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Mobile Health Technology Development: Adaptations for Children and Adolescents with Autism

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Mobile Health Technology Development:

Adaptations for Children and Adolescents with Autism

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Introduction

Mobile health technology is a growing health resource that is usually designed for the general population. The existing literature on children and adolescents with autism suggests that their experience with mobile health technology may differ from the general population due to the coexisting conditions and social determinants of health related to autism. These differences can impact the anticipated effectiveness of mobile health technology. The goal of this qualitative study was to learn more about the experience of children and adolescents with autism with mobile health technology by interviewing health care providers, individuals who have autism, and parents of children with autism. The existing literature along with the personal experiences and recommendations discussed during these interviews provide a variety of considerations for mobile health technology developers. By incorporating these findings into new and existing mobile health technology, these resources can be more accessible and beneficial for children and adolescents with autism.

Literature Review

Pediatric Obesity and Feasibility of Mobile Health Technology Interventions for Children and Adolescents with Autism

Introduction

High pediatric obesity prevalence is an issue that has necessitated increased focus on the research of effective interventions. Although mobile health technology obesity interventions have been a recent focus for research about children and adolescents, research is limited among those who also have an autism diagnosis. Further investigation is necessary because children and adolescents who have autism may experience these interventions differently than the rest of the

population. Recently, Prisma Health referred pediatric patients who were in the 85th percentile or higher for weight to take part in the Connect 4 Health program called Wellness Engagement Chat (WE Chat) which will utilize a Conversa developed app as a healthy weight lifestyle intervention. In order to understand why the experience of autistic children and adolescents enrolled in WE Chat might differ from the experience of the general population, this literature review focuses on the social determinants of health and coexisting conditions of autistic children and adolescents. These unique factors influence obesity risk and provide insight into how mobile health technology interventions could be modified to be more feasible and effective for obese children and adolescents who also have autism.

Methods

Articles included in this literature review were first organized into three categories including pediatric obesity interventions, developmental disabilities and pediatric obesity, and developmental disabilities and social determinants of health. Based on this initial research, the topic was narrowed specifically to children and adolescents diagnosed with autism spectrum disorder. A codebook was developed to further break down the different research topics. Each article was listed on a Microsoft Excel sheet with its specific code, authors, title, keywords, key search terms, abstract, and relevant notes. The three overarching categories included pediatric obesity, social determinants of health, and coexisting conditions of autistic children and adolescents. The pediatric obesity category branched to articles related to interventions, prevalence and trends, and long-term outcomes. The social determinants of health category included the neighborhood and built environment, transportation access, economic stability, health care access and quality, education access and quality, and social and community context.

Social and community context was further broken down into family systems and parental involvement categories. Motor development, cognition and language development, social interaction skills, and mental health were all included in the coexisting conditions category.

The inclusion criteria for this literature review consisted of articles that were published within the last ten years. Articles were focused on pediatric populations but included typically developing populations as well as those with development disabilities or autism spectrum disorder. Articles that best represented the populations involved with the Conversa research were highlighted in yellow and included in the literature review while excluded articles were highlighted in red. Of the forty articles considered on the Excel sheet, twenty-six were ultimately included in the literature review.

Body of the Review

Pediatric Obesity

Prevalence

In 2017, 33% of children in the United States were classified as either overweight or obese (Kumar & Kelly, 2017). In studies involving children and adolescents who have autism, the reported prevalence of obesity was even higher. In a multisite cross-sectional study of 668 children who had autism, 914 children who had a different developmental delay or disorder, and 884 children from the general population found that an autism diagnosis had the greatest impact on the odds of being overweight or obese. While children with other developmental delays and disorders had 1.3 times the odds of being overweight or obese, children with autism were 1.57 times as likely to be overweight or obese compared to the rest of the population (Levy et al., 2019). Additionally, children with severe autism were almost twice as likely as children who had

mild autism to be overweight or obese (Levy et al., 2019). The significantly increased prevalence of obesity in children who have autism suggests that their special population represents a relevant focus for the development of obesity interventions.

Contributing Factors

A surplus in calorie intake due to a child's diet, low levels of physical activity, poor sleep quality, and high amounts of screen time are all contributing factors for childhood obesity (Tate et al., 2013). The impact of the social determinants of health and coexisting conditions of autism on these risk factors helps to explain why that population experiences a heightened prevalence of obesity compared to the general population. These factors related to autism and their impacts on a child's diet, physical activity levels, and other contributing factors are explored in depth throughout this literature review.

Long-Term Outcomes

Adult Obesity

The reported prevalence of obesity is concerning due to the negative long-term outcomes that are associated with obesity. Of the participants who took part in the Princeton Follow-Up Study, 63% of those who were classified as overweight children were classified as obese adults after twenty-five years (Kelsey et al., 2014). An analysis of twenty-three studies comprised of sixteen cohorts also found that having a BMI classified as obese as a child resulted in 5.21 times the odds of being an obese adult as compared to children who were not obese (Simmonds et al., 2015). This indicates that being overweight as a child is a strong predictor of obesity later in life among the general pediatric population. Obesity as an adolescent was an even stronger predictor of adulthood obesity. Fifty percent of the people across these studies who were obese as children

were obese as adolescents. Of the people who were still obese as adolescents, eighty percent remained obese as adults (Simmonds et al., 2015). Based on this research, childhood is a critical time for obesity intervention since the risk of remaining obese only increases with age.

Chronic Disease

In addition to being a strong predictor of adulthood obesity, childhood obesity was found in several studies to be a predictor of morbidities regardless of the adult's weight classification. Obesity in female children, for instance, was correlated with a greater risk of breast cancer no matter the adult's weight classification (Kelsey et al., 2014). In fifty blood pressure studies, childhood blood pressure was usually a strong predictor of adult blood pressure trends (Kelsey et al., 2014). Atherosclerosis, another morbidity associated with cardiovascular disease, was evident and related to the bodyweight classification in autopsies of adolescents (Kelsey et al., 2014). These studies indicated a higher risk of cardiovascular disease due to obesity prior to adulthood. Other prospective cohort studies have shown that children who are still obese as adults experience a greater risk of morbidities including hypertension, dyslipidemia, cardiovascular disease, and type 2 diabetes (Kelsey et al., 2014). Long term effects of childhood obesity highlight the importance of both obesity prevention and early intervention.

