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The effectiveness of COVID–19 vaccination against all–cause mortality in patients with type 2 diabetes mellitus: The observation during the initial period of the cancellation of the "Dynamic Zero Policy" in mainland China

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ABSTRACT

Aims: This study aims to assess the effectiveness of COVID–19 vaccination against all–cause death in patients with type 2 diabetes mellitus (T2DM).

Methods: Subjects were patients with T2DM who were administered by general practitioner (GP). Use electronic exchange platform to obtain the information on COVID–19 vaccination, all–cause deaths and risk factors. Logistic regression models were used to calculate the odd ratio (OR) and 95% CI for the association between COVID–19 vaccination and mortality. The vaccine effectiveness (VE) was calculated as (1- adjusted OR) × 100%.

Results: A total of 26,916 subjects had 53.81%, 17.65%, and 23.43% coverage for the booster, full, and partial COVID-19 vaccination, reported 328 deaths and a mortality of 1.2%. The adjusted OR (95%CI) was 0.85 (0.60–1.21) for those received partial vaccination, 0.31(0.22–0.43) for those received full vaccination, and 0.12 (0.08–0.18) for those received booster vaccination, compared to the unvaccinated individuals. The VE (95%CI) was 88.00%(82.30–91.80) of booster vaccination, 69.30%(56.60–78.30) of full vaccination, and 17.60% (-17.10–42.00) of partial vaccination.

Conclusion: COVID–19 vaccination could effectively prevent the all–cause death in patients with T2DM during the omicron variant outbreak period, after the cancellation of the "Dynamic Zero Policy" in mainland China.

1. Introduction

Diabetes was one of the most common comorbidities among patients hospitalized with COVID–19 [1]. Much evidence indicated that diabetes at significant risk of hospitalization and mortality was disproportionately affected by severe acute respiratory syndrome type 2 coronavirus (SARS–CoV–2) [2,3]. COVID–19 vaccination is a critical measure that provides effective protection against infection and death due to SARS–CoV–2 [4]. Patient with diabetes are globally prioritized in COVID–19 vaccine policy. Early as March 29, 2021, the National Health Commission of People's Republic of China issued the COVID–19 vaccination program for the public population, especially recommended for people with comorbidities who are healthy or have well conditions [5]. Subsequently, the booster vaccination campaign was launched since Oct 2021. According to the latest surveillance data from the Chinese CDC, 92.9% of the general population began vaccination and 90.6% completed primary vaccination [6].

The SARS–COV–2 omicron variant are currently predominant around the world, has characteristics as a higher viral load, longer duration of infectiousness, and higher ability to escape from natural immunity, causes less severe disease for the individual than the delta variant, results in a rapidly increased rate of transmissibility [7]. Considering the substantial decline in mortality of the omicron variant and adequate coverage of COVID–19 vaccination in population, the Chinese government terminated the "Dynamic Zero Policy" strategy since Dec 8, 2022, means that no longer emphasized the measures such as extensive nucleic acid test, isolation of cases, and quarantine of close contacts. The dominant variant of the virus in mainland China was BA.5.2 and BF.7 in that period [8]. Subsequently, majority of the Chinese population exposed to the omicron variant, would experience first–time or breakthrough infections at a short time. The surveillance data showed positive nucleic acid test rate in the general population sharply increased to a peak of 29.2% on Dec 25, 2022, and gradually fell to 1.5% on Feb 6, 2023 [6]. Two or three doses of inactivated COVID–19 vaccines which was vaccinated in most Chinese population, could provide strong and durable protection against severe disease and death,

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according to the data in omicron pandemic from HongKong [9] and ShangHai [10]. However, the above assessment was conducted prior to the cancellation of the "Dynamic Zero Policy" strategy. Because of the remarkable effect of strict public health measures on the pandemic, people might be not fully aware of the hazard of COVID–19 and advantage of the vaccination, and might produce vaccine hesitancy [11]. Population–based studies on effectiveness of COVID–19 vaccination, particularly based on patients with comorbidities, are required to assess and propose the vaccine rollout in the future. This study enrolled patients with type 2 diabetes mellitus (T2DM) who are administered by general practitioner(GP) in community healthcare center(CHC) as subjects, and used data from electronic health platforms, aims to assess the effectiveness of COVID–19 vaccination against all–cause death during the initial period of the cancellation of the "Dynamic Zero Policy" strategy in mainland China.

