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Influenza and Pneumococcal Vaccination Awareness and Uptake in Adults With Diabetes: Impact of the COVID-19 Pandemic

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ABSTRACT

Objective: Influenza (IV) and pneumococcal (PV) vaccination rates have been reported as suboptimal among patients with diabetes before the COVID-19 pandemic. This study aimed to evaluate IV and PV uptake before and during the pandemic and to assess whether awareness and attitudes toward routine vaccinations changed.

Materials and Methods: We conducted a single-center, paired within-subject study that included patients with diabetes who attended Internal Medicine and Endocrinology outpatient clinics between October 2022 and April 2023. The same patient group was evaluated, and their IV and PV status, awareness, and attitudes toward vaccination during both pre-pandemic and pandemic periods were assessed and compared to determine temporal changes.

Results: Among 515 diabetic patients (62% female, mean age of 59±11 years), IV increased from 27.7% to 40.7%, and PV rose from 11.4% to 18.4% (both $p<0.001$). Awareness of routine adult vaccinations increased substantially during the pandemic, rising from 32% to 54% for IV and from 15% to 28% for PV ($p<0.001$). During the pandemic, older age, longer diabetes duration, prior IV, history of COVID-19, and receipt of COVID-19 vaccine independently predicted IV; older age and prior COVİD-19 predicted PV. Despite gains, 46% remained unaware of recommended IV and/or PV by the end of 2021.

Conclusion: Our results are particularly valuable in highlighting the increased awareness and risk perception during the pandemic, which contributed to a rise in routine vaccination uptake among diabetic patients. However, the IV and PV coverage rates among diabetic patients remained below the targets recommended by the World Health Organization.

Keywords: COVID-19 pandemic, Diabetes mellitus, Influenza vaccines, Pneumococcal vaccines, Vaccination awareness

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INTRODUCTION

In December 2019, an infection caused by a new type of coronavirus (SARS-CoV-2) was identified in Wuhan, Hubei Province, China, causing an epidemic with a clinical presentation similar to viral pneumonia. As the COVID-19 outbreak escalated into a pandemic, various quarantine measures were implemented. Consequently, outpatient healthcare services and elective surgical procedures were suspended in many healthcare institutions to prioritize the care of the growing number of COVID-19 cases. During the quarantine, routine follow-up and care of at-risk groups, such as diabetic patients, were impacted, including the interruption of routine influenza and pneumococcal immunization practices.

The development and widespread administration of COVID-19 vaccines heightened public awareness of vaccination as a critical strategy for preventing infectious diseases. Even though efforts were focused on combating the COVID-19 pandemic, concerns emerged regarding the simultaneous resurgence of other vaccine-preventable diseases (e.g., influenza and pneumococcal infection), which might increase morbidity and mortality, particularly among vulnerable groups, and further strain healthcare systems. Although early World Health Organization (WHO) recommendations call for careful risk-benefit analysis regarding continuation of the immunization services during COVID-19, the U.S. centers for disease control and prevention issued clear guidance advocating for the uninterrupted delivery of all routine vaccinations.[1,2]

Influenza (IV) and pneumococcal (PV) vaccinations are particularly important in the primary care of diabetic patients, given their increased susceptibility to severe respiratory infections. However, data regarding the pandemic's impact on vaccination coverage remains limited. Social distancing policies, decreased healthcare service capacity, and reduced routine clinical visits were expected to result in lower uptake of IV and PV. Interestingly, an increased demand for these vaccines, along with COVİD 19 vaccine, was observed during the early pandemic among both diabetic and non-diabetic patients. Understanding the epidemiological dynamics of routine vaccinations during the pandemic, which can influence vaccination rates, may help identify factors that contribute to the success of future vaccination campaigns. This study aimed to evaluate the rates of IV and PV among diabetic patients during the COVID-19 pandemic and compare them with pre-pandemic rates to assess whether/how the pandemic-related precautionary measures influenced risk perception, knowledge, and attitudes toward these vaccines in the high-risk population.

MATERIALS AND METHODS

Study Design

This was a single-center study with a retrospective within-subject (paired) design conducted among patients with diabetes mellitus (DM) at the Department of Internal Medicine and Endocrinology outpatient clinics between October 2022 and April 2023.

Participants

Patients with Type 1 (T1DM) and Type 2 (T2DM) DM over age 18 who attended the internal medicine and endocrinology outpatient clinics, provided informed consent for data collection, and had no contraindications to vaccination were consecutively included in the study. Exclusion criteria included gestational diabetes, inability to provide reliable vaccination information, and refusal to participate.

Data Collection and Measurements

All patients were evaluated during a single study visit, conducted between October 10, 2022, and April 10, 2023. Sociodemographic data (age, marital and education status), comorbid diseases (hypertension, coronary artery disease, cerebrovascular disease, chronic kidney damage, asthma, chronic obstructive pulmonary disease [COPD]), type of diabetes, and disease duration were recorded for all the patients included in the study. We use the term "chronic pulmonary disease (CPD)" to refer to patients with asthma and COPD. A history of COVID-19 infection and vaccination status was determined for all participants. Additionally, patients were surveyed regarding their knowledge and perceptions of COVID-19, including: (i) awareness of its infectious nature and associated health risks (risk perception), (ii) understanding of respiratory transmission, and (iii) knowledge of vaccine-preventable aspects and perceived benefits of COVID-19 vaccination.

