

# Implementation of diabetes care and educational program via telemedicine in patients with COVID-19 in home isolation in Thailand: A real-world experience

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## Keywords

COVID-19, Diabetes, Home isolation

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## ABSTRACT

**Background:** The coronavirus disease (COVID-19) outbreak in Bangkok led to a shortage of hospital capacity, and a home isolation system was set up. We described the process of diabetes self-management education and support (DSMES) and glycemic management via telemedicine, along with outcomes in home-isolated patients with COVID-19 infection.

**Methods:** A retrospective chart review of glucose values, insulin and corticosteroids use, and outcomes was performed.

**Results:** A volunteer group of 21 endocrinologists and 21 diabetes educators/nurses formed the consultation team. Patients with diabetes or at high-risk of diabetes and receiving corticosteroids were referred by primary volunteer physicians. Glucometers and related supplies, and insulin were donated, and delivered via same-day delivery services. A chat group of an individual patient/their caregiver, diabetes educator, endocrinologist, and primary physician was formed (majority via LINE<sup>®</sup> platform) to assess the patient's clinical status and need. Real-time virtual DSMES sessions were performed and treatments were adjusted via smartphone application or telephone. There were 119 patients (1,398 service

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days), mean (SD) age 62.0 (13.6) years, 85.7% had a history of type 2 diabetes, and 84.0% received corticosteroids. Insulin was used in 88 patients; 69 of whom were insulin-naïve. During the first 10 days, there were 2,454 glucose values. The mean glucose level on day 1 was 280.6 (122.3) mg/dL, and declined to 167.7 (43.4) mg/dL on day 10. Hypoglycemia occurred in 1.4% of the values. A majority of patients (79.5%) recovered at home.

**Conclusion:** Diabetes care and DSMES delivered via telemedicine to patients on home isolation during COVID-19 pandemic was safe and effective.

## INTRODUCTION

Coronavirus disease 2019 or COVID-19 infection has become a global pandemic since the beginning of 2020. To date, the infection has surpassed 384 million cases and up to 5.6 million deaths worldwide<sup>1</sup>. During each period of rapid surge of COVID-19 infection, the healthcare system was severely disrupted and strained. Multiple countries including the Thai government have implemented home isolation or a home quarantine program to prevent healthcare collapse and to mitigate limited healthcare resources. In Thailand, COVID-19 disease cases surged to approximately 20,000–25,000 cases per day between July 2021 and October 2021, which created a challenge in the management COVID-19 infection in the hospitals. Previous publications described the feasibility of a COVID-19 home monitoring program using telemedicine to minimize the gap of care during the shortage of healthcare workforce in several countries<sup>2–5</sup>. These programs mainly monitored for the severity of symptoms, and alerted patients to seek a higher level of care if needed.

Since the emergence of the pandemic, diabetes has been identified as one of the risk factors associated with severe COVID-19 infection other than cardiovascular disease, hypertension and obesity<sup>6–8</sup>. Numerous observational and epidemiological studies showed that individuals with diabetes are at high risk for complications of COVID-19 infection, with increased intensive care unit admission, requiring mechanical ventilation, and death<sup>7,9–11</sup>. The presence of micro- or macrovascular complications and hyperglycemia at the time of admission were associated with higher morbidity and mortality<sup>12,13</sup>. Interestingly, outpatient insulin treatment was strongly predictive of poor outcomes<sup>13,14</sup>.

While good glycemic control is a predictor of COVID-19 outcomes and other diabetes-related complications, unfortunately, a significant number of patients with diabetes around the world do not have optimal glycemic control<sup>15,16</sup>. The results from the 6th National Health Examination Survey (2019–2020) in Thailand revealed that only 26.3% of patients with diagnosed diabetes had good glycemic control as measured by fasting glucose levels<sup>16</sup>. Besides antihyperglycemic medications and insulin, diabetes self-management education and support (DSMES) is recognized as an important strategy in managing diabetes and achieving glycemic control<sup>17</sup>. Unfortunately, it was

estimated that <5% of Medicare Beneficiaries in the US utilized DSMES services<sup>18</sup>. The use of telemedicine during COVID-19 is encouraged, and this includes the delivery of DSMES<sup>19</sup>.

