Table S1. Detailed search strategy

pubmed--825
((("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 (T1DM)) OR (T2DM)))) AND (((((((randomized controlled trial) OR (randomised controlled trial)) OR (RCT)) OR (cohort)) OR (case-control)) OR (cross-sectional)) OR (clinical study))
embase--3167
(((Vitamin D Deficiency) OR (((Deficiency, Vitamin D) OR (Deficiencies, Vitamin D)) OR (Vitamin D Deficiencies))) AND ((Diabetes Mellitus) OR ((((type 1 diabetes mellitus) OR (type 2 diabetes mellitus)) OR (T1DM)) OR (T2DM)))) AND (((((((randomized controlled trial) OR (randomised controlled trial)) OR (RCT)) OR (cohort)) OR (case-control)) OR (cross-sectional)) OR (clinical study))
crochane--332
(((Vitamin D Deficiency) OR (((Deficiency, Vitamin D) OR (Deficiencies, Vitamin D)) OR (Vitamin D Deficiencies))) AND ((Diabetes Mellitus) OR ((((type 1 diabetes mellitus) OR (type 2 diabetes mellitus)) OR (T1DM)) OR (T2DM)))) AND (((((((randomized controlled trial) OR (randomised controlled trial)) OR (RCT)) OR (cohort)) OR (case-control)) OR (cross-sectional)) OR (clinical study))
web of science—3381
(((Vitamin D Deficiency) OR (((Deficiency, Vitamin D) OR (Deficiencies, Vitamin D)) OR (Vitamin D Deficiencies))) AND ((Diabetes Mellitus) OR ((((type 1 diabetes mellitus) OR (type 2 diabetes mellitus)) OR (T1DM)) OR (T2DM)))) AND (((((((randomized controlled trial) OR (randomised controlled trial)) OR (RCT)) OR (cohort)) OR (case-control)) OR (cross-sectional)) OR (clinical study))

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

Study	Selection				Comparability		Outcome		
	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 exposure factors of cases and controls were determined by the same method	Non-response rate
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.	*	-	*	*	-	-	*	*	*

2011 [57]									
Rodrigues, Kathryna. 2019 [45]	*	-	*	*	*	-	*	*	*
Reddy, G. B.2015 [44]	*	-	*	*	-	-	*	*	*
Durgarao, Y.2017 [32]	*	-	*	*	-	-	*	*	*
Sarma, D.2018 [48]	*	*	*	*	-	-	*	*	*
Lin, Y. C.2019 [40]	*	*	*	*	*	*	*	*	*
Hassan, A. A. 2024 [36]	*	-	*	*	-	-	*	*	*
Liu, C.2018 [61]	*	-	*	*	-	-	*	*	*
Greer, Ristan M. 2013 [60]	*	-	*	*	-	-	*	*	*
Bayani, M. A. 2014 [28]	*	-	*	*	-	-	*	*	*
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. 2019 [64]	*	-	*	*	*	-	*	*	*
Bajaj, S.2014 [27]	*	-	*	*	-	-	*	*	*
Chen, X.2022 [14]	*	-	*	*	-	-	*	*	*
Gendy, H. I.E. 2019 [35]	*	*	*	*	-	-	*	*	*
El-Abd Ahmed. 2019 [58]	*	-	*	*	*	-	*	*	*
Fondjo, L. A.2017 [34]	*	*	*	*	-	-	*	*	*
Mutlu Mihcioglu, Ajda.2022 [63]	*	-	*	*	-	-	*	*	*
Abd-Allah, S. H. 2014 [51]	*	-	*	*	-	-	*	*	*
Ziaei-Kajbaf, Tahereh.2018 [69]	*	-	*	*	*	-	*	*	*
Azab, S. F.2013 [53]	*	-	*	*	*	-	*	*	*
Wierzbicka, E. 2016 [67]	*	-	*	*	-	-	*	*	*
Ghandchi, Z.2012 [59]	*	-	*	*	-	*	*	*	*
Bin-Abbas, B. S. 2011 [55]	*	-	*	*	*	-	*	*	*

*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)

Study	Selection				Comparability		Outcome		
	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

Category	No. of studies	RCTs	Cohort	Case-control	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Plausible confounding	Magnitude of effect	Dose-response gradient	Quality
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	no	very low
Follow-up													
≥5y	3	0	3	0	no serious risk	no serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	no	low
＜5y	2	0	2	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
Region													
Asia	1	0	1	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
Europe	4	0	4	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	no	very low
Sample size													
≥ 1000	4	0	4	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	no	low
＜1000	1	0	1	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
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	no	very low
Mean/median BMI													
≥25，＜30 kg/m2	2	0	2	0	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
Assay method													

CLIA	3	0	3	0	no serious risk	no serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	no	low
RIA	2	0	2	0	no serious risk	no serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
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	no	very low
Effects of T1DM on the risk 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	no	low
Region													
Asia	15	0	0	15	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes	no	low
Europe	2	0	0	2	no serious risk	no serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
North America	2	0	0	2	no serious risk	no serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
Africa	3	0	0	3	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes	no	very low
Australia	1	0	0	1	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
Sample size													
＜1000	23	0	0	23	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes	no	low
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	no	low
Mean/median BMI													
≥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	no	very low
≥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	no	very low
＜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	no	low
Assay method													
CLIA	7	0	0	7	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
RIA	3	0	0	3	no serious risk	no serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	yes	no	moderate
ELISA	6	0	0	6	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
HPLC	4	0	0	4	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low

LC-MS/MS	1	0	0	1	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes	no	very low
Latitude climate zone													
Temperate zone	19	0	0	19	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	no	no	very low
Tropical zone	4	0	0	4	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
Effects of T2DM on the risk of VDD													
total	27	0	1	26	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	no	low
Study design													
Prospective	1	0	1	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	no	very low
Retrospective	26	0	0	26	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	no	low
Follow-up													
≥ 5 y	1	0	1	0	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	no	no	very low
Region													
Asia	23	0	1	22	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	The Egger test yielded a value of 0.049, and results remained robust after adjustment using the trimming and filling method.	would not reduce effect	yes	no	low
Africa	3	0	0	3	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes	no	very low
South America	1	0	0	1	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	yes	no	low
Sample size													
≥ 1000	4	0	1	3	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	NA	would not reduce effect	yes	no	low
＜1000	23	0	0	23	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	The Egger test yielded a value of 0.024, and results remained robust after adjustment using the trimming and filling method.	would not reduce effect	yes	no	low
Mean/median age													
≥ 50 y	12	0	0	12	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes	no	low
＜50 y	11	0	0	11	no serious risk	serious inconsistency	no serious indirectness	serious imprecision 0.001	The Egger test yielded a value of 0.014, and results remained robust after adjustment using the trimming and filling method.	would not reduce effect	yes	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	no	very low
≥25，＜30 kg/m2	9	0	0	9	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
≥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	no	moderate
＜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	no	low
Assay method													
CLIA	3	0	1	2	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
RIA	2	0	0	2	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	no	no	very low
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	no	low
HPLC	4	0	0	4	no serious risk	serious inconsistency	no serious indirectness	serious imprecision	NA	would not reduce effect	yes	no	very low
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	no	low
Tropical zone	10	0	1	9	no serious risk	serious inconsistency	no serious indirectness	no serious imprecision	undetected	would not reduce effect	yes	no	low

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