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The Prevalence of COVID-19 Vaccine Uptake and Determinant Factors Among Diabetes Mellitus Patients Visiting Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia

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Abstract **Introduction:** The COVID-19 pandemic has demonstrated its capacity for rapid global transmission, leading to an unprecedented public health crisis with profound social, economic, and political repercussions. DM is one of the most common comorbidities in individuals with COVID-19 and is associated with increased risk of severe disease, intensive care unit admissions, and higher mortality. Given the high vulnerability of diabetic patients to adverse outcomes from COVID-19, primary prevention through vaccination remains the cornerstone strategy for reducing the risk of infection and its complications in this population. The aim of this study was to assess the rate of COVID-19 vaccine uptake among individuals with diabetes and to identify factors influencing vaccine acceptance. **Methods:** This was a cross-sectional study conducted in randomly selected eligible adult DM patients visiting endocrine clinic in TASH from September 1 to October 30, 2022 using structured questionnaire. Data was entered into SPSS Version 25 and descriptive statistics was done to summarize the data. Then binary logistic regression analysis using bivariate and multivariate analysis was done. **Results:** A total of 305 patients participated in the study, of whom 201 (66%) had received at least one dose of the COVID-19 vaccine. Of the vaccinated individuals, 102(50.7%) were administered two doses and 60(29.9%) received three doses. Factors associated with an increased likelihood of vaccine uptake included male sex (adjusted odds ratio [AOR] = 1.8, 95% confidence interval [CI] = 1.46–3.45), age groups of 31–40 years, 41–50 years, 51–60 years, 61–69 years, and >70 years (AOR = 3.9, 95% CI = 1.21–12.78; AOR = 9.9, 95% CI = 2.67–36.98; AOR = 8.9, 95% CI = 2.56–30.85; AOR = 7.9, 95% CI = 1.89–33.06, respectively). Additionally, higher educational attainment was associated with greater vaccine uptake, with secondary education (AOR = 3.1, 95% CI = 1.19–8.11) and tertiary education (AOR = 7.8, 95% CI = 2.54–23.87) showing significant associations. Perceived severity of COVID-19 infection was also a predictor of vaccine uptake (AOR = 2.4, 95% CI = 1.88–6.60). Beliefs about the benefits of vaccination, such as the perception that vaccination reduces the risk of transmission (AOR = 4.7, 95% CI = 1.21–18.29), the belief that vaccination is the best way to prevent complications (AOR = 12.1, 95% CI = 3.89–37.55), and the belief in the efficacy of vaccination in reducing the risk of infection when recommended by a healthcare provider (AOR = 6.1, 95% CI = 1.98–19.02), were also positively associated with vaccine uptake. **Conclusion:** COVID-19 vaccine uptake among DM patients at TASH was low. Thus, different strategies should be applied to promote COVID-19 vaccine uptake in DM patients.

Keywords: *COVID- 19 Vaccines, Determinants, DM, TASH, Uptake*

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1. Introduction

Since its emergence, the COVID-19 pandemic has demonstrated a remarkable ability to spread rapidly across the globe, becoming one of the most severe public health crises in modern history. Its widespread impact has not only triggered a catastrophic loss of life but has also led to profound social, economic, and political upheaval [1]. The pandemic has strained healthcare systems, disrupted economies, and severely impacted the quality of life, particularly in developing nations. The toll on survivors, especially in low-income countries, has been exacerbated by limited resources, inadequate healthcare infrastructure, and the social and economic fallout of prolonged

lockdowns and restrictions [2].

While the majority of COVID-19 infections result in mild symptoms, older adults and individuals with underlying health conditions—such as cardiovascular disease, respiratory disorders, and diabetes—face a significantly higher risk of severe illness and death. These high-risk groups are up to five times more likely to have increased risk of severe illness and death from the virus [3,4].

DM is one of the most common comorbidities observed in patients with COVID-19, and its growing global prevalence poses a significant health challenge. As one of the fastest expanding public health concerns of the 21st century, diabetes affects an estimated 463 million people worldwide as of 2021. In Sub-Saharan Africa, Ethiopia ranks among the top four countries with the highest adult diabetes prevalence. In 2013, the Ethiopian Diabetes Association estimated a prevalence of 2-3%, which was later revised to 4.3% in 2019 by the IDF, after adjusting for age [5].

Diabetes is associated with increased severity of disease and higher mortality rates in the context of COVID-19. Data from the US-CDC indicate that individuals with diabetes are at significantly greater risk—five times more likely to contract COVID-19 and three times more likely to die from it compared to those without diabetes [6]. This highlights the critical need for targeted interventions and management strategies for diabetic populations, especially in the face of the ongoing pandemic.

The development of safe and effective COVID-19 vaccines has been a cornerstone in the fight against the pandemic. Vaccination has long been recognized as one of the most powerful tools in infectious disease prevention. Throughout history, vaccines have saved millions of lives, playing a pivotal role in the control and eradication of numerous infectious diseases across the globe [7,8]. Beyond providing direct protection to vaccinated individuals, vaccines also contribute to herd immunity, where a sufficient proportion of the population becomes immune, thus indirectly protecting unvaccinated individuals as well [9]. For COVID-19, four main types of vaccines have been developed: inactivated or weakened virus vaccines, protein-based vaccines, viral vector vaccines, and RNA/DNA vaccines [10]. Vaccination has proven particularly important for individuals with chronic conditions, including diabetes, as it significantly reduces the risk of severe COVID-19 outcomes. Published studies have shown that there are no significant adverse effects of the COVID-19 vaccine in diabetic patients, further reinforcing its safety and efficacy [11].