For the purposes of this study, the period from January 2019 to March 2020 was defined as the pre-pandemic period, and the period from March 2020 to the end of 2021 as the (early) pandemic period. Each participant within the same group of DM patients was evaluated for routine vaccination across both time periods. Although data collection and patient interviews were conducted during a single visit, participants were asked retrospectively to report their IV and PV status, as well as their awareness and attitudes toward vaccination, for both the early pre-pandemic and pandemic periods. This design allowed for a within-subject comparison, enabling the evaluation of temporal changes in vaccination behavior, awareness, and attitudes within the same group of diabetic patients. Vaccine uptake information was obtained from patient self-reports and/or electronic medical records. Whenever possible, all patient-reported information was cross-checked against

electronic medical records to ensure accuracy. In cases where patient-reported data were inconsistent with electronic records, the latter were considered the primary source. For PV, participants were asked whether they had received a PV within the preceding 5 years, and during both study periods.

The primary source of vaccination information (healthcare professionals, close social contacts, or media) was also identified for each period. The main reasons for non-vaccination were investigated, including lack of belief in vaccine efficacy, vaccine negligence or hesitancy, fear of side effects, and anti-vaccine attitudes among vaccine-aware diabetics. Patients were asked whether their attitudes toward IV and PV had changed during the COVID-19 pandemic and subsequent vaccination campaigns. After being informed about the potential health benefits of IV and PV in diabetes, their willingness to receive vaccination was also assessed. Finally, factors associated with vaccination uptake among diabetic patients during both study periods were analyzed.

Statistical Analysis

Descriptive statistics were used to summarize the baseline characteristics of the study population. Continuous variables were expressed as mean±standard deviation, and comparisons between two groups were performed using the Student's *t*-test or the Mann–Whitney U test, depending on the normality of data distribution. Categorical variables were compared using the Chi-square test. For non-normally distributed data, comparisons were conducted using the Wilcoxon Signed-Rank test. For paired categorical comparisons within the same cohort across 2 time points, McNemar's test was applied. Comparisons across multiple groups were carried out using the Kruskal–Wallis test, followed by Dunn's *post hoc* test to identify pairwise differences. Multivariate logistic regression analysis was performed to identify independent predictors of vaccination uptake. A $p<0.05$ was assumed for statistical significance in all tests. Data were analyzed with the Statistical Package for the Social Sciences (SPSS) 21.0 (SPSS Inc. Chicago, IL, USA).

Ethics Approval

This study was conducted in accordance with the Declaration of Helsinki. Approval was first obtained from our hospital's Education Planning Committee. Subsequently, the study received ethical approval from the Institutional Ethics Committee of University of Health Sciences, Prof. Dr. Cemil Tascioglu City Hospital (Date: October 03, 2022; Decision No: E-48670771–514.99). Written informed consent was obtained from all participants. Participant confidentiality and data privacy were strictly maintained; all personal identifiers were removed from the dataset, and data were stored securely with access limited to the research team.

RESULTS

A total of 544 patients with diabetes (T1DM and T2DM) were screened. After excluding 20 participants who provided incomplete information and 9 who declined participation, 515 patients were included in the final analysis. Sociodemographic and clinical characteristics are summarized in Table 1.

COVID-19 Awareness

Of the study population, 57% recognized COVID-19 as an infectious disease with high mortality risk, 60% understood its respiratory transmission, and 87% were aware that it is vaccine-preventable. Thirteen percent reported unwillingness to receive the COVID-19 vaccine.

Table 1. Demographic and clinical characteristics of patients with diabetes mellitus (n=515)

Variables	*n*=515
Age (mean±SD, range)	59.3±11.9 (26–90)
Gender *n*, (%)	
Female/male	317 (62)/198 (38)
Marital state/life style *n*, (%)	
Married or living with family	402 (78)
Single/living alone	113 (22)
Education *n*, (%)	
Illetarate	77 (15)
Primary school	169 (33)
Middle school	122 (24)
High school	87 (17)
University	60 (11)
Diabetes duration (year; mean±SD, range)	11.8±6.3 (5–50)
Type of diabetes *n*, (%)	
Type 1 diabetes mellitus	36 (7)
Type 2 diabetes mellitus	479 (93)
Comorbidities *n*, (%)	404 (78)
Hypertension	386 (75)
Coronary artery disease	177 (34)
Cerebrovascular disease	12 (2)
Chronic kidney disease	85 (16)
Chronic pulmonary disease	85 (16)
A history of COVID-19 infection *n*, (%)	165 (32)
COVID-19 vaccination *n*, (%)	450 (87)

SD: Standard deviation

Awareness and Uptake of IV and PV

Awareness of IV among diabetics increased from 32% to 54%, corresponding to 113 (22%) newly informed patients. Pre-pandemic, 87% of IV-aware patients (*n*=164) were vaccinated compared with 76% of 277 IV-aware patients during the pandemic (Table 2 and Fig. 1).

