research investigators and assistants will also be trained in doing qualitative interviews for further dependability.

Triangulation of data sources will be possible by using both interviews and questionnaires, so as to be able to optimise accuracy, support and confirmability in themes. Pilot coding between two independent researchers will also ensure consistency and minimise bias.

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