The WHO has set a critical goal of achieving 70% global COVID-19 vaccination coverage, with a particular emphasis on ensuring full vaccination of high-risk groups, including individuals aged 60 and older, healthcare workers, and those with underlying health conditions. However, as of May 22, 2022, nearly 1 billion people in low-income countries remained unvaccinated. Only 57 countries have managed to vaccinate 70% of their populations, almost all of which are high-income nations [10]. On November 16, 2021, the Federal Ministry of Health of Ethiopia launched a comprehensive vaccination initiative, offering vaccines such as Sinopharm, AstraZeneca, Johnson & Johnson/Janssen, and Pfizer-BioNTech to individuals aged 12 and older across all accessible regions, zones, and districts. Despite these efforts, by November 5, 2022, only 43 million people (39% of the population) had received at least one dose of the COVID-19 vaccine, with just 9% having completed the full vaccination regimen [2].

Vaccine acceptance rates for COVID-19 vary significantly across different regions and populations, with some areas showing notably lower willingness to receive the vaccine. Studies have highlighted that countries like Russia, Jordan, Kuwait, several European nations, and various African nations report the lowest levels of vaccine acceptance. Conversely, higher acceptance rates have been observed in nations such as Ecuador, Malaysia, China, and Indonesia [12]. Despite strong endorsements from medical organizations and public health authorities, individuals with diabetes exhibit a higher level of vaccine hesitancy compared to the general population. Specifically, vaccine hesitancy among diabetics ranges from 14.2% to 29.0%, while only 8.7% of the general population remains hesitant [13].

Achieving sufficient vaccination coverage to effectively mitigate the spread of COVID-19 hinges on overcoming vaccine hesitancy, yet this remains a significant barrier. The reluctance to vaccinate is compounded by widespread mistrust in health authorities, governments, and healthcare professionals, often amplified by misinformation circulating on social media [14]. A key driver of vaccine hesitancy includes concerns over vaccine safety, potential side effects, and skepticism regarding vaccine efficacy. These concerns are frequently exacerbated by misleading myths, such as the unfounded associations between vaccines and autism, brain damage, or other serious health conditions [15,16]. Misinformation, especially in developing regions, can foster fear and distrust, undermining public confidence in vaccination programs [17]. To address these challenges, understanding current vaccination rates and identifying the barriers to vaccine uptake are essential steps toward increasing vaccine coverage and achieving herd immunity.

Individuals with DM are at an increased risk of experiencing severe complications and poor outcomes from COVID-19, making them a priority group for vaccination. Despite this, there is limited information on COVID-19 vaccine uptake among people with diabetes in Ethiopia, with a notable gap in the published literature on this topic. To address this gap, this study aimed to assess the rate of COVID-19 vaccination among diabetic patients attending the Endocrinology Clinic at Tikur Anbessa Specialized Hospital in Addis Ababa, Ethiopia. The findings of this study are essential for informing targeted interventions to improve vaccine acceptance and coverage in this high-risk population.

2. Methods

Study setting and period

The study was conducted at the Endocrine Clinic of Tikur Anbessa Specialized Hospital (TASH) in Addis Ababa, Ethiopia's oldest and largest tertiary hospital, established in 1972. Located in the capital city, TASH serves as a teaching hospital for Addis Ababa University's

College of Health Sciences, offering undergraduate, postgraduate, and fellowship programs in various clinical disciplines. The hospital provides comprehensive healthcare services to millions of people from across Ethiopia. TASH is renowned for its well-established and functional endocrinology department, which caters to thousands of patients with endocrine disorders. It is also the only institution in the country offering an endocrinology fellowship program. The department is staffed by medical residents, fellows, and consultant endocrinologists, ensuring high-quality care for patients. The Endocrine Clinic operates six days a week and sees over 1,500 patients monthly. Among these, T2DM accounts for nearly 50% of cases, while T1DM makes up approximately 10%.The study was conducted between September 1 and October 30, 2022, within this specialized clinic [18].

Study design

A cross-sectional study was conducted at the Endocrine Clinic of TASH to determine the vaccination status and identify the factors influencing COVID-19 vaccine uptake among individuals living with diabetes mellitus.

Population

The source population for this study consisted of all patients with diabetes mellitus attending follow-up appointments at the Endocrinology Clinic of TASH. The study population included all eligible DM patients who visited the clinic during the study period.

Eligibility criteria

This study included all adult patients aged 18 years and older with diabetes mellitus who attended Endocrinology Clinic of TASH during the study period. Participants were required to voluntarily consent to the survey and provide written informed consent. Exclusion criteria encompassed individuals with a diagnosed mental illness, those who had used medication for mental health conditions within the previous three months, patients presenting with evident dementia, and individuals unable to communicate verbally.

