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Research Article

# Knowledge and Practices of Insulin Pump among Adults with Type 1 Diabetes Attending a Specialized Center in Saudi Arabia

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## Abstract

**Background:** Successful insulin pump therapy is influenced by patient's adherence to self-care behaviors. Local data about the practices of patients using insulin pump are limited. The objective was to examine insulin pump related knowledge and practices among patients with T1D. **Methods:** A survey study was conducted among adult patients with T1D receiving care at a specialized center in Saudi Arabia. Data were collected between January and March 2021 using 56-item questionnaire covering 10 domains of insulin pump practices. **Results:** A total 71 patients were included. The average age was 27.6±7.9 years and 74.6% of the patients were females. The average duration of diabetes was 12.8±6.8 years. The overall score of knowledge and practices was 69.4%. The domain with highest score was pump operations (81.3%), followed by pump failure and issues (73.2%), recording and follow up (72.8%), temporary pump removal (71.5%), use of advanced pump features (70.6%), travel and going out (69.9%), management of acute complications (69.7%), pump maintenance (64.1%), exercises and stressful conditions (63.0%), and lastly infusion site infection (24.7%). There were no associations between the level of knowledge and practices and the patient's age and gender. Approximately half (50.7%) of the patients expressed their need for counselling to improve their skills in using insulin pump. **Conclusions:** The current findings point to the domains that need further education and training, specially guarding against infusion site infection and exercise-induced hypoglycemia. The findings justify conducting a larger pre and post study to examine the impact of customized reeducation intervention.

**Keywords:** Insulin pump; Continuous subcutaneous insulin infusion; Knowledge; Practices; Type 1 diabetes; Saudi Arabia

## Introduction

Technology has transformed almost all aspects of healthcare services from electronic patients' records to less invasive surgical techniques [1]. Consistently, technologic developments targeting blood glucose monitoring and insulin delivery has dramatically changed the paradigm of diabetes self-management over the last four decades [2,3]. In patients with Type 1 Diabetes (T1D), the most commonly adopted technologies include Self-Monitoring of Blood Glucose (SMBG), Continuous Subcutaneous Insulin Infusion (CSII), known as insulin pumps, and lastly Continuous Glucose Monitoring (CGM) [2]. The prevalence of using insulin pump has dramatically increased over the last three decades to reach 60% in USA [4] and more than 50% in Europe [5]. The corresponding numbers in developing countries are lacking but definitely much lower [2].

Insulin pump aims to imitate the physiological pattern of insulin secretion, by delivering continuous small amounts of basal rate insulin superimposed by boluses with meals [6]. Several studies have confirmed its effectiveness in achieving glycemic control, improving the quality of life, and reducing insulin requirement and the risk of hypoglycemia [7,8]. The benefits are specially more evident in adolescents and younger age patients [6,8]. However, adverse events of insulin pump interfering with its function are still common despite the modern advances [9,10]. These include pump failure, blockage or dislocation of infusion set, infusion site infection or issues, and reduced insulin stability [11,12]. Additionally, successful insulin pump therapy is considerably influenced by adherence to self-care behaviors [13,14]. The latter is dependent on patient knowledge and motivation to grasp advanced features of insulin pump [15].

Despite having one of the world's highest rates of T1D [16], data about the prevalence of using insulin pump in Saudi Arabia are still lacking [12]. Most of the local studies focused on the impact of insulin pump on the glycemic control and acute complications [12,17,18]. On the other hand, insulin pump related knowledge and practices among patients with T1D were not comprehensively examined in Saudi Arabia. Moreover, the knowledge level of insulin pump among local healthcare providers was clearly inadequate [19,20]. The objective of the current study was to examine insulin pump related knowledge and practices among patients with T1D attending a specialized center in Saudi Arabia. Additionally, to examine their associations with demographic characteristics of the patients.