Among the same group of 515 participants, the IV rate increased significantly from 27.8% before the pandemic to 40.7% during the pandemic (p<0.001, McNemar test; (Table 2; Figs 1 and 2). Specifically, 71 individuals who had not been vaccinated before the pandemic received the IV during the pandemic, whereas only 4 previously vaccinated participants did not continue vaccination. A comparative distribution of IV status before and during the pandemic is illustrated in Figure 2.

During the pandemic, awareness and uptake of PV increased concurrently (Table 2 and Fig. 1). After excluding patients vaccinated before the study period, PV uptake approximately doubled compared with the pre-pandemic period (Table 2).

Lack of awareness remained the leading reason for non-vaccination across both periods. During the pandemic, vaccine-aware but unvaccinated patients most commonly cited safety concerns, while pre-pandemic non-vaccination was mainly due to neglect (Fig. 3). Healthcare workers were the primary sources of information for both IV and PV in the pre-pandemic and pandemic periods (Fig. 4).

Changes in Attitudes toward Routine Vaccination

Among 279 diabetic patients who were informed about IV or PV during the pandemic, 66% maintained a positive attitude toward routine vaccinations in both periods, 11% reported a positive change during the pandemic, and 7% shifted from positive to negative attitudes despite prior COVID-19. Despite prior vaccination, 45 (16%) patients (16%) maintained a negative attitude during the pandemic. Following physician counseling, 81% of previously unaware patients expressed willingness to receive IV and/or PV.

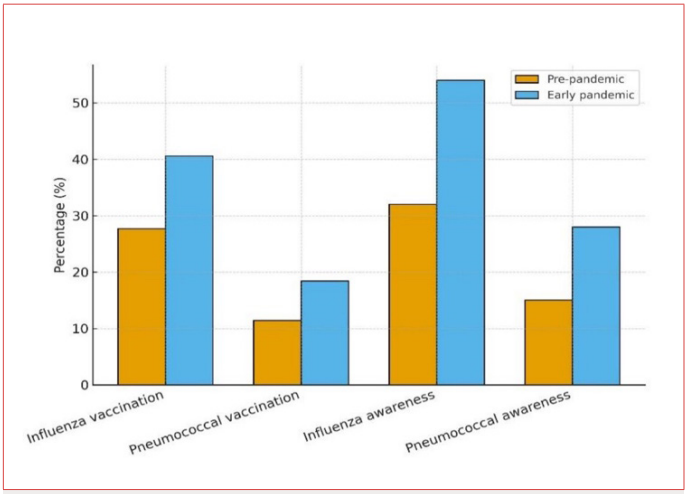

Figure 1. Comparison of vaccination awareness and rates, pre-pandemic versus pandemic.

Evaluation of Sociodemographic Factors and COVID-19-Related Factors Influencing IV and PV

Factors influencing IV rates were similar in both (pre-pandemic and pandemic) periods (Table 3). The only gender difference observed in pre-pandemic IV was equalized during the pandemic. Those who received the IV were more likely to accept the COVID-19 vaccine as well. Similarly, sociodemographic factors affecting PV rates were similar in both pre-pandemic and pandemic periods (Table 4). It was determined that 97% of the participants who were vaccinated against pneumococcus during the pandemic also had IV during the pandemic period. Most of them had IV in the pre-pandemic period. In our study, it was observed that higher education was associated with

Table 2. Changes in vaccination rates and awareness between pre-pandemic and pandemic times in the same group of adults with diabetes mellitus

Variables A total number of patients *n*=515	Pre-pandemic period January 2019–March 2020	Pandemic period March 22–December 2021	Absolute Δ pp	p
Influenza vaccination rate *n*, (%)	143 (27.7)	210 (40.7)	+13.0	<0.001*
Pneumococcal vaccination rate *n*, (%)	59 (11.4) 20 (3.9)*	95 (18.4) 36 (7.8)**	+7.0	<0.001*
Influenza vaccine awareness *n*, (%)	164 (32)	277 (54)	+22.0	<0.001*
Pneumococcal vaccine awareness *n*, (%)	78 (15)	144 (28)	+13.0	<0.001*

Data are paired within-cohort comparisons. Absolute Δ pp denotes percentage-point change from pre-pandemic to early pandemic period. *20 (3.9) vaccinated in 2019, **36 (7.8) newly vaccinated in 2020 Newly vaccinated" refers to participants who had not received a pneumococcal vaccine before the pandemic period but received at least one pneumococcal vaccine during the pandemic period

