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The impact of the COVID-19 pandemic shelter in place on glycemic control, blood pressure control, and body mass index among diabetic patients at Kaiser Permanente Northern California: a retrospective cohort study

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Abstract

Background/ introduction Regional shelter-in-place (SiP) mandates had a substantial impact on physical health and access to care. The impact of SiP on chronic disease management, specifically diabetes mellitus, is unknown. We sought to quantify the impact of California's 2020 SiP order on various health parameters in the Kaiser Permanente Northern California (KPNC) diabetic population.

Methods This retrospective cohort study included 168,621 diabetic patients, stratified by pre-pandemic HbA1c level. Our primary outcome was the difference in HbA1c, systolic blood pressure (SBP), and diastolic blood pressure (DBP) comparing the pre- (September 1, 2019, to March 31, 2020) to post-SiP period (June 1, 2020, to December 31, 2020). Our secondary endpoints included use of insulin or oral hypoglycemic agents (OHAs) during the post-SiP period and change in body mass index (BMI). This study utilized a paired t-test and chi-squared testing in order to assess for statistically significant differences in pre- versus post-SiP values.

Results Patients in this cohort were 52.29% male with 37.68% White, 22.35% Hispanic, 9.30% Black and 23.54% Asian and a mean age of 63 years. In this cohort, 44.02% of patients had a HbA1c < 7%, while 29.17%, 13.67%, 6.34% and 6.81% had an HbA1c of 7-7.9%, 8-8.9%, 9-9.9% and ≥ 10%, respectively (range 4.10 to 19.50%). Mean HbA1c, SBP, and DBP increased significantly across all groups; OHA use and insulin utilization also increased overall. Patients with lower pre-SiP HbA1c demonstrated larger increases in HbA1c and OHA utilization, while patients with higher pre-SiP HbA1c demonstrated increased rates of insulin initiation and decreases in their post-SiP HbA1c. Notably, mean BMI decreased in every HbA1c subgroup. Due to the large sample size, all p-values were < 0.0001.

Conclusions Among the KPNC diabetic population, several metrics for diabetes health management were significantly worsened after California's SiP. However, diabetic patients with the highest HbA1c values showed clinically significant improvement in their HbA1c, indicating a differential effect of the SiP on diabetes management.

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Our study helps identify higher-risk diabetic patients who require more intensive monitoring in the setting of the recent pandemic and highlights the importance of considering long-term implications of policy decisions on diabetes care.

Keywords Diabetes mellitus, Covid-19, Pandemic, Health policy

Background/ introduction

The 2019 SARS-CoV-2 (COVID-19) pandemic prompted novel measures for infection prevention and control. In March 2020, the California governor implemented an executive shelter-in-place (SiP) order as the number of COVID-19 cases and deaths began to grow at an exponential pace. The order launched the now-familiar concept of quarantining at home, introducing drastic changes in lifestyle. Initially expected to end within months, the impact of the pandemic and SiP orders on society, especially on those with chronic diseases, is still experienced today.

With the advent of SiP orders, more people than ever began working and isolating at home with notable decreases in levels of physical activity and mental wellness [1, 2] as well as increases in poor habits such as junk food consumption and resultant weight gain [3]. The fear surrounding COVID-19 and emphasis on home isolation also resulted in reduced access to healthcare [4], increased non-adherence to prescriptions, and less consistency in routine follow-up appointments [5].

Management of many chronic health conditions relies on lifestyle habits and healthcare access. Diabetes mellitus is one such condition, with the United States Centers for Disease Control estimating 37.3 million cases in the U.S. alone [6]. Diabetes management depends heavily on insulin and anti-hyperglycemic medication therapy in addition to diet and exercise, as obesity, energy-dense diets, and sedentary lifestyles are known risk factors for the development of uncontrolled blood glucose in type 2 diabetes [7, 8].

Recent studies have noted variations in glycemic control during the pandemic. Patients with type 2 diabetes were noted to have increases in their body weight and HbA1c [9] as well as their triglyceride levels [10]. Interestingly, studies focusing on type 1 diabetes found improvements in HbA1c likely due to multiple factors including the predominance of hybrid closed-loop systems and continuous glucose monitoring in type 1 diabetes management [11, 12]. One study specifically looking at type 2 diabetes noted decreased exercise, increased carbohydrate consumption, and increased stress [13] contributing to increases in body weight and HbA1c [9]. Cultural context may play a role as well– populations in Japan reported no changes in overall HbA1c, whereas HbA1c in Korea overall worsened [14, 15]. Blood glucose control has significant implications for COVID-19 outcomes: patients with uncontrolled diabetes are more likely to be mechanically ventilated [16] and have higher overall morbidity and mortality [17, 18].