While the use of telemedicine to provide DSMES and diabetes care to reduce in-person contacts has been effective, the study that examined diabetes care in patients with COVID-19 during home quarantine program is sparse. A study compared the use of telemedicine vs. in-person outpatient care on diabetes quality measures during the first 9 months of the COVID-19 pandemic found that the likelihood of meeting the care goal was 25% higher in telemedicine compared with in-person care<sup>20</sup>. Another study focusing on patients hospitalized with COVID-19 demonstrated that the use of teleconsultation (telephone and video calls) was effective in teaching insulin injection techniques and dose adjustment with a high rate of acceptability among patients<sup>21</sup>. Longo *et al.*<sup>22</sup> described worsening glycemic control in home-isolated adults with type 1 diabetes and COVID-19 using continuous glucose monitoring compared with age-matched diabetic patients without the infection. During the COVID-19 surge in Thailand (July–October 2021), the home isolation system was established. Different from the previously described studies, the system also provided treatments, including corticosteroids, in addition to symptoms monitoring. The care system encountered problems with glycemic control, especially in patients with diabetes who received corticosteroids. In this present study, we describe the system setup, the process of care and outcomes of the multidisciplinary intensive intervention using telemedicine to provide glycemic management as well as DSMES for patients with diabetes or at high risk of diabetes during the home isolation program.

## METHODS

This study was a retrospective chart review of patients who received home glucose monitoring while being cared for in one of the home isolation clinics in Bangkok, Thailand between July and October 2021. This home isolation service was established in June 2021 by the Royal College of Family Physicians of Thailand in collaboration with Pribta Clinic, Institute of HIV Research and Innovation, Bangkok, Thailand. In brief, patients who tested positive for COVID-19 self-registered through a central call center. Then they were contacted by a health care team to evaluate the severity of COVID-19. Supplies, including

a home oximeter and thermometer, and home oxygen if needed, were distributed by the clinic. Medications, including corticosteroids, were also distributed as deemed necessary by the physicians caring for the patients.

Volunteer physicians and healthcare team members conducted patient care via telemedicine (telephone or teleconference calls). It quickly became apparent that there were patients with diabetes, or at high risk for diabetes, who needed help in managing glucose levels during their illness. While heterogeneity exists in diabetes care among different health centers in Thailand, in general, patients are seen at in-person visits and medications are dispensed at that facility. The ability to contact their providers during the illness for advice varied depending upon the setup of the health centers. Because of COVID-19 infection, these patients could not be seen in person, and the use of telemedicine in health centers also varied. A majority of the patients we cared for did not get medical advice from their regular providers during this time. Therefore, a group of volunteer endocrinologists and diabetes educators was recruited, and a supply chain was established. This paper describes this process.

A retrospective chart review was performed. Data collected included demographics, diabetes history, and medication use, date of COVID-19 onset, corticosteroids use, results of home blood glucose monitoring, and insulin dose prescribed. The number of days the patients remained on service, along with outcome (home, hospitalization, death) were also collected. The protocol was approved by the Institutional Review Board, Chulalongkorn University, Bangkok, IRB no. 986/64.

### Data analysis

Data are expressed as mean (standard deviation, SD) or frequency (percent). Insulin and corticosteroids dose, and average glucose levels were calculated for the first 10 days of the service. Glucose levels were categorized as hypoglycemia (<70 mg/dL), normo- to mild hyperglycemia (70–250 mg/dL), and severe hyperglycemia (>250 mg/dL). Generalized linear model analysis (repeated measures) was performed to determine the trend in glucose levels during the first 10 days in the same individuals. Statistical analyses were performed using SPSS version 28.0 (Chicago, IL, USA). A value of  $P < 0.05$  was considered statistically significant.

## RESULTS

### System setup

A group of 21 endocrinologists (a few resided outside Thailand), and 21 certified diabetes educators/diabetes nurses formed the consultation team. Patients who contracted COVID-19 were referred by a group of volunteer physicians working with the Pribta Clinic. While there were no fixed referral criteria, most patients had pre-existing diabetes or were at high risk of hyperglycemia (e.g. obesity or a history of gestational diabetes), and receiving a high dose corticosteroids.

A general concept of diabetes care during home isolation was discussed among providers. While individual care

depended upon each endocrinologist, it was agreed that sulfonylurea could be continued and adjusted as needed, while metformin should be withheld if there was hypoxia (e.g. home oxygen saturation was <96% or dropped >3% after exercise). Insulin should be started if home blood glucose monitoring (BGM) values were consistently >200 mg/dL. Urine ketones should be tested for if there was a suspicion of diabetic ketoacidosis.

