The impact of outpatient telehealth compared to standard care on emergency room visits and hospital admissions in pediatric diabetes patients: a systematic review protocol

Katelyn Armstrong¹,² - Mary M. Moore¹,²

¹University of Mississippi Medical Center, Jackson, United States, ²UMMC School of Nursing Evidence Based Practice and Research Team: a Joanna Briggs Institute Affiliated Group

Review question: What is the effectiveness of outpatient telehealth compared to standard care on emergency room and hospital admissions in patients aged 0 to 18 years with type 1 or type 2 diabetes?

Keywords Diabetes mellitus; emergency room; hospitalization; pediatrics; telemedicine

Introduction

Diabetes mellitus is a chronic disease defined by varying amounts of pancreatic insufficiency resulting in elevated blood glucose.¹ In 2015, the worldwide prevalence of diabetes was estimated to be about 415 million. The projected estimate of people with diabetes worldwide by 2040 is 642 million.² In 2010, diabetes was listed as the seventh leading cause of death in the United States (US), and in 2011, the risk of death among people with diabetes was nearly twice that of those without diabetes.³ Not only does diabetes affect the adult population, it also affects a significant number of the pediatric population worldwide. According to the 2014 US National Diabetes Statistics Report, approximately 208,000 patients under 20 were estimated to have diagnosed diabetes.⁴ According to an initial report from the World Health Organization (WHO) Multinational Project for Childhood Diabetes (WHO DIAMOND Project), in 2000, the incidence of type one diabetes in children of age 14 or under in 50 countries was 19,164 cases from a population of 75.1 million children.⁵ From 2008 to 2009, the annual incidence of type 1 diabetes in the pediatric population in the US was estimated to be 18,436.⁶ Once thought to be a disease of adulthood, type 2 diabetes affects the pediatric population as well. Between 8% and 45% of pediatric patients presenting with newly diagnosed diabetes in the US have type 2 diabetes.⁶ From 2008 to 2009, the annual incidence of type 2 diabetes in the pediatric population in the US was estimated to be 5089.⁴ In Japan, 80% of newly diagnosed pediatric diabetes cases are type 2 diabetes and in Taiwan, about 54.2% of new cases of diabetes in children are type 2 diabetes. In the United Kingdom (UK), the incidence of type 2 diabetes in children under 17 is about 0.53 per 100,000, and the incidence of pediatric type 2 diabetes in Austria is approximately 0.25 per 100,000.⁷ Particularly in the pediatric population, diabetes has a significant impact on growth and development, and psychosocial outcomes. Other health-related outcomes include the risk of comorbidities such as cardiovascular disease, renal disease and retinopathy. Retinopathy due to diabetes results in over 10,000 new cases of blindness annually.⁴ Diabetes was listed as the primary cause of kidney failure in 44% of new cases for all ages.⁴ Cardiovascular disease is the primary cause of death in up to 65% of all deaths in people with diabetes, and greater than 70% of people with diabetes have hypertension treated with medication.³ The risk of cardiovascular complications is notably increased in patients with type 2 diabetes related to the pathophysiology of insulin resistance, and microangiopathy may be more common in patients of the same age with type 2 versus type 1 diabetes.⁶

Correspondence: Katelyn Armstrong, mkarmstrong@umc.edu

There is no conflict of interest in this project.

DOI: 10.11124/JBISRIR-2016-003328
Not only are there health outcome implications stemming from the rising prevalence of diabetes, the financial burden on the health care system in the form of emergency room visits and hospital admissions due to poorly controlled diabetes is also of particular concern. Although improvements have been made in methods of insulin delivery and glucose monitoring, hospital admission for DKA is common worldwide, with the risk of DKA in patients with type 1 diabetes being 1%-10% per patient per year. The economic burden is defined by the substantial cost, averaging $7142 per DKA admission. The estimated annual global health expenditure spent on diabetes is $673 billion. In the United States in 2011, approximately 175,000 emergency room visits listed 'hyperglycemic crisis' (diabetic ketoacidosis or hyperosmolar hyperglycemic non-ketotic syndrome) as the primary diagnosis. In 2012, the total cost of diagnosed diabetes in the US was $245 billion, and 43% of this cost was spent on hospital inpatient care due to poorly controlled diabetes. According to the Center for Disease Control, in 2009, among patients aged 0 to 17 years, diabetes was the first listed diagnosis for all hospitalizations of patients who had a previous medical history of diabetes mellitus. Of these hospitalizations for diabetes, 64% were for diabetic ketoacidosis. For patients of all ages admitted to the hospital for a diagnosis of diabetic ketoacidosis, the average length of stay was 3.4 days. According to a multicenter retrospective cohort analysis of children aged two to 18 years with a diagnosis of DKA in 42 children's hospitals, among 12,449 children, 3527 (28.3%) experienced one or more DKA admissions within a 365 interval period. Additionally, 709 patients (5.7%) experienced three or more DKA admissions within 365 days; this accounted for 24.5% of all DKA admissions. The results of the study demonstrated that although over a five-year follow-up period, one in four children hospitalized in DKA experienced more than one additional DKA admission within the next 365 days. In the UK, in 2011, there were approximately one million hospital admissions for which diabetes was listed as the primary diagnosis, and the total cost of these admissions was 2.51 billion pounds (US$3,071,888,600). About 87% of the one million admissions for diabetes were emergency-related admissions.

