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Impact of COVID-19 pandemic on glycaemic and blood pressure control among patients with type 2 diabetes in primary care in Hong Kong

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Abstract

Objectives To evaluate the impact of social distancing measures due to COVID-19 pandemic on glycemic and blood pressure control in primary care in Hong Kong.

Methods This was a retrospective cross-sectional study. Diabetic patients with regular follow-up in 8 public primary care clinics in Hong Kong within the study period were recruited. The outcomes were to detect any difference of HbA1c levels and BP between pre-pandemic group (2019 group) and the 1-year post-pandemic group (2020 group) in all patients and in sub-group analysis of different age groups, sex, body mass index, presence of diabetic complications and different diabetic treatment.

Results There was no statistically significant change in HbA1c level between 2020 and 2019 groups which was 0.019% (95% confidence interval [CI] -0.057% to 0.094%, $p=0.632$). There was also no statistically significant change in both systolic and diastolic BP between 2020 and 2019 groups which were -0.143 mmHg (95%CI -1.005 mmHg to 0.719 mmHg, $p=0.745$) and 0.148 mmHg (95%CI -0.422 mmHg to 0.718 mmHg, $p=0.611$). Subgroup analysis showed that female gender had statistically significant improvement in glycaemic control (HbA1c 6.92% in 2020 group versus HbA1c 7.03% in 2019 group, $p=0.021$). Patients with diabetic retinopathy had statistically significant lower diastolic BP (diastolic BP 73 mmHg in 2020 group versus diastolic BP 75 mmHg in 2019 group with $p=0.011$).

Conclusions Despite the implementation of various social distancing measures resulting in significant change in lifestyle, COVID-19 pandemic did not worsen glycaemic and blood pressure control in T2DM patients. In fact, slight improvement in glycaemic control among female patients was found.

Trial registration Not applicable.

Keywords COVID-19 pandemic, Glycaemic control, Blood pressure control, Type 2 diabetes

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Introduction

Coronavirus disease 2019 (COVID-19) which was first described in December 2019 in Wuhan, China was caused by severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) [1]. Due to the rapid number of growing cases over the world, the World Health Organization had declared a pandemic on 11 March 2020 [2]. In Hong

Kong, COVID-19 had become a notifiable infectious disease since 8 January 2020. There were 13 cases reported in January 2020 and with a total of 8847 cases were reported in the year of 2020 [3]. Up till June 2022, there were more than 1,000,000 cases reported with more than 9,000 deaths resulted [4].

Due to the rapid spread of the COVID-19 worldwide, effective public health measures in halting the transmission were necessary. Many countries had implemented measures in restricting citizens' activities. While complete lockdown with strict home confinement was adopted in some countries, [5] a less stringent approach was implemented in Hong Kong. The social distancing measures in Hong Kong were first introduced in January 2020. The Hong Kong Government announced citywide school closures and work at home recommendation in January 2020. Since July 2020, restaurants were not allowed to offer dine-in services for the whole day and scheduled premises including but not limited to fitness centers, sports premises and swimming pools were temporarily closed. These measures had been relaxed later as reported COVID-19 cases declined. However, to cope with the fourth and fifth wave of COVID-19, the Hong Kong Government had tightened the above social distancing measures again in November 2020. Detailed description of the major changes of social distancing measures by Hong Kong Government from January 2020 to March 2021 was summarized in Fig. 1 [6].

Diabetes is an important chronic disease and the prevalence was estimated to be 10% in Hong Kong [7]. Diabetes is known to cause significant morbidity and mortality with microvascular and macrovascular complications, causing great financial burden to health care system [8]. Diabetes is associated with adverse outcomes of COVID-19 infection [9]. In a systematic review, diabetes was associated with increased mortality (RR 2.12), severe COVID-19 (RR 2.45), acute respiratory distress syndrome (RR 4.64) and disease progression in COVID-19 (RR 3.31) [10]. A study showed that poor glycemic control in diabetes was a risk factor for poor outcomes and death in COVID-19 [11]. These findings shed light on the importance of glycemic control among patients with diabetes during the pandemic.

With the implementation of social distancing measures, it was expected that the control of diabetes and blood pressure would be affected due to the significant change in lifestyle of patients. The general population was found to be less physically active in a study in Hong Kong [12]. Similarly, diabetic patients were reported to have lower physical activity level. They were also found to have an increase in carbohydrate consumption and frequency of snacking [13]. Besides, there was evidence that patients' health seeking behavior had changed with avoiding clinic visits for fear of COVID-19 exposure risk [14]. Multiple studies had been conducted to study the effect of lockdown or social distancing policy on glycemic control in T2DM patients with mixed results. Biamonte et al. had conducted a retrospective study to evaluate the impact of COVID-19 lockdown in Italy from March to May 2020 on glycemic control which showed that the HbA1c was worsened from 7± 0.8% to 7.3± 0.9% [15]. Similar findings of worsening of HbA1c control were also shown in studies from Japan, [16, 17] Korea, [18] United States, [19] and Morocco [20]. However, studies from France and India showed that the glycemic control in T2DM patients was improved [21, 22]. Nevertheless, some studies reported no change in glycemic control. A multicenter study from Turkey which was conducted from June 2020 to November 2020 showed that no significant change in HbA1c levels in diabetic patients despite the social restriction measures implemented [23]. Another study in Japan also found no significant change in HbA1c after pandemic [24]. Even in countries with lockdown, there were studies concluded no change in glycemic control [25, 26]. Concerning blood pressure control during the COVID-19 pandemic, there were not many studies that target on diabetic patients available. While a cross sectional study in India reported no significant change in blood pressure control during lockdown, [27] a study in Japan reported that there was a significant rise in blood pressure from 130/70 mmHg to 137/74 mmHg after the state of emergency [16].

