Investigating the Role of Social Robot in improving diabetic Children Management and awareness

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Abstract-
Introduction: Type 1 diabetes (T1DM) is one of the chronic diseases, which require special attention, and a wide range of management activities. It is alarming to notice that the T1DM among the children has been increasing in the recent years, which requires special attention. The recent research shows that the use of social robots can help in fulfilling all the requirements like insulin checkup, awareness, education etc. for managing the diabetes among the children. Considering these aspects, this paper investigates the role of social robots in improving diabetes management among the children using a systematic review of recent studies conducted in this specific area.
Methods: A systematic review approach was used in this study. Four electronic databases including PubMed, IEEE Xplore, ScienceDirect Elsevier and Scopus are considered for searching the papers from the social, engineering and medical perspectives. More than 3400 titles and abstracts of various papers in these databases were reviewed.
Results: Only six papers fitted the criteria that focuses on the use of social robot in enhancing the diabetic children management OR diabetic children awareness or both. The review has found that the use of social robots could contribute in improving the diabetic children management and awareness.
Conclusion: The number of existing studies in measuring the impact of social robot is very narrow and there is a big need to expand and evaluate the use of social robot on large sample of diabetic children.

Keywords:
m-health; social Robot, Type 1 diabetes; telemedicine; e-health.

1. Introduction

Diabetes has been one of the major chronic diseases being faced by the many people worldwide, in the last few decades. On a global scale there are approximately 415 million people diagnosed with the disease as identified in the year 2016 [1]. It was also observed that the disease has resulted in 5 million deaths worldwide in the year 2016 alone. In addition to these, approximately 12% of the healthcare expenditures are incurred on the diabetes related complications in most of the countries with an estimated $673 billion annually [1].

In the past few decades it was observed that there has been an increase in the number of children under 14 years diagnosed with diabetes (type 1). It was identified that over half a million children were diagnosed with diabetes in the year 2016. In addition to these findings, it was also observed that about three quarters of the people with diabetes live in low and middle income countries. For an instance, Saudi Arabia ranked seventh among the worldwide countries with 16,100 diabetic children [1].

It is interesting to note that there has been a tremendous increase in the use of technology in the recent years, especially internet related applications such as mobile applications, robots, wireless sensors, Bluetooth devices, and internet related devices etc. Considering it as an advantage, these technologies have been increasingly used in the management of various healthcare activities, especially chronic disease management. Various clinical studies were conducted in examining the role of these technologies in managing various chronic diseases and obtained positive results. It was observed that technology related applications like smart phones, social networking, and mobile applications etc. proved to be successful strategic tools in enhancing the disease management and awareness, especially diabetes management [2].

Robotic technology has attracted the researchers' attention in the last few years for the perspective of disease management. Social Robot is an Artificial Intelligence system (AI) developed to cooperate with humans and other robots in various aspects. This process is also known as Human Robot Interaction (HRI). It is an interdisciplinary research field intended at developing and enhancing the interaction between human beings and robots. It aims to develop and design robots that are capable of functioning effectively in real-world domains, employing and cooperating with humans in their daily activities [7]

In the last decade, number of studies [3, 4, 5, 6] has found that the use of robot technology proved to be effective in the area of disease management through interactive applications, especially for children for creating health awareness. Usually, children need something more

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attractive, playful and pretty to hold their attention and dedicate their time to. They need something that captures their attention such as toys, musical/ magical instruments, action figures etc. for delighting them, and allowing them to be engaged in a modern health awareness program. However, it is important that such robotic technologies should provide a playful experience when engaging in an education about chronic disease and self-management.

Considering these aspects, this paper aims to investigate and study the impact and acceptability of using social robots in improving children diabetes self-management and awareness using systematic review approach. To bring it to the attention of the readers it is highlighted that this is the first study to discuss the role of social Robots in enhancing children diabetes self-management and awareness, helping in filling the research gap.

2. Method

This study uses a systematic review approach in order to investigate the role of social robots in diabetes self-management among the children. Various perspectives such as social, engineering, and medical need to be considered for developing a Social Robot system. Four electronic databases including PubMed, IEEE Xplore, ScienceDirect Elsevier and Scopus are considered for searching the papers using the above mentioned perspectives. As these databases publish only papers written in English Language, hence, this investigation considers the papers published only in English language. The search is guided by three keywords: social robots, social robotics, and diabetic children. Table 1 shows the Social Robot perspectives for investigation and their related databases.

Table 1: The Social Robot perspective and its database.

