ACCESSIBILITY IMPLICATIONS OF T1D INTERVENTIONS (MDI, CSII, AID) FOR CHILDREN AND ADOLESCENTS AGED 5-15 IN THE US AND CANADA: IDENTIFYING GAPS AND FUTURE ADVANCEMENT OPPORTUNITIES

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ABSTRACT

This narrative review delves into the growing challenge of Type 1 Diabetes (T1D) among children and youth, characterized by the autoimmune destruction of insulin-producing beta cells, necessitating lifelong management and impacting health and well-being. It explores the accessibility and challenges of commonly employed T1D interventions such as Multiple Daily Injections (MDI), Continuous Subcutaneous Insulin Infusion (CSII), and Automated Insulin Delivery (AID) in the pediatric population. The article focuses on financial and geographical barriers within the United States of America (US) and Canada and providing policy and integration suggestions for better accessibility of these interventions. The financial burden of T1D management is significant, with rising costs of insulin and diabetes management technologies posing barriers to access. Geographical disparities further exacerbate these challenges, particularly in rural areas where specialized care and resources are scarce. The need for policy reform strategies to mitigate financial barriers and enhance care accessibility is highlighted, emphasizing the role of telehealth and digital interventions to bridge the geographical divide. Future research should focus on the long-term outcomes of these interventions and the impact of policy changes on accessibility and health outcomes for children and youth. Throughout these future discoveries, age-appropriate adaptations to insulin delivery methods must be constructively considered. This review emphasizes the critical need for innovative, cost-effective, and accessible T1D care for children. Addressing financial and geographical barriers is essential to ensure equitable access to treatment and support for the pediatric population, emphasizing the need for a comprehensive approach that supports both physical health and overall well-being.

Type 1 Diabetes (T1D), children, youth, United States of America (US), Canada, accessibility, continuous subcutaneous insulin infusion (CSII), automated insulin delivery (AID), multiple daily injections (MDI), continuous glucose monitoring (CGM), geographical disparities in healthcare, rural healthcare access, telemedicine in diabetes care, financial barriers, T1D treatment

INTRODUCTION

Type 1 Diabetes (T1D) represents a significant and growing challenge in pediatric healthcare, characterized by the autoimmune destruction of insulin-producing beta cells in the pancreas [1]. This chronic condition, predominantly diagnosed in childhood and adolescence, necessitates lifelong management and has far-reaching implications for both physical health and psychosocial well-being [1,2]. The etiology of T1D is multifactorial, involving a complex interplay of genetic predisposition and environmental triggers, leading to a dependency on exogenous insulin for glucose regulation [2]. The incidence of T1D in children has been witnessing a steady increase globally, highlighting an urgent need for comprehensive research into its pathophysiology, early detection, and innovative management strategies [3].

This review aims to explore the accessibility in T1D interventions, namely Multiple Daily Injections (MDI), Continuous Subcutaneous Insulin Infusion (CSII), and Automated Insulin Delivery (AID) for the pediatric population, the challenges in management, and the potential pathways for improved care and quality of life for children and youth living with the condition. MDI is a regimen for managing T1D, involving several insulin injections daily to better mimic natural insulin release and offer dietary and scheduling flexibility, enhancing glucose control [4]. CSII, commonly known as insulin pump therapy, is a method of insulin delivery for managing T1D and involves using a small, portable device that delivers insulin continuously through a small catheter placed under the skin [4]. AID systems represent an advanced method for insulin administration, aiming to closely mimic the natural insulin release of a healthy pancreas by using continuous glucose monitoring (CGM) and insulin pump technologies in conjunction with a control algorithm to automate insulin delivery based on real-time glucose readings [5]. By delving into these critical aspects, this narrative review seeks to contribute to the growing body of knowledge which informs clinical practices and supports children and their families in navigating the complexities of T1D.

METHODS

The research question aims to take an extensive look into the pediatric population between the ages of 5-15 within the US and Canada. The initial literature search yielded results mainly from US and Canada, and thus the article will encompass a thorough investigation regarding the various interventions available in the treatment and management of T1D in these countries and will investigate the financial and geographical accessibility of these interventions for various pediatric patients. A literature search was conducted using databases such as PubMed, NCBI, and Web of Science, with key terms including Type 1 Diabetes (T1D), children, youth, United States of America (US), Canada, continuous subcutaneous insulin infusion (CSII), automated insulin delivery (AID), multiple daily injections (MDI), continuous glucose monitoring (CGM), geographical disparities, policy changes, among others. Upon discussing the current interventions available, the article will also highlight areas that require further advancement in accessibility in the scientific community, highlighting the shortcomings in current interventions.