Female [17, 20], older age [17, 26] and obesity [17] were found to be risk factors for worsening of glycemic control during COVID-19 pandemic. Presence of macrovascular complications was associated with increase in HbA1c levels with an odd ratio of 5.33 in a Poland study [25]. The use of insulin was identified as a risk factor for worsened glycemic control in 2 studies in Italy [15, 26] but it was found to be a protective factor in a Japanese study [17].

In Hong Kong, most diabetic patients had follow-ups in the public sector and about sixty percent were under primary care. Under the COVID-19 pandemic, some patients were arranged to refill chronic medication without formal doctor consultation to avoid overcrowding the clinic and spare manpower to serve COVID-19 patients. Despite there were tremendous international studies on the impact of COVID-19 pandemic on the metabolic control in diabetic patients, data in local studies were lacking. Our study hypothesized that glycemic and blood pressure control of diabetic patients in primary care would be affected under COVID-19 pandemic in view of the change in lifestyle and health seeking behavior of patients. This study was conducted with the aim to evaluate the impact of COVID-19 pandemic on glycemic and blood pressure control in primary care in Hong Kong so

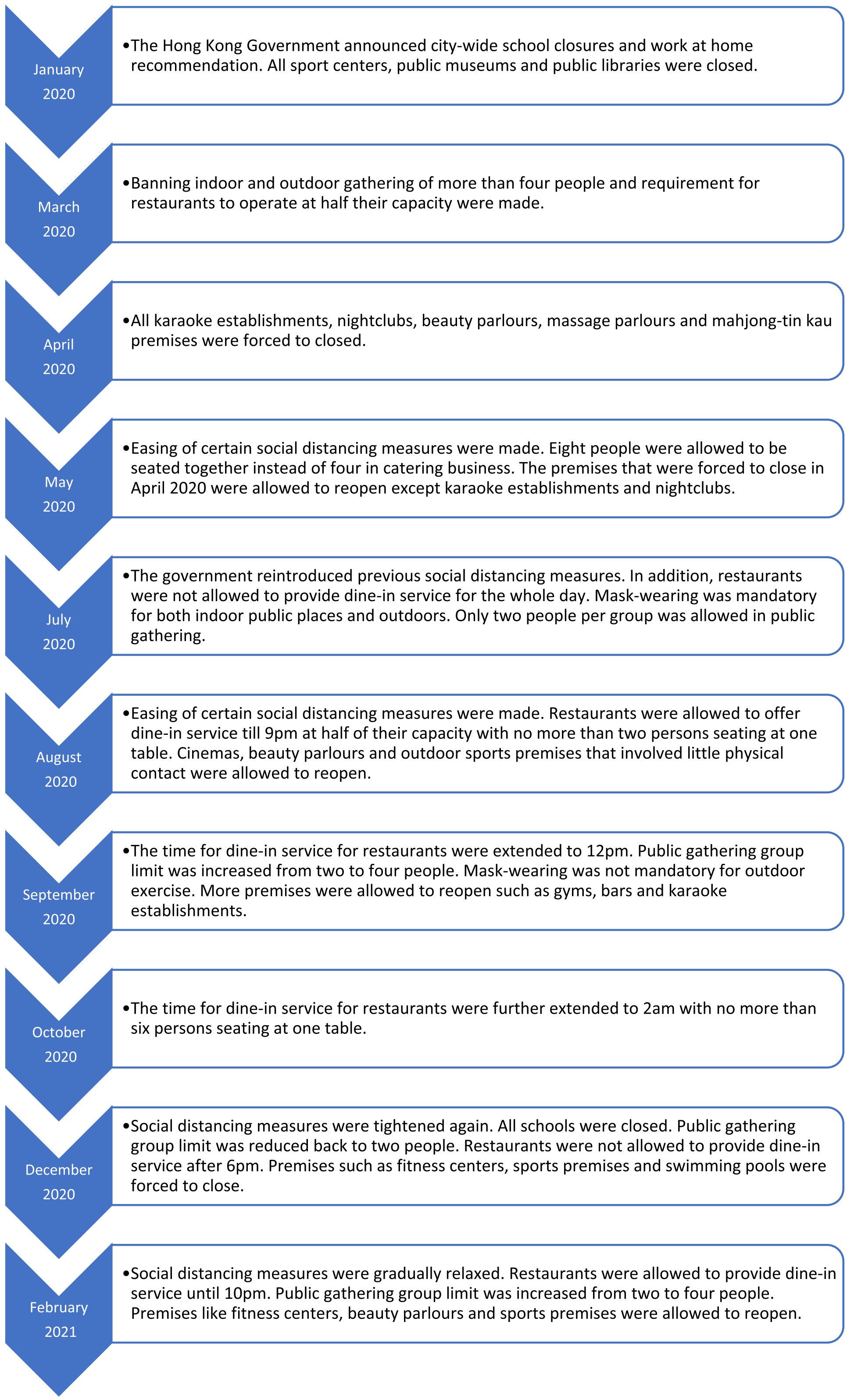

Fig. 1 Flow chart on changes of social distancing measures by Hong Kong Government

as to provide insight on how well our health care system in managing diabetic patients and to raise the awareness of doctors to better manage diabetic patients during the pandemic.