## Methods

### Setting

The current study was conducted at the Obesity, Endocrine, and Metabolism Center (OEMC) of the King Fahad Medical City (KFMC). The KFMC is 1200-bed tertiary care hospital located in the center of Riyadh, the capital of Saudi Arabia. It provides specialized and tertiary care to 300 thousand inpatients and 500 thousand outpatients every year. OEMC is one of four specialized centers run by the KFMC. It provides preventive and therapeutic services to inpatients and outpatients with obesity, endocrinal diseases, and metabolic diseases. It is one of the few centers in Saudi Arabia that manage advanced cases of morbid obesity and diabetes.

### Design

It was a survey study that was conducted between January and March 2021. The study design obtained all required ethical approvals from the ethical committee of KFMC.

### Population

The study targeted adult patients diagnosed with T1D and receiving care at the OMEC at the time of the study. Only patients who were using insulin pump during the last 6 months were included. Medtronic® insulin pump was the only pump used at OEMC. There were no exclusions based on age, gender, and duration of diabetes.

### Recruitment

A list of patients meeting the study eligibility criteria were provided by a certified insulin pump diabetes educator at OEMC. Due to COVID-19 restrictions, the patients were contacted by phone to confirm eligibility, take informed consent, and complete the study questionnaire. Out of 97 potentially eligible patients who have been contacted, 71 agreed to join the study and completed the study questionnaire. The response rate was 73.2%.

### Data collection tool

A structured study questionnaire was used to collect the data. The questionnaire was designed to cover 10 domains/aspects of insulin pump, including pump operations, maintenance, advanced features, failure, infusion site infection, acute complications, exercises, temporary removal, travel, and recording and follow up. The questions were based on similar studies [21] and related guidelines [8,22]. Face and content validity were done by four endocrinologists at KFMC, three of them are specialized in insulin pump therapy, and a certified diabetic educator. The questionnaire was designed in English then translated into Arabic and back to English by two independent bilingual individuals. The questionnaire had good reliability (Cronbach's alpha of 0.652).

### Statistical analysis

Categorical variables were presented as frequencies and percentage. Continuous variables were presented as means and Standard Deviations (SD). Overall and domain-specific scores of knowledge and practices were calculated based on the answers for 56 questions. Correct answer was given one point while incorrect answer was given zero points. Overall and domain-specific scores of knowledge and practices were then transformed into 100-point scale for easy interpretation. Overall and domain-specific scores of knowledge and practices were compared by groups identified by age, gender, and duration of diabetes, and need of diabetic counselling. Significant differences between groups were examined using Kruskal-Wallis test or Mann–Whitney test, as appropriate. All P-values were two-tailed. P-value $<0.05$ was considered as significant. SPSS software (release 25.0, Armonk, NY: IBM Corp) was used for all statistical analyses.

## Results

A total 71 patients were included in the current analysis. As shown in Table 1, the average age was 27.6±7.9 years, with almost half (49.3%) of the patients between 25 and 34 years. The majority (74.6%) of the patients were females. The average age at the diagnosis of T1D was 14.8±6.2 years. The average duration of diabetes was 12.8±6.8 years, with the majority (60.6%) of the patients had diabetes for 10 to 20 years. Approximately half (50.7%) of the patients expressed their need for counselling to improve their skills in using insulin pump.

| | Number or Mean | Percentage or SD |
|---|---|---|
| **Age (years)** | | |
| Mean±SD | 27.6 | 7.9 |
| <25 Years | 26 | 36.6% |
| 25-34 years | 35 | 49.3% |
| ≥35 years | 10 | 14.1% |
| **Gender** | | |
| Male | 18 | 25.4% |
| Female | 53 | 74.6% |
| **Age at diagnosis (years)** | | |
| Mean±SD | 14.8 | 6.2 |
| **Duration of diabetes** | | |
| Mean±SD | 12.8 | 6.8 |
| <10 Years | 17 | 23.9% |
| 10-19 years | 43 | 60.6% |
| ≥20 years | 11 | 15.5% |
| **Need counselling to improve pump skills** | | |
| No | 35 | 49.3% |
| Yes | 36 | 50.7% |
| SD: Standard Deviation | | |