The purpose of this study is to determine changes in glycemic control and management, blood pressure, and body mass index pre- and post-SiP orders in a diabetic population in Northern California. The cohort was stratified based on pre-pandemic HbA1c levels to determine whether pre-pandemic glycemic control could identify more at-risk populations. We aim to evaluate the impact of the pandemic and State of California (March 19, 2020) SiP order on glycemic and blood pressure control in Kaiser Permanente Northern California (KPNC) members with diabetes in a large integrated healthcare system.

Methods

The study was approved by the Institutional Review Board of Kaiser Permanente Northern California and individual consent for this retrospective analysis was waived.

Study design

The source population for this retrospective cohort study was from KPNC, an integrated health care delivery system that provides comprehensive care for over 4.5 million members throughout Northern and Central California. The KPNC membership is highly representative of the local surrounding and statewide population with regard to age, gender, race/ ethnicity and socioeconomic status [19]. Race/ ethnicity were self-identified, with "Multi-Ethnic" referring to those patients who identified more than one race/ ethnicity and "Unknown" as no self-reported race/ ethnicity. We conducted a retrospective cohort study of all adult (age ≥ 18) patients identified as having type 1 or type 2 diabetes prior to 2019 and with at least one HbA1c result during both the pre-SiP period (September 01, 2019 to March 31, 2020) and the post-SiP period (June 01 2020 to December 31, 2020). In addition, patients were required to have at least 9 months of KPNC membership in the 12 months prior to the first HbA1c during the pre-SiP period as well as at least 5 months of KPNC membership with drug coverage during both pre-SiP and post-SiP periods. Data was collected by electronic health record review and validation of subsamples of the derived electronic health record data were manually performed by two reviewers. When multiple values were present, we used the latest value during the pre-SiP period and the earliest value in the post-SiP period such that the values used reflect most closely the SiP period.

Table 1 Baseline characteristics stratified by Pre-SiP HbA1c

	Baseline Characteristics					
	Total group	**HbA1c (< 7%)**	**HbA1c (7-7.9%)**	**HbA1c (8-8.9%)**	**HbA1c (9-9.9%)**	**HbA1c (≥ 10)**
n	168,621	74,219	49,182	23,055	10,690	11,475
Age	63.69 (12.20)	65.34 (12.00)	64.21 (11.48)	62.37 (12.06)	59.91 (12.69)	56.98 (12.96)
% Male	52.29	51.21	52.46	54.11	54.54	52.77
White	37.68	41.72	36.59	34.66	32.41	27.26
Black	9.30	9.30	8.04	9.04	10.12	14.52
Asian	23.54	22.90	26.60	23.54	20.92	16.98
Hispanic	22.35	19.16	21.39	25.51	29.36	34.19
Multiethnic	5.52	5.44	5.64	5.65	5.57	5.31
Unknown Race/ Ethnicity	1.60	1.49	1.74	1.60	1.62	1.74

Age is reported in mean (SD) and race by proportion. Note $p < 0.0001$ for age, sex, and race/ ethnicity comparisons across HbA1c groups

Table 2 Change in HbA1c, blood pressure, diabetic medication use, and BMI

Period	**HbA1c (%)**	**BMI (kg/m^2)**	**SBP (mmHg)**	**DBP (mmHg)**	**OHA Users**	**Insulin Users**
Pre-SiP	7.45 (1.48)	31.81 (7.29)	133.04 (13.84)	70.79 (9.97)	72.06	28.64
Post-SiP	7.49 (1.57)	31.51 (7.39)	134.12 (15.68)	71.30 (10.52)	72.41	29.25

Glycated hemoglobin (HbA1c), body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), oral hypoglycemic agent (OHA) are compared between pre-SiP and post-SiP time periods. Values reported as mean (standard deviation) for continuous variables (HbA1c, BMI, SBP, DBP) and as a proportion (%) for OHA/Insulin users. Note $p < 0.0001$ for all pre- and post-SiP comparisons

Patients not meeting these criteria were excluded from our analysis.