Methodology

Study design

This was a retrospective cross-sectional study involving 8 public primary care clinics serving around 53,000 diabetes patients in year 2021 in Hong Kong. Cross-sectional study was chosen because the study aimed to evaluate the impact of COVID-19 on glycemic and blood pressure control in the past time point.

Subject

The study included 2 groups of T2DM patients which were the pre-pandemic group (2019 group) and the 1-year post-pandemic group (2020 group). The study period was divided according to the timing of the World Health Organization declared a pandemic on 11 March 2020. Patients with HbA1c measured within a defined 1-month period would be recruited. 2020 cohort was selected for comparison with the 2019 cohort as we would like to capture the change in relatively early phase to see how well our health care system to handle the emerge of a public health crisis. A 1-month recruitment period was chosen to minimize the effect of seasonal change affecting the diabetic control. For the pre-pandemic group (2019 group), the defined period would be from 11 Feb 2020 to 10 March 2020. For the 1-year post-pandemic group (2020 group), the defined period would be from 11 Feb 2021 to 10 March 2021.

The exclusion criteria were as follows:

1. Patients who were newly diagnosed to have diabetes within 1 year
2. Patients who did not have regular follow-up in the studying clinics

Data collection

Diabetic patients assigned with the International Classification of Primary Care (ICPC) code T90 (Type II diabetes mellitus) and with HbA1c measured during the studying periods were identified from an electronic Clinical Data Analysis and Reporting System (CDARS). After retrieval of lists of patients in the 2019 group and the 2020 group, a subject number would be assigned for each patient. Randomization was done by a computerized calculator which randomly generated numbers in each list. Patients who fulfilled inclusion and exclusions criteria would be included.

Patients' demographic and clinical data including age, gender, body mass index (BMI), HbA1c levels and blood pressure within the study period, presence of macrovascular complications including ischemic heart disease, stroke and peripheral vascular disease, presence of microvascular complications including diabetic nephropathy (defined as having estimated glomerular filtration rate < 60 ml/min/1.73m^2 and/or presence of albuminuria), peripheral neuropathy (defined as having abnormal 10 g monofilament test or vibration perception threshold ≥ 25 V during feet examination) and diabetic retinopathy, the types of antidiabetic therapy (diet, oral antidiabetic agents and insulin) used and any history of medication refill without formal doctor consultation would be retrieved from the electronic medical records and supplemented by medical record review.

Sample size calculation

The sample size calculation was based on detecting difference of means of HbA1c between two groups using independent sample t-test. We assumed the two groups have similar variance in HbA1c and use a population variance of HbA1c as 0.689 for sample size calculation, which was based on previous data of 2,620 DM patients in one of our primary care clinics. In order to detect a difference of 0.1% in HbA1c with Type I error as 0.05 and power as 90%, the sample required was 2,976 (1488 in each group) [28]. The sample size calculation was also calculated based on use of multiple regression model using a sample size calculator [29]. To detect a small effect size (Cohen's F square as 0.02) using multiple regression of 14 predictors, with Type 1 error as 0.05 and power as 90%, the sample size required to avoid overfitting of the regression models was 1,164. Therefore, a sample size of 2,976 was sufficient. In order to achieve the minimal sample size after some subjects were excluded due to the eligibility criteria, 20% more subjects were recruited, resulting in 1,800 patients in each group were included after randomization.

Outcomes

The outcomes were to detect any difference of HbA1c level and blood pressure between pre-pandemic group (2019 group) and the 1-year post-pandemic group (2020 group) in subgroup analysis of different age groups, sex, BMI, presence of diabetic complications and different diabetic treatments. The study would also detect any statistically significant associations of HbA1c level and blood pressure between 2019 and 2020 group in all patients by using multivariate analysis after adjusting effect of other clinical variables including age, sex, history of atherosclerotic cardiovascular diseases, history of diabetic complications, current diabetic treatment and history of refill without formal consultations.

Statistical analysis

Statistical analysis was performed using SPSS version 21. For descriptive statistics, continuous variables with symmetrical distribution were presented as means and standard deviations (SD). Skewed continuous variables were presented as median and 1st/3rd quartiles. Normality of continuous variables were determined by Kolmogorov–Smirnov test, Shapiro–Wilk test, pattern of histogram, normal Q-Q plot and detrended normal Q-Q plot. Categorical variables of descriptive statistics were presented as percentages.

Comparisons of continuous variables with symmetrical distribution between 2019 and 2020 group were done by independent sample t-test. Comparisons of continuous variables with skewed distribution between 2019 and 2020 group were done by Mann Whitney U test. Categorical variables between 2019 and 2020 group were compared with Chi-square test or Fisher's Exact test. The unstandardized coefficients on HbA1c, systolic and diastolic blood pressure were calculated after adjustment for multiple confounding factors using multiple regression so that despite the 2 study groups were recruited at different time point, their HbA1c levels and blood pressure could still be compared to reveal the impact of COVID-19 on glycaemic and blood pressure control in the subjects. A p-value < 0.05 would be considered statistically significant in all the statistical analysis.