#	Social Robot perspectives	Database
1	Social	Scopus; ScienceDirect
2	Engineering	IEEE Xplore
3	Medicine	PubMed

More than 3,400 titles and abstracts from various conference papers and journal articles were reviewed to identify how many studies fits the criteria set out for the investigation. The criteria set in this study includes any papers that refer to

- the use of social robot in enhancing the diabetic children management OR diabetic children awareness OR both, and;
- the acceptability and usability of using social robot from diabetic children perspective.

3. Result and discussion

As shown in table 2, the systematic search has found only 6 studies according to the criteria and most of them focus on the usability and acceptability of using social robot in improving children diabetes self-management. The overview of these studies is presented in table 2.

Table 2: The Systemic review studies focusing on Social Robot in diabetes management among children

S.No.	Title	Sample Size	Study specific Targets	Duration	Intervention	Impact
1	Child's Culture-related Experiences with a Social Robot at Diabetes Camps [3]	55	To investigates the experiences of Italian and Dutch children while interacting with a social robot that is designed to support their diabetes self-management	15-30 minutes	Two activities : (1) play with Robot a quiz while the child ask the robot and the Robot answered and vice versa.(2) play game on the Touch tablet between the robot and the child	positive experiences
2	Effects of off-activity talk in human-robot interaction with diabetic children [4]	20	1. Perception of the robot and the relationship. 2. Interest to have further interaction(s) with the robot. 3. Adherence to filling in a nutritional diabetic diary	9 days and session for individual	Two specific questionnaires were used to measure (1) self-assessment of the child engaging and relation to the Robot. (2) to elaborate on the child perception of the Robot through multiple-adjective choice to describe Naos characteristics	positive experiences
3	A remote social robot to motivate and support diabetic children in keeping a diary [8]	6	1. adherence 2. engagement 3. bonding	2 weeks	7 questionnaires were used to measurement the targets outcomes (pre and post questionnaires) and usability questionnaire	Positive in general

4	Using Robot for personal health education for children with diabetes type 1: a pilot study. [9]	5	Assess the effects of personalised Robot behaviours on enjoyment and motivations of diabetic children and their acquisition of knowledge in educational play.	2-3 weeks	The child played diabetes quizzes against a personal or neutral robot on three occasion: once at clinic, twice at home.	Positive
5	Acceptability of Robot Assistant in Management of Type 1 Diabetes in Children[10]	37	Acceptability of a humanoid robot as an assistant in their diabetes management.	3 months	child interacted with the robot and accessed different data collection and educational modules on one occasion for at least 30min in the clinic environment in the presence of a clinician and the participant's parent/guardian.	the overall patients' acceptability is 86.7%.
6	Learning with Charlie A robot buddy for children with diabetes.[11]	21	Assist the child , parents and healthcare professional to jointly perform diabetes management.	5 days	Learning with Charlie through video	Positive

The first study [3] reviewed in this paper is aimed at observing and analysing the experiences of two different areas and cultures (Italian children and Dutch children) while communicating with a social robot designed to support their diabetes self-management. The study was performed in two camps: Italian camps and Dutch camps. The overall of participants were 55. 34 participants were Italian children aged between 10 and 14, and 21 were Dutch aged between 8 and 11. As a part of intervention two activities were used in the study; (1) A quiz game was played with robot by the child, where the child questions the robot, and robot answers, and vice versa; (2) The sorting game was played on a touch table between the robot and the child. Both the child and robot could drag icons to a specific side of the screen(e.g., icons of high-carbohydrates food to the left and low-carbohydrates food to the right).

After all interconnections child requested to write down how and what they felt while communicating with the robot and to write a letter to the Robot to explain they could help him in effectively managing the diabetes. All written data were reviewed and analysed. In Italian camps, structured lessons about T1DM and related topics, practical training and informational moments were provided to the child participants supervised by an expert medical staff. The environment was made for children to involve in cooperative recreational activities structured by animation staff.

In the Dutch camp, the aim of the study was to focus on sharing experience with diabetic peers in a vacation setting rather than a educational setting. The participants were divided into groups of 4 or 5 children who were supervised by 2 mentors for each group. A robot related questionnaire was filled at the beginning and the end of the camps by the children which they had to answer in plain text. The questionnaire includes two main questions: (1) would you like to play with the Robot again, why? , (2) how would you build a robot? A positive response was achieved in the study from the children in both camps with a variation where, Italian children seemed to be more open and expressive, and more close to the robot compared to the Dutch children). The study has highlighted that a culture aware robot should be sensitive to such differences.