Sample size determination

The study subjects were chosen using a consecutive sampling technique. The sample size for the study was computed from the following formula: $n = P \times (1 - P) \times Z\alpha/22 /d2$,where $Z\alpha/2$ represents the critical value for a 95% confidence interval (1.96), and d is the desired precision, set at 5%. Given the lack of prior studies on COVID-19 vaccine uptake among diabetic patients in Ethiopia, the prevalence of vaccine uptake was assumed to be 50%. Since the estimated population of diabetic patients visiting the clinic during the study period was less than 10,000, the sample size was adjusted using the finite population correction formula [19, 20]; $N_f = n_i / (1 + n_i/N)$, where n_i is initial sample size, N_f is the adjusted sample size and N is the total estimated population of diabetic patients visiting the clinic (approximately 1,500). This adjustment resulted in a final sample size of 305 participants.

Data collection tools and procedure

Data collection was conducted using a structured questionnaire, adapted from previously published studies on individuals with DM in China [21], Sudan [22] and Saudi Arabia [23]. The questionnaire was tailored to align with the objectives of the current study. Three trained medical interns carried out data collection through face-to-face interviews, ensuring a personalized and consistent approach. To enhance data reliability, the interns underwent a comprehensive two-day training session led by the principal investigator. The training emphasized the study's objectives, questionnaire content, ethical considerations, and standardized data collection techniques, ensuring methodological rigor and ethical compliance.

Study variables

Dependent variable: COVID-19 vaccine uptake

Independent variable: Includes socio-demographic characteristics, Characteristics of DM, presence of Chronic DM Complications and other chronic illness, history of COVID-19 infection, knowing anyone infected with COVID-19 and Perceptions related to COVID-19 vaccination based on the Health Belief Model.

Operational definition

COVID-19 vaccine uptake: defined as the total number of individuals who have received at least one dose of a COVID-19 vaccine, was assessed using a straightforward, closed-ended question: *"Have you received any COVID-19 vaccine?"* Respondents who had been vaccinated selected "Yes," indicating vaccine uptake, while those who had not were categorized as "No."

Chronic DM complications: defined such as Neuropathy, Nephropathy, eye damage, cardiovascular and cerebrovascular diseases, Coronary heart diseases, stroke, and PAD. Previous studies commonly used the same definition [21].

Perceptions related to COVID-19 Vaccination: Participants provided responses to items designed to evaluate their perceptions of COVID-19 vaccination, guided by constructs of the Health Belief Model (HBM). Using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), the survey assessed various dimensions: perceived susceptibility to COVID-19 (1 item), perceived severity of COVID-19 (1 item), perceived benefits of vaccination (4 items), perceived barriers to vaccination (2 items), and cues to action (5 items). These items were adapted from a validated instrument in a previous study focusing on individuals with diabetes mellitus, ensuring relevance and reliability in this context [21].

Data analysis procedures

The collected data underwent thorough checks for completeness and consistency before analysis, with incomplete questionnaires excluded from further processing. A manually prepared tally sheet was used for initial organization. Data entry was conducted using Epi-Data version 4.6 and subsequently exported to SPSS version 25.0 for cleaning and statistical analysis. Descriptive statistics, such as frequencies and percentages, were employed to summarize key findings. To explore associations between variables, binary logistic regression analysis was performed in two stages: bivariate and multivariate analysis. In the bivariate analysis, crude odds ratios (COR) were calculated, and variables with p-values below 0.3 were selected for multivariate analysis. In the subsequent multivariate analysis, adjusted odds ratios (AOR) were determined, with variables achieving

statistical significance defined by p-values less than 0.05 at a 95% confidence interval.

Ethical consideration

The study protocol underwent thorough review and approval by the Ethical Review Committee of the Department of Internal Medicine and the Addis Ababa University College of Medicine and Health Sciences. The objectives and purpose of the study were clearly communicated to all potential participants, and only those who expressed willingness to participate were included. Informed written consent was obtained from each participant prior to initiating data collection. To uphold data confidentiality, participants were identified through coded identifiers, and access to collected data was strictly restricted to authorized personnel.

3. Results

Sociodemographics characteristics of participants

A total of 305 participants were included in the final analysis of this study. Majority were women, making up 178(58.4%) of the group and 189(62%) were above 50 years. Most participants 215(70.5%) identified as Orthodox Christians, and 241(79%) were married. Significant portions 251(82.3%) were from Addis Ababa, with 285(93.4%) living in urban areas. Education levels varied, but 101(33.1%) of the participants had attended college or higher institutions. Additionally, 232(76.1%) reported having health insurance, and 277 (90.8%) of participants had never smoked cigarettes (Table 1).

Diabetes Mellitus characteristics of participants

Of the study participants, 246(80.7%) were living with type 2 diabetes mellitus, and 136(44.6%) had a family history of the condition. 155(50.8%) had diabetes mellitus for more than 10 years, while 20 (39.3%) faced chronic complications related to their illness. Additionally, 145 (47.5%) of the participants have hypertension alongside DM (Table 2).

Characteristics of Diabetes Mellitus of the study participants

Of the study participants, 246(80.7%) were living with type 2 diabetes mellitus, and 136(44.6%) had family history of the condition. 155(50.8%) had diabetes mellitus for more than 10 years, while 120(39.3%) faced chronic complications of DM. Additionally, 145(47.5%) of the participants have hypertension alongside diabetes (Table 2).

