Table S1. Detailed search strategy

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(randomised controlled trial)) OR (RCT)) OR (cohort)) OR (case-control)) OR (cross-sectional)) OR (clinical study))
((("Vitamin D Deficiency"[Mesh]) OR (((Deficiency, Vitamin D) OR (Deficiencies, Vitamin D)) OR (Vitamin D Deficiencies))) AND (("Diabetes Mellitus"[Mesh]) OR ((((type 1 diabetes mellitus)) OR (type 2 diabetes mellitus)) OR (The second secon

(((Vitamin D Deficiency) OR (((Deficiency, Vitamin D) OR (Deficiencies, Vitamin D)) OR (Vitamin D Deficiencies))) AND (((Diabetes Mellitus) OR (type 2 diabetes mellitus)) OR (T1DM)) OR (T2DM)))) AND ((((((randomized controlled trial)) OR (randomised controlled trial)) OR (RCT)) OR (cohort)) OR (cohort))

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(((Vitamin D Deficiency) OR (((Deficiency, Vitamin D)) OR (Deficiencies, Vitamin D)) OR (Vitamin D Deficiencies))) AND (((Diabetes Mellitus) OR (type 1 diabetes mellitus)) OR (T1DM)) OR (T2DM)))) AND ((((((((andomized controlled trial)) OR (randomised controlled trial))) OR (RCT)) OR (cohort)) OR (cohor

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(((Vitamin D Deficiency) OR (((Deficiency, Vitamin D) OR (Deficiencies, Vitamin D)) OR (Vitamin D Deficiencies))) AND ((Diabetes Mellitus) OR (type 2 diabetes mellitus)) OR (T1DM)) OR (T2DM)))) AND ((((((randomized controlled trial)) OR (randomised controlled trial)) OR (RCT)) OR (cohort)) OR (cohort))

Table S2. Quality evaluation of the eligible studies with Newcastle–Ottawa scale(case-control studies)

		Selection			Compa	arability							
Study	Is the case definition adequate?	Representativeness of the cases	Selection of controls	Definition of controls	The study controls for the most important confounding factors	The study controls for any other confounding factors	Ascertainment of exposure	The case dete					
Novoa-Medina,Y. 2023 [11]	*	-	*	*	-	-	*						
Boyraz, I.2016 [29]	*	-	*	*	-	-	*						
Khudayar, Muhammad.2022 [6]	*	-	*	*	*	*	*						
Alqudsi, K. K. 2019 [52]	*	-	*	*	*	-	*						
Iqbal, Khalida. 2017 [37]	*	*	*	*	-	-	*						
Dhas, Y.2019 [31]	*	-	*	*	-	-	*						
Parveen, R.2019 [42]	*	-	*	*	*	-	*						
Razip, N. N. M. 2021 [43]	*	-	*	*	-	-	*						
Ma, L.2020 [41]	*	*	*	*	-	-	*						
Thrailkill, Kathryn M. 2011 [66]	*	-	*	*	-	-	*						
Akshay Kumar, S. V. 2017 [25]	*	-	*	*	-	-	*						
Yadavelli, P.2023 [68]	*	-	*	*	-	-	*						
Lari, F.2022 [39]	*	-	*	*	-	-	*						
Daga, R. A.2012 [30]	*	-	*	*	*	*	*						
Salih, Y. A.2021 [47]	*	-	*	*	-	-	*						
Tang, Y.2023 [49]	*	-	*	*	-	-	*						
Bae, Ki Nam.2018 [54]	*	-	*	*	*	-	*						
Borkar, Vibhor V. 2010 [56]	*	-	*	*	*	*	*						
Devaraj, Sridevi.	*	-	*	*	-	-	*						

(T1DM)) OR (T2DM)))) AND (((((((randomized controlled trial) OR

Outcome The exposure factors of ases and controls were Non-response rate letermined by the same method * *