For all pediatric patients with diabetes, it is recommended that the target glycated hemoglobin A1c (HbA1c) remains at 7.5% or below for optimal health outcomes. In order to accomplish this, the patient and family must have a certain knowledge base for the self-management of diabetes. In addition to pharmacological treatments with insulin and/or metformin, the patient must adhere to certain lifestyle modification behaviors in order to be successful. These include, but are not limited to: adequate self-monitoring of blood glucose, counting carbohydrates, maintenance of a daily exercise regimen, and follow-up with an endocrinologist every three months or as otherwise recommended. In addition, these patients may be at high risk for acute complications if blood glucose levels are too high or too low, and the patient and family must be aware of effective actions to take in these situations. Improved glucose control and a resulting decrease in emergency room visits and hospital admissions for these patients may be appreciated if effective disease self-management is performed at home.

According to the American Diabetes Association, the standard care for pediatric patients with diabetes involves face-to-face follow-up visits for monitoring and education with a pediatric endocrinologist at least every three months. However, in consideration of areas worldwide with limited resources, other levels of care are recognized by the International Diabetes Federation. For instance, in areas of low population density or where the incidence of childhood diabetes is low, diabetes care is likely to be provided by a local physician or pediatrician. According to the guidelines set forth by the International Diabetes Federation and the International Society for Pediatric and Adolescent Diabetes, such areas with limited resources should be in collaboration with a diabetes care team in a regional center of excellence. This collaboration may be facilitated by telecommunications or other internet resources.

There are novel, ongoing multidisciplinary efforts to promote effective disease self-management for pediatric patients. Several studies have included the use of outpatient technology (text messaging, web-based monitoring) and have shown promising results. For instance, a randomized controlled trial in Scotland focused on 92 patients with type 1 diabetes, aged eight to 18. One of the two experimental groups utilized Sweet Talk in addition to the normal diabetes regimen and follow-up. Sweet Talk is a one-way messaging software program which...
Such patients have the ability to receive telehealth, which may consist of SMS text messaging, web-based learning programs, computer programs, wireless software programs and other forms of telecommunications. If these patients have the ability to receive telehealth, they may be able to manage their diabetes more effectively. With the advent of telehealth approximately 40 years ago, significant advances have been made in technology, making telehealth a viable option for chronic disease management. Telehealth encompasses a variety of applications and services using two-way communication via video, email, smart phones, wireless tools and other forms of telecommunications. Not only has patient demand increased in terms of technological advances in medical treatment, the cost efficiency of improved self-management of chronic disease and comorbidities and the resulting cost efficiency of fewer hospitalizations as a result of technology are also highly beneficial. The current recommended follow-up frequency for pediatric patients with diabetes is three months. If these patients have the ability to receive additional support via telehealth (including, but not exclusive to, the use of text messaging, web-based computer programs, wireless software programs and video monitoring) between visits, this could potentially improve diabetes self-management skills, thereby decreasing emergency room visits and hospital admissions. This may also translate into improved overall health outcomes and decreased comorbidities for patients with diabetes. A Cochrane Review found that according to some studies, text messaging interventions for children and adolescents with type 1 diabetes decreased HbA1c, however, other significant outcomes were not measured, such as emergency room and hospital admission frequency. In addition, pediatric patients with type 2 diabetes were not included in the review.

An initial search in PubMed, CINAHL, JBI Database of Systematic Reviews and Implementation Reports, DARE, Cochrane Library and PROSPERO showed that no systematic review existed on this topic, or was currently underway.

**Inclusion criteria**

**Participants**

This review will consider studies that include pediatric patients aged 0 to 18 years, with a diagnosis of either type 1 diabetes or type 2 diabetes.

**Intervention**

This review will consider studies that evaluate the use of outpatient telehealth to support diabetes self-management in pediatric patients. Outpatient telehealth may include but is not limited to: SMS text messaging, web-based learning programs, computer programs, wireless software programs and other forms of telecommunications.
home-based monitoring, remote-patient monitoring or any telecommunications medium.