Diabetes Mellitus related complication

Among the study participants, 120 (39.3%) were found to have chronic complications of diabetes mellitus. The most common complications were diabetic kidney disease and diabetic retinopathy, each affecting 33 patients (27.5%) (Figure1).

Information about contracting COVID-19 during pandemic

Among all participants, 41(13.4%) had experienced a COVID-19 infection during the pandemic, while 83(27.2%) had been in contact with someone who had contracted the virus (Table 3).

Table 1. The Sociodemographics characteristics of the study participants at TASH, Addis Ababa, Ethiopia, 2022 (n= 305)

Variable	Frequency	Percent
Sex of the study participants		
Male	127	41.6
Female	178	58.4
Age in years		
18-30	36	11.8
31-40	30	9.8
41-50	50	16.4
51-60	65	21.3
61-69	86	28.2
>70	38	12.5
Religion		
Muslim	56	18.4
Orthodox	215	70.5
Protestant	26	8.5
Other	8	2.6
Marital status		
Single	32	10.5
Married	241	79.0
widowed/divorced/separated	32	10.5
Current Residence		
Addis Ababa	251	82.3
Oromia	40	13.1
Amhara	7	2.3
SNNP	7	2.3
Place of residence		
Rural	20	6.6
Urban	285	93.4
Level of education		
unable to read and write	35	11.5
Primary	64	21.0
Secondary	105	34.4
college and above	101	33.1
Occupation		
Housewife	71	23.3
Farmer	11	3.6
government employer	41	13.4
private worker	90	29.5
Students	1	.3
Unemployed	91	29.8
presence of health insurance		
Yes	232	76.1
No	73	23.9
Family income per month		
<2000	73	23.9
2000-5000	145	47.5
>5000-10000	51	16.7
>10000	36	11.8
Cigarette smoking status		
Never	277	90.8
former smoker	28	9.2

COVID-19 vaccination related Perceptions

The study findings revealed that 130(42.6%) of participants believed they were susceptible to contracting COVID-19, while 183(60%) perceived the severity of a COVID-19 infection as significant. 220(72.1%) of the participants felt that receiving the COVID-19 vaccination was beneficial both for themselves and for others. However, 108(35.4%) expressed concerns regarding the safety and potential side effects of the COVID vaccine (Table 4)

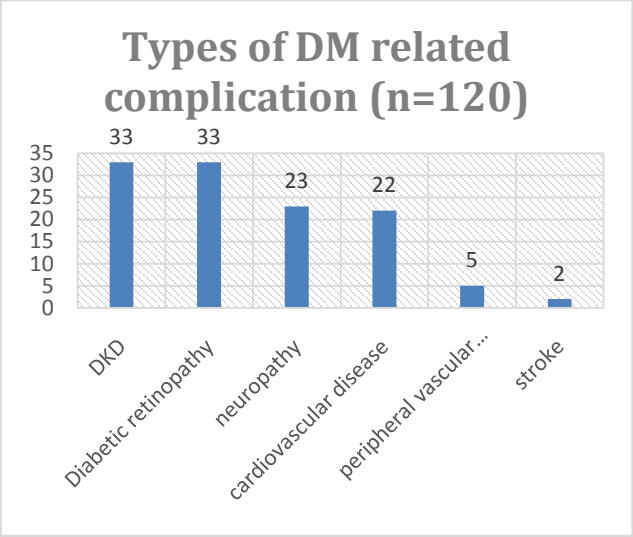

Figure 1. DM related complications among study participants at TASH, Addis Ababa, Ethiopia, 2022

Table 2. Characteristics of Diabetes Mellitus among study participants at TASH, Addis Ababa, Ethiopia, 2022 (n= 305)

Variable	Frequency	Percent
Type of Diabetes Mellitus		
type 1 DM	59	19.3
type 2 DM	246	80.7
Family history of DM		
Yes	136	44.6
No	169	55.4
Duration of DM in years		
<2	52	17.0
2-10	98	32.1
>10	155	50.8
Most recent FBS in mg/dl		
<126	125	41.0
126-250	157	51.5
>250	23	7.5
Most recent postprandial blood glucose in mg/dl		
<180	137	44.9
180-199	102	33.4
>199	66	21.6
chronic complication due to DM		
Yes	120	39.3
No	185	60.7
Other Chronic illness		
Hypertension	145	47.5
thyroid disorders	10	3.3
Malignancy	8	2.6
other cardiac illnesses	11	3.6
bronchial asthma	11	3.6
Other chronic respiratory illnesses	3	1.0
chronic liver disease	4	1.3

Table 3. Information about contracting COVID-19 during pandemic among DM patients at TASH, Addis Ababa, Ethiopia, 2022 (n= 305)

Variable	Frequency	Percent
Did you have covid-19 during this pandemic		
Yes	41	13.4
No	264	86.6
Did anyone in your contacts suffer from COVID-19 during the pandemic		
Yes	83	27.2
No	222	72.8

Table 4. Covid-19 vaccination related Perceptions of DM patients at TASH, Addis Ababa, Ethiopia, 2022(n= 305)