RESULTS

Financial Accessibility

The financial challenges associated with managing T1D for children and youth significantly impact accessibility to essential treatments and technologies, highlighting the need for strategies to mitigate these barriers and enhance care. One study explored in this section investigated high costs of insulin with suggestions to improve access in the form of a policy review, and the second study analyzed data of 9,445 children with T1D showcasing the rising insulin prices and increased use of diabetes technology. The latter study addresses the rising costs of managing T1D for children but implicitly points to the critical accessibility and resource issue at hand for many families [6]. The most concerning financial burdens include the increase of average annual cost per patient from $11,178 to $17,060, the doubling of expenses for diabetes management technologies, and the significant rise in insulin prices [6]. These rising costs can create burdensome barriers for families, potentially leading to disparities in treatment and outcomes and hindering potential pathways for improved care of children with T1D. To ensure equitable access to the latest diabetes management technologies and insulin, strategies to control or reduce costs must be considered in policy formation. Addressing the financial barriers is essential to improve accessibility to high quality diabetes care, which is a pivotal step towards enhancing the overall quality of life for affected children and youth.

Moreover, the high cost of insulin is significantly influenced by market dynamics dominated by a few pharmaceutical giants, patent strategies, and complex healthcare systems particularly impacting accessibility to insulin in low- and middle-income households [7]. This is due to a few key stakeholders controlling the insulin market, namely the three big pharmaceutical companies: Eli Lilly, Novo Nordisk, and Sanofi [7]. These companies can charge higher prices for their insulin as there is little competition in the field, allowing for a few companies to dominate a large portion of the industry, eliminating the need to compete to maintain low prices [7]. Prices have risen as well due to the preference for expensive insulin analogs over their less expensive counterparts. This shift is attributed to the superior efficacy of insulin analogs, which react more quickly and maintain their presence in the body for extended periods, facilitating more effective glucose regulation than what is achievable with less expensive human insulin [7]. The study also addresses how pharmaceutical companies delay generic drugs by securing multiple patents and making minor modifications to existing drugs, impeding the availability of cheaper alternatives. Additionally, in the US, the high cost of insulin and the limited accessibility is due to the healthcare system. Moreover, insurance plans with high deductibles and copayments make it significantly more inaccessible for people to pay for their care. These problems are made even worse by government rules and regulations, such as with Medicare, a federal health insurance program in the US not being able to negotiate drug prices [7]. Thus, all these elements combined make it difficult for US citizens and other citizens from Canada that come from lower income households to regularly receive and pay for the insulin treatments they and their children require [8].

Geographical Accessibility

The current interventions that are widely used for the treatment of T1D for children highlight specific accessibility challenges, especially in terms of financial costs and for geographical disparities in the US and Canada, which necessitate targeted advancements in future interventions. The economic strain for T1D intervention is exacerbated in rural areas where access to affordable healthcare options is often limited [9]. Children in rural areas face challenges due to the long travel distances to healthcare facilities and specialized diabetes care centers. This affects the regularity of treatment and limits access to advanced care options and educational resources necessary for effective diabetes management [9]. Moreover, the remote locations of clinics in the US and Canada pose great difficulties for families who are forced to travel longer distances, often compromising the number of visits recommended by healthcare physicians. It is critical to improve T1D monitoring access ed by children who often depend on their caregivers to organize transportation for healthcare visits. This reliance can become particularly challenging in areas with significant geographical barriers, as coordinating travel around the caregivers' work commitments adds an extra layer of difficulty. Although there are interventions that can improve the frequency of visits for patients such as mobile healthcare units (MHUs), they must still be paired with accessible locations. A recent study evaluating the impact of telemedicine care coordination on access to care in Oregon's pediatric T1D population found that telemedicine significantly increased the number of T1D patients meeting goal visit frequency when paired with care coordination services [10]. This suggests that while telemedicine has the potential to mitigate access issues, its effectiveness is contingent upon adequate support systems being in place. Moreover, comparative analysis of urban versus rural access to T1D care reveals significant disparities such as limited availability of healthcare providers, longer travel distances to specialized clinics, and reduced access to advanced diabetes management technologies like CGM and insulin pumps in rural areas [10]. The study noted that prior to telemedicine expansion, patients in rural areas were less likely to receive adequately timed monitoring care compared to their urban counterparts [10]. This disparity highlights the need for targeted interventions to improve access in rural areas. In addition, the personal experiences of families navigating T1D care in rural areas provide valuable insights. Similarly, it was found that rural families may experience dramatic lifestyle changes post-diagnosis, with technology playing a crucial role in improving health management and flexibility [11]. These testimonials emphasize the challenges and adaptations faced by rural families in managing T1D.

