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Impact of COVID-19 lockdown on diabetes management and follow-up in a broad population in Spain

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Abstract

Background: To evaluate the impact of COVID-19 lockdown on glycaemic control and diabetes follow-up in a Spanish metropolitan area with a total general population of 340,000.

Methods: A retrospective real-world study comparing HbA1c testing, an indicator of diabetes control, and mean HbA1c during different COVID-19 restriction periods in 2020 (full lockdown, post-lockdown, partial lockdown) with the same periods in 2019. HbA1c testing was analysed per study period and according to gender, age and clinical setting. Associations between HbA1c testing and different covariables were investigated using logistic regression analysis. Changes in HbA1c were evaluated by repeated measures multivariate analysis of variance (ANOVA).

Results: During full lockdown, 6847 individuals, of which 56.7% were over 65 and 6.5% below 40, were tested for HbA1c compared to 14,180 in 2019 (OR 0.47, 95% CI:0.46–0.49). Reduction in HbA1c testing was greater among older individuals (OR 0.44, 95% CI:0.42–0.45). No differences were observed for post-lockdown (OR 1.01, 95% CI:0.99–1.04). During partial lockdown, 10,816 individuals had at least one HbA1c measured compared to 12,749 in 2019 (OR 0.84, 95% CI:0.82-0.87). Mean HbA1c during full lockdown was 7.26% (±1.06) compared to 7.50% (±1.14) in 2019 ($p < .0001$). For gender and across all age groups, HbA1c levels were lower during full lockdown. HbA1c changes were not significantly different during post-lockdown and partial lockdown.

Conclusions: COVID-19 restriction measures affected HbA1c testing. During complete lockdown, HbA1c testing decreased by half across all gender and age groups. No deleterious effect on glycaemic control was observed during lockdown and post-lockdown among those tested.

KEYWORDS
COVID-19, diabetes control, HbA1c, lockdown

1 | INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic was declared on 11 March 2020 by the World Health Organization (WHO).[1] Restrictive measures were imposed worldwide to halt the spread of new cases.[2] In 2020, Spain was one of the countries that was most affected by the COVID-19 pandemic.[3] Due to an increasing number of cases, a complete national lockdown was introduced to contain the outbreak from 14 March 2020 until 21 June 2020. After a period of almost 4 months, in which some restrictive measures were removed, the government reintroduced a state of emergency on 25 October due to the resurgence of cases, including partial lockdown measures with mobility restrictions that lasted until 9 May 2021.

In Spain, the adult prevalence of diabetes has been estimated to be up to 13.8%, of which about 6% had unknown diabetes.[4] Similar prevalence values have been reported in the Valencian Community, a Spanish region with a population of five million.[5] In this region, most people with diabetes are followed up by primary care physicians who work closely with endocrinologists to manage more complex cases[5]. Many publications have reported that people with diabetes had a higher risk for developing more severe cases of COVID-19 and had poorer outcomes and higher mortality rates[6-8]. Although, no evidence has suggested higher morbi-mortality among young type 1 diabetes individuals with adequate glycaemic control than their healthy counterparts[9].

Lockdown measures have included restrictions on outdoor physical activity and social isolation leading to sedentary lifestyles, poorer dietary habits and an increase in mental health disorders, which, along with a limited access to health care, had a negative impact on diabetes self-management[10-12]. Clinical standards of care recommend continuous diabetes education, clinical monitoring, treatment adjustment, periodic blood test controls and screening for chronic complications in diabetes management[13]. Additionally, lockdown measures and overwhelming work overload in primary care centres disrupted periodic face-to-face clinical visits among people with diabetes, which might have further negatively affected diabetes control[14-16].

We hypothesized that HbA1c levels would be worse in people with diabetes because of a reduction in the number of HbA1c determinations due to the restrictive measures introduced during the COVID-19 pandemic. Thus, our aim was to evaluate HbA1c testing as an indicator of diabetes control, during either complete or partial lockdown periods, to investigate whether changes in the number of HbA1c determinations were associated with a patient-level worsening of HbA1c levels and to analyse if these changes were related to sex, age or clinical setting.

2 | MATERIAL AND METHODS

2.1 | Study design and data retrieval

This was a retrospective observational real-world study comparing HbA1c testing and the mean value of HbA1c during different COVID-19 mobility restriction periods and compared to the previous year.

The examined area included the Department of Health of Valencia Clínico-Malvarrosa (Area 05, Valencian Autonomous Community, Spain), which represents a census population of 340,000 people with public health coverage and for whom public health data are available. In the current study catchment area, the prevalence of type 2 diabetes was estimated to be close to 8.2% in 2017[5]. In 2017, the prevalence of type 1 diabetes was 0.3% in the Valencian region[5]. According to current departmental clinical guidelines, people with diabetes should have on average two HbA1c determinations per year, whereas type 1 diabetes patients should have three to four HbA1c determinations per year.[5]

The present work was based on Gestlab software ('Consellería de Sanidad'), an electronic database which stores all the Valencia Clínico-Malvarrosa's Department of Health laboratory data. All laboratory samples in the Valencia Clínico-Malvarrosa Department of Health are centrally processed at the Central Laboratory of the Hospital Clínico Universitario Valencia (HCUV). Data mining and recovery were performed between March and May 2021.