Chronic Disease in Adults with Autism

Adults diagnosed with autism have been shown to experience higher rates of obesity-related disease. One study compared chronic disease in adults in the general population with autistic adults by utilizing the electronic medical records of a health organization called Kaiser Permanente in Northern California. Of 1,507 autistic adults, 33.9% were obese compared to 27.0% of the 15,070 adults from the general population (Croen et al., 2015). Additionally, adults with autism experienced significantly higher rates of obesity-related morbidities including

dyslipidemia, hypertension, diabetes, and strokes (Croen et al., 2015). Another study on 143 adults diagnosed with autism who made Medicaid claims in Wisconsin found cardiovascular disease in 49.0% of the sample and risk factors of cardiovascular disease in 46.2% of the sample (Bishop-Fitzpatrick & Rubenstein, 2019). Since the prevalence of obesity and chronic disease is higher among adults who have autism, autistic children and adolescents are a particularly important target group for obesity interventions designed to prevent adverse lasting outcomes. Coexisting conditions and the social determinants of health of autistic individuals contribute to the risk of obesity and chronic disease.

Coexisting Conditions

Motor Development

Coexisting condtions of children and adolescents with autism consist of factors that influence their everyday function. Therefore, these factors can also impact their risk of obesity and experience with health interventions. Autistic children and adolescents often have delayed or lower motor development in comparison to the general population. In a motor skill study, all 5- to 6-year-old children from the general population were able to catch a ball thrown from two meters away as compared to only 12.5% of 5- to 6-year-old autistic children (Pusponegoro et al., 2016). A study on the motor skills of 30 autistic children found that motor skills impacted involvement in a variety of activities, especially recess activities like running, jumping, or playing a ball game (Oliveira et al., 2021). Autistic children who had better motor skills were more likely to participate in activities than those who had poor motor skills (Oliveira et al., 2021). Reduced physical activity levels contribute to obesity in children (Tate et al., 2013).

Therefore, the difficulty with motor skills experienced by children and adolescents who have autism contributes to their risk of obesity by negatively impacting physical activity participation.

Cognition and Language Development

Cognition and language development must also be taken into consideration when designing an intervention plan. Children with autism may not be able to read or comprehend on the same level as other children their age. Forty percent of autistic girls involved in a study on reading comprehension had one or more reading and writing disorders (Asberg et al., 2010). Other studies reported that adolescents who have autism but have no intellectual disability were able to recognize and read words but struggled with comprehension, especially when mental flexibility was required (Baixauli et al., 2021). Autism severity is perhaps the most important factor related to cognition and language development. A study that tested the word recognition and comprehension of 81 children with autism found that increased autism severity level was related to lower reading comprehension level (McIntyre et al., 2017). Since autism occurs on a spectrum, reading and comprehension may need to be evaluated on a case-by-case basis. While some individuals who have autism may be able to read and understand written material on their own, others may require significant assistance. People who have autism may struggle to understand written nutritional information, follow a written fitness plan, or participate independently in interventions that require reading. Since written material can inform dietary and physical activity decisions, cognition and language development are related to obesity risk.

Social Interaction Skills

Social interaction skills have a significant impact on a child's participation in physical activity. In a study on six families with children diagnosed with autism, parents admitted to

keeping their children from participating in some group play at times due to concerns about their child being bullied or mocked due to their lack of social awareness (Ayvazoglu et al., 2015). In turn, the lack of participation kept children out of situations where they could learn and practice social skills (Fiscella et al., 2021). Parents in other studies also voiced their concerns about their child being bullied or harassed in situations involving play with other children (Bonis & Sawin, 2016). The lack of social practice due to parental worries resulted in fewer physical activity opportunities.

Social interaction skills have also been tied to a child's motor skills. A study on 21 preschoolers found that those who had poor coordination and motor skills had more social interaction issues compared to their peers during half an hour of recorded play time (Kennedy-Behr et al., 2011). They spent more time as spectators and participated with less intensity than the rest of their peers (Kennedy-Behr et al., 2011). Since participation is more sedentary among those with low motor and social skills, they engage in less physical activity which increases their obesity risk compared to peers (Tate et al., 2013). Those with lower motor and social interaction skills also had more negative experiences due to their own aggression or the being on the receiving end of aggression from other children (Kennedy-Behr et al., 2011). Negative incidents could potentially discourage participation in future group play which could also negatively impact physical activity. Based on the findings of these studies, autistic children and adolescents who exhibit poor motor and social interaction skills may engage in less physical activity than their typically developing peers. These low physical activity levels contribute to the child's risk of obesity (Tate et al., 2013).

Mental Health

Many individuals who have autism are also impacted by a mental health disorder. In a study involving 143 autistic adults in Wisconsin, 72.0% had a diagnosed psychiatric disorder (Bishop-Fitzpatrick & Rubenstein, 2019). Another study involving 1,507 autistic adults in a Northern California healthcare organization found that 54% had been diagnosed with a psychiatric disorder (Croen et al., 2015). Depression or anxiety were the most common co-diagnosis followed by bipolar disorder, obsessive-compulsive disorder, and schizophrenia (Croen et al., 2015). Mental health disorders are not unique to adults. Children and adolescents who have autism also experience mental health problems. Attention-deficit hyperactivity disorder, social anxiety disorder, and oppositional defiant disorder have been found to be the most common co-diagnoses for children who have autism (Simonoff et al., 2008). Of 112 children who had autism, 70% had at least one and 41% had at least two additional disorders (Simonoff et al., 2008). Mental health problems have been shown to be associated with obesity (Kim et al., 2020). Therefore, the higher prevalence of mental health problems is a contributing factor to the higher prevalence of obesity among children and adolescents who have autism.

Social Determinants of Health for Children and Adolescents with Autism

The social determinants of health for pediatric patients with autism differ from the social determinants of typically developing children and adolescents. These factors impact obesity risk as well as the efficacy of potential mobile health technology interventions. The research on social determinants of health can be used to determine how to adapt programs to be more practical and effective for people who have autism.

Neighborhood and Built Environment

The neighborhood environment is one factor that could influence the efficacy of traditional interventions for children and adolescents with autism. Within the population of children who have autism, an analysis of data from the National Survey of Children's Health on 494 autistic children was done to investigate the neighborhood environment's impact on physical activity participation (Fiscella et al., 2021). The analysis found safety to be the most important neighborhood environment factor that impacted physical activity while the built environment had no significant impact on participation in children who had autism. The lack of impact from the built environment differed from the general population which experienced significant benefits to physical activity due to the availability of parks, playgrounds, and sidewalks (Fiscella et al., 2021). Since built environments are not usually designed specifically for children with autism, the built environment in most neighborhoods might not contribute to physical activity participation in children who have autism the way it does for the general population. Reduced participation in physical activity provides another possible explanation for the higher rates of obesity experienced by children and adolescents who have autism.

