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基于国家基本公共卫生服务体检的中老年人2型糖尿病风险预测模型构建*

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【摘要】 **目的** 利用基本公共卫生服务体检数据，通过Meta分析构建普适于中老年人群的2型糖尿病（diabetes mellitus type 2, T2DM）logistic函数风险预测模型。**方法** 模型构建：计算机检索中英文数据库关于T2DM危险因素的队列研究，Meta合并危险因素效应值（odds ratio, OR），转换为logistic函数的偏回归系数β；常数项α通过合并各队列研究的发病率进行估计。模型验证：使用受试者操作特征（receiver operator characteristic, ROC）曲线，以成都市某社区卫生服务中心2017年–2022年7 602名初次体检未患T2DM者的基公卫体检随访数据验证模型预测效果。**结果** 危险因素Meta分析具有统计学意义的基公卫体检条目有10个，来自40项队列研究，分别为年龄、中心性肥胖、吸烟、缺乏运动、空腹血糖受损、低高密度脂蛋白胆固醇（high-density lipoprotein cholesterol, HDL-C）、高血压、体质量指数（body mass index, BMI）、甘油三酯-葡萄糖（triglyceride glucose, TYG）指数和糖尿病家族史，OR（95%置信区间）为1.04（1.03, 1.05）、1.55（1.29, 1.88）、1.36（1.11, 1.66）、1.26（1.07, 1.49）、3.93（2.94, 5.24）、1.14（1.06, 1.23）、1.47（1.34, 1.61）、1.11（1.05, 1.18）、2.15（1.75, 2.62）、1.66（1.55, 1.78）；37项研究报告了发病率，合并发病率（95%置信区间）为0.08（0.07, 0.09），常数α为－2.442。将构建的T2DM风险预测模型在7 602例基公卫体检数据中进行外部验证，曲线下面积（95%置信区间）为0.794（0.771, 0.816）。**结论** 利用基公卫健康体检数据构建的T2DM风险预测模型具有较好的预测性能，可作为中老年人群T2DM风险预测的实用工具。

【关键词】 2型糖尿病　风险预测　基本公共卫生服务　中老年人群

Construction of a Predictive Model for Diabetes Mellitus Type 2 in Middle-Aged and Elderly Populations Based on the Medical Checkup Data of National Basic Public Health Service

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【**Abstract**】 **Objective** To establish a universally applicable logistic risk prediction model for diabetes mellitus type 2 (T2DM) in the middle-aged and elderly populations based on the results of a Meta-analysis, and to validate and confirm the efficacy of the model using the follow-up data of medical check-ups of National Basic Public Health Service. **Methods** Cohort studies evaluating T2DM risks were identified in Chinese and English databases. The logistic model utilized Meta-combined effect values such as the odds ratio (OR) to derive β, the partial regression coefficient, of the logistic model. The Meta-combined incidence rate of T2DM was used to obtain the parameter α of the logistic model. Validation of the predictive performance of the model was conducted with the follow-up data of medical checkups of National Basic Public Health Service. The follow-up data came from a community health center in Chengdu and were collected between 2017 and 2022 from 7 602 individuals who did not have T2DM at their baseline medical checkups done at the community health center. This community health center was located in an urban-rural fringe area with a large population of middle-aged and elderly people. **Results** A total of 40 cohort studies were included and 10 items covered in the medical checkups of National Basic Public Health Service were identified in the Meta-analysis as statistically significant risk factors for T2DM, including age, central obesity, smoking, physical inactivity, impaired fasting glucose, a reduced level of high-density lipoprotein cholesterol (HDL-C), hypertension, body mass index (BMI), triglyceride glucose (TYG) index, and a family history of diabetes, with the OR values and 95% confidence interval (CI) being 1.04 (1.03, 1.05),