**Table 1:** Demographic characteristics of the patients.

Table 2 shows the answers to the knowledge and practices questions of the insulin pump questionnaire. The questions that received the highest percentage (>90%) of correct answers included having internet connection at home/work (100.0%), taking insulin dose before meals (98.6%), entering carbohydrate amounts in the pump before meals (98.6%), wearing the pump when going out in the heat (97.2%), using bolus wizard to direct all insulin doses (93.0%), temporary pump removal during radiological testing such as X-ray, CT, and MRI (93.0%), carrying extra pump supplies during travel (93.0%), checking the expiration date of insulin (91.5%), and carrying carbohydrate to treat low blood glucose if needed (90.1%). On the other hand, the questions that received the lowest percentage (<40%) of correct answers included getting antibiotic prescription in case of infusion site infection (1.4%), using of airplane mode of the pump during travel (8.5%), fixing the prime with every new set/site change (18.3%), using ketone test strips at home (28.2%), using Carelink at home/work to download the pump report (32.4%), and keeping temporary pump removal guidelines at home (39.4%).

| Questions | Answers | |
|---|---|---|
| | Yes | No |
| **Pump operations** | | |
| Take insulin dose before meals | 70 (98.6%) | 1 (1.4%) |
| Take insulin dose after meals* | 17 (23.9%) | 54 (76.1%) |
| Enter carbohydrate amounts in the pump before meals | 70 (98.6%) | 1 (1.4%) |
| Use the manual bolus feature* | 10 (14.1%) | 61 (85.9%) |
| Use bolus wizard to direct all insulin doses | 66 (93.0%) | 5 (7.0%) |
| Follow insulin pump recommended insulin doses | 53 (74.6%) | 18 (25.4%) |
| Know how to review total daily doses of insulin | 39 (54.9%) | 32 (45.1%) |
| Know how to review your "status" screen | 43 (60.6%) | 28 (39.4%) |
| Need to increase basal insulin rate than the pump allows* | 12 (16.9%) | 59 (83.1%) |
| Need to bolus more than the pump allows* | 9 (12.7%) | 62 (87.3%) |
| **Pump maintenance** | | |
| Change the infusion set every 3 days | 54 (76.1%) | 17 (23.9%) |
| Fix prime with every new set/site change | 13 (18.3%) | 58 (81.7%) |
| Change insulin reservoir every 3 days | 55 (77.5%) | 16 (22.5%) |
| Let insulin get to room temperature before filling a reservoir | 45 (63.4%) | 26 (36.6%) |
| Know when to change the site (without reservoir) | 41 (57.7%) | 30 (42.3%) |
| Check expiration date of insulin | 65 (91.5%) | 6 (8.5%) |
| **Use of advanced pump features** | | |
| Calibrate the insulin pump | 29 (40.8%) | 42 (59.2%) |
| Use temporary basal rate reduction feature | 55 (77.5%) | 16 (22.5%) |
| Use temporary basal rate increase feature | 48 (67.6%) | 23 (32.4%) |
| Use of square wave boluses feature | 42 (59.2%) | 29 (40.8%) |