Transportation

Depending on the activity opportunities in the neighborhood, children and adolescents who have autism may need to travel to access other physical activity opportunities. In a study on perceptions about driving, adolescents who had autism experienced significantly higher perceived driving difficulty, emotional dysregulation, depression, anxiety, and stress than the adolescents who did not have autism (Fok et al., 2022). Due to these factors, autistic adolescents often do not obtain a driver's license and are limited in their ability to transport themselves. They may be more reliant than the general population on public transportation or rides from family

and friends to access exercise facilities. Since low physical activity is a risk factor for obesity (Tate et al., 2013), autistic children and adolescents who rely on others for transportation and experience limited access to physical activity resources may be at a greater risk for obesity.

Economic Stability

Economic stability can heavily influence health by impacting a person's access to technology. The first wave of COVID-19 exposed socioeconomic disparities as telehealth was increasingly utilized in healthcare settings. People who were classified in the lowest quartile of income were less likely to have a virtual telehealth appointment and more likely to complete their visit over a phone call (Darrat et al., 2021). These findings suggest people who have a lower socioeconomic status may not receive the same level of care compared to people who are able to meet virtually. In children who have autism, neighborhood economic status has also been shown to impact development. Compared to neighborhoods with higher socioeconomic status, a Canadian study found that autistic children who lived in a low socioeconomic status neighborhood were more susceptible to developmental weaknesses in social competence, communication skills, and general knowledge (Siddiqua et al., 2020). In interviews of six families with a child diagnosed with autism, parents reported how their child's social deficits resulted in limited physical activity participation (Ayvazoglu et al., 2015). The negative impact of low socioeconomic status on social interaction skills for children with autism contributes to lower physical activity levels which is ultimately a contributing factor for obesity (Tate et al., 2013).

Healthcare Access and Quality

Access to quality healthcare is another determinant that impacts children and adolescents who have autism. Studies on parents of children with autism showed that parents often felt

disregarded by their health care provider when they initially brought their child in due to developmental concerns. When providers blamed the problematic behaviors on parenting rather than diagnosing the child with autism from the start, problems intensified. The children missed out on services designed for children with autism until they were officially diagnosed (Bonis & Sawin, 2016). The lack of access to doctors who understood and recognized autism was a healthcare barrier that kept autistic children from having obesity risks addressed through an autism-specific lens.

Education Access and Quality

Education access and quality can also influence obesity risk for autistic children and adolescents. Many children who have autism have an Individualized Education Program (IEP) that follows them throughout their schooling. An IEP evaluation tool was used to assess the quality of 35 students' IEPs and found that service quality was equal despite any different factors related to the students. However, the service quality was equally poor rather than equally beneficial to students (Ruble et al., 2010). In addition to the services being subpar, the use of services was found to decrease for autistic children with each year as they progressed through the school system (Laxman et al., 2019). Poor quality services and the loss of services throughout the child's schooling could both contribute to educational disparities between students who have autism and the rest of the students at the school. Children develop their reading skills within the school system, and as mentioned previously, reading comprehension impacts a person's ability to read and understand health material. Therefore, education access and quality impact the understanding of written nutritional and physical activity information which influences obesity risk.

Social and Community Context

Family Systems

Social and community context are perhaps the most important factors that affect young people who have autism. Parents of children with high functioning autism reported that they had trouble meeting the needs of every family member due to the increased responsibilities of parenting a child with autism (Ayvazoglu et al., 2015). Some mothers reported quitting their job in order to stay home and support their autistic child which halved the family's finances. Marital strain was also reported which has led to higher rates of divorce for parents of autistic children compared to the general population (Bonis & Sawin, 2016). Other parents of autistic children felt that they lost friendships with other parents due to their children struggling to socialize together (Bonis & Sawin, 2016). Some families also stopped attending church services and lost support from their church community due to complaints about their child's behavior during church (Bonis & Sawin, 2016). Ordinary family challenges were only amplified by the recent COVID-19 pandemic (Lee et al., 2021). Parents of children diagnosed with autism face additional strain and a lack of support compared to parents of typically developing children. It may not be feasible for these parents to cook nutritious meals every night or facilitate additional physical activity opportunities for their children which are factors that impact obesity risk.

Parental Involvement

Parental involvement with child feeding practices can also have a significant impact on the child's health. A study on 261 autistic children and their parents found that children whose mothers who reported high concern about their weight experienced a heightened risk of obesity (Eow et al., 2021). In another study that included children who had autism, Down syndrome, and spina bifida, 262 of the 356 parents surveyed were worried about the weight of their child

(Polfuss et al., 2017). Parents who voiced concern about their child's obesity were also more restrictive of their child's eating behaviors than parents who were not concerned by their child's weight (Polfuss et al., 2017). This restrictive feeding could contribute to the child's obesity if the child acquires a craving for and overindulges in the foods that are restricted (Polfuss et al., 2017). Food limits may also interrupt the child's instinctual hunger cues which could lead to them overeating because they cannot discern when they are hungry or full (Polfuss et al., 2017). These findings suggest overly restrictive parents may actually contribute to their autistic child's obesity risk.

Interventions

Mobile Health Technology Interventions

A variety of electronic interventions for obesity have been designed for the general population. Perhaps most related to the Conversa app utilized by Prisma Health, chatbots such as WeightMentor have been developed to provide several benefits to users (Holmes et al., 2018). The chatbot was designed to be compatible with Facebook messenger on any computer or smart device which would allow for easy access. Since users would anonymously communicate with a robot, anxiety about truthfully answering health related questions would also be reduced (Holmes et al., 2018). Being open about health concerns would be beneficial since the patient could receive health advice on concerns they might not have mentioned in an in-person setting.

Some pilot studies on electronic health obesity interventions have also been successful, including a study involving 51 girls who were part of a minority. Participants experienced moderate increases to their fruit and vegetable consumption and moderate decreases to their consumption of sugar-sweetened beverages following the twelve-week program (Nollen et al.,

2014). Although mobile interventions may not always create the strongest response, this study demonstrates that mobile health technology can be utilized by anyone who has a smartphone as a simple way to prompt small improvements to nutrition. An intervention involving 80 African American girls who were enrolled in a home computer program to receive emails about nutrition and physical activity was also successful. Participants received five dollars for every week that they completed all activities assigned over email. Following the program, the girls reported significantly higher fruit and vegetable consumption as well as increased physical activity (Thompson et al., 2008). The health improvements associated with these interventions are promising for future electronic programs.

Despite these successes, certain limitations to participation or program efficacy need to be addressed. Although the home computer intervention was successful for participants in improving nutrition and physical activity, lower-income girls were excluded because they had no access to a home computer (Thompson et al., 2008). Thus, economic factors can potentially impact the feasibility of any programs involving electronics. Another study used the myBigO app and smartwatches to measure physical activity through movement tracking. Attrition rate was 63% in the group assigned to participate in the intervention, and only 50% of the children participating in the study logged any physical activity on their smart watches (Browne et al., 2020). There were various reasons for this failure to participate in the electronic intervention including children disliking the feeling of wearing the smartwatch, the data not syncing correctly to the parents' phone, or the parent deleting the app altogether to save phone storage (Browne et al., 2020). Although a variety of limitations need to be considered, the successes of technology-based interventions in the general population suggest that the efficacy of this intervention type is worth studying for children and adolescents who have autism.