Variable	Frequency	Percent
perceived susceptibility and severity of COVID19		
Have a high risk of contracting COVID -19		
strongly disagree	35	11.5
Disagree	96	31.5
Neutral	44	14.4
Agree	82	26.9
strongly agree	48	15.7
The consequence of contracting covid-19 is severe if infected		
strongly disagree	17	5.6
Disagree	64	21.0
Neutral	41	13.4
Agree	114	37.4
strongly agree	69	22.6
Perceived benefits of COVID-19 vaccination		
Receiving COVID-19 vaccination could reduce risk of contracting COVID-19		
strongly disagree	28	9.2
Disagree	37	12.1
Neutral	36	11.8
Agree	127	41.6
strongly agree	77	25.2
Receiving COVID-19 vaccination is beneficial for you and others		
strongly disagree	26	8.5
Disagree	30	9.8
Neutral	29	9.5
Agree	125	41.0
strongly agree	95	31.1
Receiving covid-19 vaccination could reduce your risk of transmitting COVID-19		
strongly disagree	26	8.5
Disagree	42	13.8
Neutral	51	16.7
Agree	119	39.0
strongly agree	67	22.0
The best way to avoid complication (hospitalization and death) of COVID-19 is by vaccination		
strongly disagree	18	5.9
Disagree	39	12.8
Neutral	36	11.8
Agree	138	45.2
strongly agree	74	24.3
Perceived barriers		
As a person with diabetes, you are worried about the safety of the vaccination		
strongly disagree	34	11.1
Disagree	118	38.7
Neutral	43	14.1
Agree	88	28.9
strongly agree	22	7.2
Concerned about the side effects of COVID-19 vaccination		
strongly disagree	33	10.8
Disagree	119	39.0
Neutral	45	14.8
Agree	83	27.2
strongly agree	25	8.2
Cues to action; would you more likely to get the COVID-19 vaccine		
Vaccination among your families and friends would influence your decision to receive the vaccination		
strongly disagree	66	21.6
Disagree	86	28.2
Neutral	39	12.8
Agree	107	35.1
strongly agree	7	2.3
You believe in your doctor's statement that vaccination can reduce the risk of infection		

Variable	Frequency	Percent
strongly disagree	12	3.9
Disagree	44	14.4
Neutral	24	7.9
Agree	141	46.2
strongly agree	84	27.5
Mass media/internet suggestion of DM patients to receive COVID-19 vaccination, will affect your vaccination behavior		
strongly disagree	14	4.6
Disagree	66	21.6
Neutral	29	9.5
Agree	140	45.9
strongly agree	56	18.4
If it is mandatory to be vaccinated for continuing your job, will affect your Job, will affect your vaccination behavior		
strongly disagree	13	4.3
Disagree	48	15.7
Neutral	25	8.2
Agree	148	48.5
strongly agree	71	23.3
If it is compulsory by the gov't (MOH) to be vaccinated, will affect your vaccination behavior		
strongly disagree	10	3.3
Disagree	41	13.4
Neutral	21	6.9
Agree	156	51.1
strongly agree	77	25.2

Table 5. The characteristics of COVID-19 vaccine uptake of DM patients at TASH, Addis Ababa, Ethiopia, 2022

Variable	Frequency	percent
Number of doses taken (n=201)		
One	39	19.4
Two	102	50.7
Three	60	29.9
Any adverse event within one month vaccination		
Yes	54	27.0
No	146	73.0
Adverse event experienced		
Headache, fever	17	**31.5**
pain, readiness, itch, swelling	16	29.6
joint pain, muscle pain	11	20.4
fatigue, malaise	6	11.1
Dizziness	4	7.4

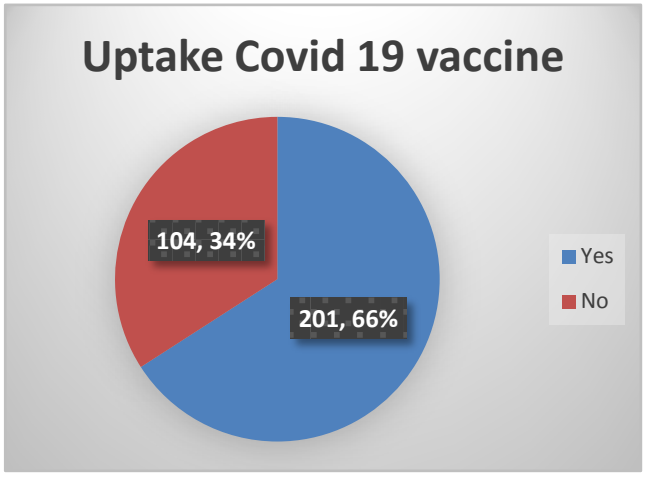

Figure 2. Uptake of COVID-19 vaccine among DM patients at TASH, Addis Ababa, Ethiopia, 2022

Uptake of COVID-19 vaccine

201(66%) of the study participants had received at least one dose of COVID-19 vaccine (Figure 2) .Among the participants who received the vaccine, 102(50.7%) were administered two doses, while 60(29.9%) received three doses. Notably, 146(73%) of these individuals did not report any adverse events within one month of vaccination. The most commonly observed side effects, experienced by 17(31.6%) of participants, included headache and fever. Importantly, no serious adverse events requiring hospitalization were reported, indicating a favorable safety profile for the vaccine (Table 5).