The cohort was stratified by pre-SiP HbA1c ranges: less than 7.0%, 7.0 to 7.9%, 8 to 8.9%, 9 to 9.9%, and ≥ 10%. Demographic data, including age, gender, and race/ ethnicity were collected.

Our primary outcome was the difference in HbA1c, systolic blood pressure (SBP), and diastolic blood pressure (DBP) comparing the pre- to post-SiP period. Our secondary endpoints included use of insulin or oral hypoglycemic agents (OHAs) during the post-SiP period and change in body mass index (BMI). OHAs included the following: metformin, sulfonylureas, meglinitide derivatives, alpha-glucosidase inhibitors, thiazolidinediones, bile acid sequestrants, glucagon-like peptide-1 agonists, dipeptidyl peptidase IV inhibitors, and sodium glucose cotransporter-2 inhibitors.

Statistical analysis

We performed a descriptive analysis comparing the mean pre-SiP and post-SiP HbA1c, SBP, DBP, use of OHA, use of insulin and BMI. We assessed normality assumptions for continuous variables using both statistical testing (Kolmogorov-Smirnov or K-S test for normality) and graphical (histogram) methods. The K-S test p-values for our continuous variables were all < 0.01; however, based on our experience and Mishra et al. [20], in a large sample size, the K-S test can be overly sensitive and statistically significant even when the distribution is only slightly different from a normal distribution. Based on histograms, with a normal distribution curve overlaid for our continuous variables (Supplemental Figure) and based on the central limit theorem (indicating that violation of normality is unlikely with a sample size of 100 or greater observations) [20], we provide rationale for normality assumption.

We then used paired t-test for continuous numeric variables and chi-square test for categorical variables to identify differences in pre- and post-SiP values for each strata of pre-SiP HbA1c as defined below (Tables 3 and 4).

Mean (SD) for numeric and frequency (%) for categorical variables are reported for all analyses. Statistical significance was assumed when $p < 0.05$. All analyses were conducted using SAS 9.4.

Results

A total of 168,621 members, 52.29% male, were identified with HbA1c data available during the pre- and post-SiP periods. Mean age was 63.69 years and there were 37.68% White, 22.35% Hispanic, 9.30% Black and 23.54% Asian. We stratified our sample population via pre-SiP HbA1c values (range 4.10 to 19.50%): HbA1c < 7.0%: 74,219 individuals, 7.0-7.9%: 49,182, 8.0-8.9%: 23,055, 9.0-9.9%: 10,690, and ≥ 10.0%: 11,475 (Table 1). The mean age for the cohort was 63.69 years, with a decrease in mean age noted for higher HbA1c categories. Additional pre-SiP data, including body mass index (BMI), mean systolic blood pressure (SBP) and diastolic blood pressure (DBP), and use of insulin or oral hypoglycemic agents (OHAs) are shown in Table 2. Post-SiP values for the same parameters can also be seen in Table 2.

For the entire cohort, HbA1c increased by 0.05% (SD = 1.17, $p < 0.0001$). When stratified by pre-SiP HbA1c, those with HbA1c < 7.0% had a mean increase of 0.23% ($SD = 0.78$, $p < 0.0001$) and those with HbA1c between

Table 3 Difference in HbA1c, blood pressure, and BMI comparing pre- and Post-SiP

	Total Group	HbA1c (< 7%)	HbA1c (7-7.9%)	HbA1c (8-8.9%)	HbA1c (9-9.9%)	HbA1c (≥ 10)
HbA1c (%)	0.05 (1.17)	0.23 (0.78)	0.24 (1.05)	-0.15 (1.23)	-0.44 (1.45)	-1.13 (2.06)
BMI (kg/m^2)	-0.30 (2.02)	-0.26 (2.01)	-0.39 (1.87)	-0.36 (2.02)	-0.20 (2.12)	-0.13 (2.35)
SBP (mmHg)	1.07 (15.60)	1.39 (15.53)	1.02 (15.45)	0.57 (15.70)	0.46 (16.01)	0.76 (16.52)
DBP (mmHg)	0.51 (9.49)	0.78 (9.54)	0.51 (9.42)	0.23 (9.38)	-0.02 (9.40)	-0.24 (9.67)