Mobile Health Technology Interventions for Children and Adolescents with Autism

Current interventions may be even less practical for the special population of children and adolescents who have autism due to additional barriers. In 2021, Ketcheson and Pitchford published a conceptualization of a telehealth obesity intervention designed for autistic children and their families. Both live Zoom sessions and prerecorded videos were planned to be utilized every week to teach the viewers a physical activity skill as well as how to make a nutritious recipe (Ketcheson & Pitchford, 2021). Involving family members in this intervention design was one way to increase the feasibility of a study by accounting for an autistic child's family system. The many other social determinants of health for children and adolescents with autism need to be considered to address how they might impact potential electronic interventions.

Impact of Coexisting Conditions on Intervention Efficacy

In addition to their impacts on obesity risk, coexisting conditions of autism have implications on the efficacy of mobile health technology obesity interventions. In comparison to interventions designed for typically developing children, interventions for autistic children may need to incorporate activities appropriate for each child's level of motor skills or include support for motor development. Reading and comprehension skills can also influence the effectiveness of health interventions. A mobile health app would not be effective for children who are unable to read and understand the alerts they receive. Children with high functioning autism could potentially take part in a mobile health intervention with no problems, but children with more severe autism may need the app to be adjusted to the appropriate reading and comprehension level in order to benefit from the intervention. In terms of social interaction skills, interventions designed for children who have autism could increase feasibility by suggesting social play opportunities as well as possible physical activity alternatives that can be completed as an

individual. The mental health of autistic children and adolescents is another important consideration. Each co-diagnosis opens the potential for different social determinants of health that could impact the efficacy of a health intervention. Knowing and understanding all the child's diagnoses is vital to determining if they could benefit from the mobile health technology intervention format.

Impact of Social Determinants of Health on Intervention Efficacy

The social determinants of health related to autism impact how an autistic child or adolescent might experience a health intervention. Neighborhood environment factors including the built environment and transportation access need to be taken into consideration in order to design an effective program plan. For example, recommendations to utilize the neighborhood's built environment may not result in the same benefit for an autistic child as it might for a typically developing child. Additionally, the increased likelihood of reliance on others for transportation may limit the effectiveness of intervention tasks that require transportation. The feasibility of mobile health technology intervention tasks may increase if they can be completed successfully from home.

Economic instability can limit access to technology and hinder the effectiveness interventions that rely on mobile health technology. The developmental issues related to the socioeconomic status of autistic children (Siddiqua et al., 2020) may also limit their ability to understand and engage with mobile health technology. Healthcare quality can impact the effectiveness of interventions if doctors are unable to recognize and diagnose autism. A lack of an official diagnosis may result in the child participating in programs designed for typically developing children without considering autism-specific factors. The lack of adjustments for these factors may limit the intervention's efficacy. Access to quality education may also improve

the efficacy of mobile health technology interventions. Better and more consistent educational resources throughout schooling could provide children and adolescents with autism with the reading comprehension skills to make intervention participation more effective.

Social and community context can affect the feasibility of interventions. The additional strains placed on parents of autistic children (Ayvazoglu et al., 2015) may inhibit them from assisting their child's participation in a mobile health technology intervention. The amount of parental assistance necessary for an intervention should be taken into consideration when designing the program. The negative impacts of restrictive feeding (Polfuss et al., 2017) also suggest that restrictive intervention programs could have adverse effects on autistic children. These outcomes should be considered when establishing the intensity of the obesity intervention during the design process.

Application to Wellness Engagement Chat

Certain modifications to the Wellness Engagement Chat could make the intervention more useful for participants who have autism. Typically, adolescents who are sixteen or older can participate in the program on their own without parental consent. Participants who have autism would likely benefit from co-engagement and additional support from parents as they progress through the program. Autism severity may impact the child's ability to read and comprehend the mobile health technology messages utilized by WE Chat. Parental support could help address any deficit to the child's reading and comprehension skills. Family involvement would also be helpful for the arrangement of physical activity opportunities, any necessary transportation, and the supervision of social interactions. WE Chat also has a social-emotional component that assumes the child experiences typical social-emotional development. The stress,

emotions, conflict resolution, and social-emotional needs associated with WE Chat may create difficultly for children and adolescents who have autism and necessitate additional support.

Summary

The success of technology-based interventions in the general population shows that mobile health technology interventions have the potential to be beneficial for obese children and adolescents who also have autism. The high prevalence and adverse outcomes related to obesity in children and adolescents who have autism emphasize the need for interventions designed specifically for that special population. A current limitation is that there is little autism-specific research related to obesity and mobile health interventions like WE Chat. Children and adolescents may experience interventions differently due to their social determinants of health and individual outcomes. Accounting for these differences in future program designs could improve both the practicality and efficacy of mobile health technology interventions for that special population.

Methods

In order to research children and adolescents with autism and their experience with mobile health technology, qualitative data was collected through two methods. In depth, semi-structured healthcare provider interviews were conducted to learn more about what providers consider when recommending mobile health technology for patients with autism. A group discussion with people diagnosed with autism and parents of children with autism was also led to learn about past mobile health technology experiences and considerations for future technology development.

Healthcare Provider Interviews

Healthcare provider interviews were conducted to learn more from providers about their experiences with mobile health technology as well as with children and adolescents who have autism. The leader of the efforts to develop WE Chat was contacted by email and asked to participate in an interview. This doctor was also asked to recommend other pediatric healthcare providers within the Prisma Health system who treat children with autism and who may have experience recommending lifestyle behavior management programs. This provider agreed to participate and recommended multiple others to contact. Three additional providers were contacted by email, and all three agreed to participate. In total, four interviews were scheduled and completed virtually with Microsoft Teams between November 4, 2022 and November 11, 2022.

A written interview guide was approved by the Prisma Health Institutional Review Board prior to the interviews. The first part of the interview was focused on prior experiences with mobile health technology and recruitment considerations. The second part of the interview was focused on factors related to autism that could impact experience with mobile health technology. These topics included motor skills, social interaction skills, sensory issues and hunger cues, support systems, and other accessibility barriers. The interview was designed to last fifteen to twenty minutes. Participants were made aware that there were no wrong answers, they could skip any questions, and there was no risk related to participating in the interview. All four participants agreed to participate and agreed to their responses being recorded. Recordings were later reviewed and used to identify common themes and differences between the four healthcare providers.