2. Method and materials

2.1. Subjects

The subjects in this study were patients with T2DM who had participated in the health management of the Essential Public Health Service (EPHS) program in Hangzhou City, Zhejiang Province, China. The EPHS program is proposed and approved by the National Health Commission, and follows a national standardized procedure, aims to reverse the major health burden of non–communicable disease such as hypertension and T2DM. Briefly, confirmed patients who voluntarily consent to join the EPHS program, will set an electronic health record (EHR) and receive regular and comprehensive interventions from a healthcare team of GPs, nurses and public health physicians.

On July 29, 2022, about 0.27 million of patients with T2DM were managed in 198 CHCs in Hangzhou city, according to the EHR system. A multistage stratified random sampling process was performed using an automated procedure defined within the EHR system. The first phase grouped patients by CHC, and the second phase stratified patients into age groups (10 years by group). Subsequently, 10% of individuals were randomly selected by CHCs and by age distribution. A total of 27,156 individuals were randomly selected. Because the purpose of this study was to estimate the effectiveness of COVID–19 vaccination in first wave of omicron outbreak, 240 subjects who died before Dec 8, 2022, the date of the cancellation of the "Dynamic Zero Policy", were excluded. In addition, these individuals were confirmed not to be infected with SARS–CoV–2 due to the extensive nucleic acid test. Finally, the sample size was 26,916 in this study. All individuals had signed an informed consent document when they decided to take part in EPHS program and to vaccinate the COVID–19 vaccines. All procedures and activities of EPHS program and COVID–19 vaccination were consistent with the 1975 Helsinki Declaration. The personal information of subjects was protect anonymity and used in terms of characteristics of the population. The ethics approval of this study does not require re–approval.

2.2. Data collection

The EHR system records personal healthy information including general characteristics, regional location, body measurements, lifestyle factors, medication adherence, and comorbidities as hypertension, cardiovascular diseases (CVD), Diabetic nephropathy (DN) and cancer. The unified electronic immunization systems used to record the COVID–19 vaccination information including vaccinated status, date, and vaccine varieties. Physician in medical institutions are responsible for the identification of death cases and required to report the relative information on the electronic death surveillance system. This study used an electronic exchange platform to obtain information regarding COVID–19 vaccination and mortality. The vaccination information was exchanged until Aug 3, 2022, and the death information was collected between Dec 9, 2022 and Jan 31, 2023.

2.3. Variables and criterion

The COVID–19 vaccine species in this study included inactivated virus vaccine, recombinant protein vaccine and viral vector vaccine. Full vaccination was defined as two doses of inactivated virus vaccine, three doses of recombinant protein vaccine, or one dose of viral vector–based vaccine. Booster vaccination was defined as three doses of inactivated virus vaccine or two doses of viral vector–based vaccine. An additional dose of viral vector–based vaccine with two doses of inactivated vaccine was also considered as booster vaccination. The booster vaccination was not available to recombinant protein vaccine for no official guidelines before August 3, 2022. The interval between different doses must meet the minimum requirement of the official guideline, otherwise the latest vaccination would define invalid vaccination. Having a vaccination record but not receiving the required dose was defined as a partial vaccination. All above definitions are consistent with the Technical Vaccination Recommendations for COVID-19 Vaccines in China [5]. Risk factors contained age, sex, body mass index (BMI), waist circumference (WC), current smoking, alcohol consumption and physical exercise, urban–rural disparities, medication adherence, and comorbidities as hypertension, CVD, DN and cancer. The definition of risk factors followed the National Primary Hypertension Prevention and Treatment Management manual (in Chinese). The BMI is calculated as Weight/Height^2 (kg/m^2). BMI $\geq$ 28.0 kg/m^2 and (or) WC $\geq$ 90 cm (male), $\geq$85 cm (female) were considered as obesity. Smoking status is a dichotomous variable, and one cigarette per day, at least during the last 6 months considered current smoking. Use of weekly periods to define the frequency of alcohol consumption and physical exercise. 5 days a week at least defined as the "daily" frequency. The region of administered CHCs was divided into urban, suburban and rural groups. Irregular medication adherence means patient has poor adherence to GPs' prescription and intervention. Patients with comorbidities means they have one of hypertension, CVD, DN, and cancer at least. The interval time was calculated between date of the last dose and Dec 8, 2022.