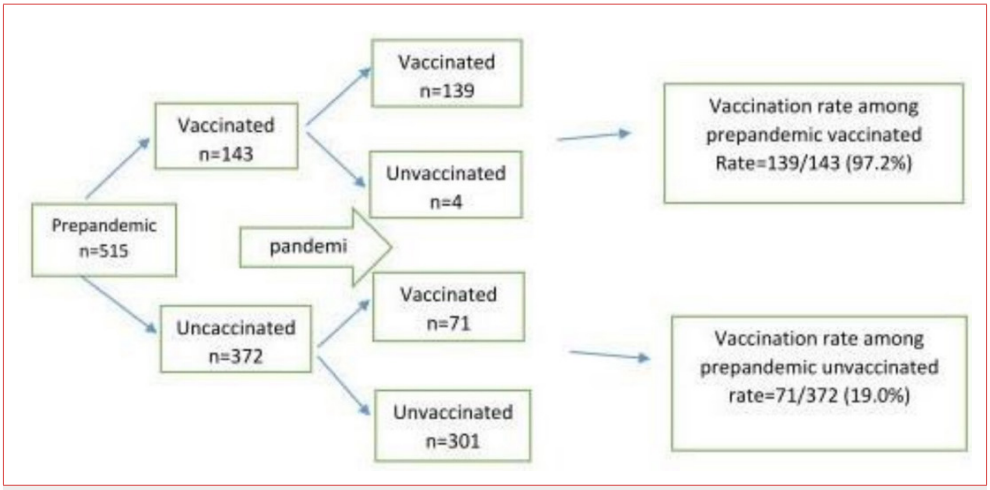

Figure 2. Comparison of influenza vaccination status before and during the COVID-19 pandemic (McNemar: ×2 (1)=58.08, p<0.00).

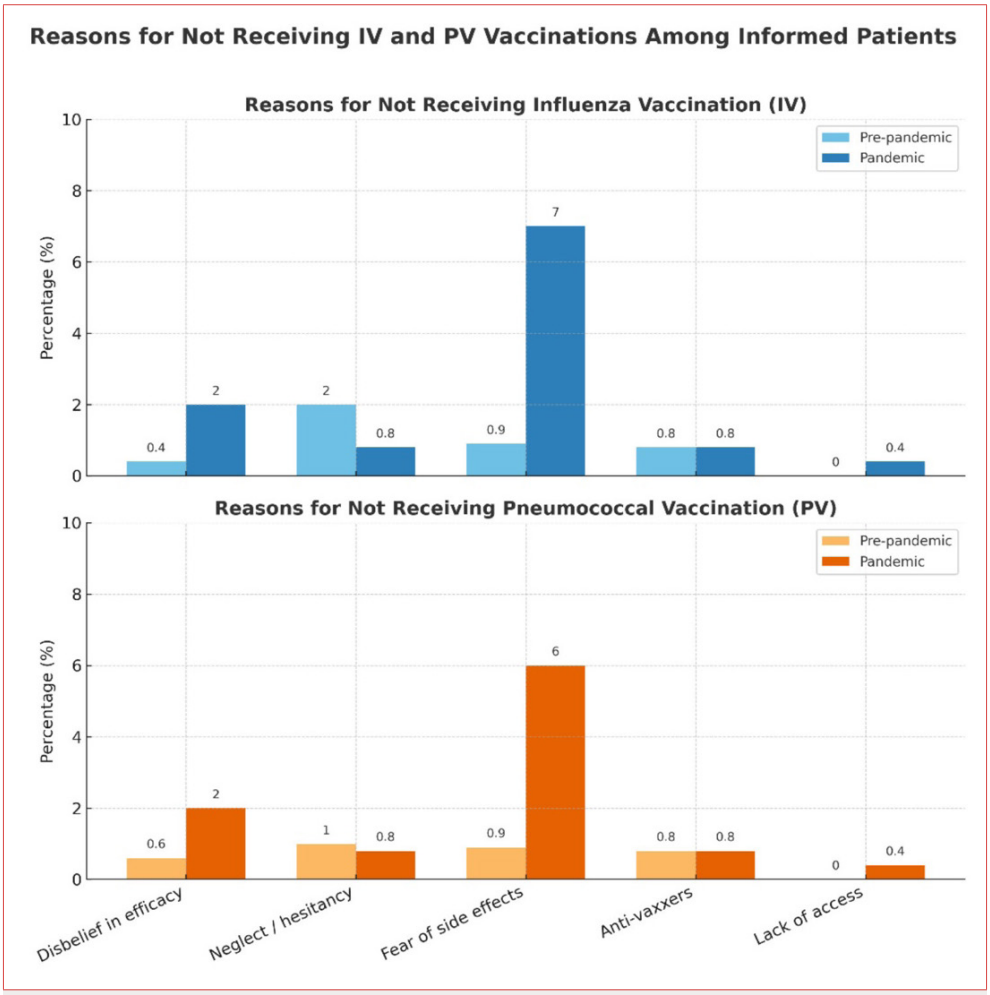

Figure 3. Reasons for not receiving influenza and pneumococcal vaccinations among vaccine-aware patients.