Results

Study population

There were 1,605 patients in 2019 group and 1,507 patients in 2020 group after applying the inclusion and exclusion criteria (Fig. 2). Tables 1 and 2 summarized the patients' characteristics.

Among all the recruited patients, the mean age was 66.0 ± 10.6 years with 46.0% were male. The mean HbA1c value was 7.2 ± 1.1% while the mean systolic and diastolic blood pressure were 131.6 ± 14.0 mmHg and 73.7 ± 9.7 mmHg respectively. Only a quarter of patients with BMI measured and the mean value was 25.9 ± 4.1 kg/m^2. For macrovascular complications, 5.6%, 5.4% and 0.3% of patients had history of ischemic heart disease, stroke and peripheral artery disease respectively. For microvascular complications, 29.8% of patients had history of DM retinopathy, 32.5% of patients had history of DM nephropathy and 7.4% of patients had history of peripheral neuropathy. Majority of patients (81.3%) were on oral anti-diabetic drugs only while 4.3% of patients were on insulin and 14.4% patients were on diet control.

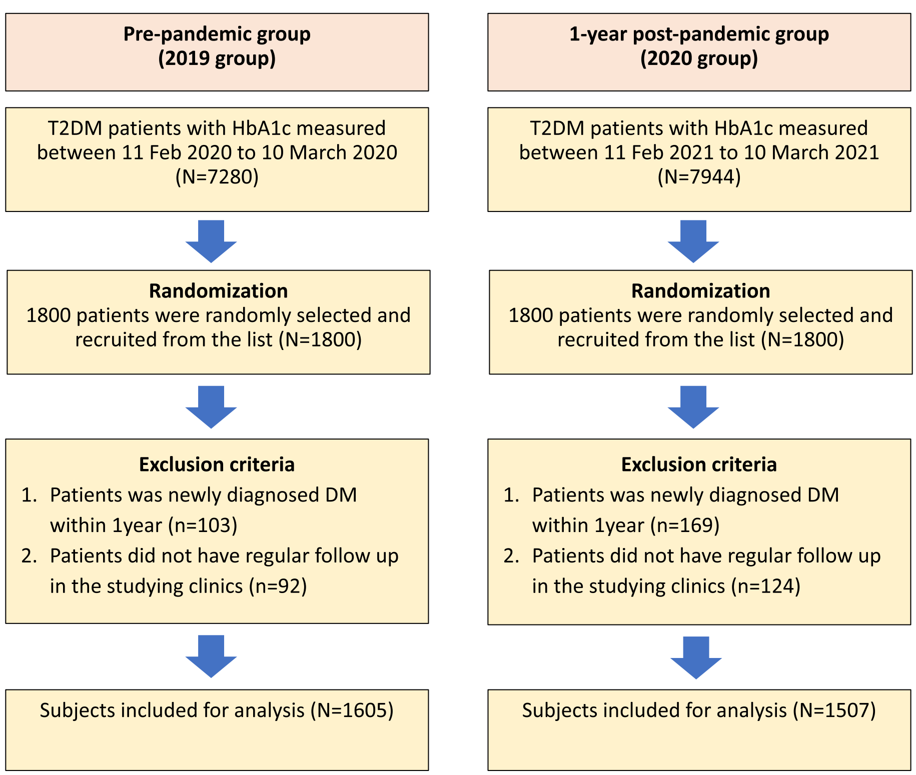

Fig. 2 Flow chart on subject selection

Table 1 Characteristics of all recruited patients ($N=3112$)

Parameters	Mean ± SD	Count (%)
Groups		
2019 group		1605 (51.6)
2020 group		1507 (48.4)
Age, (years)	66.0 ± 10.6	
< 65		1417 (45.5)
≥ 65		1695 (54.5)
Gender		
Male		1432 (46.0)
Female		1680 (54.0)
BMI (kg/m^2)	25.9 ± 4.1	
< 23		180 (5.8)
23–24.9 (overweight)		144 (4.6)
≥ 25 (obesity)		411 (13.2)
Unknown		2377 (76.4)
HbA1c(%)	7.2 ± 1.1	
< 6.5		667 (21.4)
6.5–6.9		810 (26.0)
≥ 7		1635 (52.6)
Systolic BP (mmHg)	131.6 ± 14.0	
< 130		1518 (48.8)
130–139		826 (26.5)
≥ 140		755 (24.3)
Unknown		13 (0.4)
Diastolic BP (mmHg)	73.7 ± 9.7	
< 80		2287 (73.5)
80–89		667 (21.4)
≥ 90		143 (4.6)
Unknown		15 (0.5)
Presence of IHD		
Yes		173 (5.6)
No		2939 (94.4)
Presence of stroke		
Yes		169 (5.4)
No		2943 (94.6)
Presence of PVD		
Yes		10 (0.3)
No		2961 (95.2)
Unknown		141 (4.5)
Presence of DM retinopathy		
Yes		926 (29.8)
No		2057 (66.1)
Unknown		129 (4.1)
Presence of DM nephropathy		
Yes		1012 (32.5)
No		2100 (67.5)
Presence of peripheral neuropathy		
Yes		230 (7.4)
No		2752 (88.4)
Unknown		130 (4.2)
Types of DM treatment		
Diet only		447 (14.4)
OAD		2531 (81.3)
Insulin		134 (4.3)