2.4. Statistical analysis

The characteristics of the subjects were summarized for COVID–19 vaccination status, using means with standard deviation for continuous data, percentages and proportions for categorical data. One way ANOVA tests and chi–squared tests were used to compare continuous and categorical variables among different groups. Logistic regression models were used to calculate the odd ratio (OR) and 95% CI for the association between the COVID–19 vaccination status and all–cause mortality. The adjusting variables contained age, gender, obesity, lifestyle factors, urban–rural disparities, medication adherence, and comorbidities, unless they were considered to be grouping factors. The OR (95%CI) of COVID–19 vaccination was estimated according to different control groups, including unvaccinated individuals and those who were received full vaccination. The vaccine effectiveness (VE) against all–cause death was estimated using the unvaccinated group as reference, was calculated as (1- adjusted OR) $\times$ 100%, and stratified by age groups (35–59, 60–79, and $\geq$ 80 years), interval time ($<$ 180, 180–365, and $>$ 365 days), and comorbidities (with and without). All statistical analyses were performed using R version 4.1.1 (URL https://www.R–project.org/). All p values were two–sided and statistical significance was defined as $p < 0.05$.

3. Results

3.1. The general characteristics of subjects

As of Aug 3, 2022, 53.81% of subjects completed the booster COVID–19 vaccination, and 17.65% only completed the full vaccination. Of the remained individuals, 5.10% were partially vaccinated and 23.43% were unvaccinated. The majority (98.37%) exclusively received inactivated virus vaccine among the vaccinated individuals. The average age was 68.59 ± 9.30 year and 69.85% ranged from 60 to 79 years. 45.05% was male and 54.95% was female. 54.84% of individuals were selected from the suburban CHCs, 32.32% and 12.84% from the urban and rural CHCs. 4.35% of individuals had irregular medication adherence. The proportion of obesity, current smoke, daily alcohol consumption, and daily physical exercise was 46.14%, 16.73%, 9.08%, and 33.60%, respectively. 71.95% of subjects had at least one of comorbidities like hypertension (67.78%), CVD (13.22%), DN (1.77%) and cancer (6.14%). Among the vaccinated individuals, the interval time between the last dose and Dec 8, 2022 was 10.92% less than 180 days, 70.94% from 180 to 365 days and 18.14% more than 365 days. From Dec 9, 2022 to Jan 31, 2023, 328 death cases were reported, accounting for 1.2% of subjects. There was a significant difference in characteristics among groups by COVID–19 vaccination status (Table 1).

3.2. COVID–19 vaccination status associated with risk of all–cause death

The adjusted OR(95%CI) related all–cause death was 0.85 (0.60–1.21) for those received partial vaccination, 0.31(0.22–0.43) for full vaccination, and 0.12(0.08–0.18) for booster vaccination, compared to the unvaccinated individuals. The OR (95%CI) of the comparison between full and booster vaccination was 0.40(0.24–0.64). Significant associations between adjusted variables and the risk all–caused death were found, as 0.43(0.34–0.55) of the females, 1.71(1.29–2.26) of the non–daily physical exercise, 1.71(1.06–2.76) of the irregular medication adherence, and 1.70(1.18–2.45) of the rural area. Comorbidities like CVD and DN could affect the risk of death, the OR(95%CI) was 1.54 (1.20–1.97) and 2.09(1.21–3.62) (Table 2).

3.3. The effectiveness of COVID–19 vaccine against all–cause death by age, interval time, and comorbidities

The overall VE (95%CI) of COVID–19 vaccination against all–cause death was 88.00%(82.30–91.80) of booster vaccination, 69.30% (56.60–78.30) of full vaccination, and 17.60%(-17.10–42.00) of partial vaccination. The lower bound value of VE was negative in the partial groups, irrespective of age groups, interval time, and comorbidities. In contrast, the lower limits of the 95% CI were greater than zero for both full and booster groups, except that of 35–59 years in the full groups. Higher VE were estimated in age groups 35 to 59 years, interval time less

Table 2
The association between characteristics, COVID–19 vaccination and all–cause death.