2.2 | Study population inclusion and exclusion criteria

All individuals who had at least one HbA1c per year were included in our analysis. Additionally, individuals with all HbA1c values below 6.5% were excluded because it was assumed that they did not have diabetes.

2.3 | Study periods

Three study periods during 2020 were examined and defined according to the changes in mobility restriction measures that were imposed in Spain to contain COVID-19 cases, as follows: period 1, from 14 March until 21 June 2020, when full lockdown measures were imposed; period 2, from 22 June until 30 September, when mobility restrictions were relaxed; and period 3, from 1 October until 31 December, when partial lockdown measures were established based on an accumulated PCR-positive incidence >500/100,000 inhabitants.

Each period in 2020 was compared with its corresponding period in 2019.

2.4 | Variables included in the analysis

The following variables were obtained automatically from Gestlab software ('Consellería de Sanidad') and analysed: HbA1c values, gender, age and clinical setting.

Clinical data on the type of diabetes, diabetes duration or current treatment were not available and therefore not included in this study.

2.4.1 | HbA1c determinations

HbA1c values were accepted as an indicator of diabetes control. All HbA1c determinations that were performed at the HCUV central laboratory during each defined study period were and recorded. HbA1c values were measured using high-performance liquid chromatography (HPLC) methodology (ADAMS™ HA-8180 chromatography analyser, Menarini ARKRAY). HbA1c determinations were analysed during the study periods and according to available demographic variables (ie age and gender) and the clinical setting.

2.4.2 | Clinical setting

The following four different clinical settings were described according to where the blood sampling was performed: hospital, primary care centres within the city of Valencia, peripheral primary care centres away from the metropolitan area, and nursing homes.

2.5 | Statistical analysis

Data for qualitative variables are presented as the number and percentage, and quantitative variables are presented as the mean and standard deviation.

The number of HbA1c determinations was analysed per study period and according to gender, age and clinical setting and compared with the number of HbA1c determinations that were performed during the corresponding 2019 period. In addition, if a patient had more than one HbA1c determination during one of the examined periods, the mean of all the HbA1c determinations performed during that specific period was calculated and included in the analysis, so that each patient had only one HbA1c value per study period.

Associations between having an HbA1c determination and various covariables (ie year in which it was performed, age group and gender) were investigated using logistic regression analysis: factors influencing whether HbA1c was tested were analysed, with the dependent variable being whether or not HbA1c was tested and the independent variables being the year of measurement, age group and sex and also including interactions between the variables.

Changes in the mean HbA1c values were analysed and compared between the lockdown period (period 1), the post-lockdown period (period 2), and the partial lockdown period (period 3) and the corresponding periods in 2019. To assess the change in HbA1c, a paired comparison was made, so the values were compared among those subjects who had HbA1c determinations in both years during the same period for each case. Differences between HbA1c values were analysed for significance using a repeated measures multivariate analysis of variance (ANOVA), where the repeated measure was the HbA1c determination. The significance of the difference in the HbA1c and the influence of the variables sex, age group and origin of the sample on this difference (within-subject effects), as well as the influence of sex, age group and origin—not dependent on the year of measurement (between-subject effects)–were analysed. Interactions between the examined variables (testing year, gender, age and clinical setting) were also analysed.

A statistical significance level of 0.05 was used. For post hoc comparisons, the significance level was corrected using the Bonferroni method. The statistical analysis was performed using IBM SPSS Statistica v. 26.0.

Reporting of the study conforms to broad EQUATOR guidelines[17].

3 | RESULTS

Individuals' characteristics with at least one HbA1c determination performed during the study periods are described in Table 1. Among people who were tested, and across all three study periods in 2019, there were more males than females, the large majority were over 65 and individuals were more often tested in the primary care centres within the city compared to the other clinical settings (Table 1). This trend was similar for the 2020 study periods with some differences: during the post-lockdown period, there were more females than males who were tested (50.12% females versus 49.88% males), and during the full and partial lockdown periods, there were more people who were tested in the hospital setting versus the primary care centres within the city (47.2% in the hospital setting versus 31.8% in the primary care centres within the city during full lockdown; 40.0% in the hospital setting versus 38.4% within the primary care centres within the city during partial lockdown) (Table 1).

TABLE 1 Individuals with HbA1c determinations according to gender, age and clinical setting

Individuals with HbA1c determinations*, *n* (%)	Period 1		Period 2		Period 3	
	2019	2020	2019	2020	2019	2020
Total	14,180 (100.00)	6,847 (100.00)	10,287 (100.00)	10,418 (100.00)	12,749 (100.00)	10,816 (100.00)
Gender						
Women	6,875 (48.5)	3,228 (47.1)	5,067 (49.26)	5,222 (50.12)	6,148 (48.22)	5,318 (49.17)
Men	7,305 (50.50)	3,619 (52.90)	5,220 (50.74)	5,196 (49.88)	6,601 (51.78)	5,498 (50.83)
Age groups (years)						
<40	784 (5.53)	427 (6.24)	668 (6.49)	663 (6.36)	710 (5.57)	672 (6.21)
40–65	5,119 (36.10)	2,536 (37.04)	3,915 (38.06)	3,935 (37.78)	4,530 (35.53)	4,023 (37.20)
>65	8277 (58.37)	3884 (56.72)	5704 (55.45)	5820 (55.86)	7509 (58.90)	6121 (56.59)
Clinical setting						
Hospital	4,643 (32.7)	3,234 (47.2)	3,490 (33.9)	3,809 (36.6)	4,225 (33.1)	4,333 (40.0)
PCC city	6,194 (43.7)	2,179 (31.8)	4,312 (41.9)	4,060 (39.0)	5,439 (42.7)	4,156 (38.4)
PCC peripheral	3,080 (21.7)	1,287 (18.8)	2,291 (22.3)	2,348 (22.5)	2,885 (22.6)	2,171 (20.1)
Nursing home	263 (1.9)	147 (2.2)	194 (1.9)	201 (1.9)	201 (1.6)	159 (1.5)

Abbreviation: PCC, primary care centres.