Abbreviations: *BMI* Body mass index, *Systolic BP* Systolic blood pressure, *Diastolic BP* Diastolic blood pressure, *IHD* Ischemic heart disease, *PVD* Peripheral vascular disease, *OAD* Oral anti-diabetic drugs

Comparing the 2019 and 2020 groups, the 2020 group was slightly older (mean age 66.7 versus 65.3 in 2019 group, $p<0.001$). There were more patients on diet control (15.6% in 2020 group versus 13.2% in 2019 group), less number of patients on oral-anti-diabetic drugs (80.5% in 2020 group versus 82.1% in 2019 group) and insulin (3.9% in 2020 group versus 4.7% in 2019 group) when compared with the 2019 group ($p=0.037$). 3.5% of patients in the 2020 group had history of drug refill while there were no patients doing so in the 2019 group ($p<0.001$). Other clinical characteristics did not differ between the 2019 and 2020 groups.

The univariate analyses of effect of COVID-19 pandemic on HbA1c and blood pressure at different subgroups

The univariate analyses of effects of COVID-19 pandemic on HbA1C, systolic and diastolic blood pressure at different subgroups were summarized in Table 3. Female gender was the only subgroup that showed statistically significant change in HbA1c using univariate analysis with 2020 group having lower HbA1c value when compared with 2019 group (HbA1c 6.92% in 2020 group versus HbA1c 7.03% in 2019 group, $p=0.021$), and the clinical significance of this difference was minute. No significant change in systolic blood pressure was observed in all subgroups included in the analysis. In the subgroup of presence of DM retinopathy, 2020 group showed lower diastolic blood pressure comparing with 2019 group and was statistically significant (diastolic BP 72.9 mmHg in 2020 group versus diastolic BP 74.6 mmHg in 2019 group with $p=0.011$). Again, the clinical difference of the diastolic blood pressure was small.

Multivariate analyses of effect of COVID-19 pandemic on HbA1c and blood pressure in all patients

Multivariate analyses were carried out to study the associations of HbA1c, systolic blood pressure, and diastolic blood pressure between pre-COVID period and post-COVID period for potential confounding factors control using three multiple regression models. In these three models, HbA1c, systolic blood pressure and diastolic blood pressure were the dependent variables respectively. Predictors included in the regression models to control their potential confounding effects were age, sex, history of ischaemic heart disease, history of stroke, history of peripheral vascular disease, established DM retinopathy, established nephropathy, established peripheral neuropathy, on anti-diabetic drugs without insulin, on insulin treatment, history of refill medications without formal consultations, and post-COVID period versus pre-COVID period. HbA1c, systolic blood pressure and diastolic blood pressure were also included as predictors

Table 2 Differences in characteristics of 2019 and 2020 groups

	2020 group $N=1507$ unless specified		2019 group $N=1605$ unless specified		
	mean ± SD	count (%)	mean ± SD	count (%)	*p* value
Age (years)	66.7 ± 10.5		65.3 ± 10.7		< 0.001
Gender					0.722
Male		688 (45.7)		744 (46.4)	
Female		819 (54.3)		861 (53.6)	
BMI (kg/m^2)	25.9 ± 4.3		26.0 ± 4.0		0.791
($n=385$ in 2020 group)					
($n=350$ in 2019 group)					
HbA1c (%)	7.2 ± 1.2		7.2 ± 1.1		0.731
Systolic BP, (mmHg)	131.7 ± 14.3		131.5 ± 13.8		0.672
($n=1498$ in 2020 group)					
($n=1600$ in 2019 group)					
Diastolic BP, (mmHg)	73.4 ± 9.5		73.7 ± 9.8		0.645
($n=1496$ in 2020 group)					
($n=1600$ in 2019 group)					
Presence of IHD		81 (5.4)		92 (5.7)	0.722
Presence of stroke		79 (5.2)		90 (5.6)	0.711
Presence of PVD		5 (0.4)		5 (0.3)	1
($n=1428$ in 2020 group)					
($n=1543$ in 2019 group)					
Presence of DM retinopathy		434 (30.2)		493 (31.9)	0.334
($n=1439$ in 2020 group)					
($n=1544$ in 2019 group)					
Presence of DM nephropathy		481 (31.9)		531 (33.1)	0.512
Presence of peripheral neuropathy		107 (7.5)		123 (7.9)	0.678
($n=1433$ in 2020 group)					
($n=1549$ in 2019 group)					
Types of DM treatment					0.037
Diet only		235 (15.6)		212 (13.2)	
OAD		1213 (80.5)		1318 (82.1)	
Insulin		59 (3.9)		75 (4.7)	
History of drug refill		52 (3.5)		0 (0)	< 0.001

Abbreviations: *BMI* Body mass index, *Systolic BP* Systolic blood pressure, *Diastolic BP* Diastolic blood pressure, *IHD* Ischemic heart disease, *PVD* Peripheral vascular disease, *OAD* Oral anti-diabetic drugs

if they were not the dependent variables. The results are shown in Table 4.