Variables	Categories	B	S.E.	Wald–χ^2	OR(95%CI)
Age	In continuous	0.11	0.01	219.03	1.11 (1.10–1.13)
Sex	0 = male, 1 = female	−0.85	0.12	47.18	0.43 (0.34–0.55)
Obesity	0 = no, 1 = yes	−0.12	0.12	0.99	0.89 (0.71–1.12)
Daily alcohol consumption	0 = no, 1 = yes	−0.16	0.24	0.46	0.85 (0.53–1.36)
Current smoking	0 = no, 1 = yes	−0.17	0.19	0.81	0.85 (0.59–1.22)
Daily physical exercise	0 = yes, 1 = no	0.54	0.14	14.23	1.71 (1.29–2.26)
Medication adherence	0 = regular, 1 = irregular	0.53	0.25	4.77	1.71 (1.06–2.76)
Region	0 = urban, 1 = suburban	0.09	0.13	0.51	1.10 (0.85–1.42)
	0 = urban, 1 = rural	0.53	0.19	8.05	1.70 (1.18–2.45)
Hypertension	0 = no, 1 = yes	−0.12	0.15	0.59	0.89 (0.67–1.20)
CVD	0 = no, 1 = yes	0.43	0.13	11.35	1.54 (1.20–1.97)
DN	0 = no, 1 = yes	0.74	0.28	6.90	2.09 (1.21–3.62)
Cancer	0 = no, 1 = yes	0.14	0.20	0.53	1.15 (0.78–1.70)
COVID-19 vaccination*	0 = unvaccinated, 1 = partial	−0.17	0.18	0.84	0.85 (0.60–1.21)
	0 = unvaccinated, 1 = full	−1.18	0.18	43.98	0.31 (0.22–0.43)
	0 = unvaccinated, 1 = booster	−2.12	0.20	114.16	0.12 (0.08–0.18)
COVID-19 vaccination&	0 = full, 1 = booster,	−0.93	0.25	14.07	0.40 (0.24–0.64)

Abbreviations: CVD, cardiovascular diseases; DN, diabetic nephropathy.
* The control group was unvaccinated individual.
& The control group was individual with full vaccination.

Table 1
The general characteristics of subjects by the COVID–19 vaccination status.

		Total	Unvaccinated	Partial	Full	Booster	F/χ^2	P value
N (%)		26916(100.00)	6307(23.43)	1374(5.10)	4751(17.65)	14484(53.81)		
Age(year)		68.59 ± 9.30	71.69 ± 10.17	73.12 ± 9.02	69.93 ± 9.07	66.37 ± 8.33	701.384	< 0.001
Age groups (%)	35–59y	18.94	14.57	8.22	14.99	23.16		
	60–79y	69.85	63.56	68.12	71.33	72.27	1794.78	< 0.001
	≥80y	11.21	21.86	23.65	13.68	4.58		
Sex (%)	male	45.05	41.08	33.33	42.77	48.65	201.99	< 0.001
	female	54.95	58.92	66.67	57.23	51.35		
Region (%)	urban	32.32	46.42	20.89	36.31	25.95		
	suburban	54.84	45.05	68.41	54.16	58.04	1082.34	< 0.001
	rural	12.84	8.53	10.70	9.53	16.00		
Irregular medication adherence (%)		4.35	3.58	3.93	3.52	5.01	32.38	< 0.001
Obesity (%)		46.14	46.73	48.18	48.35	44.96	20.61	< 0.001
Current smoke (%)		16.73	14.17	12.37	15.85	18.54	85.17	< 0.001
Daily alcohol consumption (%)		9.08	6.12	6.33	8.69	10.76	130.04	< 0.001
Daily physical exercise (%)		33.60	32.00	26.06	33.13	35.17	58.80	< 0.001
Comorbidities (%)	hypertension	67.78	74.22	73.29	71.12	63.36	292.74	< 0.001
	CVD	13.22	19.98	18.78	13.79	9.57	457.58	< 0.001
	DN	1.77	3.00	1.09	1.73	1.32	75.15	< 0.001
	caner	6.14	10.27	7.71	5.70	4.33	277.07	< 0.001
Interval time (%)	< 180 days	10.92	—	38.06	21.07	5.01		
	180–365 days	70.94	—	36.54	36.31	85.57	5525.54	< 0.001
	> 365 days	18.14	—	25.40	42.62	9.42		
Death (%)		1.22	3.39	2.98	0.84	0.23	407.02	< 0.001

Abbreviation: CVD, cardiovascular diseases; DN, diabetic nephropathy.

than 180 days, and no comorbidities, respectively. The VE value of booster vaccination was generally higher than that of full vaccination (Table 3).