**Comparator**
This review will consider studies that compare the intervention to standard care for pediatric patients with diabetes as defined by the American Diabetes Association, as well as other levels of care recognized by the International Diabetes Federation, without the use of telehealth. The American Diabetes Association’s standard of care involves face-to-face follow-up visits for monitoring and education with a pediatric endocrinologist at least every three months. According to the International Diabetes Federation, in certain areas, children with diabetes are managed by a local physician or pediatrician in collaboration with a diabetes care team.

**Outcomes**
This review will consider studies that include the following outcomes: emergency room visits, discharges home from emergency rooms, 24-hour observation admissions, emergency room admissions and subsequent hospital admissions, and hospital admissions from the pediatric intensive care unit. More specifically, the frequency of admissions, the length of stay, and 30-day re-admission rates will be the focus of the review.

**Types of studies**
This review will consider both experimental and quasi-experimental study designs including randomized controlled trials, non-randomized controlled trials, before and after studies and interrupted time-series studies. In addition, analytical observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies will be considered for inclusion. This review will also consider descriptive observational study designs including case series, individual case reports and descriptive cross-sectional studies for inclusion. Studies published in English will be included. Studies published since 1992 will be included in this review as there were no studies found prior to this date that involved children with diabetes and telehealth.

**Methods**

**Search strategy**
The search strategy will aim to find studies, both published and unpublished, since the year 1992. When a preliminary search was performed, studies involving children with diabetes and the utilization of telehealth were found dating back to 1992 but not prior to 1992. An initial limited search of Embase, CINAHL, ProQuest Dissertations and Theses, Ovid Healthstar, Cochrane Central Register for Controlled Trials and PubMed has been undertaken to identify articles on this topic, followed by analysis of the text words contained in the titles and abstracts, and of the index terms used to describe these articles. This informed the development of a search strategy including identified keywords and index terms which will be tailored for each information source. A full search strategy for each database searched is detailed in Appendix I. The reference list of all studies selected for critical appraisal will be screened for additional studies.

**Information sources**
The databases to be searched will include: PubMed, CINAHL, Embase.
- The trial registers to be searched will include: Cochrane Central Register of Controlled Trials, Ovid Healthstar
- The search for unpublished studies will include: ProQuest Dissertations and Theses.

**Study selection**
Following the search, all identified citations will be collated and uploaded into Endnote (Clarivate Analytics, PA, USA) and duplicates removed. Titles and abstracts will then be screened by two independent reviewers for assessment against the inclusion criteria for the review. Studies that meet the inclusion criteria will be retrieved in full and their details imported into the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI-SUMARI). The full text of selected citations will be retrieved and assessed in detail against the inclusion criteria by two independent reviewers. Full text studies that do not meet the inclusion criteria will be excluded and reasons for exclusion will be provided in an appendix in the final systematic review report. Included studies will undergo a process of critical appraisal. The results of the search will be reported in full in the final report and presented in a PRISMA flow diagram. Any disagreements that arise between the reviewers will be resolved through discussion, or with a third reviewer.
Assessment of methodological quality
Selected studies will be critically appraised by two independent reviewers at the study level for methodological quality in the review using standardized critical appraisal instruments from the Joanna Briggs Institute for experimental and quasi-experimental studies, along with analytical and descriptive observational studies. Any disagreements that arise between the reviewers will be resolved through discussion, or with a third reviewer. The results of critical appraisal will be reported in narrative form and in a table.

Data extraction
Data will be extracted from papers included in the review using the standardized data extraction tool available in JBI SUMARI by two independent reviewers. The data extracted will include specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives. Any disagreements that arise between the reviewers will be resolved through discussion, or with a third reviewer. Authors of papers will be contacted to request missing or additional data where required.

Data synthesis
Papers will, where possible, be pooled in statistical meta-analysis using JBI-SUMARI. Effect sizes will be expressed as either odds ratios (for dichotomous data) and weighted (or standardized) mean differences (for continuous data) and their 95% confidence intervals will be calculated for analysis. Heterogeneity will be assessed statistically using the standard chi-squared and I² tests. The choice of model (random or fixed effects) and method for meta-analysis will be based on the guidance by Tufanaru et al. 2015. Subgroup analyses will be conducted where there is sufficient data to investigate: type 1 versus type 2 diabetes, age groups, gender, and types of telehealth. Sensitivity analyses will be conducted to test decisions made regarding the impact of outpatient telehealth on emergency room visits and hospital admissions. Where statistical pooling is not possible the findings will be presented in narrative form including tables and figures to aid in data presentation where appropriate.

A funnel plot will be generated within JBI-SUMARI to assess publication bias if there are 10 or more studies included in a meta-analysis. Statistical tests for funnel plot asymmetry (Egger test, Begg test, Harbord test) will be performed where appropriate.