| | | |
|---|---|---|
| Use of dual wave boluses feature | 58 (81.7%) | 13 (18.3%) |
| Use of glucose check alarm feature | 59 (83.1%) | 12 (16.9%) |
| Use of different patterns of basal insulin | 60 (84.5%) | 11 (15.5%) |
| **Pump failure and issues** | | |
| Keep extra pump supplies at work/ school | 58 (81.7%) | 13 (18.3%) |
| Keep long acting insulin in case of pump failure | 47 (66.2%) | 24 (33.8%) |
| Use additional insulin syringe to lower high blood glucose* | 21 (29.6%) | 50 (70.4%) |
| Change site after 2 blood glucose readings > 250 mg/dL | 53 (74.6%) | 18 (25.4%) |
| **Infusion site infection** | | |
| Know symptoms of infusion site infection | 34 (47.9%) | 37 (52.1%) |
| Get antibiotic prescription in case of infusion site infection | 1 (1.4%) | 70 (98.6%) |
| **Management of acute complications** | | |
| Know the carbohydrate amount needed to treat low blood glucose | 57 (80.3%) | 14 (19.7%) |
| Carry carbohydrate with you to treat low blood glucose if needed | 64 (90.1%) | 7 (9.9%) |
| Keep glucagon to use if needed | 62 (87.3%) | 9 (12.7%) |
| Check the expiration date of glucagon | 57 (80.3%) | 14 (19.7%) |
| Family know how to use glucagon | 49 (69.0%) | 22 (31.0%) |
| Check for ketones in urine when blood glucose > 250 mg/dL | 29 (40.8%) | 42 (59.2%) |
| Use ketone test strips at home | 20 (28.2%) | 51 (71.8%) |
| Skip a meal in case of high blood glucose | 58 (81.7%) | 13 (18.3%) |
| **Exercises and other stressful conditions** | | |
| Check blood glucose before exercise | 60 (84.5%) | 11 (15.5%) |
| Check blood glucose during exercise | 35 (49.3%) | 36 (50.7%) |
| Check blood glucose after exercise | 56 (78.9%) | 15 (21.1%) |
| Decrease basal insulin 2 hours before exercise | 46 (64.8%) | 25 (35.2%) |
| Eat 20g of carbohydrate during exercise | 44 (62.0%) | 27 (38.0%) |
| Basal insulin reduction in case of severe vomiting | 29 (40.8%) | 42 (59.2%) |
| Change basal insulin during periods | 31 (58.5%) | 22 (41.5%) |
| **Temporary pump removal** | | |
| Temporary remove of pump before swimming | 57 (80.3%) | 14 (19.7%) |
| Keep temporary pump removal guidelines at home | 28 (39.4%) | 43 (60.6%) |
| Check blood glucose if pump is removed more than 1 hour | 52 (73.2%) | 19 (26.8%) |
| Temporary pump removal during taking X-ray \ CT \ MRI | 66 (93.0%) | 5 (7.0%) |
| **Travel and going out** | | |
| Wear your pump outside in the heat | 69 (97.2%) | 2 (2.8%) |
| Travel warning report indicating the use of insulin pump | 52 (73.2%) | 19 (26.8%) |
| Use of airplane mode of the pump | 6 (8.5%) | 65 (91.5%) |
| Use of insulin cool | 55 (77.5%) | 16 (22.5%) |
| Carry extra pump supplies during travel | 66 (93.0%) | 5 (7.0%) |
| **Recording and follow up** | | |
| Use Carelink at home/work to download your pump report | 23 (32.4%) | 48 (67.6%) |
| Have internet connection at home/ work | 71 (100.0%) | 0 (0.0%) |
| Have access to printer at home/work | 61 (85.9%) | 10 (14.1%) |

*Negative statements

**Table 2:** Answers to the knowledge and practices questions of the insulin pump questionnaire.

Figure 1 shows the overall and domain-specific average scores of knowledge and practices. The overall score of knowledge and practices was 69.4%. The domain with highest score of knowledge and practices was pump operations (81.3%), followed by pump failure and issues (73.2%), recording and follow up (72.8%), temporary pump removal (71.5%), use of advanced pump features (70.6%), travel and going out (69.9%), management of acute complications (69.7%), pump maintenance (64.1%), exercises and stressful conditions (63.0%), and lastly infusion site infection (24.7%).