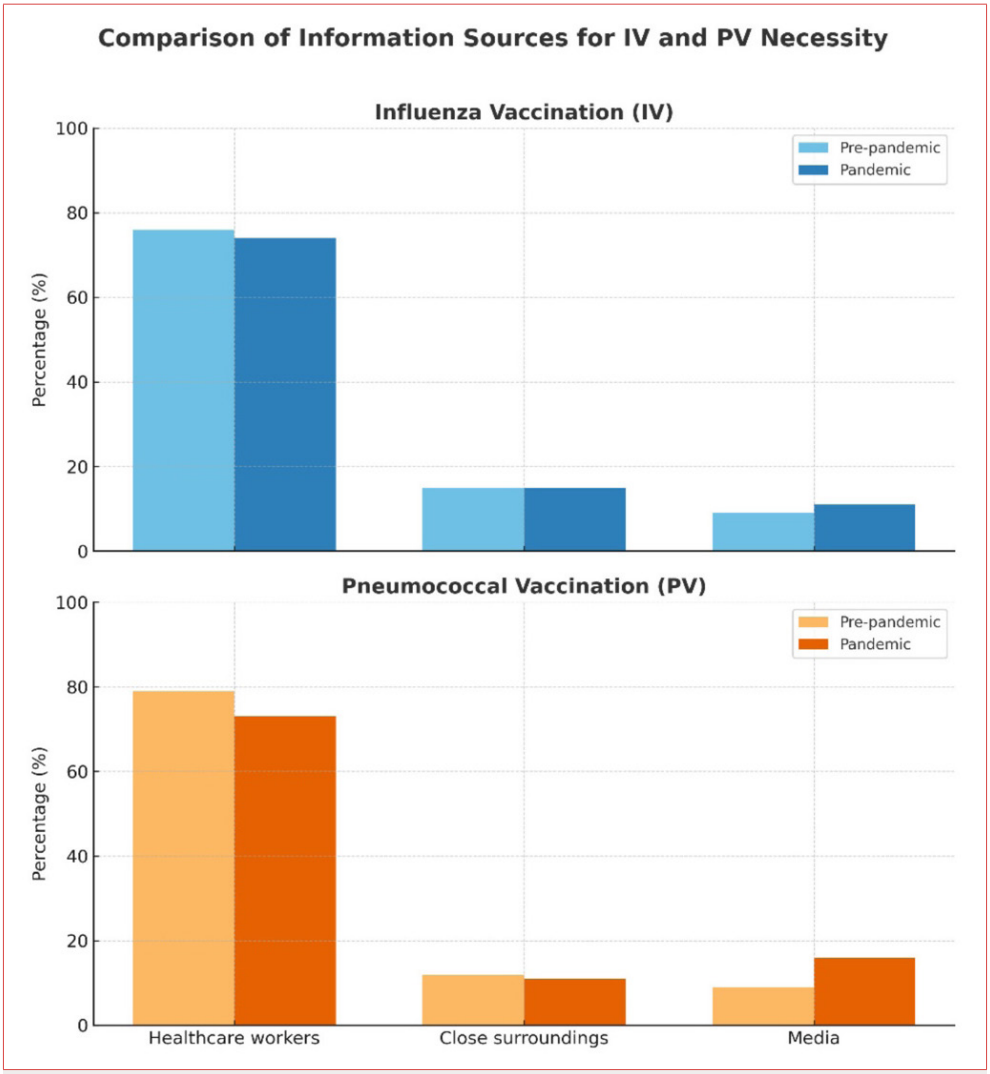

Figure 4. Comparison of first sources of information for influenza and pneumococcal vaccination necessity across pre-pandemic and pandemic periods (p-values: Influenza vaccination p=0.159, Pneumococcal vaccination <0.001).

lower routine IV and PV rates. In our sample, no individuals with a diagnosis of T1DM received the IV or PV during the COVID-19 pandemic.

During the pandemic, regression analysis identified several predictors of IV. Older age (67±10 vs. 53±9.5 years; odds ratio [OR] 1.065, 95% confidence interval [CI] 1.023–1.120; p=0.002); longer diabetes duration (14±8 vs. 9.9±4.4 years; OR 1.064, 95% CI 1.011–1.126; p=0.017); prior IV predicted continued IV (97% vs. 3%; OR 0.011, 95% CI 0.004–0.036; p=0.001). History of COVID-19 infection (44% vs. 24%; OR 0.392, 95% CI 0.218–0.707; p=0.001) and COVID-19 vaccination (99% vs. 79%; OR 0.078, 95% CI 0.012–0.503; p=0.007). For PV, older age (73±7 vs. 56±10 years; OR 1.139, 95% CI 1.069–1.214; p<0.001), prior IV (97% vs. 3%; OR 0.053, 95% CI 0.031–0.090; p<0.001), history of COVID-19 infection (57% vs. 26%; OR 0.325, 95% CI 0.137–0.658; p=0.013).