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1.55 (1.29, 1.88), 1.36 (1.11, 1.66), 1.26 (1.07, 1.49), 3.93 (2.94, 5.24), 1.14 (1.06, 1.23), 1.47 (1.34, 1.61), 1.11 (1.05, 1.18), 2.15 (1.75, 2.62), and 1.66 (1.55, 1.78), respectively, and the combined β values being 0.039, 0.438, 0.307, 0.231, 1.369, 0.131, 0.385, 0.104, 0.765, and 0.507, respectively. A total of 37 studies reported the incidence rate, with the combined incidence being 0.08 (0.07, 0.09) and the parameter α being -2.442 for the logistic model. The logistic risk prediction model constructed based on Meta-analysis was externally validated with the data of 7602 individuals who had medical checkups and were followed up for at least once. External validation results showed that the predictive model had an area under curve (AUC) of 0.794 (0.771, 0.816), accuracy of 74.5%, sensitivity of 71.0%, and specificity of 74.7% in the 7602 individuals. **Conclusion** The T2DM risk prediction model based on Meta-analysis has good predictive performance and can be used as a practical tool for T2DM risk prediction in middle-aged and elderly populations.

【Key words】 Diabetes mellitus, Type 2　Risk prediction　Basic public health service　Middle-aged and elderly populations

在全球范围内，2型糖尿病（diabetes mellitus type 2, T2DM）的发病率不断上升，每年有100多万人死于糖尿病，为全球第九大死因，是全球公共卫生领域关注的重要疾病[1]。随着人口老龄化和不良行为生活方式的增加，我国糖尿病患病率从2013年的10.9%增至2018 年的12.4%，且中老年人占比较高[2]。国家基本公共卫生服务（以下简称基公卫）具有均等化、可及性高的优点，其中每年一次的老年人和慢病患者健康体检是基层防控T2DM的重要途径。目前基公卫体检存在仅关注体检本身、忽略健康全程管理、缺乏个性化健康教育和反馈的局限[3]。有研究表明，参与老年体检者对体检报告解读、体检后健康宣教指导等需求未得到满足[4]。通过控制疾病主要危险因素预防和控制慢性病，提高居民健康水平，是基公卫服务的目标之一，但目前基层的糖尿病管理主要针对血糖异常者，没有实现T2DM防控关口前移。

目前对T2DM危险因素的研究全面，涵盖人口学特征、行为生活方式和临床生化指标，为糖尿病风险预测提供了基础[5-6]，但在不同研究中危险因素的风险值存在差异。现有的T2DM风险预测模型多是基于特定人群队列研究[7-8]，其代表性和外推性没有得到验证。本研究期望使用基公卫体检数据构建普遍适用的中老年人T2DM发病风险预测模型，综合T2DM危险因素计算个体的发病风险，形成实用的风险评价工具，识别高危人群，实现早期干预和健康连续管理，为T2DM防控提供科学指导，提高居民的健康水平。

1　资料与方法

1.1　确定危险因素

1.1.1　文献检索策略

计算机检索CNKI、WanFang Data、VIP、SinoMed、PubMed 、EMbase、Web of Science、Cochrane Library等数据库关于T2DM危险因素的大样本队列研究。中文检索词为“2型糖尿病、队列研究、风险模型、风险预测、危险因素”；英文检索词为“type 2 diabetes/prospective study/predictive model/cohort study/predictor/risk factor”。主题词与关键词相结合进行检索，检索期限为2010年1月1日–2023年5月30日，语种仅限中、英文。

1.1.2　文献纳排标准

纳入标准：①样本量1 000及以上的队列研究或基于队列研究开展的T2DM发病风险预测模型；②T2DM诊断标准明确；③提供危险因素的风险比（hazard ratio, HR）/相对危险度（relative risk, RR）/比值比（odds ratio, OR）及95%置信区间（confidence interval, CI）；④研究对象为成年或中老年人群，且基线时无糖尿病；⑤对同一危险因素变量的定义及量化基本一致。排除标准：①T2DM诊断标准不明确；②关于细胞、分子或基因型的研究；③动物研究；④研究对象为婴幼儿、青少年、孕妇等特殊人群的研究。

1.1.3　数据提取与危险因素效应值Meta分析

由2名研究者独立完成文献筛选，交叉核仍有分歧则交由第3位评价者裁决。提取文献基本信息和危险因素的HR/RR/OR及其95%CI并进行质量评价，纳入中等及以上质量研究。使用Stata17.0对危险因素风险值和发病率进行Meta分析并进行异质性检验。若I^2>50%，研究间存在异质性，使用随机效应模型；如果I^2≤50%，认为研究间不存在异质性，采用固定效应模型。P<0.05具有统计学意义，纳入模型构建。