For these multiple regression models, model assumptions were carefully checked. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.986, 1.968 and 1.99 for HbA1c, systolic and diastolic blood pressure respectively. The independent variables collectively were linearly related to the dependent variable, as checked by a scatter plot of the studentized residuals against the (unstandardized) predicted values. Each independent variable was linearly related to the dependent variable, as checked by plotting the studentized residuals against the (unstandardized) predicted values. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No obvious multicollinearity was noted, as checked by the correlation coefficients and Tolerance/Variance Inflation Factor (VIF) values. Outliers have been checked and reviewed, and included in the regression model after the review. There were no obvious high leverage points and highly influential points as checked by the leverage value and Cook's distance respectively. Normality of the residuals were checked by plotting a histogram and Normal P-P plot on studentized residuals.

The unstandardized regression coefficient of post COVID versus pre-COVID of the multiple regression

Table 3 Univariate analysis of effect of COVID-19 pandemic on HbA1c, systolic and diastolic blood pressure at different subgroups

		HbA1c (%)			Systolic BP (mmHg)			Diastolic BP (mmHg)		
		2020 group	2019 group	*p* value	2020 group	2019 group	*p* value	2020 group	2019 group	*p* value
Age (years)	< 65	7.03	7.12	0.099	128.5	129.3	0.240	76.5	77.0	0.359
	≥ 65	6.94	7.00	0.230	134.4	133.6	0.211	71.5	70.8	0.120
Gender	Male	7.05	7.09	0.529	130.7	131.0	0.688	75.9	75.9	0.871
	Female	6.92	7.03	0.021*	132.8	132.0	0.254	71.9	71.8	0.815
BMI (kg/m^2)	23–24.9	7.34	7.57	0.259	129.6	131.8	0.294	71.3	71.8	0.765
	≥ 25	7.59	7.62	0.805	130.8	131.0	0.856	74.9	74.2	0.476
Presence of DMR	No	7.15	7.12	0.578	131.2	131.2	0.987	73.9	73.4	0.268
	Yes	7.38	7.48	0.187	132.4	132.0	0.620	72.9	74.6	0.011*
Presence of DMN	No	7.14	7.15	0.770	130.4	130.3	0.803	73.8	74.2	0.280
	Yes	7.36	7.37	0.838	134.8	134.1	0.496	73.4	72.9	0.429
Presence of PN	No	7.21	7.22	0.739	131.5	131.4	0.736	73.8	73.9	0.734
	Yes	7.15	7.41	0.113	132.9	132.7	0.941	70.3	71.5	0.341
DM Treatment	Diet only	6.45	6.49	0.538	133.6	133.3	0.834	74.3	74.2	0.930
	OAD	7.29	7.28	0.654	131.5	131.2	0.538	73.6	73.8	0.718
	Insulin	8.46	8.53	0.743	129.3	132.6	0.133	71.3	71.9	0.670

Abbreviations: *BMI* Body mass index, *Systolic BP* Systolic blood pressure, *Diastolic BP* Diastolic blood pressure, *DMR* Diabetic retinopathy, *DMN* Diabetic nephropathy, *PN* Peripheral neuropathy, *OAD* Oral anti-diabetic drugs

model on HbA1c was not statistically significant, with a *p*-value of 0.632. The unstandardized regression coefficient of post COVID versus pre-COVID of the multiple regression model on systolic blood pressure was not statistically significant, with a *p*-value of 0.745. The unstandardized regression coefficient of post COVID versus pre-COVID of the multiple regression model on diastolic blood pressure was also not statistically significant, with a *p*-value of 0.611 (Table 4).

Discussion

This was the first study to investigate the impact of COVID-19 pandemic on glycemic and blood pressure control in diabetic patients in primary care in Hong Kong. As mentioned, overseas studies on this topic had yielded mixed results. This might be due to multiple factors including timing of conducting the study, severity of COVID-19 burdens, intensity of government policy on imposing movement restriction and different cultural background which influenced how an individual would response to the pandemic. The result of our study showed that there was no clinically significant change in HbA1c and blood pressure control before and 1 year after COVID-19 pandemic. Previous studies showed worsening of HbA1c control in the first few months of lockdown [15–20]. Instead of evaluating the early impact of COVID-19, our study evaluated the impact of COVID-19 pandemic at a longer period of time. Hong Kong was one of the places that was affected by COVID-19 early, patients might therefore already adapt to the lifestyle change brought by COVID-19 and found their ways to cope. In addition, as there was no true lockdown in Hong Kong, patients could gain access to medical care for chronic follow up. Patient initiated drug refill request without formal doctor consultation was allowed in public primary care clinics early in COVID-19 pandemic. However, the drug refill rate was low in our study suggesting that majority of patients still preferred formal doctor consultation. The finding was consistent with the report of same compliance rates of glycemic testing in general practice during COVID-19 pandemic in an Australian study [30]. The formal doctor consultation not only allowed doctors to help their patients to titrate medication, but also provided opportunity to advise patients with practical tips to keep up with good lifestyle for chronic illnesses and alleviate stress under the pandemic. Indeed, dietary change, sedentary lifestyle and mental stress were reasons that postulated for deterioration of glycemic control in studies with worsened control [15–20]. Doctor consultation was likely a protective factor for change of HbA1c and blood pressure in COVID-19 pandemic.