DISCUSSION

In addition to its alarming impact on human health, the COVID-19 pandemic has also promoted public awareness of health-protective behaviors, particularly vaccination, clearly reflected in our study findings. Specifically, the heightened awareness of vaccine-related benefits during the pandemic appeared to positively influence IV and PV acceptance among diabetic patients. Although the observed increases in IV and PV uptake were still suboptimal, a measurable improvement was noted during the early pandemic compared to pre-pandemic

Table 3. Factors associated with IV rates before and during the COVID-19 pandemic

Variables	IV in the pre-pandemic period			IV during the pandemic period		
	Vaccinated (*n*=143)	Non-vaccinated (*n*=372)	p	Vaccinated (*n*=210)	Non-vaccinated (*n*=305)	p
Age, year, mean±SD	70.4±9.9	55.03±9.5	<0.001	67.5±10.1	53.7±9.5	<0.001
Gender *n*, (%)						
Male	67 (47)	131 (36)		86 (41)	112 (37)	0.332
Female	76 (53)	241 (64)	0.015	124 (59)	193 (63)	
Marital status *n*, (%)						
Living with family	87(61)	315 (85)		143 (68)	259 (85)	<0.001
Living alone	56 (39)	57 (15)	<0.001	67 (32)	46 (15)	
Education *n*, (%)						
Illiterate	23 (16)	54 (15)		38 (18)	39 (13)	
Primary school	54 (38)	115 (31)		78 (37)	91 (30)	
Middle school	53 (37)	69 (18)		68 (32)	54 (18)	<0.001
High school	6 (4)	81 (22)	<0.001	16 (8)	71 (23)	
University	7 (5)	53 (14)		10 (5)	50 (16)	
Diabetes duration, years (mean±SS)	14.7±8.2	10.4 ±5.3	<0.001	14±8.1	9.9±4.4	<0.001
Diabetes type *n*,(%)						
Type 1 DM*	4 (2,8)	32 (8.6)	0.012	0	36(12)	<0.001
Type 2 DM*	143 (97.2)	336 (91.4)		210 (100)	269 (88)	
Comorbidities *n*, (%)						
Hypertension	130 (91)	256 (69)	<0.001	189 (90)	197 (64)	<0.001
CAD**	92 (64)	85 (23)	<0.001	132 (63)	45 (13)	<0.001
CVD***	10 (7)	2 (0.5)	<0.001	11 (5)	1(0.3)	<0.001
CKD[&]	45 (32)	40 (11)	<0.001	65 (31)	20 (6)	<0.001
CPD[&&]	45 (32)	40 (11)	<0.001	68 (32)	17 (5)	<0.001
COVID-19 infection *n*, (%)	-	-	-	92 (44)	73 (24)	<0.001
COVID-19 vaccination *n*, (%)	-	-	-	208 (99)	242 (79)	<0.001
Awareness of COVID-19 vaccination and its benefits *n*, (%)	-	-	-	205 (98)	244 (80)	0.023*
Pre-pandemic PV *n*, (%)				59 (28)	0	<0.001
Pre-pandemic IV *n*, (%)	-	-	-	139 (97)	4(3)	<0.001

*DM: Diabetes mellitus, **CAD: Coronary artery disease; ***CVD: Cerebrovascular disease; CKD[&]: Chronic kidney disease, CPD[&&]: Chronic pulmonary disease, SD: Standard deviation, IV: Influenza vaccination, PV: Pneumococcal vaccination

levels. However, 46% of study participants remained unaware of the recommended IV and/or PV for diabetics by the end of 2021. Conventional factors affecting IV and PV remained consistent across both periods. Nevertheless, during the pandemic, a history of COVID-19 infection and prior COVID-19 vaccination emerged as significant determinants of routine vaccination uptake.

Previous national studies, conducted before the COVID-19 pandemic, most of which were limited by relatively small

Table 4. Factors associated with pneumococcus vaccination rates before and during the COVID-19 pandemic

Variables	PV in the pre-pandemic period			PV during the pandemic period		
	Vaccinated (*n*=59)	Non-vaccinated (*n*=456)	p	Vaccinated (*n*=95)	Non-vaccinated (*n*=420)	p
Age, years; mean±SD	70.6±5.1	56.9±10.3	<0.001	73.6±7.6	56±10.1	<0.001
Gender n, (%)						
Male	21(36)	177 (39)		33 (35)	165 (39)	0.410
Female	38 (65)	279 (61)	0.672	62 (65)	255 (61)	
Marital status *n*, (%)						
Living with family	36(61)	379 (83)		54 (57)	348 (85)	<0.001
Living alone	23 (39)	77 (17)	0.051	41 (43)	72 (15)	
Education *n*, (%)						
İlliterate	9 (15)	68 (15)		16 (17)	61 (14)	
Primary school	12 (20)	157 (34)		24 (25)	145 (35)	
Middle school	37 (63)	85 (19)		49 (52)	73 (17)	<0.001
High school	0 (0)	87 (19)	<0.001	3 (3)	84 (20)	
University	1 (2)	59 (13)		3 (3)	57 (14)	
Diabetes duration years; mean±SD	17.8±7.6	10.8±5.9	<0.001	15.7±7.5	10.6±5.9	<0.001
Diabet type *n*,(%)						
Type 1 DM*	0	36(8)	0.025	0	36 (8)	0.003*
Type 2 DM*	59 (100)	420 (92)		95 (100)	384 (92)	
Comorbidities *n*, (%)						
Hypertension	57 (97)	329 (72)	<0.001	91 (96)	295 (70)	<0.001
CAD**	50 (85)	127 (28)	<0.001	72 (76)	105 (25)	<0.001
CVD***	6 (10)	6 (1)	<0.001	8 (8)	4 (0.9)	<0.001
CKD[&]	28 (47)	57 (12)	<0.001	39 (41)	46 (11)	<0.001
CPD[&&]	30 (51)	55 (12)	<0.001	44 (46)	41 (10)	<0.001
COVID-19 infection history *n*, (%)	-	-	-	54 (57)	111 (26)	<0.001
COVID 19 vaccination *n*, (%)	-	-	-	95 (100)	355 (85)	<0.001
Awareness of COVID-19 vaccination and their benefits *n*, (%)	-	-	-	95 (100)	354 (85)	0.016
Pandemic IV *n*, (%)	-	-	-	92 (97)	118 (28)	<0.001
Pre-pandemic IV *n*, (%)				76 (80)	67(16)	<0.001