DISCUSSION & FUTURE IMPLICATIONS

Future research should explore the long-term outcomes of digital interventions in rural settings and the impact of healthcare service inaccessibility on health outcomes. Investigating the barriers to the adoption of telemedicine and digital health technologies in rural areas can also provide insights on how to better tailor interventions to meet the needs of these communities. Amidst this exploration, policy changes targeting increased awareness of telehealth visit tools could be key to improving patient health outcomes by increasing engagement with the healthcare system, allowing for early screening of comorbid disease and mental distress [12].

When exploring the existing literature for age-appropriate accessibility implications of insulin delivery in children and youth diagnosed with T1D, it is evident that this area of research is lacking. Overcoming geographic and financial accessibility barriers are just as integral as ensuring safe delivery of insulin to these pediatric patients once they can regularly access them. Without sufficient research outlining the precise capacity for improvement in age-adapted insulin delivery methods, the most valuable and relevant available resources are recommendations from reputable academic and medical institutions regarding pediatric diabetic care. It is necessary to view these recommendations with the perspectives highlighted in the geographic and financial accessibility implications to better understand the foundational recommended guidelines in pediatric T1D care. According to recent reports, integrating a multidisciplinary team has proven to be an efficient, coordinated way to improve a child’s long-term health outcomes through simultaneous assessment of multiple patient health aspects, monitoring, and check-ins by nutritionists, social workers, doctors, and mental healthcare providers [13]. As children spend 30 to 35 hours every week at school, it is vital that there be school administrators and aides trained in supporting children with T1D ensuring that a proper diabetic care plan is carried out for any diabetic student [14]. One in every 300 Canadian children has diabetes, making it likely for there to be a minimum of one student with diabetes at any given school [14], reinforcing the importance of staff training so they may be aware of potentially undiagnosed diabetes or hypoglycemic complications occurring in real-time [14]. An equally concerning statistic supporting this change is that children aged less than five years old and early school-aged children make up the “fastest growing segment of the population” with T1D, further emphasizing the need for trained staff at all schools [14].

A holistic diabetic care plan would include an appropriate diet, constant glycemic monitoring, and insulin delivery alongside care from the multidisciplinary team, parents or guardians, and school staff [13, 15] . Children with T1D are recommended to perform blood sugar level checks at a minimum of four times daily depending on their individualized care plan, with others using CGMs reporting their levels every 5 minutes [14] . Younger-aged children who have not yet reached independence in fulfilling decision-making skills and everyday tasks may not be capable of checking their own blood sugar levels or ensuring their proper use of insulin delivery methods [14]. Policies and resources tailored towards these barriers must address future directions and recommendations to strongly improve the patients’ health outcomes, requiring consistent and safe diabetic care at even the youngest age group once diagnosed. Extremely young children diagnosed with T1D could greatly benefit from a CGM or AID device, allowing their families to adjust insulin delivery as per the child’s needs [15], if they are able to financially access such diabetic management tools. Though hybrid closed loop (HCL) insulin pumps used in conjunction with AID devices are typically provided to older children with T1D, they have been limited in use to clinical trials for children between the infant and preschool ages. As per the SickKids foundation, the blood sugar target range is 6-10 mmol/L for children under 6 years old, 4-10 mmol/L for children between 6 to 12 years old, and 4-8 mmol/L for children ages 12 years old and above [16]. This data emphasizes the necessity to expand HCL/AID system trials to cater to the precise and varying needs of these younger demographics. By doing so, one can ensure broader access to life-enhancing technologies and alleviate the financial strain on families, making a pivotal step toward equitable healthcare solutions for all children with T1D.

Caregivers arguably play the most integral role in the diabetic child's self-management skills and care journey over the years as they grow into complete independence [14]. Access to healthcare professionals or diabetes educators who can teach them strategies on easing the child's anxiety or pain with insulin delivery systems or frequent blood checks are crucial, so that the daily insulin delivery is not frightening nor unnerving, using distinctly age-appropriate calming strategies [15]. One example of a behavioural strategy may be 'think aloud', where the child can be verbally asked about which one of two injection sites they would like the insulin to be delivered, providing them an opportunity to feel ownership over their own health management [15]. A "supportive and emotionally warm parenting style" can promote these children's overall quality of life, thereby directly improving their long-term health status as well [15]. If the child uses MDI or CSII, there could be physical ways to manage pain in addition to these verbal and psychological standpoints, such as topical anesthetic cream applied before the insertion of a subcutaneous catheter insulin port for both injections and infusion [15]. These strategies must be considered when the preferred insulin pump technology is unaffordable or unavailable, causes negative skin reactions, or if the local healthcare provider in charge of delivering insulin to the pediatric patient is not experienced with their given age group [15].