*If an individual had more than one HbA1c determination during one of the examined periods, the mean of all the HbA1c determinations performed during that specific period was calculated.

TABLE 2 HbA1c determinations and study periods

Individuals with HbA1c* (*n*, %)	Period 1 2019	Period 1 2020	OR (95%CI)	*p*-value
No	331,582 (95.90)	338,915 (98.02)	0.47 (0.46-0.49)	<.0001
Yes	14,180 (4.10)	6,847 (1.98)		
Total	345,762 (100.00)	345,762 (100.00)		
HbA1c (n, %)	**Period 2 2019**	**Period 2 2020**	**OR (95%CI)**	***p*-value**
No	335,475 (97.02)	335,344 (96.99)	1.01 (0.99–1.04)	.355
Yes	10,287 (2.98)	10,418 (3.01)		
Total	345,762 (100.00)	345,762 (100.00)		
HbA1c (n, %)	**Period 3 2019**	**Period 3 2020**	**OR (95%CI)**	***p*-value**
No	333,013 (96.31)	334,946 (96.87)	0.84 (0.82-0.87)	<.0001
Yes	12,749 (3.69)	10,816 (3.13)		
Total	345,762 (100.00)	345,762 (100.00)		

*Individuals with at least one HbA1c determination in each study period.

3.1 | HbA1c determinations

3.1.1 | First study period: Full lockdown (14 March to 21 June 2020)

Among a total population of 345,762 individuals, 6847, had at least one HbA1c determination during the full lockdown period (1.035 determination per individual) compared to 14,180 over the corresponding period in 2019 (1.050 determination per individual) (Table 2; Table S1). A statistically significant difference was found between the two periods (OR 0.472, 95% CI: 0.46–0.49, *p*-value <.0001). Across all the examined groups during the full lockdown period (according to gender, age and clinical setting), the number of individuals who were tested decreased compared to 2019 (Table 1).

Following a regression analysis and considering the study period-year, age and gender, a significant interaction was found between study period-year and age (Table 3). Older subjects were least likely to be HbA1c tested among all the age groups during this period when compared to the previous year (OR 0.436 [95%CI: 0.419–0.45] in the over 65 years vs. OR 0.485 [0.462–0.509] in the 40–65 years vs. OR 0.543 [0.486–0.611] among those below 40 years; $p < .0001$). There was no interaction between study period-year and gender.

TABLE 3 HbA1c determinations by year and age group

Age group (years)	Period 1				
	OR 2020/2019	**95% CI**		**Wald**	***p*-value**
<40	0.543	0.483	0.611	102.5	<.0001
4065	0.485	0.462	0.509	863.6	<.0001
>65	0.436	0.419	0.454	1673.1	<.0001
Age group (years)	Period 3				
	OR 2020/2019	95% CI		Wald	*p*-value
<40	0.946	0.851	1.052	1.1	.306
4065	0.884	0.847	0.923	31.1	<.0001
>65	0.796	0.768	0.825	157.1	<.0001

For the clinical setting, a change in the distribution of the HbA1c testing was observed (Table 4). During full lockdown, there was a significant increase in the proportion of patients having HbA1c determinations in hospital compared to the other clinical settings combined (OR 1.84, 95% CI: 1.73-1.95, p<0.0001) (Table S2).

3.1.2 | Second study period: Post-lockdown (from 21 June 2020 to 1 October 2020)

During the post-lockdown period, where COVID-19 restrictive measures were lifted, 10,418 individuals (1.053 determination per individual) had at least one HbA1c determination compared to 10,287 (1.049 determination per individual) during the corresponding period in 2019 (Table 2; Table S1). No significant differences were found between the two periods (OR 1.01, 95% CI: 0.99–1.04, $p = .355$). However, a significant increase in HbA1c testing among hospital patients was observed (although more modest than the one observed during full lockdown) compared to the other clinical settings (OR 1.12, 95% CI: 1.06–1.1, $p < .0001$) (Table S2). There were no interactions between variables during this period.

3.1.3 | Third study period: Partial lockdown (from 1 October 2020 to 31 December 2020)

During the partial lockdown period, variable restrictive measures were introduced. Among 345,762 individuals, 10,816 had at least one HbA1c determination (1.035 determination per individual), whereas in the corresponding period in 2019, there were 12,749 (1.051 determination per individual) (OR 0.84, 95% CI: 0.82–0.87, $p < .0001$) (Table 2; Table S1).

Consistent with the results from the full lockdown period, an interaction was found between period-year and age ($p < .0001$) (Table 3). The reduction in patients being tested for HbA1c was significantly more pronounced in the older age groups than in the younger groups when compared to the previous year (Table 3).