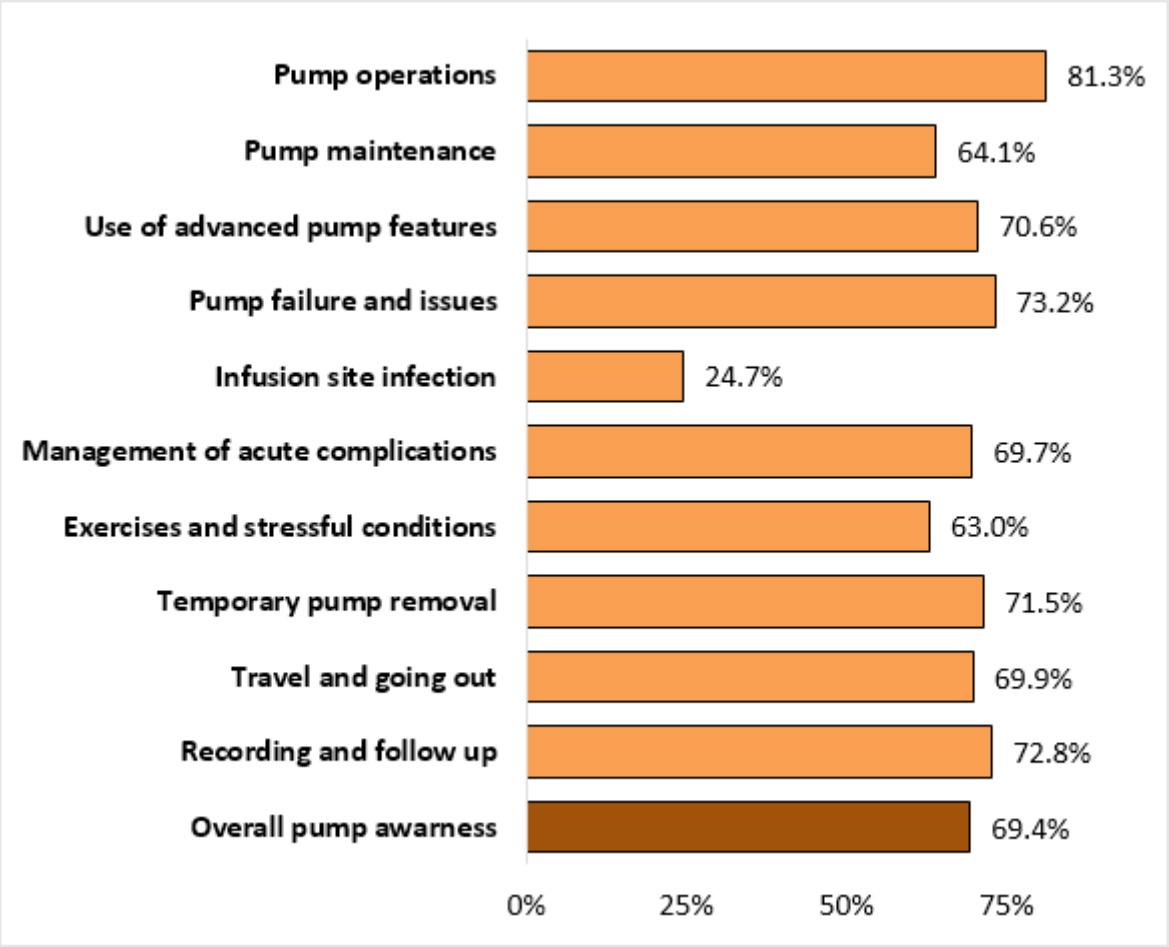


**Figure 1:** Average overall and domain-specific scores of knowledge and practices questions of the insulin pump questionnaire.

Table 3 shows the associations of demographic characteristics with scores of knowledge and practices. There overall scores of knowledge and practices were 69.8%±7.9%, 70.0%±11.1%, and 66.4%±9.5% in patients aged <25, 25-34, and ≥35 years (respectively), with no significant associations between age groups and both overall (p=0.433) and domain-specific scores of knowledge and practices (p>0.05). There overall scores of knowledge and practices were 69.4%±11.9% in males and 69.5%±9.1% in females, with no significant associations between gender and both overall (p=0.525) and domain-specific scores of knowledge and practices (p>0.05). The overall scores of knowledge and practices were 69.7%±8.8%, 69.2%±9.6%, and 69.8%±12.5% in patients with duration of diabetes <10, 10-19, and ≥20 years (respectively). Although there were no significant association between the duration of diabetes and overall score of knowledge and practices (p=0.977), the score of knowledge and practices related to the management of acute complications was significantly decreasing as the duration of diabetes is increasing (76.5%±17.6%, 69.5%±16.2%, and 60.2%±19.2% respectively, p=0.039). The overall scores of knowledge and practices were 69.8%±10.9% and 69.0%±8.6% among those who need and those did not need counselling to improve pump skills (respectively). Although there were no significant association between the need of counselling and overall score of knowledge and practices (p=0.977), the score of knowledge and practices related to the infusion site infection was significantly higher among those who needed counselling (31.9%±24.4% versus 17.1%±24.1%, p=0.013).