Assessing confidence
The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach for assessing confidence in the quality of evidence will be used for this review, with the results presented in a summary of findings table created using GRADEPro.

Acknowledgements
This systematic review will contribute towards the attainment of a Doctor of Nursing Practice degree.

References


Appendix I: Search strategy

CINAHL
Fields searched: title, keywords, abstract, body

[MH telemedicine OR MH telehealth OR “mobile health” OR ehealth OR Telecommunications OR “remote consultation” OR “mobile health” OR ehealth] AND [MH pediatrics OR MH paediatrics OR MH child OR MH children OR MH adolescence OR pediatrics] AND [MH diabetes mellitus OR MH diabetes mellitus, type 1 OR MH diabetes mellitus, type 2 OR diabetic ketoacidosis] AND [MH emergency service OR MH hospitalization OR patient admission OR emergency room]

Embase
Fields searched: title, keywords, abstract, body

[telemedicine/de OR telemedicine/exp OR teleconsultation OR telemonitoring OR telecommunications OR telehealth] AND ['Diabetes mellitus'/de OR ‘diabetes mellitus’/exp OR ‘insulin dependent diabetes’/de OR ‘insulin dependent diabetes’/exp OR ‘non-insulin dependent diabetes’/de OR ‘non insulin dependent diabetes’/exp OR diabetes OR Diabetic] AND [pediatrics/de OR pediatrics/exp OR child/de OR child/exp OR adolescent/de OR adolescent/exp OR ‘hospitalized child’ OR ‘hospitalized adolescent’ OR paediatrics OR ‘pediatric care’ OR ‘pediatric service’ OR juvenile OR teenager] AND ['Emergency ward'/de OR ‘emergency ward’/exp OR hospitalization/de OR hospitalization/exp OR ‘hospital admission’/de OR ‘hospital admission’/exp OR ‘emergency department’ OR ‘emergency room’ OR ‘emergency unit’ OR ‘hospital stay’ OR ‘child hospitalization’/de or ‘child hospitalization’/exp OR ‘child hospitalization’ OR ‘patient admission’ OR ‘hospital admittance’]

PubMed
Fields searched: title, keywords, abstract, body

[telemedicine [mh] OR telemedicine OR telehealth OR “remote patient monitoring” OR telecommunications OR “remote consultation” OR “Mobile health” OR ehealth OR mhealth] AND [“diabetes mellitus” [mh] OR “diabetes mellitus” OR “diabetes mellitus, type 1” OR “diabetes mellitus, type 2” OR “diabetic ketoacidosis”] AND [pediatrics [mh] OR pediatrics OR children OR child OR adolescent OR child OR children] AND [hospitalization [mh] OR hospitalization OR “emergency service” OR hospital [mh] OR “emergency service, hospital” OR “Emergency Services, Hospital” OR “Hospital Emergency Services” OR “Services, Hospital Emergency” OR “Emergency Departments” OR “Department, Emergency” OR “Departments, Emergency” OR “Emergency Department” OR “Emergency Hospital Service” OR “Emergency Hospital Services” OR “Hospital Service, Emergency” OR “Hospital Services, Emergency” OR “Service, Emergency Hospital” OR “Services, Emergency Hospital” OR “Service, Hospital Emergency” OR “patient admission” OR “child, hospitalized”]

ProQuest Dissertations and Theses
Fields searched: title, keywords, abstract, body

[tele’ OR Telemedicine OR telecommunications OR telecasts OR remote patient monitoring] AND [P’ediatrics OR paediatrics OR children OR child’ OR adolescent OR adolescence AND “Diabetes mellitus” OR diabetes OR “diabetes Mellitis type 1” OR “diabetes mellitis type 2’”] AND [“Emergency room” OR “emergency services” OR hospitalization OR “hospital admission”]
Cochrane Central Register of Controlled Trials
Fields searched: title, keywords, abstract, body
[tele” OR telemedicine OR “telemedicine methods” OR “telemedicine trends” OR “telemedicine utilization”] AND [p’ediatrics OR paediatrics OR adolescent OR child’ OR children] AND [“diabetes mellitus” OR “diabetes mellitus, type 1” OR “diabetes mellitus, type 2”] AND [hospitalization OR “emergency service, hospital”]

Ovid Healthstar
Fields searched: title, keywords, abstract, body
[Telemedicine OR telehealth OR “remote patient monitoring” OR teleconsultation] AND [pediatrics OR child OR children OR adolescent] AND [“diabetes mellitus” OR “diabetes mellitus, type 1” OR “diabetes mellitus, type 2”] AND [“emergency service, hospital” OR “hospital admission”]