HbA1c determinations from hospital patients increased during partial lockdown, whereas among patients from the other clinical settings, HbA1c determinations decreased (Table 4). When comparing the hospital setting to the other clinical settings combined, the OR of having an HbA1c measured in hospital was 1.35, 95% CI: 1.28–1.42, $p < .0001$) (Table S2).

3.2 | Change in HbA1c levels during study periods

3.2.1 | First study period: Full lockdown (from 14 March to 21 June 2020)

When examining the full lockdown period and the corresponding period in 2019, there were 1919 individuals (863 women and 1056 men) who had at least one HbA1c measured during both periods (Table S3).

The mean HbA1c level during full lockdown was 7.26% (±1.06) compared to 7.50% (±1.14) during the first study period in 2019 ($p < .0001$) (Table 5).

Across all gender and age groups, HbA1c levels were lower during full lockdown than in 2019 (Table 5). A significant interaction was found between the study period-year and clinical setting ($p = .013$); HbA1c levels were lower during full lockdown in all clinical settings, but individuals from nursing homes experienced the largest reduction in HbA1c levels compared to the previous year (6.82 ± 1.10 vs 7.52 ± 1.41; $p = .001$) (Table 5).

3.2.2 | Second study period: Post-lockdown (from 21 June 2020 to 1 October 2020)

There were 2163 individuals (1043 women and 1120 men) with HbA1c determinations during both, the post-lockdown period and its corresponding period in 2019

TABLE 4 Individuals with HbA1c determinations and clinical setting

	Period 1 2019		Period 1 2020		Period 2 2019		Period 2 2020		Period 3 2019		Period 3 2020	
	N	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Hospital	4,643	32.74	3,234	47.23	3,490	33.93	3,809	36.56	4,225	33.14	4,333	40.05
PCC city	6,194	43.68	2,179	31.82	4,312	41.92	4,060	38.97	5,439	42.66	4,156	38.41
Peripheral PCC	3,080	21.72	1,287	18.80	2,291	22.27	2,348	22.54	2,885	22.63	2,171	20.07
Nursing homes	263	1.85	147	2.15	194	1.89	201	1.93	201	1.58	159	1.47
Total	14,180	100.00	6,847	100.00	10,287	100.00	10,418	100.00	12,750	100.00	10,819	100.00
p-value	<.0001				<.0001				<.0001			

Abbreviation: PCC, primary care centres.

(Table S3). Mean HbA1c was 7.42% (±1.11) during post-lockdown compared to 7.43% (±1.15) in 2019, but the difference was not significant (Table 5). Additionally, a significant interaction was found between study period-year and age ($p = .006$). Interestingly, only individuals below 40 years showed a significant decrease in HbA1c levels during this period (7.70% ± 1.16 vs 7.98% ± 1.44; $p = .034$), compared with 2019 (Table 5). No other clinically significant results were found.

3.2.3 | Third study period: Partial lockdown (from 1 October 2020 to 31 December 2020)

During partial lockdown and its corresponding period in 2019, 2519 individuals (1179 women and 1340 men) were tested for HbA1c (Table S3). Mean HbA1c levels during this period were 7.40% (±1.08) compared to 7.34% (±1.15) during 2019 ($p = .543$) (Table 5). Similar to the post-lockdown period, individuals below 40 years of age showed a significant reduction in HbA1c when compared to 2019 (7.78% ± 1.21 vs 8.04% ± 1.37; $p = .033$) (Table 5).

Table 6 shows more detailed results of the multivariate analysis.

4 | DISCUSSION

This large retrospective real-life study highlights the effect of COVID-19 restrictive measures on diabetes control in a large Spanish metropolitan area. During full lockdown, the odds of having an HbA1c determination were halved compared to the previous year. Moreover, all gender and age groups experienced a reduction in HbA1c testing, and the oldest participants were the most affected group. After restrictions were lifted (post-lockdown), no differences were found in HbA1c testing compared to the corresponding period in 2019. However, when new variable restrictive measures were applied in the last third of 2020 (partial lockdown) due to a resurgence of cases, a significant decrease in HbA1c determinations was observed, although the magnitude of the decrease was less than that observed during complete lockdown. Conversely, there was a significant improvement in HbA1c values during the total lockdown across all genders, age groups, and clinical settings compared to 2019. Subsequently, significant changes in HbA1c were no longer observed after completely lifting the lockdown. During the partial lockdown period, HbA1c decreased among individuals younger than 40 years, but not for other age groups. These results suggest that, although diabetes care was disrupted during the lockdown, it did not appear to be associated with a deterioration in glucose control in those patients