Subgroup analysis showed that female gender had statistically improved HbA1c control despite clinically insignificant. Interestingly, female patients were shown to have worsened glycemic control in some studies [17, 20]. It was thought to be due to higher stress level in response to pandemic [17] and increased in snack and sugary food consumption [20] in females. However, individual psychological and behavioral response to pandemic was

Table 4 Multiple regression model on HbA1c and blood pressure comparing 2020 group with 2019 group

	B	95% CI for B lower limit	upper limit	SE B	Beta	*p* value	R square	adjusted R square
Multiple regression results for HbA1c								
Model							0.145	0.141
(Constant)	6.343	5.816	6.869	0.268		< 0.001		
Age	-0.003	-0.007	0.001	0.002	-0.030	0.147		
Sex	-0.058	-0.137	0.021	0.040	-0.026	0.149		
IHD	-0.214	-0.384	-0.044	0.086	-0.043	0.013		
Stroke	-0.004	-0.177	0.169	0.088	-0.001	0.963		
PVD	0.948	0.304	1.591	0.328	0.050	0.004		
DM retinopathy	0.150	0.067	0.232	0.042	0.062	< 0.001		
DM nephropathy	0.1710	0.087	0.255	0.043	0.072	< 0.001		
PN	0.074	-0.072	0.221	0.075	0.018	0.321		
OAD vs Diet only	0.772	0.661	0.883	0.056	0.267	< 0.001		
Insulin vs Diet only	1.923	1.715	2.130	0.106	0.357	< 0.001		
History of drug refill	-0.150	-0.468	0.168	0.162	-0.016	0.354		
Systolic BP	-0.003	-0.006	0	0.002	-0.037	0.073		
Diastolic BP	0.010	0.005	0.015	0.002	0.085	< 0.001		
Post COVID vs Pre-COVID	**0.019**	**-0.057**	**0.094**	**0.039**	**0.008**	**0.632**		
Multiple regression results for systolic blood pressure								
Model							0.294	0.291
(Constant)	41.814	35.468	48.16	3.236		< 0.001		
Age	0.486	0.44	0.531	0.023	0.366	< 0.001		
Sex	3.591	2.703	4.478	0.452	0.128	< 0.001		
IHD	-0.607	-2.538	1.323	0.984	-0.01	0.537		
Stroke	2.632	0.664	4.599	1.004	0.041	0.009		
PVD	5.07	-2.282	12.421	3.749	0.021	0.176		
DM retinopathy	1.291	0.352	2.23	0.479	0.043	0.007		
DM nephropathy	2.509	1.557	3.461	0.485	0.084	< 0.001		
PN	-1.071	-2.733	0.59	0.847	-0.02	0.206		
OAD vs Diet only	-0.823	-2.113	0.466	0.658	-0.023	0.211		
Insulin vs Diet only	0.862	-1.632	3.355	1.272	0.013	0.498		
History of drug refill	-6.18	-9.801	-2.559	1.847	-0.053	0.001		
Diastolic BP	0.742	0.695	0.79	0.024	0.513	< 0.001		
HbA1c	-0.403	-0.815	0.009	0.21	-0.032	0.055		
Post COVID vs Pre-COVID	**-0.143**	**-1.005**	**0.719**	**0.439**	**-0.005**	**0.745**		
Multiple regression results for diastolic blood pressure								
Model							0.353	0.35
(Constant)	58.197	54.428	61.965	1.922		< 0.001		
Age	-0.374	-0.403	-0.344	0.015	-0.408	< 0.001		
Sex	-3.623	-4.201	-3.044	0.295	-0.187	< 0.001		
IHD	-0.324	-1.601	0.953	0.651	-0.007	0.619		
Stroke	-0.351	-1.655	0.953	0.665	-0.008	0.598		
PVD	-3.518	-8.383	1.346	2.481	-0.021	0.156		
DM retinopathy	-0.406	-1.028	0.216	0.317	-0.019	0.201		
DM nephropathy	-0.544	-1.176	0.089	0.322	-0.026	0.092		
PN	-0.437	-1.536	0.663	0.561	-0.012	0.436		
OAD vs Diet only	-0.994	-1.847	-0.142	0.435	-0.04	0.022		
Insulin vs Diet only	-3.696	-5.34	-2.051	0.839	-0.079	< 0.001		
History of drug refill	2.43	0.031	4.829	1.224	0.03	0.047		
Systolic BP	0.325	0.304	0.346	0.011	0.471	< 0.001		
HbA1c	0.564	0.292	0.836	0.139	0.065	< 0.001		
Post COVID vs Pre-COVID	**0.148**	**-0.422**	**0.718**	**0.291**	**0.008**	**0.611**		

Model "Enter" method in SPSS statistics

Abbreviations: *B* unstandardized regression coefficient, *CI* Confidence interval, *SE B* Standard error of the coefficient, *Beta* standardized coefficient, *R square* coefficient of determination, *adjusted R square* adjusted coefficient of determination, *IHD* ischaemic heart disease, *PVD* Peripheral vascular disease, *DM* Diabetic, *PN* Peripheral neuropathy, *OAD* Oral anti-diabetic drug, *Systolic BP* Systolic blood pressure, *Diastolic BP* diastolic blood pressure likely to be variable with influence of social and cultural background. Our study revealed female patients had slight improvement in HbA1c control showing that our female population coped well under COVID-19 pandemic in terms of glycaemic control. This might be due to many of our female patients were housewives who were more likely to cook and dine at home with the implementation of social distancing measures while more male patients were belonged to working class and still needed to have meal take away even the restaurant did not provide dine in service. Presence of DM retinopathy was found to have statistically significant improvement in diastolic blood pressure. The reason for that was unclear. However, the difference was likely clinically insignificant.