| | | Age (years) | | | Gender | | Duration of diabetes | | | Need counselling | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | <25 | 25-34 | ≥35 | Male | Female | <10 | 10-19 | ≥20 | Yes | No |
| Pump operations | Mean | 78.5% | 83.4% | 81.0% | 84.4% | 80.2% | 79.4% | 80.7% | 86.4% | 81.4% | 81.1% |
| | SD | 12.9% | 13.3% | 12.9% | 12.0% | 13.4% | 9.7% | 14.2% | 12.9% | 13.8% | 12.5% |
| Pump maintenance | Mean | 60.9% | 63.8% | 73.3% | 69.4% | 62.3% | 68.6% | 61.6% | 66.7% | 62.0% | 66.2% |
| | SD | 19.4% | 18.7% | 14.1% | 13.1% | 19.9% | 19.4% | 19.1% | 14.9% | 19.8% | 17.4% |
| Use of advanced pump features | Mean | 73.1% | 69.4% | 68.6% | 67.5% | 71.7% | 66.4% | 71.4% | 74.0% | 70.2% | 71.0% |
| | SD | 16.3% | 21.4% | 13.1% | 21.2% | 17.6% | 14.2% | 19.7% | 20.0% | 20.6% | 16.4% |
| Pump failure and issues | Mean | 76.0% | 72.1% | 70.0% | 72.2% | 73.6% | 64.7% | 75.6% | 77.3% | 74.3% | 72.1% |
| | SD | 21.8% | 26.3% | 23.0% | 28.3% | 22.7% | 23.5% | 24.1% | 23.6% | 24.3% | 24.1% |
| Infusion site infection | Mean | 25.0% | 24.3% | 25.0% | 16.7% | 27.4% | 17.6% | 26.7% | 27.3% | 31.9%* | 17.1% |
| | SD | 25.5% | 25.4% | 26.4% | 24.3% | 25.1% | 24.6% | 25.2% | 26.1% | 24.4% | 24.1% |
| Management of acute complications | Mean | 70.7% | 70.0% | 66.3% | 64.6% | 71.5% | 76.5% | 69.5% | 60.2%* | 70.8% | 68.6% |
| | SD | 17.3% | 18.5% | 15.6% | 19.8% | 16.5% | 17.6% | 16.2% | 19.2% | 18.2% | 17.0% |
| Exercises and stressful conditions | Mean | 65.4% | 64.2% | 52.9% | 68.5% | 61.2% | 66.7% | 61.8% | 62.1% | 60.2% | 66.0% |
| | SD | 23.3% | 21.7% | 36.9% | 20.5% | 26.0% | 20.5% | 25.4% | 30.0% | 25.8% | 23.8% |
| Temporary pump removal | Mean | 71.2% | 74.3% | 62.5% | 68.1% | 72.6% | 72.1% | 73.3% | 63.6% | 72.9% | 70.0% |
| | SD | 16.9% | 23.1% | 21.2% | 25.4% | 19.2% | 19.5% | 20.0% | 25.9% | 20.2% | 21.7% |
| Travel and going out | Mean | 71.5% | 69.7% | 66.0% | 67.8% | 70.6% | 67.1% | 70.2% | 72.7% | 72.8% | 66.9% |
| | SD | 12.9% | 18.4% | 16.5% | 18.3% | 15.5% | 14.0% | 17.1% | 16.2% | 16.0% | 16.0% |
| Recording and follow up | Mean | 75.6% | 74.3% | 60.0% | 75.9% | 71.7% | 78.4% | 69.8% | 75.8% | 75.0% | 70.5% |
| | SD | 17.8% | 24.4% | 21.1% | 25.1% | 21.1% | 16.4% | 22.8% | 26.2% | 20.1% | 23.9% |
| Overall pump awareness | Mean | 69.8% | 70.0% | 66.4% | 69.5% | 69.4% | 69.7% | 69.2% | 69.8% | 69.8% | 69.0% |
| | SD | 7.9% | 11.1% | 9.5% | 11.9% | 9.1% | 8.8% | 9.6% | 12.5% | 10.9% | 8.6% |

*Significant associations. P-values were calculated using Kruskal–Wallis test or Mann–Whitney test (as appropriate).