* *

2011 [57]							
Rodrigues, Kathryna.	*		*	*	÷		*
2019 [45]	*	-	*	*	Ŷ	-	Ť
Reddy, G. B.2015 [44]	*	-	*	*	-	-	*
Durgarao, Y.2017 [32]	*	-	*	*	-	-	*
Sarma, D.2018 [48]	*	*	*	*	-	-	*
Lin, Y. C.2019 [40]	*	*	*	*	*	*	*
Hassan, A. A.	*		*	*			*
2024 [36]	*	-	*	*	-	-	Ť
Liu, C.2018 [61]	*	-	*	*	-	-	*
Greer, Ristan M.			J.	*			ste
2013 [60]	*	-	*	*	-	-	Ť
Bayani, M. A.	*		*	*			*
2014 [28]	*	-	*	*	-	-	Ť
Wang, Y.2018 [50]	*	*	*	*	-	-	*
Saleem, S.2017 [46]	*	-	*	*	-	-	*
Majeed, M.2023 [62]	*	-	*	*	-	*	*
Esteghamati, A.	*			*			
2015 [33]	*	-	*	*	-	-	*
Alduraywish, A. A.	*		*	*			
2019 [26]	*	*	*	*	-	-	*
Rochmah, N.2022 [65]	*	-	*	*	*	*	*
Nam, Hyo-Kyoung.	*		*	*	J.		ste
2019 [64]	*	-	*	*	*	-	*
Bajaj, S.2014 [27]	*	-	*	*	-	-	*
Chen, X.2022 [14]	*	-	*	*	-	-	*
Gendy, H. I.E.		J.	*	*			ste
2019 [35]	*	Ť	*	*	-	-	Ť
El-Abd Ahmed.	*		*	*	÷		*
2019 [58]	*	-	*	*	*	-	*
Fondjo, L. A.2017 [34]	*	*	*	*	-	-	*
Mutlu Mihcioglu, Ajda.2022 [63]	*	-	*	*	-	-	*
Abd-Allah, S. H.	*		*	*			*
2014 [51]	*	-	*	*	-	-	Ť
Ziaei-Kajbaf, Tahereh.2018 [69]	*	-	*	*	*	-	*
Azab, S. F.2013 [53]	*	-	*	*	*	-	*
Wierzbicka, E.	*		*	*			*
2016 [67]	÷	-	<u>т</u>	ዮ	-	-	*
Ghandchi, Z.2012 [59]	*	-	*	*	-	*	*
Bin-Abbas, B. S.	*		ىد	*	ىك		*
2011 [55]	Ŷ	-	*	*	*	-	*

*indicates that the study meet the criterion; - indicates that the study does not meet the criterion

- *

- *

Table S3. Quality evaluation of the eligible studies with Newcastle–Ottawa scale (cohort studies)

		Selection			Compara	ability		Outcome	
Study	Representativeness of the exposed cohort	Representativeness of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	The study controls for the most important confounding factors	The study controls for any other confounding factors	Assessment of outcome	Was Follow-up long enough	Integrity of exposed and non-exposed groups
Tsur, A.2013 [23]	*	-	*	*	-	-	*	*	*
Jayashri, R.2020 [38]	*	-	*	*	-	-	*	*	*
Veronese, N. 2014 [24]	*	-	*	*	-	-	*	*	*
Husemoen, L. L. 2012 [21]	*	-	*	*	-	-	*	*	*
Pilz, S.2012 [22]	*	-	*	*	-	-	*	*	*
Fu, Yanqi.2024 [5]	*	-	*	*	-	-	*	*	*

*indicates that the study meet the criterion; - indicates that the study does not meet the criterion

Table S4. GRADE classification of quality of evidence

Table S4. GRADE c	No. of	RCTs	Cohort	Case-	Risk of bias	Inconsistence	In dias sta soo	Immediation	Publication bias	Plausible	Magnitude of	
Category	studies	KUIS	Conort	control	KISK OF DIAS	Inconsistency	Indirectness	Imprecision	Publication bias	confounding	effect	
Effects of VDD on the	risk of T2DM											
Study design												
Prospective	5	0	5	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	no	
Follow-up					115K	meonsistency	maneemess	Imprecision		reduce effect		
≥5y	3	0	3	0	no serious risk	no serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	
<5y	2	0	2	0	no serious risk	serious	no serious indirectness	serious	NA	would not reduce effect	no	
Region						5		1				
Asia	1	0	1	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	
Europe	4	0	4	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	
Sample size												
≥ 1000	4	0	4	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	
<1000	1	0	1	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	
Mean/median age												
≥ 50 y	2	0	2	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	
Mean/median BMI												
\geq 25, <30 kg/m2	2	0	2	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	
Assay method												