1.2　模型验证对象

1.2.1　验证对象来源

模型验证对象来自成都市郫都区红光街道，该地区城镇和农村片区占比相当，且中老年人口数量大，其基本公共卫生服务人口数量有19万余人，基公卫慢病和老年人健康体检参与率高。研究人群的纳入标准如下：①中年及老年人群；②2017–2022年期间至少参与两次体检；

③首次基公卫体检未患T2DM;④血液学检查、体格检查等体检病历资料完善。排除标准:①妊娠妇女;②恶性肿瘤、严重精神障碍疾病患者。

1.2.2 糖尿病诊断及生存时间

由四川省卫生健康信息中心病案首页和社区卫生服务中心基公卫健康体检数据共同判断T2DM诊断情况。基公卫T2DM诊断:①健康体检诊断;②疾病筛查诊断;③临床诊断;④患者自报,长期服用T2DM治疗药物。生存时间为首次体检至首诊T2DM或失访所间隔的时间。

1.3 模型构建及验证

在验证数据中计算各危险因素的方差膨胀因子(VIF),其值小于10为没有共线性。将排除共线性所筛选的危险因素作为自变量,T2DM的发生概率为因变量构建logistic函数风险预测模型:$Logit(P)=Ln\left(\frac{P}{1-P}\right)=\alpha+\beta_1x_1+\beta_2x_2+\cdots\cdots\beta_nx_n$。$x_n$表示第$n$个危险因素,分类变量取值0或1,定量变量取值$x\sim x^*$,$x^*$为起始值,该为危险因素对应Meta文献的均值减去标准差均值;β_n表示第n个危险因素的偏回归系数,由Meta汇总的OR转换;常数项α由Meta所得的T2DM发生率P_e估计:$\alpha=\text{Ln}\frac{P_e}{(1-P_e)}$。

模型验证及共线性检验使用R4.2.1软件。绘制受试者工作特征(receiver operator characteristic, ROC)曲线,计算曲线下面积(area under curve, AUC)及其95%CI,最佳截断值及其灵敏度、特异度、准确度,评价模型的预测能力。$P<0.05$为差异有统计学意义。

2 结果

2.1 文献筛选及Meta分析结果

文献筛选流程见图1。初检到1 154篇,经阅读排除T2DM诊断不明确、研究对象非成年人等文献1 083篇,最终纳入71篇文献进行Meta分析。有37篇文献报告了T2DM发病率,合并发病率Pe(95%CI)为0.08(0.07,0.09)。经分析后共有13个危险因素OR值有统计学意义(表1),因国家基本公共卫生服务体检项目中不含餐后2 h血糖、糖化血红蛋白和脂肪肝等3个指标,故我们进行模型验证时只纳入了10个危险因素。

2.2 模型的构建及验证

2.2.1 验证对象基本特征

首次体检未患T2DM的体检者有7 602名,年龄为43~102岁,平均年龄(69.83±5.54)岁(基本信息见表2)。2017–2022年随访期间,有434人(5.71%)诊断T2DM,平均随访时间3.1年。

2.2.2 危险因素确定及模型构建

用10个危险因素单独预测T2DM(表3),AUC从大至小依次为TYG、空腹血糖受损、BMI、中心性肥胖、高血压、家族史、年龄、低HDL-C、缺乏运动和吸烟,将AUC<0.5的吸烟排除。对剩余9个危险因素进行共线性