Patient Engagement Studio Discussion

In addition to provider interviews, a discussion in the Patient Engagement Studio was conducted to learn more from the perspective of individuals who have autism as well as parents of children from autism. A meeting with the director and the program manager from the University of South Carolina's Patient Engagement Studio took place to propose the presentation and request help with recruiting the desired audience. A presentation template was then completed and submitted to the program manager for review. Upon review, the project manager provided suggestions on how to phrase the questions to stimulate better conversation and feedback. The final updated presentation was submitted two days prior to the scheduled discussion.

The Patient Engagement Studio discussion took place on October 26, 2022 virtually through Webex. The Patient Engagement Studio manager and director recruited six patient experts to participate including two young adults diagnosed with autism and four parents of children diagnosed with autism or otherwise neurodivergent. The first ten minutes of the meeting were made up of introductions from the hosts and participants followed by a brief presentation about the topics and goals of the discussion. The next fifty minutes of the meeting consisted of a discussion with the patient experts. Topics included prior mobile health technology experiences, reading and cognition, motor skills, social interaction skills, transportation, nutrition, and major takeaways. Notes were taken by the researchers and a detailed report written by the Patient Engagement Studio was reviewed to identify common themes mentioned by young adults with autism and caregivers of children with autism.

Results

Feedback from Healthcare Providers Summarized by Question

Four healthcare providers within the Prisma Health system were individually interviewed to learn more about prior experiences and the factors they consider when recommending mobile health technology. Results are organized based on the semi-structured questions asked during each interview. Several emerging concepts that were not specifically mentioned in questions are also described.

What mobile health technology applications have you suggested for patients to try?

Providers mentioned a variety of mobile health apps they have recommended for patients. The provider in charge of developing WE Chat regularly suggested that resource to patients as a healthy weight lifestyle intervention. MyFitnessPal was also suggested by two providers to use for tracking food and water intake as well as physical activity. Other nutrition focused apps or websites that were mentioned included Dr. Yum and MyPlate. One provider also recommended the meditation app called Headspace.

In terms of mobile health technology recommendations specifically for children and adolescents with autism, two providers had experience making recommendations for this population. One provider recommended downloading the YouTube app in order to access specific health videos created for children with autism. Another provider recommended an app called Goally as an applied behavioral analysis tool. This app was specifically designed for children with special needs and provides a visual schedule to help establish daily routines. This provider also occasionally recommended technology that required a fitness band, a tablet, and subscription to an app. The provider could not recall the specific name of this app but reported

that the purpose was to help with self-regulation by playing games on the app while the fitness band measured heart rate.

How do you identify which patients you would suggest these applications for? Probe: Thinking about reading level and cognition, how do you decide which children would benefit from independently using a mobile health app?

Providers mentioned an assortment of factors they consider when identifying patients who might benefit from mobile health technology. Several of the providers emphasized that their recommendations were contingent on cognitive ability. They recognized that some children may be able to participate independently, others may need assistance from a parent, and others may require apps that have been adapted to match their cognitive ability. Two providers reported that they were able to identify families who were interested in mobile health technology because they would often come in asking for resources to address a developmental concern. One provider mentioned that some families brought up technology that had already been recommended by their speech language pathologist. If the child's speech language pathologist suggested the app, it was usually a good indication that the app was cognitively appropriate for the child.

How might a child with autism's motor skills impact their experience with mobile health technology? Probe: What are some examples of physical activities that could be suggested for people who have lower motor skills?

Providers generally agreed that the most important motor skill for mobile health technology use was the ability to use the mobile device. Smaller devices such as a phone could be more difficult to use than larger devices like a tablet. Additionally, apps that require lots of manipulation would be more challenging than apps that just require tapping. In terms of the activities that could be suggested by a mobile health app, providers agreed that activities

involving fine motor skills could be a barrier to participation. Several ideas were offered for physical activities appropriate for people with lower fine motor skills. Multiple suggestions from providers incorporated the support of family members. One recommended exercising with family so that the family could assist or modify challenging movements. Another provider proposed the idea of creating a visual scavenger hunt in which the parent names something for the child to find and bring back in a set amount of time. This activity would be novel to the child and affordable and easy to execute for the parent. Another suggestion was to examine the child's abilities on a case-by-case basis and make activity modifications to match those abilities. Parental support and activity modifications could both be incorporated to improve mobile health technology experience.

How might a child's social interaction skills impact their experience with mobile health technology?

An autism diagnosis is often associated with social-emotional interaction impairments. Two providers agreed that social interaction skills would have the most impact with apps that are very interactive or have lots of steps to follow. Another provider described how children with autism may be more rigid with the recommendations they read and have a very literal interpretation compared to other children. The steps to use an app come naturally to many children, but children with autism may have to be taught to use an app and how to interpret its messages. Despite the barriers that may arise due to the social-emotional components of mobile health technology, one provider highlighted how many children with autism really enjoy the rigidity and routine of following a digital tracker. Parents are sometimes surprised to see how engaged their child is with mobile technology when they may not show engagement during conversations or other activities with peers.

Apps like "My Food – Nutrition for Kids" help children learn about good nutrition. How do these apps help or benefit children who are picky eaters due to food sensory problems?

One provider shared that repetitive patterns with a lack of variety can lead to children becoming picky at a young age which is magnified even more in children who have autism. When combatting picky eating, there may be other factors at play including sensitivities or swallowing difficulties. Apps may have great suggestions, but one provider emphasized that they need to be used in conjunction with a therapist to discuss how they can be used safely and with additional support.

Even when children have rejected certain foods, several providers emphasized the need for parents to stay open-minded and reintroduce foods in a variety of ways. In the case of texture issues, one provided recommended blending fruits into a smoothie or blending vegetables into pasta sauce. One nurse practitioner specifically recommended the Meal-o-matic feature on the Dr. Yum website as a resource for picky eaters. Meal-o-matic allows the child to choose a type of meal, choose a variety of ingredients to include, and then generates the corresponding recipe and nutrition information. The provider discussed how she directs patients to the website during their visit and guides their choices by describing the different vegetables. The child's "first homework assignment" is then to prepare and try the meal at home. In her experience, Meal-o-matic has been successful because choices are attractive to children, and children also like to take control of their own eating. One adolescent with autism under her care went from eating zero to twelve different vegetables within the span of a month after trying Meal-o-matic.

What concerns do you have about interventions that involve specific nutrition plans, particularly related to if they pose a risk for interrupting instinctual hunger cues?