With regards to financial accessibility and insulin prices, a 2021 study examining the high costs of insulin emphasizes the need for a strategic plan to lower them, which will require individuals from different fields to collaborate, which include policy makers in government and healthcare organizations such as Medicare [7]. The authors recommend bringing generic drugs and biosimilars to the market and advertising them to increase competition, which could lead to lower insulin prices for families. To prevent brand-name drug monopolies from perpetuating high insulin prices, the current patent systems and market exclusivity rules need to be re-evaluated and changed [7], making it easier for cheaper insulin options to enter the market. This study also emphasizes the importance of eliminating practices which harm competition, such as "pay-for-delay" deals that lead to difficulty in acquiring cheaper insulin variants [7]. Another vital recommendation involves enhancing the transparency of insulin pricing by clarifying the complex pricing structures so that families can better navigate the system and identify opportunities for financial savings [7]. The study advocates for policy reforms that would authorize government initiatives, such as Medicare, to directly negotiate drug prices with pharmaceutical firms, potentially reducing prices significantly [7]. It also calls for regulatory reforms to prevent pharmaceutical companies from exploiting consumers through practices such as filing numerous patents for the same medication and making minor modifications to extend patent protection [7]. Additionally, it highlights the advantages of adopting value-based pricing strategies and insurance models, supporting a pricing system that connects the cost of insulin with its clinical effectiveness and patient benefits [7]. In this manner, patients' out-of-pocket costs are more in line with the medication's therapeutic value.

Furthermore, when exploring other promising areas which could improve the quality of life for affected patients, telehealth emerges as a transformative approach in treating T1D by offering better care than during traditional in-person visits, enhancing convenience and accessibility to healthcare providers. By integrating advanced technologies like machine learning, telehealth not only improves the management of diabetes-related complications, but also supports mental health needs, making it an invaluable tool in the holistic treatment of T1D [17]. Telehealth has also been recognized as a valuable tool in managing the psychosocial impact of T1D in young people. Young individuals with T1D often face higher rates of psychological distress, including periods of burnout and challenges in coping with the daily management of their condition [17]. Family, peer, and psychological support, coupled with education on living with diabetes, are crucial for reducing distress and enhancing overall well-being and diabetes management [17]. Psychological screening tools and appropriate local referral pathways are recommended to ensure that young patients receive the mental health support they need. Various psychological and behavioral interventions – such as solution-focused therapy, coping skills training, motivational interviewing, cognitive behavioral therapy, and family-centered interventions – have been shown to significantly improve the quality of life and diabetes management in young individuals with T1D [18]. Furthermore, telehealth has shown to be particularly effective for younger patients with T1D, enhancing their engagement and adherence to treatment plans. A study on the CoYoT1 Clinic, a telemedicine appointment care model, demonstrated that young adults with T1D who participated in this program had significantly higher clinic attendance rates, met American Diabetes Association guidelines for appointment frequency more consistently, and reported greater satisfaction with their care compared to those receiving standard care [19]. This indicates that telehealth can effectively keep young adults engaged in their diabetes management during critical transition periods, closing the accessibility gaps caused by geographic and potentially financial challenges. However, some challenges have been noted in the literature, including disparities in access to telehealth services due to socioeconomic factors, digital literacy barriers, and potential limitations in the quality of remote care compared to in-person visits. Understanding these drawbacks is essential to optimizing telehealth's effectiveness and ensuring equitable healthcare access for all pediatric patients with T1D.

CONCLUSION

In conclusion, this review has discussed the challenges and critical needs in managing T1D in the pediatric population from ages 5-15 across the US and Canada. It is evident that while there are several effective treatments available, such as MDI, CSII, and AID, their accessibility is significantly hindered by a variety of factors [6,20]. Financial constraints remain a primary barrier, as the escalating costs of insulin and diabetes management devices place a substantial burden on families, particularly those with limited economic resources [6]. Geographical disparities further exacerbate these challenges, with children and youth in rural areas facing considerable difficulties in accessing specialized diabetes care due to long travel distances and a lack of local healthcare resources [20]. Moreover, the need for age-appropriate and emotionally supportive care emphasizes the necessity for a comprehensive approach to T1D management in children and youth. The review highlighted a pressing need for innovations in T1D care that are not only more cost-effective but also widely accessible, regardless of a patient's location or financial status. These interventions must be designed with an understanding of the diverse needs of the pediatric population, ensuring that every child with T1D can receive comprehensive, effective, and empathetic care that supports not only their physical health but also their overall well-being.

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