Assay method

Dose-response gradient	Quality
no	very low
no	low
no	very low
no	very low
no	very low
no	low
no	very low
no	very low
no	very low

CLIA	3	0	3	0	no serious risk	no serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no
RIA	2	0	2	0	no serious risk	no serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
Latitude climate zone Temperate zone	5	0	5	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	no
Effects of T1DM on the r	isk of VDD										
Study design											
Retrospective	23	0	0	23	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes
Region											
Asia	15	0	0	15	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes
Europe	2	0	0	2	no serious risk	no serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
North America	2	0	0	2	no serious risk	no serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
Africa	3	0	0	3	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes
Australia	1	0	0	1	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
Sample size						5		Ĩ			
<1000	23	0	0	23	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes
Mean/median age								-			
<50 y	23	0	0	23	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes
Mean/median BMI											
\geq 25, <30 kg/m2	2	0	0	2	no serious risk	no serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
\geq 18.5, <25 kg/m2	4	0	0	4	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
<18.5 kg/m2	9	0	0	9	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	yes
Assay method											
CLIA	7	0	0	7	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
RIA	3	0	0	3	no serious risk	no serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	yes
ELISA	6	0	0	6	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
HPLC	4	0	0	4	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no

no	low
no	very low
no	very low
no	low
no	low
no	very low
no	very low
no	very low
no	very low
no	low
no	low
no	low
no	low very low
no no no	low very low very low low very low
no no no	low very low very low low
no no no no	low very low very low low very low wery low