Providers agreed that overly restrictive diets are inappropriate for children. For children and adolescents with autism, one provider emphasized that there is no evidence-based diet shown to be effective for all of that population. Generally, the goal of pediatric nutrition is to get necessary nutrients and appropriate portions. Although fad diets may be popular in the media, restrictive eating patterns in childhood can lead to the development of eating disorders. While parents usually have the best intentions, they may be overly restrictive. Providers mentioned that nutrition apps should be used under the guidance of a nutritionist, pediatrician, or speech language pathologist to ensure a child is getting adequate nutrition for healthy development.

Are there any other barriers you would anticipate for a child with autism concerning the structure or content of existing mobile health technology?

Multiple providers mentioned that limited access to broadband internet would be a barrier for any person trying to use mobile health technology. Families who do not have access to the internet at home have to be more reliant on transportation to locations that provide free internet access such as libraries or coffee shops. While some individuals who have autism can drive, all children and some adults may be reliant on rides from friends and family. One provider recommended making patients aware of bus availability in the area or if they qualify to utilize a Medicaid transportation service. In addition to access to the internet, one provider stressed the importance of digital literacy. Mobile health technology users must also be able to navigate the apps and websites that have been recommended to them.

Would co-engagement in the program with a parent address these concerns?

Providers had varying feedback regarding co-engagement with parents. Several felt that co-engagement would be a way to address all of the aforementioned barriers. Since children often care the most about short-term satisfaction, one provider argued that parental involvement

is key for all children to make good long-term decisions. On the other hand, some providers weighed in on the potential conflicts that could be introduced by co-engagement. One of the providers who also parents a child with autism discussed how some children with autism may want to be more independent or fail to recognize the need for parental assistance. In order to avoid frustration, a parallel support app could be a helpful option for providing support while still keeping some boundaries.

Three out of four providers also mentioned how parents can become frustrated if an app makes recommendations that do not work for their child. Two providers emphasized encouraging parents to be persistent and keep trying. In terms of food sensory problems, these providers advised the reintroduction of food on multiple occasions and prepared in several different ways. Another provider stressed the importance of providing realistic expectations with mobile health technology use so that parents are not discouraged if major changes do not happen right away.

Emerging Concepts

Autism Variability

Several concepts were brought up during conversation even though they were not specifically related to the questions asked. The most common concept mentioned by the providers was the variability of autism. Autism is not a homogenous diagnosis which means each child can vary in cognition, fine motor skill ability, social skills, and eating behaviors. Therefore, any app designed for people with autism must be adaptable to meet specific parameters that change case by case. One provider specifically mentioned that WE Chat lacked decision trees and would need more branching adaptations to be beneficial for children and adolescents with autism.

Cost of Participation

Another common topic was the financial barrier that can be created by the expenses of mobile health technology. The cost of the required devices as well as the cost of the app or any necessary subscriptions influenced whether it was worth making a recommendation. While augmentative and alternative communication devices can be incredibly useful, they are not always covered by insurance. Expensive devices can also be accidentally broken since they are regularly used by children. One provider summarized her stance by saying “I don’t think you should have to pay to be healthy” and discussed how this belief influences which mobile health technology she is willing to recommend.

Interdisciplinary Support

Each healthcare provider mentioned the value of support from other disciplines. Physical therapists, occupational therapists, and speech language pathologists were all mentioned as vital resources for creating the best experience for children and adolescents with autism. While pediatricians may be well versed in giving recommendations for picky eaters, one provider mentioned how a speech language pathologist could give better advice on tolerating textures for children with autism. Another doctor stated how speech language pathologists and medical doctors will work together to prescribe an augmentative and alternative communication device. In addition to speech language pathologists, one provider mentioned how a care team with multiple disciplines can provide patients with a variety of helpful resources. Able SC, for example, is a resource that could be suggested to help find accessible parks or provide access to transportation. Parent forums are another way for families of children of autism to collaborate and support each other by sharing specific resources. Overall, the healthcare providers who were

interviewed advocated for collaboration between disciplines to best support children and adolescents with autism.

Feedback from Patient Experts Summarized by Discussion Topic

The University of South Carolina's Patient Engagement Studio brought together a group of participants consisting of two young adults with autism and four parents of children with autism. These patient experts discussed prior experiences with mobile health technology as well as a variety of factors that could influence their experience. Several emerging topics that were not included in the planned questions were also discussed during the conversation.

Prior Mobile Health Technology Experiences

Patient experts reported the use of fitness trackers such as Fitbits and Apple watches. Reasons for using these apps included schedule integration, assistance during transitions, and facilitating independence. One patient expert mentioned the app TracknShare which they used to record a variety of health-related information including food intake, exercise, medications, and mood. TracknShare also has a specialized Autism tracker that can be used to track behaviors. Patient experts also reported the use of mindfulness apps such as Headspace and Calm.

Reading and Cognition

The two young adults with autism who participated in the discussion were both students in medical school with very high cognitive skills. A parent also spoke of how their child with autism was reading at the college level as early as fourth grade. Despite the high reading level, the parent also pointed out that reading skills do not equate to the health literacy needed to comprehend health information that might be included in a mobile health app. On the other hand, another parent described a child with autism in their extended family who is nonverbal and has

cognitive deficits. This child requires assistive technology as their main form of communication. These differing responses highlighted that cognition widely varies for individuals who have autism. Patient experts felt that it was important for app developers to know that making an app for children with autism is different than designing an app for people with lower intelligence.

Motor Skills

One parent described her child's difficulties with fine motor skills and suggested for apps to include activities that require only basic motor skills. Several participants agreed that activities like jump roping or gymnastics could be too challenging for children with low fine motor skills, proprioception issues, and coordination struggles. More basic activities like walking or running would be more inclusive of children with fine motor skill difficulties. In contrast, one adult with autism explained that they had less of a problem with motor skills and more of a problem with understanding why activities would benefit them. This patient expert reflected on her childhood and recalled how running "seemed like the most pointless thing" since she "ended up in the very same place". However, running for activities like dodgeball was more appealing since there was a clear objective. Her suggestion for encouraging physical activity was to include reasoning in each prompt. She provided the example "if you want to learn how to jump higher, try this activity and do some squats".

Overall, patient experts agreed that motor skills of children and adolescents with autism vary from person to person. While basic activities would be the most appropriate for some children, others may be able to complete more advanced activities. Participants suggested an app that would allow participants to set parameters based on their ability level in order to receive appropriate physical activity recommendations. Another idea was to provide two options of varying difficulty with each prompt so that users could select a suitable activity.

Social Interaction Skills

Patient experts spoke of how social interaction skills could be accounted for in activity recommendations suggested through an app. One mother of a child with autism suggested solo physical activity recommendations or activities that involve one friend or a small group. Based on this parent's previous experience, activities that involved their child interacting with a large group were too overwhelming. In the case of group activities, a young adult with autism spoke in favor of providing defined roles. She felt more successful socially when she had a clear understanding of her responsibilities.