4. Discussion

This study found that COVID-19 vaccination can effectively prevent the all–cause death in patients with T2DM, when the first wave of omicron variant outbreak occurred after the cancellation of the "Dynamic Zero Policy" strategy. The booster vaccination has a significant benefit over full vaccination, but partial vaccination has not been effective in any situation. The VE against all–cause death was higher in individuals who had completed the booster vaccination, were younger, had a shorter interval time, and had no comorbidities.

The inactivated virus vaccine against the COVID–19 has been the mostly used in mainland China, such as 98.37% of constituent ratio in this study. A case control study in HongKong showed a weak VE of three doses (19.8, 95%CI: 17.2–22.3) and two doses (-0.3, 95%CI: −2.7–2.1) of inactivated virus vaccine (CoronaVac) in preventing the SARS–CoV–2 infection among patient with diabetes mellitus, during the period principally driven by the omicron variant [12]. Data collected from Jilin province, China, showed that no significant protection was obtained from any dose of inactivated vaccine against the any symptomatic disease of the omicron infection [13]. Therefore, it reasonably considered that people in mainland China were vulnerable to the omicron variant. While the infectious status has not been collected, subjects in this study probably become infected on a large scale during the first wave of omicron outbreak from December 9, 2022. In this study, more than 80% of the subjects were 60 years old or more, showed 71.46% and 53.81% of them had received the full and booster COVID–19 vaccination, as of Aug 3, 2022, and lagged behind the reported coverage rates (85.6% and 67.8%) for the older adults at the same time [14]. A nationally representative sample showed 92.3% of the Chinese older adults (≥60 years) had received at least one COVID–19 vaccination, 88.6% and 72.4% had completed the full and booster vaccination, as of Jul/Aug 2022 [15]. T2DM and hypertension (the most comorbidities in this study) as well as other comorbidities were a barrier to COVID–19 vaccination coverage probably due to efficacy and safety concerns [16].

Several covariates as age, gender, body measurements, rural–urban disparity, lifestyle factors, medication adherence, and comorbidities were included into the multivariable analysis when estimated the VE of COVID–19 vaccination. Female, regular medication adherence and daily physical exercise were protective factors for the all–cause death. A clinical observation involving 168 severe patients with COVID–19 in Wuhan, China found that the male rather than female patients with comorbidities were at risk of severe illness [17]. This performance might attribute to the difference in immune responses to the COVID–19 disease between the male and female, according to Takehiro Takahashi and colleagues' study [18]. This also possible be related with the fact that the male had a lower coverage rate of COVID–19 vaccination compared to the female in this study. The COVID–19 pandemic has dramatically transformed health systems, including significantly reducing general practitioner health services, such as restricting face–to–face consultations, laboratorial tests and annual diabetes reviews [19]. Patients with regular medication adherence means a well self–health management and contribute to glycemic control [20]. Physical activity has significant health and disease benefits, particularly in patient with T2DM, linked to decreased systolic pressure, reduced the risk of relative complications, myocardial infarction, and mortality [21]. Furthermore, physical exercise is associated with more effective immune defense and better glycemic control, both of which could provide benefits in reducing immune cell activation of SARS–Cov–2 infection [22]. Older age, rural area, CVD, and DN were risk factors for the all–cause mortality in this study. Higher COVID–19 incidence and mortality in rural than in urban areas were reported in the United State, attributed to poor conditions as older age, more comorbidities, inadequate insurance, shortage of medical facilities and lower COVID–19 vaccination rate in rural population [23]. However, these shortcomings were not entirely the same as in rural China. For instance, rural participants in this study had higher coverage rates both of full and booster vaccination, compared with those in urban and suburban area. There were other reasons for the higher mortality in rural areas, such as nutrient intake. Data collected in rural China revealed that an increase of 100 confirmed cases in a county resulted in a 1.30%, 1.42%, 1.65%, and 1.15% decrease in per capita intake of dietary energy, carbohydrates, fats, and proteins, respectively [24]. Patient with T2DM who coexisted with CVD and DN, probably had difficulties in glycemic control or progress to a serious state, and subsequently led to they tend to the hesitancy of vaccination and impair the immune defense.