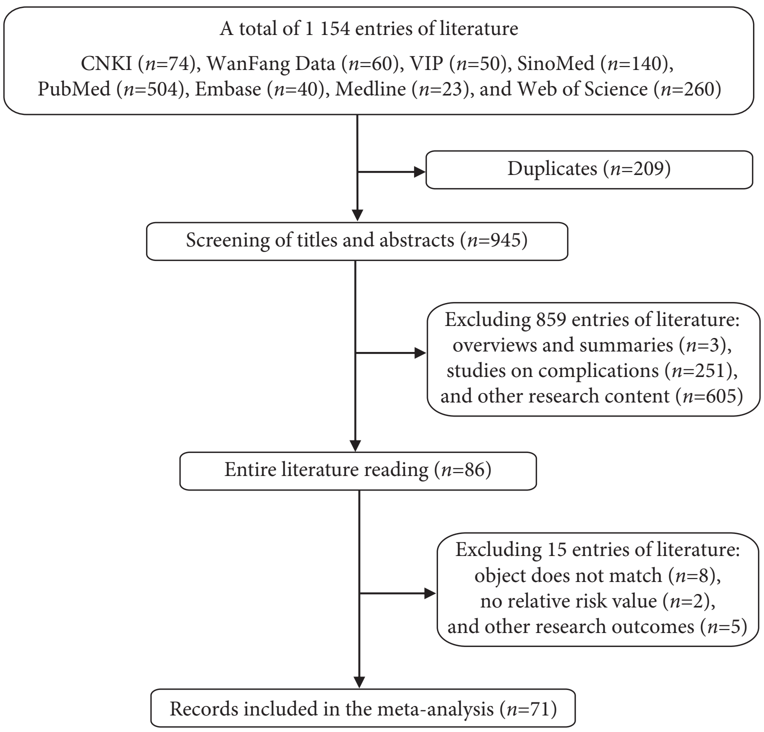

图 1 文献筛选流程图

Fig 1 Process of literature selection

表 1 T2DM危险因素OR值的Meta分析及异质性检验结果

Table 1 Meta analysis and heterogeneity test results of the OR values of risk factors for T2DM

Risk factor*	Study number	Heterogeneity test		Effect model	OR (95% CI)	β	Overall test (P)
		I^2/%	P				
Age[7, 9-27]	19	95.2	<0.001	Random	1.04 (1.03, 1.05)	0.039	<0.001
Hypertension[7, 11-12, 18, 22, 28-38]	18	76.6	<0.001	random	1.47 (1.34, 1.61)	0.385	<0.001
Family history of diabetes[7, 10- 11, 17, 19, 23, 28-29, 33-34, 39-40]	13	33.0	0.118	Fixed	1.66 (1.55, 1.78)	0.507	<0.001
Central obesity[10-11, 18, 29, 31-33, 35, 41]	9	97.9	<0.001	Random	1.55 (1.29, 1.88)	0.438	<0.001
Smoking[10-11, 13-14, 23, 28, 30, 32, 39, 42]	10	89.6	<0.001	Random	1.36 (1.11, 1.66)	0.307	0.003
BMI[7, 14, 16, 25-27, 40, 43]	9	96.3	<0.001	Random	1.11 (1.05, 1.18)	0.104	<0.001
TYG index[16, 22, 39, 42, 44-47]	5	89.4	<0.001	Random	2.15 (1.75, 2.62)	0.765	<0.001
Impaired fasting glucose[11, 14, 31, 37]	4	89.0	<0.001	Random	3.93 (2.94, 5.24)	1.369	<0.001
Lack of exercise[10, 13, 14, 29, 42]	5	0	0.508	Fixed	1.26 (1.07, 1.49)	0.231	0.005
Reduced HDL-C[10-11, 32, 37]	5	21.2	0.276	Fixed	1.14 (1.06, 1.23)	0.131	0.001
2 h PG[10, 17, 20-21]	4	96.8	<0.001	Random	1.15 (1.07, 1.23)	0.140	<0.001
HbA1c[10, 21-22, 24]	4	98.9	<0.001	Random	2.53 (1.76, 3.65)	0.928	<0.001
Fatty liver[14, 24, 48, 49]	4	80.4	0.002	Random	2.29 (1.66, 3.15)	0.829	<0.001

* Hypertension: clear diagnosis by a physician or long-term use of hypertension medication. Family history of diabetes: at least one first-degree relative suffering from diabetes. Central obesity: waist circumference ⩾90 cm for males and ⩾80 cm for females. Smoking: previously or currently smoking. BMI: body mass index. TYG index: triglyceride glucose index. Impaired fasting glucose: fasting plasma glucose (FPG) ⩾5.6 mmol/L. Lack of exercise: no active exercise (activities that are consciously carried out to strengthen the body according to the third edition of the National Basic Public Health Service Standards). Reduced high density lipoprotein cholesterol (HDL-C): HDL-C<1:03 mmol/L (40 mg/dL) in men and <1.29 mmol/L (50 mg/dL) in women.