TABLE 5 Change in HbA1c value and study periods

HbA1c % **Mean (SD)	Period 1			Period 2			Period 3		
	2020	2019	*p*-value†	2020	2019	*p*-value†	2020	2019	*p*-value†
Total	7.26 (1.06)	7.50 (1.14)	<.0001	7.42 (1.11)	7.43 (1.15)	.563	7.40 (1.08)	7.34 (1.15)	.543
Gender	0.166*		.426*		0.799*				
Women	7.30 (1.06)	7.50 (1.13)		7.44 (1.04)	7.42 (1.09)		7.37 (0.99)	7.39 (1.17)	
Men	7.23 (1.06)	7.49 (1.14)		7.30 (1.12)	7.23 (0.98)		7.36 (1.05)	7.35 (1.22)	
Age group (years)	0.107*		.006*		0.008*				
<40	7.58 (1.10)	8.05 (1.30)		7.70 (1.16)	7.98 (1.44)	.034	7.78 (1.21)	8.04 (1.37)	.033
40–65	7.35 (1.18)	7.61 (1.26)		7.51 (1.16)	7.53 (1.22)	.658	7.47 (1.21)	7.39 (1.25)	.444
>65	7.19 (0.97)	7.38 (1.02)		7.32 (1.05)	7.28 (1.01)	.187	7.32 (0.97)	7.24 (1.05)	.471
Clinical setting	0.013*		.781*		0.106*				
Hospital	7.34 (1.10)	7.64 (1.13)	<.0001	7.56 (1.07)	7.62 (1.16)		7.51 (1.11)	7.54 (1.21)	
City PCC	7.23 (1.04)	7.42 (1.19)	<.0001	7.36 (1.19)	7.34 (1.16)		7.33 (1.02)	7.24 (1.11)	
Peripheral PCC	7.19 (0.98)	7.30 (1.00)	.006	7.28 (1.03)	7.24 (1.05)		7.32 (1.09)	7.17 (1.09)	
Nursing homes	6.82 (1.10)	7.52 (1.41)	.001	7.12 (1.00)	6.92 (1.12)		7.04 (0.92)	7.10 (0.98)	

Abbreviation: PCC, primary care centres.

**p*-value for interaction.; ***Non-adjusted data (mean and *SD*).

†*p*-value after multivariate analysis.

who were able to have an HbA1c assessment during this time of confinement.

Unprecedented lockdown measures that were implemented to contain the increase of COVID-19 cases had negative effects on the ongoing care for chronic diseases such as diabetes[11,18]. Results from a UK study based on an on-line survey targeting healthcare professionals from 47 countries showed that diabetes was the chronic condition that was most impacted due to the reduction in access to health care[19]. Significant adverse effects on diabetes management and its comorbidities have been previously described in the context of other exceptional situations such as natural disasters[20]. As expected, our study showed that the imposed restrictions were associated with a significant decrease in the number of individuals having HbA1c determinations during lockdown. This reduction in HbA1c testing is likely to reflect disruption of diabetes care pathways that occurred due to the COVID-19 epidemic, with the suspension of face-to-face outpatient visits. Moreover, HbA1c determinations decreased more markedly in the older age groups. Older people, who are often the most fragile patients with more chronic conditions, have been the age group that was most impacted by COVID-19[21]. Besides, a poorer prognosis and higher mortality rates among this age group might have favoured stricter self-confinement at home[22]. Because of increased fear of COVID-19, routine medical appointments and blood tests might have been avoided in some cases[22]. Therefore, we could assume that older patients had lower testing probabilities for HbA1c during the confinement. Additionally, aged patients were more difficult to reach by telemedicine and, at least in Spain, they usually did not have continuous glucose monitoring devices that could be reviewed remotely. As a result, aged individuals would appear to be the ones to have suffered the most from the negative lockdown effects on diabetes care[23].

HbA1c is known to be a valuable indicator of glycaemic control over the previous three months and has a central role in the follow-up of patients with diabetes[24]. Previous data have also shown that elevated HbA1c values are associated with an increased risk of chronic diabetic complications[24]. The present study demonstrated an overall decrease in HbA1c values during the full lockdown period compared to the previous year for those subjects with an HbA1c determination. Following relaxation of the restrictive measures, no significant changes in HbA1c were observed. Consistent with previous research, our analysis showed no deleterious effect of the lockdown and post-lockdown periods on glycaemic control[25-29]. Studies that included individuals with type 2 diabetes showed no significant worsening of glucose control during the lockdown[25,26]. Moreover, data from people with type 1 diabetes who were using glucose monitoring devices have revealed an improvement in time in range and glycaemic

TABLE 6 Multivariate analysis evaluating the change in HbA1c value

		Within-subject effects††					
		Change in HbA1c (HbA1c 2020–HbA1c 2019) (95% CI)					
Variable	**Group**	**Period 1**	***p*-value**	**Period 2**	***p*-value**	**Period 3**	***p*-value**
HbA1c	Total	−0.40 (−0.54 to −0.26)	<.0001	−0.04 (−0.16 to 0.09)	0.563	−0.04 (−0.18 to 0.10)	.543
Gender			.166*		0.426*		.799*
	Women	†−0.37 (−0.51 to −0.22)	<.0001	−0.02 (−0.15 to 0.12)	0.794	−0.05 (−0.19 to 0.10)	.509
	Men	†−0.44 (−0.58 to −0.29)	<.0001	−0.06 (−0.19 to 0.08)	0.412	−0.04 (−0.19 to 0.11)	.613
Age group (years)			.107*		0.006*		.008*
	<40	†−0.54 (−0.79 to −0.29)	<.0001	†−0.22 (−0.43 to −0.02)	0.034	†−0.24 (−0.45 to −0.02)	.033
	40–65	†−0.36 (−0.50 to −0.22)	<.0001	0.03 (−0.10 to 0.16)	0.658	0.06 (−0.09 to 0.20)	.444
	>65	†−0.30 (−0.42 to −0.18)	<.0001	0.08 (−0.04 to 0.20)	0.187	0.05 (−0.08 to 0.18)	.471
Clinical setting			.013*		0.781*		.106*
	Hospital	†−0.35 (−0.44 to −0.26)	<.0001	†−0.10 (−0.18 to −0.02)	0.011	†−0.08 (−0.15 to 0.00)	.039
	City PCC	†−0.27 (−0.39 to −0.16)	<.0001	−0.07 (−0.17 to 0.03)	0.156	0.00 (−0.09 to 0.09)	.956
	Peripheral PCC	†−0.19 (−0.32 to −0.05)	.006	−0.06 (−0.17 to 0.06)	0.351	0.06 (−0.05 to 0.16)	.303
	Nursing homes	†−0.80 (−1.25 to −0.34)	.001	0.08 (−0.36 to 0.52)	0.715	−0.15 (−0.66 to 0.35)	.549