COVID-19 vaccine Uptake and Sociodemographics characteristics

The strength of association was assessed using odds ratios (OR) along with 95% confidence intervals (CI). Bivariate logistic regression revealed significant associations between various factors, including gender, age, educational level, health insurance status, and the type of diabetes mellitus (DM). Multivariate logistic regression analysis further indicated that, compared to individuals aged 18-30 years; older DM patients exhibited significantly higher odds of receiving the COVID-19 vaccine. Specifically, patients aged 31-40 years, 41-50 years, 51-60 years, 61-69 years, and those over 70 years had odds of vaccine uptake approximately 3.9, 9.9, 8.9, and 7.9 times higher, respectively. Additionally, males were found to be 1.8 times more likely to receive the COVID-19 vaccine than females (AOR=1.8, 95% CI=1.46, 3.45).

The likelihood of COVID-19 vaccine uptake among individuals with DM was significantly higher for those with secondary and college education levels compared to those with no formal education. Specifically, individuals with secondary education had a 3.1-fold greater likelihood (AOR=3.1, 95% CI=1.19, 8.11), while those with a college education exhibited a 7.8-fold increase in vaccine

uptake (AOR=7.8, 95% CI=2.54, 23.87), compared to participants who were illiterate. Regarding income, participants with a monthly household income of <2000 ETB and 2000-5000 ETB were 4.2 and 3.5 times more likely to receive the COVID-19 vaccine, respectively, than those with a monthly income exceeding 10,000 ETB (AOR=4.2, 95% CI=1.34, 13.39 and AOR=3.5, 95% CI=1.36, 8.98). However, these findings suggest that income level does not significantly contribute to the overall uptake of the vaccine (Table 6).

COVID-19 vaccine uptake and perceptions related to COVID-19 vaccination

The multivariate logistic regression analysis revealed that participants who perceived the severity of contracting COVID-19 were approximately 2.4 times more likely to receive the COVID-19 vaccine compared to those who did not perceive it as severe (AOR = 2.4, 95% CI = 1.88, 6.60). Furthermore, individuals who believed that vaccination could reduce the risk of transmitting COVID-19 had odds of vaccine uptake that were 4.7 times higher than those who did not share this belief (AOR = 4.7, 95% CI = 1.21, 18.29). The study also found that participants who considered vaccination the most effective way to prevent COVID-19 complications were 12 times more likely to get vaccinated compared to those who did not hold this belief (AOR = 12.1, 95% CI = 3.89, 37.55). Additionally, individuals who trusted doctors' statements about the vaccine's ability to reduce infection risk were 6 times more likely to receive the vaccine than those who did not agree (AOR = 6.1, 95% CI = 1.98, 19.02)(Table 7).

Table 6. Bivariate and multivariate analysis of COVID-19 vaccine uptake and Sociodemographics characteristics of DM patients at TASH, Addis Ababa, Ethiopia, 2022

Variable	COVID 19 vaccine uptake		COR with 95%CI	P-Value	AOR with 95%CI	P-value
	Yes	No				
Gender						
Male	99	28	2.6(1.58, 4.41)	0.000	**1.8(1.46. 3.45)**	0.043
Female	102	76		1		1
Age in years						
18-30	15	21		1		1
31-40	11	19	0.81(0.30, 2.19)	0.679	1.4(0.46, 4.47)	0.534
41-50	29	21	1.9(0.81, 4.61)	0.137	**3.9(1.21, 12.78)**	0.023
51-60	51	14	5.1(2.09, 12.39)	0.000	**9.9(2.67, 36.98)**	0.001
61-69	68	18	5.3(2.28, 12.27)	0.000	**8.9(2.56, 30.85)**	0.001
>70	27	11	3.4(1.31, 9.02)	0.012	**7.9(1.89, 33.06)**	0.005
place of residence						
Rural	12	8		1		1
Urban	189	96	1.3(0.52, 3.32)	0.250	0.64(0.18, 2.240	0.484
level of education						
unable to read and write	17	18		1		1
Primary	37	27	1.5(0.63, 3.32)	0.378	1.3(0.52, 3.48)	0.538
Secondary	69	36	2.1(0.93, 4.41)	0.074	**3.1(1.19, 8.11)**	0.020
college and above	78	23	3.6(1.59, 8.07)	0.002	**7.8(2.54, 23.87)**	0.000
Presence of health insurance						
Yes	162	70	2.0(1.18, 3.46)	0.011	1.7(0.88, 3.31)	0.111
No	39	34		1		1
Family income per month						
<2000	48	25	1.7(0.76, 3.88)	0.192	**4.2(1.34, 13.39)**	0.014
2000-5000	97	48	1.8(0.86, 3.79)	0.117	**3.5(1.36, 8.98)**	0.010
>5000-10000	37	14	2.4(0.96, 5.80)	0.060	2.5(0.82, 7.41)	0.108
>10000	19	17		1		1
Type of DM						
type 1 DM	28	31		1		1
type 2 DM	173	73	2.6(1.47, 4.68)	0.001	0.70(0.28, 1.78)	0.457
Duration of DM in years						
<2	32	20		1		1
2-10	69	29	1.5(0.73, 3.02)	0.272	0.88(0.35, 2.19)	0.781
>10	100	55	1.1(0.59, 2.17)	0.699	0.48(0.20, 1.11)	0.088
Most recent FBS in mg/dl						
<126	80	45	1.6(0.66, 3.99)	0.285	2.1(0.69, 6.20)	0.196
126-250	109	48	2.1(0.86, 5.06)	0.105	2.9(0.97, 8.78)	0.056
>250	12	11		1		1
Had covid-19 during this pandemic						
Yes	31	10	1.7(0.81, 3.65)	0.162	1.5(0.61, 3.64	0.382
No	170	94		1		1