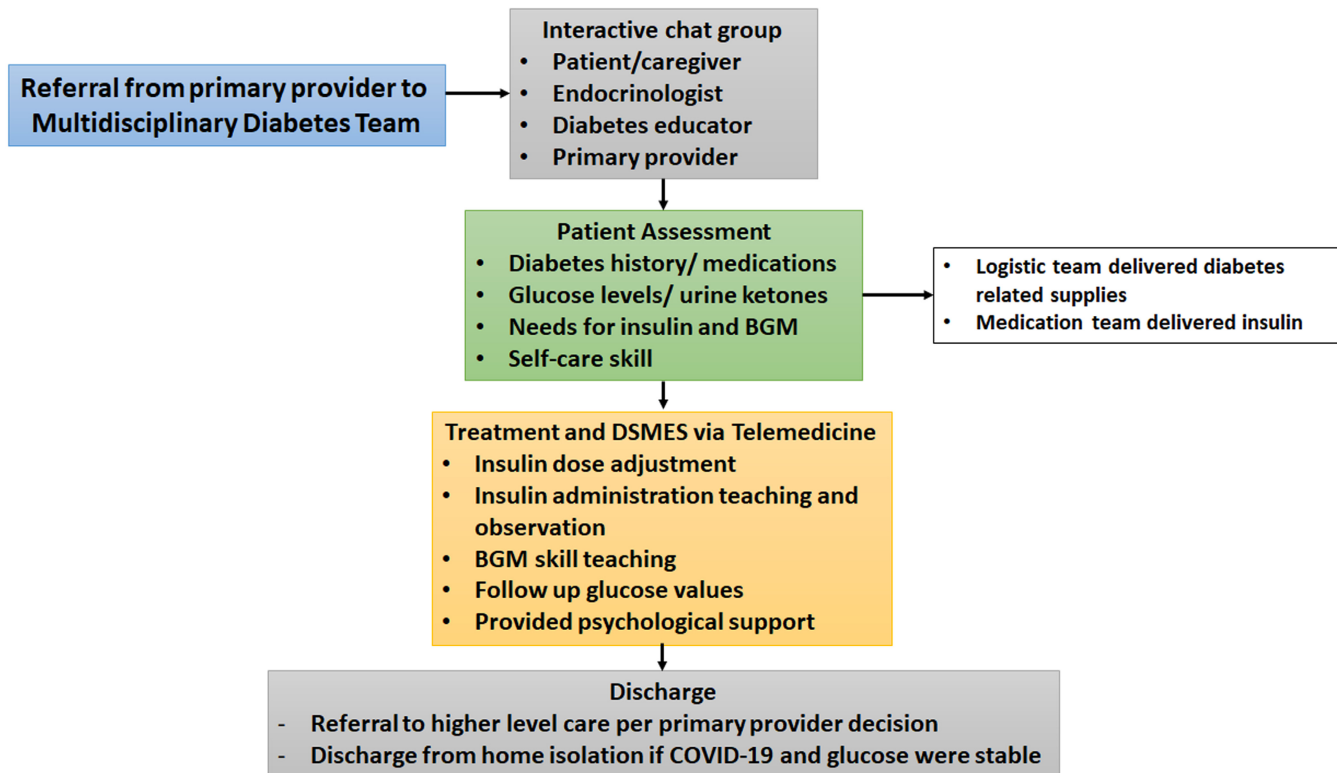
Medical supplies, including glucometers, blood glucose test strips, lancets, urine test strips were donated or purchased using donated funds. The supplies were stocked at a central location and distributed by volunteers, utilizing same-day commercial delivery services.

For antihyperglycemic agents, the team only provided insulin, as other non-insulin agents were deemed likely insufficient in managing COVID-associated hyperglycemia. Adjustments of patients' home antidiabetic medications, mainly sulfonylurea, were occasionally performed according to the endocrinologists' opinion. Disposable prefilled insulin pens, both long-acting and short-acting analogs, were chosen instead of insulin vials to reduce the errors of administration particularly in insulin-naïve patients. Insulin pens were kept at a medical clinic and distributed in a temperature-controlled container by same-day delivery service.