Patient experts also recommended designing a health app that would foster social interaction. People with autism may experience isolation more than the general population, but a mobile health app can provide an opportunity to connect with others. One suggestion was to assign each user a buddy of the same gender and age to help establish a social connection. Another parent suggested having stars or badges that can be earned by completing different activities. A child's stars or badges could be displayed on their user profile, and viewers could "cheer them on". Interactions that take place "behind the screen" could create a since of safety. The parent explained that online interactions would keep a child from worrying about skills that might be challenging like maintaining eye contact. An interactive aspect could encourage program participation and help with the development of social skills.

Transportation

Access to transportation varied among the group. Several parents indicated their children were entirely reliant on others for transportation. One teen had a learners permit but was not a confident driver. Other participants who had autism were able to drive independently. When asked about bike riding as a transportation option, parents reported different levels of comfort

with their child riding a bike unsupervised. One of the young adults with autism recalled bike riding experience from his teenage years. He had the motor skills to successfully ride a bike but did not understand why his parents were so concerned with him riding on main roads when it was dark outside. Both the physical ability to ride a bike and the ability to make appropriate judgements can impact the safety of riding a bike.

Support Systems

Parents advised app developers to consider the cognitive load that can be placed on the caretakers of children with autism. One parent described remembering to bring charged watches, phones, and tablets as "one more layer of things that we need to do." In addition to day-to-day tasks, parents may not have lots of extra time to spend co-engaging in a mobile health app with their child. When adapting an app for children and adolescents with autism, developers should consider the strains each aspect could place on parents.

Nutrition

Participants agreed that it would be helpful to set parameters within an app or provide a variety of options to accommodate picky eating due to sensory issues. One of the patient experts with autism mentioned how one specific food recommendation may not be appealing, but he would be more likely to choose something from a list of options. A parent also mentioned how there are certain foods their child would absolutely refuse to eat. Setting parameters based on food preferences would be helpful so that the app could generate personalized suggestions for that child. Another individual with autism suggested providing an explanation of why certain foods are healthy. She indicated a greater willingness to comply with recommendations if an app explained how foods would benefit her.

Emerging Concepts

Autism Variability

All patient experts agreed that levels of social impairment or physical impairment are highly variable among individuals with autism. Patient experts proposed two possible solutions that could be incorporated into a mobile health app. The first suggestion was to include optional "parameter identifier questions" that could be filled out to generate a more personalized experience. Users could select their reading level, food preferences, fine motor skill level, and times of day they would like to receive alerts. The user could also input their zip code and select the distance they are willing and able to drive for an activity.

The other suggested solution was an option that did not require the development of branching logic. "This or that" prompts would suggest two options with every recommendation alert. For a physical activity prompt, the app might suggest fifteen minutes of basketball or fifteen minutes of jogging outside around the house. This provides two options that differ in the fine motor skills required to successfully complete the task. Another example was the choice between a sweet or savory balanced snack. The "this or that" method would allow the child to have autonomy in their mobile health technology experience without presenting an overwhelming number of choices.

Safety Concerns

Safety was a common concern mentioned by the patient experts. Many individuals with autism take statements extremely literally, so any prompts generated by an app must be very specific. A child may walk all the way out of the neighborhood without telling anyone if a prompt tells them to go on a walk. "Check with your parents first" should be a prompt that comes before a suggestion to ride a bike or go on a walk. Additionally, children with autism may

not recognize that it is unsafe to ride their bike or go on a walk when it is dark outside. Outdoor activities should not be suggested after sunset. Specific wording and timing of prompts must be considered to ensure safety when completing activities.

Auditory and Visual Components

Patients discussed several auditory and visual components that should be taken into consideration by app developers. Visually, patient experts said that pictures and other visual cues would be a useful tool to help understand any auditory or written components. A young adult with autism agreed that engaging visual components would make them much more likely to read than a basic wall of text. However, patient experts also discussed the importance of making sure engaging components did not become a hindrance to the experience. While one person with autism spoke in favor of visual stimulation, one parent felt that too many things on one screen would be overwhelming to her child. She suggested a minimalist approach with a calming color scheme. A young adult with autism also expressed that if an app surprised her with a really loud noise, she would shut it off and never turn it on again. Vibrations were also mentioned as a sensory component that needs to be considered.

Discussion

WE Chat Recommendations

Parameters and Choices

Incorporating branching logic into WE Chat would address many of the varying factors related to mobile health technology experience. In terms of reading comprehension, reading level might not match a child's physical age. Patient experts reported both a child with autism reading at the college level and a child with autism reliant on pictures for communication. These findings

were in support of the study that found that increased autism severity was correlated with lower reading comprehension (McIntyre et al., 2017). Due to these varying levels of cognition, health care providers emphasized the importance of adapting mobile health technology to match each child's cognitive ability. WE Chat could include an option to select a reading level. Users with a lower reading level could receive basic prompts with pictures to help with understanding. Those with higher reading levels could opt-in to a more detailed experience that includes reasoning for the different recommendations.

Physical activities recommended for the general population through WE Chat may or may not be inclusive of children with autism. In a study on thirty children with autism, those with better motor skills participated in complex physical activities more than those with lower motor skills (Oliveira et al., 2021). Patient experts supported the literature by demonstrating the varying degrees of fine motor skills that are observed in the population of children and adolescents with autism. One parent felt that their child would only be able to complete activities that require basic motor skills. One the other hand, one young adult with autism shared that her impairment was more related to social skills and had less of an impact on her fine motor skills. In order to address these differences, one of the providers recommended evaluating patients on a case-by-case basis and modifying activities to fit their ability level. A prompt for a child with higher motor skills could include activities like jumping rope or dribbling a ball. For children with lower motor skills, one provider recommended prompting a scavenger hunt around the house. Allowing users to set parameters for their level of fine motor skills would filter the experience so that the child would receive prompts appropriate for them.

Social interaction skills also vary from person to person. Some children might really enjoy prompts that include social interaction such as the suggestion to play a game of pick-up

basketball with other children at the park. In previous interviews on the families of children who have autism, parents described how their child had reduced physical activity participation due to their poor social interaction skills (Ayvazoglu et al., 2015). Patient experts from the Patient Engagement Studio also suggested that activities involving one friend or a few friends would be less of a barrier than large group activities. App developers could account for different levels of social interaction skills by allowing users to set preferences for solo, small group, and large group physical activity recommendations.