Table 7. Bivariate and multivariate analysis of COVID-19 vaccine uptake and perceptions related to COVID-19 vaccination among DM patients at TASH, Addis Ababa, Ethiopia, 2022

Variable	COVID-19 uptake		COR with 95%CI	P-Value	AOR with 95%CI	P-value
	Yes	No				
Perceived susceptibility and severity						
have a high risk of contracting COVID -19						
Disagree/strongly disagree/neutral	96	79		1		1
Agree/strongly agree	105	25	3.5(2.04, 5.86)	0.000	1.8(0.75, 4.19)	0.189
The consequence of contracting COVID -19is severe if infected						
Disagree/strongly disagree/neutral	73	49		1		1
Agree/strongly agree	128	55	1.6(0.96, 2.53)	0.069	**2.4(1.88, 6.60)**	0.046
perceived benefits of COVID-19 vaccination						
Receiving COVID-19 vaccination could reduce risk of contracting COVID-19						
Disagree/strongly disagree/neutral	34	67		1		1
Agree/strongly agree	167	37	8.9(5.16, 15.34)	0.000	1.1(0.24, 4.98)	0.905
Receiving COVID-19 vaccination is beneficial for you and others						
Disagree/strongly disagree/neutral	49	70		1		1
Agree/strongly agree	152	34	6.4(3.79, 10.75)	0.000	2.3(0.56, 9.19)	0.252
Receiving COVID -19 vaccination could reduce your risk of transmitting COVID-19						
Disagree/strongly disagree/neutral	13	72		1		1
Agree/strongly agree	188	32	32.5(16.17, 65.49)	0.000	**4.7(1.21, 18.29**	0.026
The best way to avoid the complication (hospitalization and death) of COVID-19 by vaccination						
Disagree/strongly disagree/neutral	15	78		1		1
Agree/strongly agree	186	26	37.2(18.69, 74.04)	0.000	**12.1(3.89, 37.55**)	0.000
Perceived barriers						
As a person with diabetes, you are worried about the safety of the vaccination						
Disagree/strongly disagree/neutral	147	48	0.32(0.19, 0.52)	0.000	1.8(0.62, 3.39	0.280
Agree/strongly agree	54	56		1		1
Concerned about the side effects of COVID -19vaccination						
Disagree/strongly disagree/neutral	147	50	2.9(1.79, 4.82)	0.004	1.2(0.41, 3.39)	0.759
Agree/strongly agree	54	54		1		1
Cues to action; would you more likely to get the COVID-19 vaccine						
Uptake of covid-19 vaccination among your families and friends would influence decision to receive the vaccination						
Disagree/strongly disagree/neutral	120	71		1		1
Agree/strongly agree	81	33	1.5(0.88, 2.39)	0.056	1.29(0.12, 1.79	0.068
You believe in your doctor's statement that vaccination can reduce the risk of infection						
Disagree/strongly disagree/neutral	16	64		1		1
Agree/strongly agree	185	40	18.5(9.70, 35.29)	0.000	**6.1(1.98, 19.02)**	0.002
Mass media/internet suggest DM patients receive COVID-19 vaccination						
Disagree/strongly disagree/neutral	36	73		1		1
Agree/strongly agree	165	31	10.8(6.20, 18.78)	0.000	1.7(0.68, 4.47)	0.261
Mandatory to be vaccinated for continuing job, will affect your Job, will affect your vaccination behavior						
Disagree/strongly disagree/neutral	39	47		1		1
Agree/strongly agree	162	57	3.4(2.03, 5.77)	0.000	0.5(0.13, 1.94)	0.319
If it is compulsory by the gov't (MOH) to be vaccinated, will affect your vaccination behavior						
Disagree/strongly disagree/neutral	28	44		1		1
Agree/strongly agree	173	60	4.5(2.59, 7.91)	0.000	2.4(0.65, 8.89)	0.191

4. Discussion

This study evaluated the uptake of COVID-19 vaccine among individuals with diabetes mellitus (DM) and identified factors influencing vaccination behavior, using the Health Belief Model (HBM) as a guiding theoretical framework. The findings revealed that two third of participants had received at least one dose of the COVID-19 vaccine, with one third of participants completing the two-dose regimen. However, only 20% of participants had received three doses. These figures are higher than those observed in similar studies conducted in South Gondar Zone, Ethiopia (18.7%) [24], Sudan (31%) [22], India (21.5%) [25], and China (25.2%) [26]. Nevertheless, they remain notably lower compared to a study in Saudi Arabia, where 84.8% and 55.5% of participants had received the first and second doses, respectively [27]. The rate of full vaccination (33%) among individuals with diabetes in this study is concerning, as it highlights a substantial number of individuals who remain either unvaccinated or only partially vaccinated. This rate falls short of expectations, particularly since elderly individuals and those with chronic conditions, such as diabetes, were prioritized for vaccination. Furthermore, the observed vaccination rates are inconsistent with the World Health Organization's goal

of achieving 70% vaccination coverage globally, with a specific focus on 100% vaccination for individuals aged 60 and older, healthcare workers, and those with underlying health conditions [2,10]. Lower vaccination coverage could be attributed to vaccine hesitancy, which has been reported in many countries, including Ethiopia [28,29].