### Patient care and education process via telemedicine

Figure 1 illustrates the overall process. Multidisciplinary care group which consisted of patient or caregiver, diabetes educator, endocrinologist, and primary physician was established for each patient using the LINE<sup>®</sup> platform, a smartphone application. In a rare instance that the patients did not have access to smartphones, regular phone calls were used (two patients in the study). The LINE<sup>®</sup> platform is a closed group chat, which allows text messages, sending pictures and videos, making calls (similar to telephone) as well as video calls. This application was very popular in Thailand with an estimated 84% of Thai internet users had active line accounts in 2019<sup>23</sup>, making it the choice of communication as most patients and/or their family members had existing accounts. Through this platform, the patient's clinical status and needs were assessed, and education and care instructions were delivered.

Although the precise amount of time spent in educational sessions was not tracked, an initial assessment by endocrinologists and educators lasted between 15 and 30 min. Instructions and education on BG testing, insulin injections, self-care skills were performed by educators. The methods used included text messages (including sending pictures) and video calls. Education materials (e.g. video on how to inject insulin, perform BGM, hypoglycemia detection and management) were delivered via this platform. For those who had never performed BGM or insulin injection, the instruction took approximately 15–20 min for each skill. Follow up of glucose levels, urine test results, and food intake were assessed in real-time by the consultation team to adjust the treatment. Many patients sent pictures of their



**Figure 1** | Process of providing glycemic management and DSMES.

glucometers after performing BGM, containing glucose values and times, which increased the accuracy of data transmission. These interactions generally occurred 2–4 times daily (at the time of BGM) and took approximately 5–10 min each time. In most cases when insulin was initiated in insulin-naïve patients, educators observed insulin injections along with the patients or caregivers. Additional interactions occurred if there were questions from the patients or problems that needed additional advice. The content of the text messages did not have a fixed format but rather was adapted by educators as appropriate. An example of teaching materials is shown in Figure 2.

Patients were discharged when their COVID-19 status had improved and glycemic control was stable.

**Patients’ baseline characteristics**

One hundred and nineteen patients received glucose monitoring (Table 1). The mean age (SD) was 62.0 (13.6) years and one-third were obese (BMI ≥30 kg/m<sup>2</sup>). The patients had symptoms on average of 7.9 days before being cared for by our service. A majority (85.7%) had a history of type 2 diabetes, while 14.3% had no diabetes history. About one-third of patients were not using any diabetes medications; and among those on medications, sulfonylureas and metformin were most frequently used, while 17.2% of patients reported using insulin. The mean number of days on the service was 11.8 (9.2), amounting to 1,398 service days.

**Glycemic control, insulin, and corticosteroids use during treatment**

Daily mean glucose levels, insulin dose, and corticosteroids dose (mg equivalent to prednisolone) are shown in Table 2.

There was a total of 2,454 glucose values from all patients during the first 10 days. Of these, 1.4% were in the hypoglycemic range, 30.7% were in the severe hyperglycemic range (≥250 mg/dL), and 67.8% were in the normo- to mild hyperglycemic range (70–250 mg/dL). The mean glucose level (SD) on day 1 of service was 280.6 (122.3) mg/dL, and the values gradually reduced during the treatment to 167.7 (43.4) mg/dL on day 10. The proportion of glucose values in the severe hyperglycemic and normo-to-mild hyperglycemic range decreased and increased from day 1 to day 10, respectively (Figure 3). When analyzing within-person values for those who had glucose levels for 10 days (n = 56), the values significantly declined from 306.7 (129.6) mg/dL on day 1 to 168.5 (41.7) mg/dL on day 10 (P < 0.001), Figure 4. This decline paralleled the decline in steroid dose, while the insulin dose lagged behind, Figure 4.

A total of 100 patients (84.0%) were treated with corticosteroids during their illness. Among those receiving corticosteroids, the mean dose ranged between 30 and 38 mg/day of prednisolone equivalent from day 1–7, and declined on day 8. A total of 89 patients received insulin; of these, 67 patients were



**Figure 2** | An example of educational materials delivered to the patients. Left: QR codes linked to paper and video instructions. Right: a part of the instruction on blood glucose monitor. The materials were developed by the Faculty of Medicine Ramathibodi Hospital, Bangkok, Thailand, with permission to use.