Between-subject effects†††								
	p*-value*					**Difference in HbA1c (Group 1-Group 2) (95% CI)**		
Variable	**Period 1**	**Period 2**	**Period 3**	**Group 1**	**Group 2**	**Period 1**	**Period 2**	**Period 3**
Gender	.327	.644	.005	Women	Men	0.04 (−0.04 to 0.13)	0.02 (−0.06 to 0.10)	0.11† (0.03 to 0.19)
Age group (years)	<.0001	<.0001	<.0001	<40	40–65	0.28† (0.04 to 0.52)	0.25† (0.06 to 0.45)	0.38† (0.17 to 0.59)
				<40	>65	0.45† (0.21 to 0.69)	0.43† (0.23 to 0.63)	0.51† (0.31 to 0.72)
				40–65	>65	0.17† (0.06 to 0.28)	0.18† (0.07 to 0.29)	0.14† (0.04 to 0.24)
Clinical setting	.014	<.0001	.0002	Hospital	City PCC	0.09 (−0.04 to 0.22)	0.16† (0.03 to 0.29)	0.16† (0.04 to 0.28)
				Hospital	Peripheral PCC	0.18† (0.03 to 0.34)	0.26† (0.10 to 0.41)	0.21† (0.07 to 0.35)
				Hospital	Nursing homes	0.22 (−0.30 to 0.74)	0.43 (−0.08 to 0.95)	0.38 (−0.25 to 1.00)
				City PCC	Peripheral PCC	0.09 (−0.06 to 0.25)	0.10 (−0.05 to 0.25)	0.04 (−0.09 to 0.18)
				City PCC	Nursing homes	0.13 (−0.38 to 0.65)	0.28 (−0.23 to 0.78)	0.21 (−0.41 to 0.84)
				Peripheral PCC	Nursing homes	0.04 (−0.48 to 0.56)	0.18 (−0.34 to 0.69)	0.17 (−0.46 to 0.80)

PCC, primary care centres.

*p-value for interaction.; **p-value for between-subject factors.

†These differences are significant after Bonferroni correction.

††Within-subject effects show the change in HbA1c between 2019 and 2020 for each study period.

†††Between-subjects effects show the change in HbA1c between group 1 and group 2 for each study period.

variability[27,28]. Additionally, a recent study including 145 type 1 diabetes patients found an improvement in glycaemic control during lockdown that was sustained for several months into the post-lockdown period[29]. These findings have been attributed to changes in self-care routines such as more regular mealtimes and an increase sleep time, although people reported less exercise and higher stress levels[29,30].

For diabetes management, face-to-face visits remain essential to improve treatment adherence and achieve optimal glycaemic goals[27]. When the restriction measures were implemented in March 2020 for the total lockdown, our healthcare delivery systems had to be reorganized to face the large number of COVID-19 cases. Thus, outpatient visits were cancelled or postponed, and then, they were switched to telephone consultations and remote patient monitoring when possible. Overall, telemedicine was found to be efficient and safe[31,32]. However, caution is required for widespread use of telemedicine for all patients. Absence or reduce face-to-face consultations may result in lower treatment adherence levels and may discriminate against people with no technology skills[33]. Special care is needed for older and more fragile individuals as well as for those who are least acquainted with technological devices. Indeed, local COVID protocols should be redesigned to cover for those specific cases.

Major strengths of this real-world study are outlined below. First, this retrospective study involved analysing data from a large and diverse population in a metropolitan area of Valencia, Spain. Additionally, all HbA1c determinations were performed in the same laboratory using the same methodology. We analysed the number of HbA1c values, which were used as a proxy for the quality of diabetes management. However, we recognize some limitations of this study. The most important limitation is that data on clinical characteristics were not available for the analysis. These include the type of diabetes, diabetes duration, active treatments and presence of co-morbidities, and, as a consequence, results should be interpreted with caution. Patients were followed up in different health centres, and, as a result, patients' data were included in different databases not easily accessible. Our data only described how the degree of lockdown measures affected HbA1c testing and the quality of glycaemic control among patients with HbA1c assessments over time. For those individuals with no available HbA1c values during lockdown and partial lockdowns, we do not have data and, thus, cannot be sure to what extend pandemic restrictions and temporary loss of follow-up affected their glycaemic control, and a causal relationship cannot be demonstrated. Another limitation of this study relates to HbA1c values that were not corrected for the possible presence of anaemia. Finally, these data were obtained from a specific Spanish metropolitan area with the same age and gender distribution as the rest of the Valencian Autonomous Community, but they cannot be generalized to other regions in Spain and other countries worldwide.