This study investigated the factors influencing COVID-19 vaccine uptake, with a focus on sex, age, and education level. The findings revealed that female patients had a lower vaccination rate compared to their male counterparts, a trend that aligns with other research indicating higher vaccine hesitancy and lower vaccination rates among females. One potential explanation for this discrepancy could be a greater fear of vaccination among women [27,30]. Age also played a significant role in vaccine uptake, with older individuals (aged 31-40, 41-50, 51-60, 61-69, and over 70) showing higher vaccination rates than those in the 18-30 age group. This observation is consistent with studies from China [21] and Saudi Arabia [27], which suggest that older individuals may have a heightened awareness of the risks associated with COVID-19, driving their higher vaccination rates.

Regarding education, respondents with secondary education, college degrees, or higher were more likely to get vaccinated compared to those with no formal education. This finding supports previous studies in Ethiopia, which suggest that higher educational attainment may be linked to greater acceptance of recommended vaccinations, possibly due to increased health literacy [31,32]. Factors such as smoking status, health insurance coverage, diabetes type, family history of diabetes, blood sugar control, and the presence of other chronic conditions not directly related to diabetes complications were not found to be associated with vaccination uptake. This is consistent with similar research conducted in China [26].

The findings of this study offer valuable insights for designing targeted health promotion programs for individuals with DM. Future interventions should prioritize females, younger populations, and individuals with lower educational levels, as these groups may benefit most from tailored approaches. Specifically, strategies for encouraging COVID-19 vaccination in DM patients should incorporate diverse methods. One such approach is the fear appeal strategy, which has proven effective in promoting health behaviors by emphasizing potential risks [33]. Our results show that the perceived severity of COVID-19 significantly correlates with increased vaccination uptake. This suggests that individuals who view COVID-19 as a substantial threat may be more likely to seek vaccination as a preventive measure.

In addition, the perception of COVID-19 vaccination as a means to reduce transmission risk, coupled with the belief that vaccination is the most effective way to prevent complications, was significantly associated with higher vaccination uptake. This finding aligns with similar studies conducted in China [26]. Emphasizing both personal and social benefits of vaccination could prove particularly effective in encouraging COVID-19 vaccination among individuals with diabetes mellitus (DM). Additionally, a belief in the protective efficacy of vaccination, as endorsed by healthcare providers, was strongly linked to increased vaccination rates. Notably, a significant proportion of hesitant participants in our study indicated a willingness to receive the vaccine, particularly if recommended by their healthcare provider. This is consistent with other studies that found a majority of initially reluctant diabetic individuals would be more inclined to get vaccinated upon a doctor's recommendation [21,25,27]. Thus, physician endorsements emerge as a critical factor in promoting COVID-19 vaccination among people with DM.

In this study, nearly three-quarters of participants did not report any adverse events within one month of receiving the COVID-19 vaccination. The most common adverse effects were injection site pain and headaches, which are consistent with findings from other similar studies [22,27]. Importantly, there were no reported serious adverse events requiring hospitalization. These findings emphasize the overall safety profile of the vaccine.

5. Conclusion

Given the heightened risk of severe and potentially life-threatening complications from COVID-19 in individuals with DM, it is imperative to implement targeted interventions to increase vaccination coverage within this vulnerable population. Strategies such as fear-based messaging, coupled with strong endorsements from healthcare providers, could enhance vaccine acceptance. Additionally, reinforcing health education campaigns that emphasize both the individual and societal benefits of COVID-19 vaccination may further encourage uptake. Healthcare professionals play a pivotal role in fostering vaccine confidence by assuring diabetic patients of the safety of the COVID-19 vaccines, highlighting that the majority of individuals experience only mild side effects. To better understand the barriers to vaccination, large-scale, multicenter studies are needed to assess vaccine uptake among individuals with DM and other chronic conditions, providing valuable data to inform tailored interventions.

Abbreviations

AAU, Addis Ababa University; CDC, Centers for Disease Control and Prevention ; DM, Diabetes Mellitus; HBM , Health belief model; IDF, International Diabetes Federation; MOH, Ministry of Health; TASH, Tikur anebesa specialized hospital; T1DM,Type 1 Diabetes Mellitus; T2DM,Type 2 Diabetes Mellitus; WHO, world health organization .

Institutional Review Board Statement

The study was approved by the Institutional Review Board of college of medicine and health sciences of Addis Ababa University (protocol number: 18/22).

Data Sharing Statement

The datasets used in this study are available from the corresponding author on reasonable request.

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Disclosure

All authors declare no conflicts of interest regarding this work.

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Informed Consent Statement

Written informed consent was obtained from all subjects involved in the study.

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