**Table 1** | Patients’ characteristics and outcomes

	N = 119
Age (year), n = 117	62.1 (13.7)
Female	72 (61.5%)
Male	45 (38.5%)
Weight (kg), n = 111	72.1 (18.9)
Body mass index (kg/m <sup>2</sup> ), n = 107	28.2 (6.9)
Obese, n = 108	38 (35.2%)
COVID-19 day of illness, n = 84	7.9 (4.0)
Number of days on service	11.8 (9.2)
History of chronic kidney disease	6 (5.0%)
Diabetes history	
Type 2 diabetes	102 (85.7%)
No history of diabetes	17 (14.3%)
Number of home diabetes medications, n = 116	
None	34 (29.3%)
1	37 (31.9%)
2	37 (31.9%)
3	6 (5.2%)
4	1 (0.9%)
5	1 (0.9%)
Type of home diabetes medications	
Sulfonylurea	41 (35.3%)
Metformin	58 (50.0%)
Insulin	20 (17.2%)
Others	13 (11.3%)
Outcome, n = 116	
Home	93 (79.5%)
Hospital/hospital or community isolation	20 (17.1%)
Death	4 (3.4%)
Presence of urine ketones	6 (5.0%)

Data presented as mean (SD) or count (%).

**Table 2** | Glucose values, insulin, and corticosteroids dose during the first 10 days

	Mean glucose levels (mg/dL)			Insulin dose in those receiving insulin (units/kg)			Corticosteroids dose in those receiving steroids (mg/day, prednisolone equivalent)		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
Day 1	109	280.6	122.3	62	0.34	0.25	82	35.9	16.3
Day 2	109	236.4	90.2	74	0.57	0.40	90	38.6	16.5
Day 3	108	215.5	73.4	76	0.63	0.40	90	36.6	17.6
Day 4	106	205.3	68.1	74	0.68	0.44	86	35.7	18.9
Day 5	99	201.5	64.7	69	0.70	0.42	79	33.9	20.1
Day 6	95	202.8	71.4	72	0.67	0.45	69	33.1	22.3
Day 7	82	196.6	61.7	64	0.71	0.51	60	30.8	21.5
Day 8	75	186.0	48.5	54	0.71	0.50	56	26.6	20.9
Day 9	71	177.7	50.0	50	0.64	0.48	44	24.2	19.5
Day 10	60	167.7	43.4	41	0.61	0.48	33	26.8	32.1

insulin-naïve. Among those receiving insulin, the daily dose increased on day 2 (mean 0.57 (0.40) units/kg), remained high from day 4–8, and started declining on day 9–10. The pattern of insulin dose paralleled that of the steroid dose, as expected in corticosteroid-induced hyperglycemia.

The patients’ outcomes are shown in Table 1. A majority of patients (79.5%) remained at home, while 17.1% were transferred to hospitals/community isolation centers. The latter was not always due to worsening of symptoms as the Thai government preferred COVID-19 patients to be treated in a facility if