*DM: Diabetes mellitus, CAD: Coronary artery disease, ***CVD: Cerebrovascular disease, CKD[&]: Chronic kidney disease, CPD[&&]: Chronic pulmonary disease, IV: Influenza vaccination, PV: Pneumococcal vaccination, SD: Standard deviation

sample sizes, consistently reported low IV and PV rates in diabetic patients, with only minimal annual fluctuations (Table 5).[3-7] Rates tended to be higher and more variable in studies involving older populations.[4] In 2013, Satman et al.[8] published the results of a large-scale epidemiological study (based on data from 2009), which revealed rates of 27% and 9.8% for IV and PV, respectively, among diabetic patients. Eight years later, a nationwide multicenter survey involving 37 cities, utilizing data from 2017, demonstrated comparable IV and PV rates among diabetic patients.[9] Our pre-pandemic findings align closely with these observations, confirming persistently low coverage levels. During the pandemic, however, the results of studies conducted in our country were reported to be mixed.[10-14] Korkmaz et al.,[10] observed a rise in PV rates, but

Table 5. Studies evaluated the rates of IV and PV among patients with diabetes mellitus

Studies and published years	Data collection years	Age Mean±SD	Number of patients	IV (%)	PV (%)	Period
Satman et al.[8]	2009		5682	27	9.8	Pre-pandemic
Apaydın et al.[3]	2014–2017	58±11	504	10.1	5	Pre-pandemic
Isık et al.[4]	2020	65	293	34.1	9.9	Pre-pandemic
Arslan et al.[6]	2016	54	318	14.6	3.8	Pre-pandemic
Sözen et al.[7]	2019	57±11	202		14.7	Pre-pandemic
Yeşilova et al.[5]	2019	57±10.7	350	26	10.8	Pre-pandemc
Demirci et al.[9]	2017		5175	23.6 T1DM* 21.2 T2DM**	8 (T1DM) 7 (T2DM)	Pre-pandemic
Mercan Baspinar et al.[12]	2022	59.7±13	280	16.8	17.5	Pandemic
Karagun et al.[11]	2021	53±12	424	36.6	34.9	Pandemic
Korkmaz et al.[10]	2023	52±17	500	28.2	23.6	Pandemic

*T1DM: Type 1 diabetes mellitus, **T2DM: Type 2 diabetes mellitus, [&]: Reference number, SD: Standard deviation, IV: Influenza vaccination, PV: Pneumococcal vaccination

no change in IV rates. Karagun et al.,[11] reported higher uptake for both vaccines (34.9% for PV and 36.6% for IV), whereas Mercan Baspinar and Demirali found rates comparable to those of the pre-pandemic period.[12] All reported high uptake of COVID-19 vaccination (87.4–91.2%), similar to our cohort.[10,14] Overall, our findings regarding IV and PV fall within the range reported by Karagun et al.[11] and Korkmaz et al.,[10] but remain well below the WHO-recommended levels >75% coverage for high-risk populations.[15]

International data on routine vaccination rates during the pandemic in specific risk populations have shown heterogeneity, with some studies reporting declines and others reporting increases.[16-20] For example, Breuker et al.[16] observed a small increase in infection risk awareness among patients with chronic diseases, including 750 people with diabetes, but without a change in willingness to vaccinate. Their reported IV and PV rates (59.7% and 28.4%, respectively) were still higher than ours.[16] Similarly, Sosa Liprandi et al.[17] found that immunization coverage during the pandemic remained low in cardiometabolic patients, most of whom were diabetics. In contrast, in a different high-risk population (psoriasis), a significant increase was reported, with a lifetime PV prevalence rising from 16.0% to 41.5% and IV prevalence from 50.5% to 66.2%.[18] Such variability in routine vaccination rates among high-risk patients likely reflected differences in geography, healthcare access, and sociocultural attitudes.