0									
0	0	1	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes
0	0	19	no serious	serious	no serious	no serious	undetected	would not	no
0	0	4	risk no serious	inconsistency serious	indirectness no serious	imprecision serious	NA	reduce effect would not	no
0	0	-	risk	inconsistency	indirectness	imprecision	1111	reduce effect	по
							The Egger test yielded a value of		
0	1	26							yes
			IISK	inconsistency	munectness	Imprecision	and filling method.	reduce effect	
0	1	0					NA		no
			r18K	inconsistency	indirectness	imprecision	The Enger test yielded a value of	reduce effect	
			no serious	serious	no serious	no serious	0.038, and results remained robust	would not	
0	0	26	risk	inconsistency	indirectness	imprecision	after adjustment using the trimming	reduce effect	yes
							and filling method.		
0	1	0	no serious	serious	no serious	no serious	NA	would not	no
			risk	inconsistency	indirectness	imprecision		reduce effect	
							The Egger test yielded a value of		
0	1	22	no serious	serious	no serious	no serious	0.049, and results remained robust	would not	
0	1	22	risk	inconsistency	indirectness	imprecision	after adjustment using the trimming and filling method.	reduce effect	yes
0	0	3	no serious	serious	no serious	serious	ΝA	would not	VAC
0	0	5	risk	inconsistency	indirectness	imprecision	INA	reduce effect	yes
0	0	1	no serious	serious	no serious	no serious	NA	would not	yes
-	-		risk	inconsistency	indirectness	imprecision		reduce effect	j
			no corious	sorious	no sorious	no corious		would not	
0	1	3					NA		yes
			TISK	meensisteney	maneetiiess	mpreension	The Egger test yielded a value of		
0	0	22	no serious	serious	no serious	no serious	0.024, and results remained robust	would not	
0	0	25	risk	inconsistency	indirectness	imprecision	after adjustment using the trimming	reduce effect	yes
							and filling method.		
0	0	10	no serious	serious	no serious	no serious		would not	
0	0	12	risk	inconsistency	indirectness	imprecision	undetected	reduce effect	yes
						serious	The Egger test yielded a value of		
0	0	11	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	The Egger test yielded a value of 0.014, and results remained robust after adjustment using the trimming	would not reduce effect	yes
		0 0 0 1 0 0 1 0 0 1 0 1 0 1 0 0 0 1 0 0 1	0 0 4 0 1 26 0 1 0 0 0 26 0 1 0 0 1 22 0 0 3 0 0 1 0 1 3	0019risk no serious risk004no serious risk0126no serious risk010no serious risk010no serious risk0126no serious risk0126no serious risk0126no serious risk0122no serious risk0122no serious risk013no serious risk013no serious risk013no serious risk013no serious risk013no serious risk013no serious risk	0019risk no serious riskinconsistency serious inconsistency0126no serious riskserious inconsistency0126no serious riskserious inconsistency010no serious riskserious inconsistency010no serious riskserious inconsistency010no serious riskserious inconsistency0122no serious riskserious 	0019risk no serious riskinconsistency serious inconsistencyindirectness no serious indirectness0126no serious riskserious inconsistencyno serious indirectness010no serious riskserious inconsistencyno serious indirectness010no serious riskserious inconsistencyno serious indirectness010no serious riskserious 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filling method. 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 26 no serious serious risk inconsistency risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 22 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 23<td>0 0 19 risk inconsistency indirectness imprecision oserious serious indirectness imprecision NA reduce effect would not reduce effect 0 1 26 no serious inconsistency indirectness inprecision no serious indirectness inprecision NA would not reduce effect 0 1 26 no serious inconsistency indirectness inprecision no serious inprecision NA would not reduce effect 0 1 0 no serious inconsistency indirectness inprecision no serious inprecision NA would not reduce effect 0 1 0 no serious inconsistency indirectness inprecision no serious inprecision NA would not reduce effect 0 1 0 no serious inconsistency indirectness inprecision NA would not reduce effect 0 1 0 no serious inconsistency indirectness inprecision NA would not reduce effect 0 1 0 no serious inconsistency indirectness inprecision no serious inprecision NA would not reduce effect 0 1 22 no serious inconsistency indirectness inprecision no serious inprecision NA would not reduce effect</td></td></br<>	0 0 19 risk inconsistency indirectness imprecision oserious serious indirectness imprecision indirectness serious indirectness imprecision NA 0 0 4 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 26 no serious risk inconsistency indirectness indirectness imprecision no serious indirectness imprecision The Egget test yielded a value of 0.038, and results remained robust after adjustment using the trimming and filling method. 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 26 no serious serious risk inconsistency risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 0 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 22 no serious risk inconsistency indirectness indirectness imprecision NA 0 1 23 <td>0 0 19 risk inconsistency indirectness imprecision oserious serious indirectness imprecision NA reduce effect would not reduce effect 0 1 26 no serious inconsistency indirectness inprecision no serious indirectness inprecision NA would not reduce effect 0 1 26 no serious inconsistency indirectness inprecision no serious inprecision NA would not reduce effect 0 1 0 no serious inconsistency 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no	very low	
no	very low	
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no	low	
no	very low	
no	low	
no	very low	
no	low	
no	low	
no	low	
no	low	
no	very low	

Mean/median BMI										would not reduce effect	
≥30 kg/m2	2	0	0	2	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes
\geq 25, <30 kg/m2	9	0	0	9	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
\geq 18.5, <25 kg/m2	2	0	0	2	no serious risk	no serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	yes
<18.5 kg/m2	1	0	0	1	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	yes
Assay method											
CLIA	3	0	1	2	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
RIA	2	0	0	2	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no
ELISA	12	0	0	12	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	The Egger test yielded a value of 0.004, and results remained robust after adjustment using the trimming and filling method.	would not reduce effect	yes
HPLC	4	0	0	4	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes
Latitude climate zone											
Temperate zone	17	0	0	17	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	The Egger test yielded a value of 0.038, and results remained robust after adjustment using the trimming and filling method.	would not reduce effect	yes
Tropical zone	10	0	1	9	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes

BMI:body mass index;VDD:vitamin D deficiency;T1DM:type 1 diabetes mellitus;T2DM:type 2 diabetes mellitus;NA: not available; RCTs:Randomized controlled trials; GRADE:Grades of Recommendation, Assessment, Development and Evaluation;CLIA:Chemiluminescence immunoassay method;RIA:Radioimmunoassay;ELISA:Enzyme-linked immunosorbent assay;HPLC:High Performance Liquid Chromatography;LC-MS/MS:Liquid chromatography-tandem mass spectrometry;ECLIA:Electrochemiluminescence immunoassay

no	very low
no	very low
no	moderat e
no	low
no	very low
no	very low
no	low
no	very low
no	low
no	low