Furthermore, the launching of these camps are organised annually in Italy and Netherlands. At the summer of 2016 in Netherlands [11], 21 diabetic children aged between 8-11 years joined five days camp to learn with Charlie which is Robot buddy for children with diabetes through video. The video learning with Charlie aims to demonstrate how different robot buddies and children interact in a camp setting and learn about diabetes through educative activities. The study found that the participants got pleasurable experience and they go home in good spirit regarding their illness.

While the above study focused on the interactions between the children and robots, the next study [10] in the review focused on investigating if T1DM children would accept the humanoid Robot as an assistant in the process of managing their diabetic condition. The major focus of the study was to analyse how the T1DM children feel about the Robot which might contribute in improving their care and how they receive the advice and education delivered by the Robot. The study included 37 children aged between (6-16 years) with T1DM and was conducted during the clinic visit of the children in the presence of their parents/guardians. The children interacted with the Robot and accessed various data resources and educational modules in the session that lasted for at least 30 minutes. Then the data was collected from the participants through a questionnaire for assessing the acceptance and attitudes of the Robot. The responses were then analysed with a focus on assessing the following functions:

- Physical activity collection: the robot will collect the information by asking questions with multiple choice answers with the child.

- Carbohydrate and insulin intake: this information is provided by the child to the robot through a sensors placed on the Robot head while increment the number of inserted calories and taken insulin.
- The measurement of blood Glucose and blood pressure were collected wirelessly through Bluetooth device and stored in remote database which is shared with the Robot.

The study has found that the use of Robot can support the self-management of T1DM among the children. The overall acceptability of the robot for self-management of diabetes was found to be 86.7%, which reflects a positive outcome. However, there are some drawbacks in the study that have been identified which include short communication time period between the child and the robot, and doesn't seem to give full picture of the interaction and acceptance of the robot. For example, carbohydrate and insulin intake and measurements of blood glucose and blood pressure need at least 24 hours to measure, while the study lasted only for short time and the overall interaction was not possible.

Maintaining a diary plays a significant role in planning for diabetes management as the diabetes management need history of data to create and structure future course of actions/plans. The next study [8] reviewed in this paper focuses on investigating the impact or role of a robot in supporting and motivating the children in keeping an online diary. Three aspects including adherence, engagement, and bonding were focused in this study. A popular robot (NAO) developed by Aldebaran robotics was used in the study. It was well suited for the study because of its sociable childlike appearance, and its body language is able to deliver a wide range of emotions. The robot was called as "Charlie" during the study, which is a unisex name, given in order to make it appealing to both girls and boys. Charlie could answer questions like its preferences and its motivation to participate in the experiment based on the previous written story in its database. A dialogue delivery model was used in the study that focused on the following:

- Diary-related dialogue: It contains the login process, explanation of dairy components and filling in the diary itself. It is very well structured and did not give too much flexibility other than child selecting what component he/she prefer to start with. Basically, it should be the same for every participated child.
- Interpersonal dialogue (OR small talk): It is much flexible than the diary dialogue. It includes two type of small talk: (a) Small talk to share information about the NAO itself and optionally ask child to do the same. (b) Small talk to speak about what it learned from school about disease and ask child some basic questions about the same disease.

Six children (2 girls and 4 boys) aged between 9 -12 were recruited with help of diabetic nurse to participate in the study. Three metrics were assessed in the study which include adherence (defined as the level to which the children keep an accurate account of their measurements, mood and activities to their dairies on time); engagement (defined as how much time he spent on his dairy with and without Robot and make a comparison between those spent times; bonding (a post condition questionnaire that focused on the degree of relatedness the child experienced with the Robot was used to measure the bond between child and Robot).

The results indicated that the adherence with using Robot was found to be better than the adherence without Robot, which indicated that the Robot contribute in motivating the child to adhere with keeping dairy. It was found that the engagement with robot is better than without robot, which indicated that the robot encourage the diabetic child to engage in their daily activities. The third metric, boding between robot and children was measured used a post-condition questionnaire. In the post-condition questionnaire, the children were asked to agree or disagree with a number of statements on a scale of 1 to 5, where 1 meant 'completely disagree' and 5 meant 'completely agree'. The results have shown most of the children reacted positively for the performance of the Charlie as shown in the figure 1.