Concerted efforts from governmental institutions and the media largely influenced the elevated COVID-19 vaccination rates found among our patients. However, during the pandemic, similar to pre-pandemic study findings, the primary source of information for both IV and PV remained healthcare workers, reaffirming their pivotal role in patient education and vaccine advocacy.[8,10,11,16-18] Before the pandemic, a lack of sufficient awareness about vaccination was identified as a significant issue, contributing to low vaccination rates.[4-6] In some samples, 18.9–47.8% of diabetic patients reported awareness of IV/PV recommendations, with much lower figures for PV.[4,6,21] In our data, awareness increased from 32% to 54% for IV and 15% to 28% for PV during the pandemic, paralleling increases in vaccine uptake. Unlike pre-pandemic studies where awareness exceeded vaccination, during the pandemic, diabetic patients showed more actionable awareness. However, despite this improvement in vaccination awareness during the pandemic, the lack of knowledge about the necessity of IV and PV persisted as the most frequently cited reason for non-vaccination in both periods, echoing findings from previous studies.[4,5,8,10,16,17,22]

The pandemic reshaped attitudes toward routine vaccinations. While many patients maintained a positive attitude, some previously hesitant individuals became more accepting, as reported in the literature.[16,20,23] In our study, a small subgroup, however, shifted from a positive to a negative stance, even among some who had received IV and/or COVID-19 vaccines, indicating residual doubt. Among our aware subgroup, explicit anti-vaccine sentiment was <1%, markedly lower than the 8.7% reported by Karagun et al.[11] Reasons for vaccine refusal also evolved in our patients; in pre-pandemic, negligence and indecision were predominant, while safety concerns became more prominent during the pandemic. This shift in

refusal reasons mirrors the patterns reported in other studies and highlights the need for sustained targeted educational strategies to address the misinformation and prevent the spread of conspiracy beliefs.[13,16] Consistent with prior literature, we found that IV and PV uptakes were influenced by age, diabetes type and duration, education level, living arrangements, and comorbidities.[3,5,10,16,17]

Despite the generally positive effect of education level on vaccination uptake, our study revealed an unexpected finding: individuals with higher education attainment had significantly lower rates of IV and PV.[11,24] Most of these participants were younger patients with TIDM. Thus, the lower IV and PV rates associated with higher education level were driven partly by the subset of highly educated and partly younger T1DM patients. Early-pandemic debates on vaccine efficacy and safety in autoimmune conditions likely influenced vaccine avoidance behaviors, including routine vaccinations, among patients with T1DM in our cohort. Given the small T1DM subgroup, these results should be interpreted as preliminary rather than definitive. Nevertheless, the observed gap between educational attainment and certain preventive health behaviors highlights a critical gap, suggesting that general education alone may be insufficient and that vaccine-specific health literacy is essential. Although early-pandemic debates on vaccine efficacy and safety in autoimmune conditions likely led to the avoidance of all vaccinations, including routine ones, among these T1DM patients, this finding emphasizes that general education alone is insufficient; vaccine-specific health literacy is critical. Supporting this, Guclu et al.[25] linked greater "disease prevention health literacy" with higher IV/PV rates within the general population, and Satman et al.[8] demonstrated that a 4-month physician-led education initiative increased IV and PV uptake by 2.5–4-fold in the pre-pandemic period. In our study, 81% of previously vaccine-unaware diabetic patients expressed willingness to vaccinate after receiving physician advice, illustrating once more the leverage of direct healthcare provider communication and highlighting the need for system-level interventions to "nudge" patients toward preventive action.

In multivariate analysis, older age, longer diabetes duration, prior IV vaccination, history of COVID-19, and COVID-19 vaccination were identified as independent predictors of IV during the pandemic.[5,8,10] For PV, older age and a history of COVID-19 infection emerged as independent factors. These findings suggested that personal experience with COVID-19 may influence engagement in preventive health behaviors. Moreover, previous positive attitudes toward vaccination may reinforce acceptance of other vaccines, consistent with the "spill-over" effect described in the literature.[23,26]

Limitation

This study has several limitations. The single-center design may limit generalizability. Partial reliance on self-reported vaccination status introduces potential recall bias, although electronic health records were used for verification whenever possible. Residual confounding was possible despite the multivariable adjustment. Despite these limitations, the within-subject comparison provides valuable insight into temporal changes in vaccination behavior among diabetic patients.

CONCLUSION

The COVID-19 pandemic catalyzed increased awareness and uptake of IV and PV among diabetic patients; however, coverage remains below international targets. Older age, prior vaccination behavior, and personal experience with COVID-19 were key facilitators of vaccine acceptance. To close the persistent coverage gap, multifaceted strategies are needed to improve access and reduce vaccine refusal by combining physician-led education, increased patient vaccine accountability, proactive risk communication, and systems-level interventions.

DECLARATIONS

Ethics Committee Approval: The study protocol was approved by the University of Health Sciences, Prof. Dr. Cemil Tascioglu City Hospital Ethics Committee (No: E-48670771–514.99, Date: 03/10/2022).

Informed Consent: Written informed consent was obtained from all participants. Participant confidentiality and data privacy were strictly maintained; all personal identifiers were removed from the dataset, and data were stored securely with access limited to the research team.

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