Glycated hemoglobin (HbA1c), body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP) are shown, with difference in mean (standard deviation). Note $p < 0.0001$ for all variables across HbA1c groups

Table 4 Change in diabetic medication management stratified by Pre-SiP HbA1c categories

Treatment	Total group	HbA1c (< 7%)	HbA1c (7-7.9%)	HbA1c (8-8.9%)	HbA1c (9-9.9%)	HbA1c (≥ 10)
Discontinuation of oral hypoglycemic	3.06	2.97	2.32	2.99	3.98	6.11
New use of oral hypoglycemic	3.42	3.04	3.74	2.68	3.50	5.91
Net increase/decrease in OHA use	0.36	0.07	1.42	-0.31	-0.48	-0.20
Discontinuation of insulin	1.64	1.04	1.42	2.02	2.83	4.58
New use of insulin	2.24	1.00	1.90	3.20	4.47	7.77
Net increase/decrease in insulin use	0.60	-0.04	0.48	1.18	1.64	3.19

Values represent change in percentage; $p < 0.0001$ for all variables across HbA1c groups

7 and 7.9% had a mean increase of 0.24% (SD = 1.05, $p < 0.0001$). Members with HbA1c ≥ 8.0% all had statistically significant reductions in HbA1c from pre- to post-SiP periods (Table 3). For the cohort, BMI decreased from pre- to post-SiP periods with a mean difference of 0.30 kg/m2 (SD = 2.02, $p < 0.0001$) with overall similar decreases in mean BMI noted in each HbA1c stratum.

Mean SBP and DBP also significantly increased between pre- and post-SiP, with a mean increase of 1.07mmHg in SBP (SD = 15.60, $p < 0.0001$) and a mean increase of 0.51mmHg in DBP (SD = 9.49, $p < 0.0001$). Within the HbA1c subgroups, the largest increase in SBP was noted in the HbA1c < 7.0 group (1.39mmHg, SD = 15.53, $p < 0.0001$). While increases in mean SBP were noted in each HbA1c subgroup, decreases in mean DBP were noted in the HbA1c groups ≥ 9.0% (Table 3).

Use of both insulin and OHA also increased significantly between the pre- and post-SiP periods across all strata (Table 4). There was an overall 0.36% net increase in OHA use in our cohort, with the largest net increase of 1.42% in OHA use noted in the HbA1c 7-7.9% group. Of note, net decreases in OHA use were seen in the HbA1c 8-8.9%, 9.0-9.9%, and ≥ 10.0% groups (-0.31%, -0.48%, and −0.20% respectively). A net increase in insulin use of 0.60% was also noted in the entire cohort, with net increases in insulin use noted in all HbA1c subgroups except for the HbA1c < 7.0% group with a net decrease of -0.04%. The largest increases in insulin use were noted in the HbA1c 9.0-9.9% and ≥ 10.0% groups, with a 3.19% and 1.64% increase, respectively.

Discussion

The COVID-19 pandemic and subsequent shelter-in-place order caused significant disruption in the medical management of chronic conditions, particularly in decreased adherence to follow-up appointments and medications [14]. Coupled with generally increasing rates of unhealthy lifestyle behaviors [3], it is unsurprising that mean HbA1c, SBP, DBP and use of both insulin and OHAs increased in our diabetic patient population when comparing pre- to post-SiP values. Interestingly, mean BMI decreased for the entire cohort, when this data was available. Stratifying our study's cohort into subgroups based on pre-SiP glycemic control reveals an interesting pattern– overall net increase in insulin use exceeded overall net increase in OHA use throughout our sample population. Expectedly, the greatest increase in insulin use was present in the highest HbA1c subgroups, correlating with the decreases in HbA1c noted in those groups (HbA1c 8-8.9%, 9-9.9%, and ≥ 10.0%). These findings are likely multifactorial. In the KPNC system, virtual care significantly increased during SiP, and patients with worse glycemic control may have had more stringent virtual medical follow-up during the pandemic. The management of our diabetic population (intensification and/or de-escalation of medical therapy and lifestyle recommendations) was still based on HbA1c values when available, and thus likely led to the more significant increases in insulin initiation in those with the highest HbA1c levels. Continuous glucose monitor data was not specifically assessed in this study, though we anecdotally appreciate greater adoption of this technology during and following the pandemic. More lenient follow-up and recent pushes for laxer HbA1c goals [21] for patients with better but still suboptimal HbA1c (e.g., HbA1c 7-7.9% and 8-8.9%) may explain the decreased rate of insulin (and total hypoglycemic agent) initiation and consequent increases in mean HbA1c in those patients with lower HbA1c, reflecting prior findings which noted the most marked increases in HbA1c in patients with better pre-SiP glycemic control [14]. Other studies have also noted increased morbidity and mortality of COVID-19