In children with autism, one provider emphasized how sensory sensitivities and swallowing difficulties may prevent them from eating certain foods. Traditional methods included in nutrition apps to address picky eating may not be an effective solution to these problems. Parents also discussed how their child would never eat certain foods regardless of how they were presented through mobile health technology. An option to select food likes and dislikes would allow WE Chat to make nutrition recommendations that the child is more likely to try. Another provider shared how choices are popular among children. A young adult with autism confirmed that one recommendation might not appeal to him at a specific moment, but he would be more likely to select a healthy meal from a list of choices. Prompts with several options would increase the likelihood of following WE Chat recommendations. Overall, the option to specialize the in-app experience by setting parameters or providing different choices would address the variability of physical and social impairments related to autism.

Auditory and Visual Components

For the general population, auditory and visual components within mobile health technology can be used as a tool to increase engagement. However, patient experts agreed that loud noises or surprising vibrations could be undesirable for many individuals with autism. This

is supported by literature on sound sensitivities which reported that 50% to 70% of people who have autism have "decreased sound tolerance (DST) at some point in their lives" which can lead to "significant distress and impairment" (Williams et al., 2021). The option to enable or disable any sounds or vibrations would accommodate different preferences by allowing users to customize their experience. Those who have increased engagement as a result of sounds could enable the feature while those who are deterred by the sounds could still participate by disabling the feature.

Advice on the visual components of mobile health technology varied from person to person. The Meal-o-matic feature on the Dr.Yum website was highly recommended by one of the healthcare providers for children with autism. This resource is bright, colorful, and engaging with lots of different food options. One of the patient experts with autism also emphasized how she would want to use mobile health technology that involved engaging visuals rather than text alone. Another parent suggested including a variety of stickers and badges that could display a child's achievements on their profile and add to visual engagement. In contrast, some parents expressed concern that excessive visuals would be overwhelming to their child. One parent proposed that any prompts involving choices should be limited to two options at a time. Several parents were in favor of this minimalistic approach along with calming background colors.

The current literature on sensory sensitivity supports these differences in preference. A study on assistive robots found that the sensory sensitivities of individuals with autism did influence the results of robot-assisted therapy. These researchers recommended for the robots to be programmed for "different levels of intensity that can be adapted to the individual's sensitivity" (Chevalier et al., 2022). Likewise, WE Chat should create a default for the general

population that is very engaging but provide the option to simplify visuals and choices for those who would be overwhelmed.

Safety Considerations

All of the patient experts expressed safety concerns related to mobile health technology participation. Parents discussed how their children can read or listen to information but often have a very literal interpretation. For example, if an app prompted the child to go for a walk, they might immediately walk a large distance from the house without consulting the parent. As mentioned in the literature review, studies found that even those with autism who were able to read words still often struggled with comprehension (Baixauli et al., 2021). This helps to explain the tendency of people with autism to literally interpret the content they read. Due to the range of cognition levels, providers responded similarly to patient experts, saying that children with autism might benefit from modified prompts to match a range of comprehension levels. Patient experts recommended providing specific prompts to ask for a parent's permission to address these concerns about literal interpretation.

Patient experts also pointed out how a lack of safety awareness could contribute to dangerous situations. One individual with autism specifically recalled times in high school that he would bike alone in the dark without realizing why that presented a safety concern. Potential safety concerns during solo activities include traveling too far from home, chasing a ball into the street, and a lack of motor skills to react quickly to oncoming cars. Again, prompts to consult the parent would create the opportunity for parents to establish any other necessary rules and boundaries. The recommendation for WE Chat to include this type of prompt would be a crucial safety feature and also help to ease the mind of parents.

Support Systems

In previous research on parents of children with high functioning autism, parents reported that increased responsibilities and difficulties with meeting the needs of every family member (Ayvazoglu et al., 2015). Multiple parents of children with autism from the Patient Engagement Studio discussion also mentioned the cognitive load and strain that can come as a result of caring for children with autism. Parents mentioned how tasks associated with mobile health technology such as remembering to bring charged devices would just add "one more layer of things" for parents to worry about. Due to these additional loads, parents may not have the time to co-engage in mobile health technology with their child. Based factors identified in the literature review, co-engagement from parents of children with autism was a recommended solution for the potential barriers of mobile health technology. Several of the interviewed healthcare providers agreed that parental involvement would help address the concerns associated with mobile health technology. However, co-engagement might not be a feasible option for every family. Other providers expressed how co-engagement could introduce another source of strain and frustration between participating parents and children. A parallel support app could be a useful option for those who do want to co-engage, but it would not be the perfect solution for every child or adolescent with autism enrolled in WE Chat.

Multiple healthcare providers recommended using occupational therapy or speech language pathology services in conjunction with mobile health technology participation. These support systems can help with the identification and implementation of helpful resources. These health professionals can guide children and adolescents with autism to the most applicable recommendations and help ease the strain on parents. Therefore, children with autism who have

an occupational therapist or speech language pathologist and also participate in WE Chat should utilize these professionals as part of their support system.

Cost of Participation

As examined in the literature review, people in the lowest quartile of socioeconomic status were less likely to utilize telehealth resources during the COVID-19 pandemic (Darrat et al., 2021). This demonstrates how the cost of technology impacts participation among the general population. The Prisma Health providers who were interviewed were especially conscious of the cost of the technology they recommended to parents of children with autism. As discussed in the results section, the cost of internet, the cost of a mobile device, the cost of the app itself, and the cost of any in-app purchases can result in expenses that limit the accessibility of mobile health technology. While there are places with free internet connection such as libraries and coffee shops, reliance on these establishments introduces a potential transportation barrier. For some children and adolescents with autism, augmentative and alternative communication devices may be extremely beneficial. However, these expensive devices may or may not be covered by insurance. Children are also at a greater risk for accidentally breaking an AAC device or other mobile devices. The costs associated with mobile health technology participation could add to the strain experience by parents of children with autism. Fortunately, WE Chat is currently free for users. Following any developments that allow for personalization of the experience, the recommendation is to keep the app free and accessible for families of children with autism.

Conclusion

The existing literature shows that mobile health technology is a promising resource for the general population. For children and adolescents with autism, there are a variety of factors

that can impact experience with mobile health technology. Interviews of healthcare providers and a discussion with young adults with autism and parents of children with autism showed how these factors can vary from person to person. Due to the variability of autism, there is no one solution that can account for everyone. Although the proposed solution of parental co-engagement would be useful for some individuals, this method may create added frustration for others. Developers of WE Chat could make the resource more beneficial for children and adolescents with autism by developing branching logic that allows users to customize their experience. Other disciplines such as occupational therapy and speech language pathology should be utilized in conjunction with WE Chat. These support systems can ease the strain on parents and help modify the patient's mobile health technology experience. The development of WE Chat to fit the needs of children and adolescents with autism will result in a more accessible and effective mobile health technology resource for that special population.

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