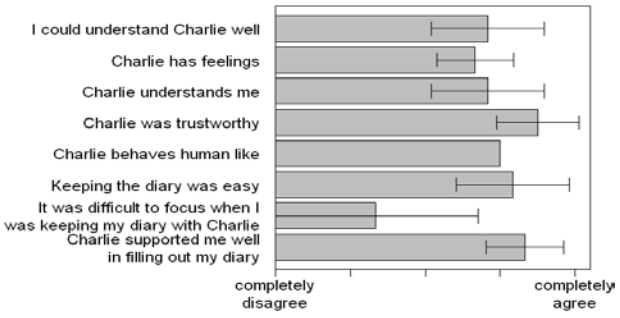

Fig. 1 Post-condition questionnaire

Though the small sample is one of the drawbacks in the study, the study has revealed that social robots could play

an important role in improving the adherence, bonding, and the engagement in activity for diabetic children.

One of the major functions of the diabetes management system is its application in long term. The next study [4] reviewed in this paper focuses on analyzing the impact of a conversational human-robot interaction which is aimed to support diabetes management in long term. The system delivers a set of activities that aimed at motivating diabetic children to improve their diabetes self-management. The most important aspects of this study is the enclosure of off-activity talk scattered within talk related to the activity at hand with aim to elicit the child's self-disclosure. 20 diabetic children aged between 11-14 years participated in the study.

The participants were randomly assigned to two groups. The first group would take individual session with OAT Robot and the other group without OAT Robot (NOAT). The available activities were included: (1) quiz activity, which is very simple while the child and robot will make a conversation and ask each other series of multiple choice quiz questions from different domain; (2) the Sandtray in which diabetic children and the robot solve sorting tasks on a shared touch-table. (3) Dance activity in which the robot discovers different moves with child, making a connection between nutritional concept and motions. I addition, the child could interact with the robot for 30 minutes as maximum and could stop at any point. After the interaction was finished, the participant was asked to fill a questionnaire administered by staff member.

The study focused on three specific targets, which include (I), perception of the Robot and relationship: the indicators of this target were collected through a questionnaire. The authors calculated the mean and standard deviation of scores for each question. The Overall outcomes, by comparing between the two means corresponding to the same question with and without NAO using t-test double tailed revealed no statistical significant. (2) interested to have further interaction: this is measured through a questionnaire question: "Do you want to play again with NAO?". The overall acceptance of want to play with NAO again was strong statistical significant which measured through double tail t-test. (3) Adherence to filling in nutritional diary: the number of participants who filled the nutritional dairy at least once during the summer camp was same in both groups with and without NAO. The comparison of the results from the NAO and NOAT groups combined against the CONTROL group reveals an effect of the individual interaction with the robot", which reveals the important role of NAO in improving individual adherence.

The overall outcomes of this study refer to the NAO ability to play an important role in improving and enhancing the diabetes management especially in increasing the patient awareness, adherence, and interest. It was identified that there is a strong acceptance by children to responding and interacting with NAO Robot.

Another similar study [9] reviewed in this paper is focused on assessing the impact of personal robot behavior in educational play on the enjoyment and motivation of diabetic children with their condition, and in their acquisition of health knowledge. the diabetic children plays a diabetic quiz against a personal robot or neutral robot in which the child and robot will ask each other about general questions like their names and favorite support etc. referred to these data through the interaction and involved in small talk. Diabetes knowledge, motivation and fun are measured by asking questions to the child during the quiz. Five children with minimum age of nine years participated in the study. They were assigned into two groups: intervention group and control group (neutral robot). The child played with the robot three times, once at clinic and two times at the home.

The overall findings of this study found that personalized robots can help children in improving their literacy levels by educating and playing in a fun filled interactive manner. The children appreciated that the interactive method was fun. However, it was observed that this appreciation declined over the time. The study concluded that there is a strong indication of how a personal robot could help diabetic children to improve health literacy in an enjoyable way.

4. Conclusion

This paper has reviewed six studies focusing on the role and impact of social robots in managing diabetes among the children in various perspectives including awareness, education, play, interaction, and disease monitoring and management (keeping diary). All the studies reviewed in this paper have reported a positive impact of the social robots on the children in diabetes self-management. There are few drawbacks that are identified in this paper which include using small sample population in few studies [9, 8], where the performance or impact in the presence of large sample cannot be predicted. The systematic search conducted in this study found only six papers with their topics relating to the social robots and their impact on children with diabetes in managing their disease. High costs of robots and its related components can be one of the major reasons in limiti8ng the number of research studies in this specific area. However, considering the positive results analyzed in the studies reviewed in this paper, it is high time that the number of research studies in identifying the use of social robots for diabetes management among the children needed a boost.

However, this paper has found that the use of social robot in improving diabetes management with children mostly contributed in enhancing the diabetes management and awareness among the diabetic children.

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