Percentages of glucose values in each range from Day 1-10

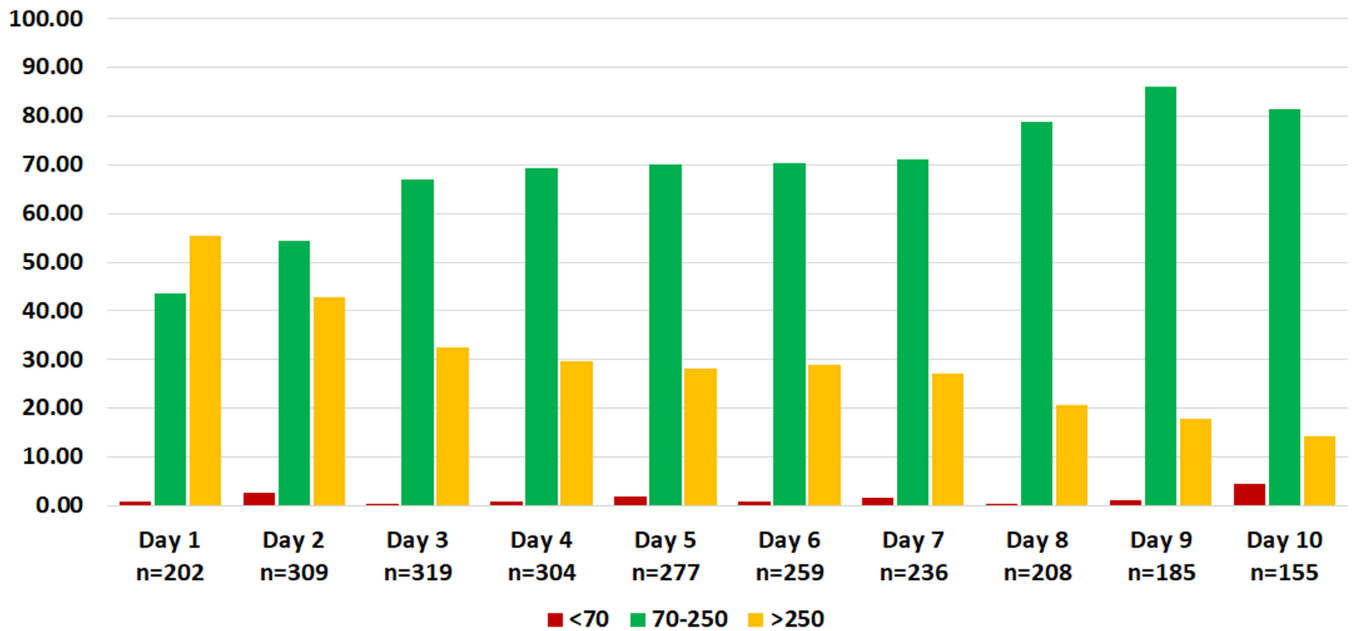


Figure 3 | Percentages of glucose values in each range from day 1 to 10.

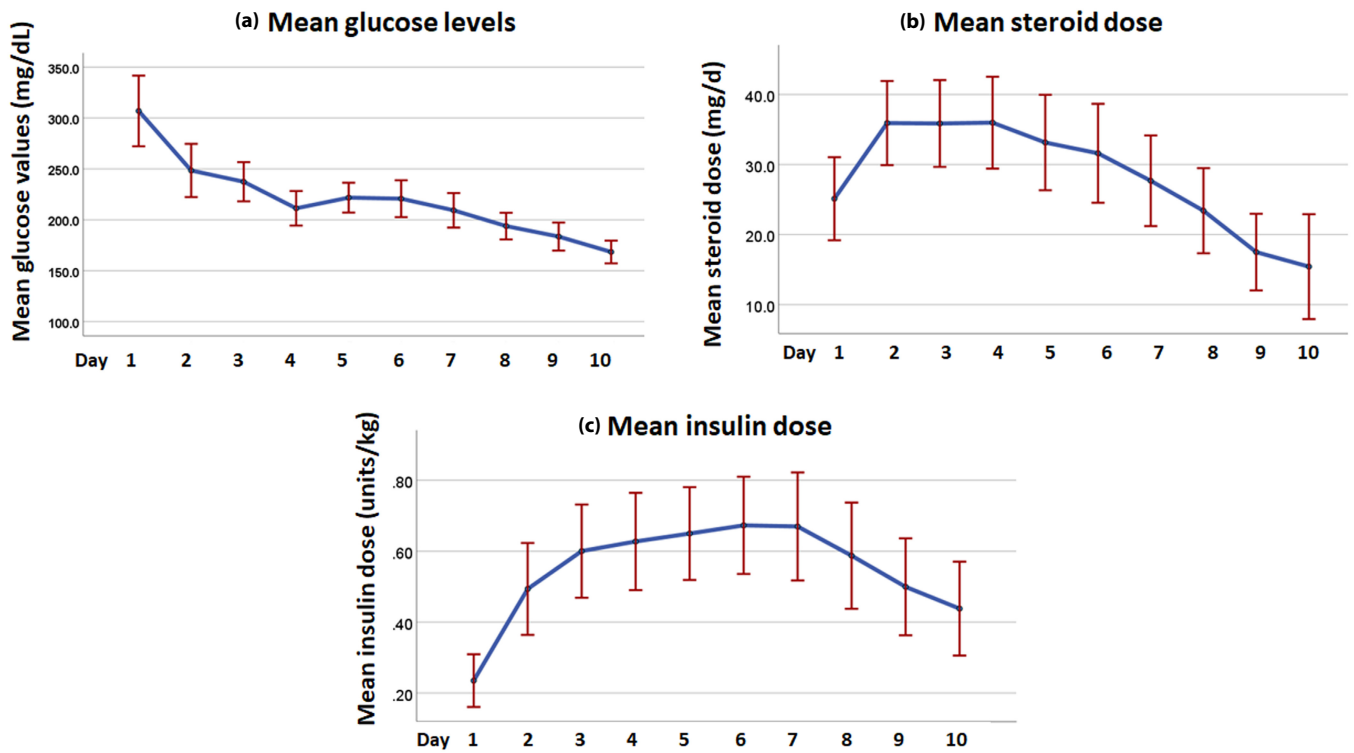


Figure 4 | Longitudinal changes in (a) mean glucose levels; (b), mean daily steroid dose (prednisolone equivalent, mg); and (c) mean daily insulin dose (units/kg) during the first 10 days (n = 56).