5 | CONCLUSIONS

This study showed the effect of the COVID-19 lockdown on managing diabetes as a chronic disease in a metropolitan area of a western country. We used the number of HbA1c determinations as a proxy for diabetes management. HbA1c testing was halved during lockdown for all gender and age groups, irrespective of the clinical settings where blood sampling was performed. There was no detrimental effect on glycaemic control during the lockdown and post-lockdown periods in individuals with HbA1c determinations and, presumably with clinical contacts, throughout this time.

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CONFLICT OF INTEREST

F.J.A.B. has served as a consultant/advisor for Abbott Diabetes Care, AstraZeneca, Boehringer Ingelheim, Eli Lilly, GlaxoSmithKline, LifeScan, MannKind Co., Medtronic, Menarini, Merck, Novartis, Novo Nordisk and Sanofi, and as a speaker for Abbott Diabetes Care, AstraZeneca, Boehringer Ingelheim, GlaxoSmithKline, LifeScan, Eli Lilly, Madaus, Medtronic, Menarini, Merck, Novartis, Novo Nordisk and Sanofi and has received grant support from Novo Nordisk and Sanofi. A. P., C. Q. T., J. G. and J. T. R. have no relevant conflict of interest to disclose.

AUTHOR CONTRIBUTIONS

C.Q.T., J.G. and F.J.A.B. conceived and designed the study; C.Q. T. contributed to the acquisition of data. J.G. analysed and A.P., C.Q.T., J.G., and F.J.A.B. interpreted the study data; A.P. wrote the manuscript; A.P., C.Q.T., J.G., J.T.R., and F.J.A.B. contributed to the interpretation of the results, discussion and reviewed the manuscript. All authors read and approved the final manuscript.