in patients with poorly controlled diabetes [17, 18] with increased risk of hospitalization. This finding may also explain improved HbA1c levels in patients with worse initial glycemic control, whether it be due to weight loss (as evidenced by decreased mean BMI post-SiP) and poor oral intake during an inpatient admission for COVID-19 pneumonia or from improved blood glucose control as a function of closer dietary scrutiny and insulin management while hospitalized. Overall, while our study noted an expected increase in mean HbA1c across all subjects, increased rates of hospitalizations and more stringent follow-up in patients with worse glycemic control likely offset the negative impacts of SiP on diabetes management. Although the total changes found in HbA1c in our study are small, prior studies have found that even changes as small as 0.3% can significantly impact the rate of diabetes-related complications [22]. It is also important to note that the meaningful changes in medication use, especially at higher HbA1c values, may have blunted the absolute HbA1c changes seen in our study.

This study has several limitations. Restricting the study to KPNC patients may limit the generalizability of our study results to those patients with continuous medical insurance during the pandemic and fewer barriers to healthcare access. By selecting for a cohort of subjects who had both pre- and post-SiP parameters available, the sample population may have been biased toward patients who were more motivated to participate in routine medical follow-up and adherence to medication or a healthier lifestyle. The inclusion criteria in our sample population may have resulted in survivorship bias, as patients who passed during or immediately post-SiP would not have been included in the study. KPNC, along with many other health systems, are still in the process of understanding member access to care during the pandemic. While our study selected for those who maintained access to consistent care, we are aware that some members may have experienced financial hardship which may have resulted in changes in medical care or loss of insurance.

This study's largest strength is its sample size. The KPNC patient database provides access to over 160,000 diabetic patients and is a population that is representative of the socioeconomic and racial/ ethnic diversity of the broader Northern California population. The use of an integrated healthcare system also limits systematic differential access to healthcare.

Conclusions

This study sought to understand the impact of the pandemic and State of California SiP order on glycemic and blood pressure control among diabetic patients in the KPNC system. As expected, mean HbA1c, SBP, and DBP increased throughout the sample population. Interestingly, mean HbA1c decreased in those with higher pre-SiP HbA1c, potentially explained by increased medical follow-up that could have offset the negative effects of the pandemic in those with worse glycemic control. Future studies on the effects of SiP and COVID-19 on control of chronic medical conditions can help healthcare systems target efforts in this post-pandemic era.

Abbreviations

SiP	Shelter-in-Place
KPNC	Kaiser Permanente Northern California
BMI	Body Mass Index
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
OHA	Oral Hypoglycemic Agents

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-21916-z.

Supplementary Material 1

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Not applicable.

Author contributions

K.Y. contributed to the discussion and wrote the first draft of the manuscript as well as prepared Tables 1, 2, 3 and 4. M.M. researched data and edited the manuscript. A.B. contributed to the discussion and reviewed and edited the manuscript. J.V. and S.P. researched data and reviewed and edited the manuscript. All authors reviewed and approved the final version of the manuscript.

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Data availability

Requests to access the dataset from qualified researchers trained in human subjects' confidentiality protocols may be sent to Dr. Seema Pursnani, Principal Investigator, at the Division of Research, email: Seema.K.Pursnani@kp.org. The patient data is owned by the Kaiser Foundation Health Plan, Inc., Kaiser Foundation Hospitals, Inc., and The Permanente Medical Group, Inc. Because of their third-party rights, it is not possible to make the data publicly available without restriction.

Declarations

Ethical approval

This study was reviewed and approved by the Kaiser Permanente Northern California Institutional Review Board under exempt status on 5/27/2021 (IRB #1760881).

Consent for publication

Not applicable.

Consent to participate

Not applicable.

Competing interests

The authors declare no competing interests.

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