at all possible. Four patients (3.4%) died, one on the day of consultation to service, and one on day 4 shortly after arriving to the emergency room (patient had previously refused to go to the hospital despite the care team's suggestion), and two after several days of hospital admission.

Ketosis (measured by urine test strips) occurred in six patients (5.0%), of these, three were successfully treated at home and three were transferred to the hospital.

## DISCUSSION

This paper describes the process and outcomes of caring for patients with COVID-19 and hyperglycemia via telemedicine while in the home isolation system. While glycemic control has been recognized as an important risk factor in morbidity and mortality in COVID-19 patients, most studies have focused on inpatient care, or general recommendations to optimize glycemic control in patients not yet infected with COVID-19<sup>24,25</sup>. Our study is unique in describing a centralized diabetes care system in patients with COVID-19 during home isolation, most of whom received corticosteroids leading to significant hyperglycemia, requiring close monitoring using patient-generated health data (PGHD) and treatment. The results demonstrate that DSMES, along with glycemic management, could be successfully delivered and likely improved glycemic control in such patients, many of whom had never checked their home blood glucose or used insulin prior to their illness. A majority of the patients completed their COVID-19 treatment course at home, with low incidence of hypoglycemia.

Potential mechanisms of poor glycemic control during COVID-19 infection may include acute inflammatory response, insulin resistance, and impaired insulin secretion<sup>26</sup>. It has been observed that the frequency of diabetic ketoacidosis increased during the COVID-19 pandemic<sup>27,28</sup>. Treatment of COVID-19 infection specifically corticosteroids could further cause a deterioration of glycemic control. There is likely a bi-directional relationship between COVID-19 and diabetes as emerging evidence suggests that SARS-CoV-2 can infect human pancreatic  $\beta$ -cells, leading to attenuated insulin secretion and  $\beta$ -cell apoptosis<sup>29</sup>. Collectively, these factors contribute to hyperglycemia, and glycemic control is essential during the treatment of COVID-19 infection.

There are several key factors to our success. These include a real-time multidisciplinary individualized approach to care (e.g. assessment of individualized needs, real-time insulin adjustment), two way communications and feedback using PHGD, and customized education. Multiple modalities of education materials, including electronically delivered flyers/pictures and instructional videos, facilitated the patient's understanding during this remote treatment. These are key features of effective technology-enabled DSMES in order to improve health outcomes as suggested by the American Diabetes Association<sup>30</sup>. While BGM in people with diabetes is routine in many countries, glucometers and test strips are non-reimbursable items in

Thailand, and most patients had never monitored their BGM. This added another layer of complexity in care. Similarly, many patients required insulin initiation due to escalated hyperglycemia, thus the insulin device selection (prefilled pens instead of vials) and real-time observation of insulin injections likely increased safety and accuracy. The efficacy of technology-enabled DSMES has been previously demonstrated<sup>31,32</sup>. For example, in a systematic review of reviews (25 studies) found that majority used mobile phones, followed by secure messaging and web-based information<sup>32</sup>. Healthy eating, being active, and metabolic monitoring were the main areas of focus. The results showed that glycemic control as measured by HbA1c improved, ranging 0.1–0.8%, and found that 2-way communication, PGHD analysis, education and feedback were four key concepts for success<sup>33</sup>. The use of telemedicine to deliver diabetes care in low–middle income countries was also effective in lowering HbA1c, increasing treatment adherence, and improving diabetes knowledge and efficacy<sup>34</sup>. Our patients and their caregivers had a high level of cooperation in this process, likely partly because they were facing an illness with limited resources to care. Our results are in agreement with these studies and further support technology-enabled DSMES in COVID-19 patients.