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REFERENCES

1. World Health Organization. *Rolling updates on coronavirus disease (COVID-19): WHO characterizes COVID-19 as a pandemic*. WHO. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen. Updated July 31, 2020. Accessed July 31, 2021.
2. Alfano V, Ercolano S. The efficacy of lockdown against COVID-19: a cross-country panel analysis. *Appl Health Econ Health Policy*. 2020;18:509-517.
3. García-Basteiro AL, Legido-Quigley H, Álvarez-Dardet C, et al. Evaluation of the COVID-19 response in Spain: principles and requirements. *Lancet Publ Health*. 2020;5:E575. 10.1016/S2468-2667(20)30208-5
4. Soriguer F, Goday A, Bosch-Comas A, et al. Prevalence of diabetes mellitus and impaired glucose regulation in Spain: the Di@bet.es Study. *Diabetologia*. 2012;55:88-93. 10.1007/s00125-011-2336-9
5. Pomares Gómez FJ, Fernando de la Torre A, Morillas Ariño C, et al. *Estrategia de diabetes de la Comunitat Valenciana 2017–2021*. Generalitat Valenciana; 2017. http://www.san.gva.es/documents/156344/7167642/Estrategia+de+diabetes+CV_2017-2021.pdf. Accessed January 15, 2022.
6. Espinosa OA, dos Santos ZA, Antunes EF, Longhi FG, de Matos TA, Battaglini PF. Prevalence of comorbidities in patients and mortality cases affected by SARS-CoV2: a systematic review and meta-analysis. *Rev Inst Med Trop S Paulo*. 2020;62:e43. 10.1590/S1678-9946202062043.
7. Mantovani A, Byrne CD, Zheng MH, Targher G. Diabetes as a risk factor for greater COVID-19 severity and in-hospital death: a meta-analysis of observational studies. *Nutr Metab Cardiovasc Dis*. 2020;30:1236-1248. 10.1016/j.numecd.2020.05.014
8. Wu ZH, Tang Y, Cheng Q. Diabetes increases the mortality of patients with COVID-19: a meta-analysis. *Acta Diabetol*. 2021;58:139-144. 10.1007/s00592-020-01546-0
9. DiMeglio LA. COVID-19 and type 1 diabetes: addressing concerns and maintaining control. *Diabetes Care*. 2021;44(9):1924-1928. 10.2337/dci21-0002.
10. Dubey S, Biswas P, Ghosh R, et al. Psychosocial impact of COVID-19. *Diabetes Metab Syndr*. 2020;14:779-788. 10.1016/j.dsx.2020.05.035
11. Khader MA, Jabeen T, Namoju R. A cross sectional study reveals severe disruption in glycemic control in people with diabetes during and after lockdown in India. *Diabetes Metab Syndr*. 2020;14:1579-1584. 10.1016/j.dsx.2020.08.011
12. Pellegrini M, Ponzo V, Rosato R, et al. Changes in weight and nutritional habits in adults with obesity during the "lockdown" period caused by the COVID-19 virus emergency. *Nutrients*. 2020;12:2016. 10.3390/nu12072016
13. Introduction: standards of medical care in diabetes—2021. *Diabetes Care*. 2021;44(suppl 1):S1-S2. 10.2337/dc21-Sint
14. Ghosal S, Sinha B, Majumder M, Misra A. Estimation of effects of nationwide lockdown for containing coronavirus infection on worsening of glycosylated haemoglobin and increase in diabetes-related complications: a simulation model using multivariate regression analysis. *Diabetes Metab Syndr*. 2020;14:319-323. 10.1016/j.dsx.2020.03.014
15. Jacob L, Rickwood S, Rathmann W, Kostev K. Change in glucose-lowering medication regimens in individuals with type 2 diabetes mellitus during the COVID-19 pandemic in Germany. *Diabetes Obes Metab*. 2021;23:910-915. 10.1111/dom.14293
16. Scott ES, Jenkins AJ, Fulcher GR. Challenges of diabetes management during the COVID-19 pandemic. *Med J Aust*. 2020;213:56-57.e1. 10.5694/mja2.50665
17. Simera I, Moher D, Hoey J, Schulz KF, Altman DG. A catalogue of reporting guidelines for health research. *Eur J Clin Invest*. 2010;40(1):35–53. 10.1111/j.1365-2362.2009.02234.x.
18. Coma E, Mora N, Méndez L, et al. Primary care in the time of COVID-19: monitoring the effect of the pandemic and the lockdown measures on 34 quality of care indicators calculated for 288 primary care practices covering about 6 million people in Catalonia. *BMC Fam Pract*. 2020;21:208. 10.1186/s12875-020-01278-8
19. Chudasama YV, Gillies CL, Zaccardi F, et al. Impact of COVID-19 on routine care for chronic diseases: a global survey of views from healthcare professionals. *Diabetes Metab Syndr*. 2020;14:965-967. 10.1016/j.dsx.2020.06.042
20. Fonseca VA, Smith H, Kuhadiya N, et al. Impact of a natural disaster on diabetes: exacerbation of disparities and long-term consequences. *Diabetes Care*. 2009;32:1632-1638. 10.2337/dc09-0670
21. Yang J, Zheng YA, Gou XI, et al. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. *Int J Infect Dis*. 2020;94:91-95. 10.1016/j.ijid.2020.03.017
22. Bonora BM, Morieri ML, Avogaro A, Fadini GP. The toll of lockdown against COVID-19 on diabetes outpatient care: analysis from an outbreak area in northeast Italy. *Diabetes Care*. 2021;44:e18-e21. 10.2337/dc20-1872
23. Fadini GP, Bonora BM, Morieri ML, Avogaro A. Why diabetes outpatient clinics should not close during pandemic crises. *J Endocrinol Invest*. 2021;44(8):1795-1798. 10.1007/s40618-020-01474-4
24. Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. Significance of HbA1c test in diagnosis and prognosis of diabetic patients. *Biomark Insights*. 2016;11:95-104. 10.4137/BMI.S38440
25. D'Onofrio L, Pieralice S, Maddaloni E, et al. Effects of the COVID-19 lockdown on glycaemic control in subjects with type 2 diabetes: the glycalock study. *Diabetes Obes Metab*. 2021;23:1624-1630. 10.1111/dom.14380
26. Önmez A, Gamsızkan Z, Özdemir Ş, et al. The effect of COVID-19 lockdown on glycemic control in patients with type 2 diabetes mellitus in Turkey. *Diabetes Metab Syndr*. 2020;14:1963-1966. 10.1016/j.dsx.2020.10.007
27. Bonora BM, Boscari F, Avogaro A, Bruttomesso D, Fadini GP. Glycaemic control among people with type 1 diabetes during lockdown for the SARS-CoV-2 outbreak in Italy. *Diabetes Ther*. 2020;11:1-11. 10.1007/s13300-020-00829-7
28. Capaldo B, Annuzzi G, Creanza A, et al. Blood glucose control during lockdown for COVID-19: CGM metrics in Italian adults with type 1 diabetes. *Diabetes Care*. 2020;43:e88-e89. 10.2337/dc20-1127
29. Avari P, Unsworth R, Rilstone S, et al. Improved glycaemia during the Covid-19 pandemic lockdown is sustained post-lockdown and during the "Eat Out to Help Out" government scheme, in adults with Type 1 diabetes in the United Kingdom. *PLoS One*. 2021;16:e0254951. 10.1371/journal.pone.0254951

30. Ruissen MM, Regeer H, Landstra CP, et al. Increased stress, weight gain and less exercise in relation to glycemic control in people with type 1 and type 2 diabetes during the COVID-19 pandemic. *BMJ Open Diabetes Res Care*. 2021;9:e002035. 10.1136/bmjdrc-2020-002035
31. Cotovad-Bellas L, Tejera-Pérez C, Prieto-Tenreiro A, Sánchez-Bao A, Bellido-Guerrero D. The challenge of diabetes home control in COVID-19 times: proof is in the pudding. *Diabetes Res Clin Pract*. 2020;168:108379. 10.1016/j.diabres.2020.108379
32. Lian X, Dalan R, Seow CJ, et al. Diabetes care during COVID-19 pandemic in Singapore using a telehealth strategy. *Horm Metab Res*. 2021;53:191-196. 10.1055/a-1352-5023
33. Petrie JR, Boyle JG, Ali K, Smith C, Morrison D, Kar P. A post COVID-19 "Marshall Plan" for type 2 diabetes. *Diabet Med*. 2021;38:e14439. 10.1111/dme.14439

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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