Unlike other studies which showed elderly [17, 26], obesity [17] and insulin use [15, 26] as risk factors for worsened glycaemic control, our study found no difference in glycaemic control among these subgroups of patients. There was postulation that elderly patients might have difficulty to gain access to medical telematic service during COVID-19 pandemic and resulted in worsening of glycaemic control [26]. It was not the case in our study as there was no true lockdown in Hong Kong and routine chronic follow-ups in public primary care clinics were remained unaffected. It was thought that obese patients generally had unhealthy diet and such lifestyle was further exacerbated by the social restriction policy. Being retrospective in nature, our study could not get the detailed information on the diet or exercise change of the study subjects. However, subgroup analysis did not show obesity group having worse HbA1c control. It could be due to the reason that even any negative change in lifestyle if present might be offset by medication titration during chronic follow up. Insulin use was found to be a risk factor in two Italian studies and was accounted by the increased disease complexity for those using insulin therapy and decreased accessibility to diabetic care due to lockdown [15, 26]. In contrast, it was found to be a protective factor in a Japanese study and was attributed to the reimbursement policy for self-monitoring blood glucose (SMBG) in T2DM patients using insulin which potentially led to better self-care during the time when doctor consultation being less accessible [17]. Unlike the two Italian studies in which patients were recruited from hospital and diabetic center, the patients in our study were recruited from primary care and their diabetes were likely less complex in terms of disease severity. The reimbursement for SMBG as the protective factor for insulin use was also not valid in Hong Kong. Therefore, insulin use was neither as a risk factor nor a protective factor in our study.

We did not exclude patients with medication adjustment in this study. Unlike those studies which aimed at identifying only the lockdown effect of COVID-19 pandemic, our study was to investigate a broader aspect in terms of how well our public primary health care system handled T2DM patients under the COVID-19 pandemic. Medication titration according to the patients' condition reflected the real situation and was the way how our health care system functions. The result of the study was encouraging as it showed that there was no deterioration of HbA1c and blood pressure control for T2DM patients at the first year of COVID-19 pandemic in our locality. However, it was not yet the time for compliment as COVID-19 pandemic had not yet ended in the first year. Indeed, the fifth wave of COVID-19 had created an even more difficult time to our health care system. Designated Clinics had been set up to handle the large patient load. In order to compensate for the manpower diversion to Designated Clinics, Drug Refill Clinics were being set up in public primary care clinics. A lot of T2DM patients with stable control were refilled with same medication without formal doctor consultation. A much greater proportion of patients with drug refill would be expected when compared with this study. The effect of drug refill on glycemic and blood pressure control in patients with T2DM deserved further study to investigate.

Strength and limitation

The strength of this study was that it involved patients from multiple clinics (8 public primary care clinics) with a large sample size. However, there were also few limitations in this study. Firstly, despite multicenter in design, all the clinics involved were located in the same cluster and the public sector which might limit its generalizability to whole T2DM population of Hong Kong. Secondly, as a retrospective study, causal relationship could not be established. As data were limited to those documented in the medical record, missing data was a problem. Thirdly, our result might underestimate the negative impact of COVID-19 pandemic on HbA1c and blood pressure control as those who defaulted follow up or blood taking which likely had worse outcomes were not included in analysis. Lastly, although we have tried to include multiple important clinical variables for confounding factors control in the multivariate analysis, there could still be other factors such as health education received from health professionals, quantity of exercise, compliance to dietary advice, frequency of self-monitoring of blood glucose and health service utilization patterns that exist which we had not included and which could be potential confounding factors for the outcome variables.

Conclusion

Despite the implementation of various social distancing measures resulting in significant change in lifestyle, COVID-19 pandemic did not worsen glycemic and blood pressure control in patients with T2DM in primary care in Hong Kong at 1 year after the pandemic. In fact, slight improvement in glycaemic control among female patients was found in our study. Further studies were needed to evaluate the longer term impact of COVID-19 pandemic on T2DM.

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Authors' contributions
Wong Chung Ming was the principal investigator who wrote the manuscript. Chan Pang Fai and Lai Kit Ping Loretta contributed throughout the research including protocol development, data analsysis and interpretation and editing manuscript. Luk Man Hei Matthew helped in study design, sample size calculation, statistical analysis and editing the statistical and results parts of the manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Research Ethics Committee (Kowloon Central/Kowloon East) of Hospital Authority according to the guidance of Declaration of Helsinki and ICH GCP Guidelines. The need for consent to participate was waived by the ethics committee and therefore consent was not actively sought.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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