表 2 7 602名模型验证对象基本信息

Table 2 Basic information of 7 602 subjects for model verification

Characteristic	T2DM		Total (n=7 602)	P
	No (n=7 168)	Yes (n=434)		
Survival time/month	37.9±18.3	26.6±16.2	37.3±18.4	<0.001
Age/yr.	69.8±5.5	70.2±5.5	69.8±5.5	0.031
Age group				
40-50 yr.	5 (83.3%)	1 (16.67%)	6 (0.08%)	
>50-60 yr.	19 (95%)	1 (5%)	20 (0.26%)	
>60-70 yr.	4 269 (94.78%)	235 (5.22%)	4 504 (59.23%)	
>70-80 yr.	2 381 (93.34%)	170 (6.66%)	2 551 (33.56%)	
>80 yr.	494 (94.82%)	27 (5.18%)	521 (6.85%)	0.061
TYG index	8.6±0.5	9.1±0.6	8.6±0.6	<0.001
BMI/(kg/m^2)	24±3.2	25.8±3.7	24.1±3.2	<0.001
Gender				0.597 2
Male	3 276 (94.14%)	204 (5.86%)	3 480 (45.78%)	
Female	3 892 (94.42%)	230 (5.58%)	4 122 (54.22%)	
Central obesity				<0.001
No	3 692 (96.78%)	123 (3.22%)	3 815 (50.18%)	
Yes	3 476 (91.79%)	311 (8.21%)	3 787 (49.82%)	
Smoking				0.602
No	5 069 (94.20%)	312 (5.80%)	5 381 (70.78%)	
Yes	2 099 (94.51%)	122 (5.49%)	2 221 (29.22%)	
Lack of exercise				0.013
No	5 917 (94.60%)	338 (5.40%)	6 255 (82.28%)	
Yes	1 251 (92.87%)	96 (7.13%)	1 347 (17.72%)	
Impaired fasting glucose				<0.001
No	5 561 (97.37%)	150 (2.63%)	5 711 (75.12%)	
Yes	284 (15.02%)	1 607 (84.98%)	1 891 (24.88%)	
Reduced HDL-C				<0.001
No	6 229 (94.67%)	351 (5.33%)	6 580 (86.56%)	
Yes	939 (91.88%)	83 (8.12%)	1 022 (13.44%)	
Hypertension				<0.001
No	5 210 (95.54%)	243 (4.46%)	5 453 (71.73%)	
Yes	1 958 (91.11%)	191 (8.89%)	2 149 (28.27%)	
Family history of diabetes				0.002
No	5 332 (94.77%)	294 (5.23%)	5 626 (74.01%)	
Yes	1 836 (92.91%)	140 (7.09%)	1 976 (25.99%)	

The abbreviations are explained in the note to Table 1.

表 3 不同危险因素对T2DM单独预测能力及共线性检验

Table 3 Individual predictive ability and collinearity test of different risk factors for T2DM

Risk factor	Predictive ability		Collinearity test value of VIF
	AUC (95% CI)	*P*	
Age	0.531 (0.503, 0.558)	0.016	1.039
BMI	0.654 (0.627, 0.682)	<0.001	1.477
TYG index	0.723 (0.698, 0.748)	<0.001	1.156
Central obesity	0.616 (0.594, 0.638)	<0.001	1.425
Smoking	0.494 (0.011, 0.472)	0.301	–
Lack of exercise	0.523 (0.503, 0.543)	0.007	1.011
Impaired fasting glucose	0.715 (0.692, 0.738)	<0.001	1.116
Reduced HDL-C	0.530 (0.511, 0.549)	<0.001	1.032
Hypertension	0.583 (0.560, 0.607)	<0.001	1.044
Family history of diabetes	0.533 (0.511, 0.556)	0.001	1.010

The abbreviations are explained in the note to Table 1.