**Table 3:** Associations of demographic characteristics with overall and domain-specific scores of knowledge and practices questions of the insulin pump questionnaire.

## Discussion

The current study reported insulin pump related knowledge and practices among a group of patients with T1D attending a specialized center in Saudi Arabia. The finding showed that the current patients had knowledge and practices level of 69% relative to best expected knowledge and practices. It is challenging to compare such finding with previous data due to complete lack of similar local studies. Nevertheless, the current findings had more similarities than differences to those reported in the USA using a fairly similar tool. For example, lack of antibiotic prescription to use in suspected infusion site infections, failure to check for urinary ketones in case of elevated blood glucose, and lack of guidelines for temporary pump removal were among the major deficiencies in the current study and the USA study [21]. On the other hand, using manual bolus instead of calculated bolus and lack of in-date glucagon kit for the management of severe hypoglycemia were among the deficiencies in the USA study [21] but not the current study. Additionally, not completing fixed prime with every site change was among the major deficiencies in the current study but not the USA study [21].

The current findings showed that not guarding against infusion site infections, not following precautions related to exercises and stressful conditions, and inappropriate insulin pump maintenance were among the major deficiencies in the patients of the current study. The findings point to the domains that need further education and training. Reducing the risk of infection can be achieved by changing the infusion set every 3 days, recognizing the signs and symptoms of skin irritation/infection, and keeping antibiotic cream to use when needed [21,23]. Reducing the risk of exercise-induced hypoglycemia can be achieved by frequent glucose monitoring and eating carbohydrates during exercise [24]. Lack of appropriate insulin pump maintenance can be manifested in several adverse events, such as pump failure, pain, adhesion,

irritation, lipodystrophy, and technical issues [12,25]. It has been suggested that comprehensive patient education and frequent Blood Glucose Monitoring (SMBG or CGM) are necessary components of successful insulin pump therapy [8,14]. Additionally, several studies confirmed the benefits of patient education in improving the glycemic control [26]. Given the fact that insulin pump is a life-long therapy, education and training should be a continuous and customized process [8, 27]. Retraining of patients with poor knowledge level [27] or involving families of younger patients [28,29] can be very efficient in improving glycemic control.

With few exceptions, the associations of knowledge and practices with demographic and disease-related characteristics in the current study were generally weak. The negative association between the disease duration and the readiness to manage acute complications in the current study may further point to the importance of reeducation of patients with longstanding disease [27]. The lack of associations between knowledge and practices and age and gender in the current study was not surprising. Previous studies that examined patients with a wider age span showed a much higher uptake of insulin pump in children and adolescents compared with adults [30]. Additionally, adherence to self-care behaviors related to insulin pump was associated in some studies with patient knowledge and motivation rather than gender, education level, and social class [15]. This may be related to advanced features of insulin pump that cover wide range of personal preferences.

The current study is considered the first study in Saudi Arabia to comprehensively examine insulin pump related knowledge and practices in patients with T1D. The study tool covered 10 different domains of insulin pump practices in a cohort of patients using the same type of devices and receiving the same level of care. Nevertheless, few limitations should be acknowledged. The cross-sectional design can determine association but not causation. Being a single center experience and the relatively small sample size may limit the generalizability of the findings to Saudi patients with T1D. However, we believe that these limitations have minor impact on the study finding (if any).

In conclusion, patients in the current study with T1D who were attending a specialized center in Saudi Arabia had insulin pump related knowledge and practices level of 69% relative to best expected knowledge and practices. Not guarding against infusion site infections, not following precautions related to exercises and stressful conditions, and inappropriate insulin pump maintenance were the major deficiencies in these patients. With few exceptions, the associations of knowledge and practices with demographic and disease-related characteristics were generally weak.

## Conclusion and Recommendation

The findings of current study confirm the need for education and training. Additionally, there is a need for conducting a larger pre and post studies to examine the impact of customized reeducation intervention.

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