Several countries also established care systems for COVID-19 patients in home isolation, but we did not find data specifically pertaining to diabetes. For example, in the Philippines, the Department of Health required a thermometer, pulse oximeter, and a blood pressure apparatus if one has a history of hypertension, along with medications to manage COVID-19 symptoms. They also suggested psychosocial support for the patients<sup>35</sup>. In Australia, pharmacists played a role in assisting patients to ensure adequate medication supplies<sup>36</sup>. In Germany, a pilot study successfully utilized a remote monitoring system (e.g. oxygen saturation, respiratory rate, heart rate, and temperature) by an in-ear device every 15 min in 153 patients<sup>5</sup>. In the case of clinical deterioration, appropriate measures were employed by physicians. The study included 21 patients with diabetes but did not describe care specific to diabetes<sup>5</sup>. However, a few studies demonstrated the benefits of telemedicine in delivering care in patients hospitalized with COVID-19<sup>21,37</sup>. A prospective study of 100 hospitalized patients with diabetes and COVID-19 utilized teleconsultation (phone and video) to deliver diabetes education including insulin injection techniques in India<sup>21</sup>. The results showed that teleconsultation was feasible and acceptable, and a 2 week follow up revealed that 77% of the patients correctly followed insulin instruction<sup>21</sup>. Lian *et al.*<sup>37</sup> explored the use of telehealth in 84 hospitalized patients and 22 outpatients with COVID-19. Similar to our study, inpatient education focused on survival skills, BGM, and insulin injection technique and hypoglycemia/ hyperglycemia management. The study used simplified education materials available in six languages via video or weblink. Education was provided through the hospital IT-platform which enhanced security. For the outpatient care, in addition to DSMES and follow-up of glucose

results, medications and diabetes supplies were delivered to patients' home, similar to our study<sup>37</sup>. Collectively, these results, along with ours, provide strong support for the benefits of telemedicine in patients with diabetes and COVID-19.

While glycemic control improved in our cohort, they remained elevated for several days at the beginning of the illness. As the study of hospitalized COVID-19 patients found that a mean glucose above 180 mg/dL was associated with an increase mortality<sup>25</sup>, the control in our cohort was sub-optimal. This was likely associated with corticosteroids use, COVID-19 severity, and careful insulin titration to avoid severe hypoglycemia. The reasons for glycemic improvement could also be due to the decreasing severity of illness (not systematically captured in this study) and decreasing steroid dose. Without a properly designed randomized controlled study, we could not definitely conclude that our intervention resulted in improved glucose control. However, it was also likely that if the patients had not received glycemic management, diabetes emergencies would have occurred in many, resulting in increased morbidity-mortality. During this emergency and given the health care structure in Thailand, it would not have been possible for the patients to contact their physicians and to get started on insulin to combat hyperglycemia. We did, however, whenever possible, relay the care information to the patients' primary physicians once the isolation period ended and an in-person visit with their physicians was possible. Additional limitations included the lack of other laboratory data (e.g. estimated glomerular filtration rate, serum ketones, and electrolytes etc.), thus the health care team utilized available data and best clinical judgment to treat the patients. Whenever possible, the primary care team transferred the patients to the hospital as diabetes patients are considered at high-risk for severe COVID-19<sup>38</sup>. In addition, while overall outcomes were favorable, we did not have follow-up data of all hospitalized patients. The care system also required enormous dedication in time and effort of the healthcare volunteers, which might not be sustainable in a longer term. Although the general glycemic management was agreed upon among the team members, we did not have a formal peer-reviewed guideline which should be considered in the future. Lastly, while the LINE<sup>®</sup> chat group chat is accessible only to group members, the transfer of data requires a more secure platform. As a result of the pandemic, there is an initiation to implement telemedicine to combat non-communicable diseases in Thailand, with data security being one of the essential components<sup>39</sup>.

In conclusion, the diabetes care and educational program via telemedicine in patients with COVID-19 during home isolation was effective and safe in managing diabetes. Multidisciplinary team involvement and supplies logistics play a major role in the process execution. This model could potentially be adopted for future diabetes care for both COVID-19 and non-COVID-19 patients, and beyond the pandemic particularly for patients who have limited access of care.

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## DISCLOSURE

All authors declare no conflict of interest.

Approval of the research protocol: The protocol was approved by the Institutional Review Board, Chulalongkorn University, Bangkok, Thailand, and it conforms to the provisions of the Declaration of Helsinki.

Informed consent: Waived per the IRB (as this was a retrospective study on de-identified data).

Registry and the registration no. of the study/trial: N/A.

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