This study reported full and booster vaccination with an effective VE against all–cause mortality in patients with T2DM, and demonstrated that the booster vaccinations had a higher VE. A case–control study of registered patients with DM in HongKong calculated the VE of the inactive virus vaccine against all–cause mortality related to the omicron variant, and showed 74.8(70.7–78.3) of full vaccination and 94.9 (91.6–96.9) of the booster vaccination [12]. Even focused on the effectiveness of infection during the BA.2 variant outbreak, timely the third dose of CoronaVac could provide significant protection with lower incidence rates (19.4%) of breakthrough infections, compared to 44.1% of two doses of vaccination [25].

Age, duration, and comorbidities were important factors in the effectiveness of COVID–19 vaccination [26]. In this study, a higher VE was found in individuals who completed the booster vaccination and aged less than 60 years, had interval time within 180 days, and were free of comorbidities as hypertension, CVD, DN and cancer. Surveillance data in São Paulo State, Brazil showed that the increased risk of moderate and severe outcomes occurred three months after the full vaccination among older adults, and a significant increase observed starting at 70 to 97 days then reached a maximum after 182 days [27]. Tianpei Shi and colleagues found that the neutralizing antibodies level of two dose of inactivated virus vaccine decreased sustainably and culminated in a 4–fold decrease from the fifth week to 21st week [28]. Reduction in VE also occurred at two doses of mRNA vaccine along with duration after the second vaccination, especially in individuals aged 55 years or

Table 3
The vaccine effectiveness (95CI%) of COVID–19 vaccination against all–cause death by age, interval time, and comorbidities.

Groups		Partial	Full	Booster
Overall		17.60%(-17.10–42.00)	69.30%(56.60–78.30)	88.00%(82.30–91.80)
Age groups	35–59y	–23.80%(-1002.40–86.10)	52.80%(-141.80–90.80)	96.30%(67.80–99.60)
	60–79y	16.30%(-41.40–50.40)	74.90%(58.00–85.00)	90.30%(83.90–94.10)
	≥80y	17.70%(–33.80–49.40)	63.30%(39.80–77.60)	77.80%(58.70–88.10)
Interval time	< 180 days	−12.00%(-134.60–46.50)	52.00%(21.60–70.60)	96.00%(71.10–99.40)
	180–365 days	35.60%(-17.60–64.70)	79.00%(61.10–88.60)	88.80%(82.80–92.70)
	> 365 days	9.40%(-45.30–43.50)	74.50%(51.50–86.60)	65.80%(21.80–85.00)
Comorbidities*	without	5.70%(-125.50–60.50)	91.10%(62.30–97.90)	93.00%(81.10–97.40)
	with	20.30%(-17.30–45.80)	66.30%(51.80–76.50)	87.40%(80.80–91.70)

* Hypertension, cardiovascular diseases, diabetic nephropathy and cancer was grouping variables and were not included in the multivariable Logistic analysis.

older and among those with comorbidities [29]. The stratified VE of full vaccination was not entirely consistent with a booster vaccination in this study, and could be caused by inadequate sample size in some groups. For example, VE in 35–59 year olds ranged widely and was not significant because only 712 individuals with 2 deaths in this group. A mathematical modelling study based on official reported COVID–19 deaths in 185 countries and territories, estimated that vaccination globally prevented 14.4 million deaths from COVID–19 at least, between Dec 8, 2020 and Dec 8, 2021 [30]. The comparison between Singapore and HongKong showed that the higher mortality of HongKong might be attributed to relatively low vaccination coverage, particularly in older populations [31,32]. This study has several limitations. The information on COVID–19 vaccination was due in Aug 2022, about four months before cancellation of the 'Dynamic Zero Policy', individuals who completed full or booster vaccination during this period were misclassified into an unvaccinated or partial group, might result in underestimating the effectiveness. Based on data from national surveillance or this study, the coverage will no longer significantly increase after approximately six months following the proposed COVID–19 vaccination campaign. Therefore, the underestimation of VE was limited. As previously mentioned, the infectious status of SASR–CoV–2 was not verified for subjects after December 8, 2022. Whereas, it was reasonably speculated that most people were infected during the time of the outbreak of the omicron variant. Since this study was originally designed to track the coverage of vaccination, it did not consider the influence on equalization of sampling by the vaccination status, and could not distinguished the VE by vaccine species. Further collection of factors such as blood pressure, blood glucose and lipids, which have generally been used to assess the condition of T2DM, could produce a more comprehensive evaluation of effectiveness of COVID–19 vaccination.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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