检验，VIF均小于10，提示无共线性，纳入模型构建。

风险预测模型常数项$\alpha=\mathrm{Ln}\frac{P_c}{(1-P_c)}=-2.442$。年龄、BMI和TYG指数以定量变量纳入模型，起始值为对应Meta文献的均数与标准差之差的均值，分别为33、19和7.8。logistic函数风险预测模型为：Logit(*P*)=−2.442+0.039(年龄−33)+0.438中心性肥胖+0.231缺乏运动+1.369空腹血糖受损+0.131低HDL-C+0.385高血压+0.104(BMI−19)+0.765(TYG指数−7.8)+0.507糖尿病家族史。

2.2.3 与经典模型比较

将本研究构建的模型与Framingham的T2MD风险预测模型分别在7 602名基公卫体检人群中外部验证，本研究风险预测模型AUC为0.794(0.771, 0.816)，较Framingham模型的0.733(0.708, 0.757)高(表4、图2)。

表 4 本研究logistic模型与Framingham模型预测能力对比结果

Table 4 Comparison between the logistic model and the Framingham model

Model	AUC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	Youden index	Accuracy	Cutoff value
Logistic model	0.794 (0.771, 0.816)	0.710 (0.667, 0.752)	0.747 (0.737, 0.757)	0.457	0.745	0.830
Framingham model*	0.733 (0.708, 0.757)	0.654 (0.610, 0.699)	0.777 (0.767, 0.786)	0.431	0.770	0.035

* Framingham risk prediction model includes risk factors such as age, BMI, high-density lipoprotein cholesterol (HDL-C), fasting blood glucose, triglycerides (TG), and hypertension.

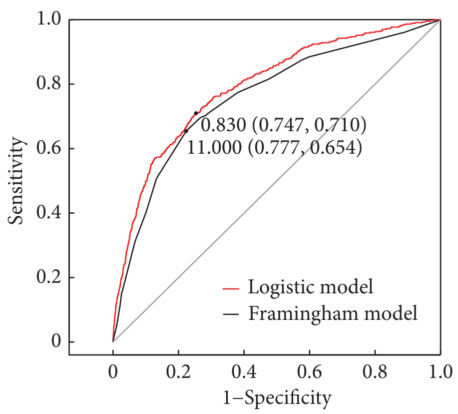

图 2 本研究logistic模型与Framingham模型ROC曲线

Fig 2 ROC curves of the logistic model and the Framingham model

The point on the curve is the location of the best cutoff value and the value refer to cutoff value (specificity and sensitivity).

2.2.4 风险等级划分

结果见图3。以发病风险最佳截断值(0.830)和中位数(0.705)划分风险组别，低、中、高风险组各有3 805人、

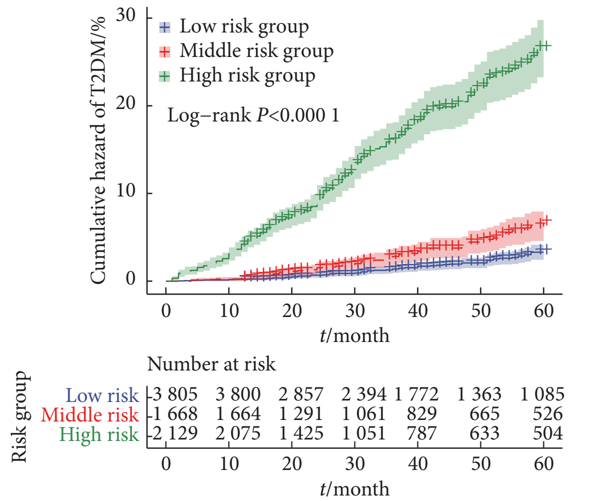

图 3 各风险组累计风险函数及风险表

Fig 3 The cumulative hazard and the risk table for each risk group

According to the ROC curve, risk groups were divided according to the best cutoff value (0.830) and median value (0.705).

1 668人和2 129人，各有65人（1.71%）、61人（3.66%）、308人（14.47%）发病。与低风险组相比，中风险组和高风险组T2DM发病的RR（95%CI）分别为2.06（1.46，2.91）和8.47（6.51，11.01），均具有统计学意义（$P<0.001$）。绘制各风险组的累积风险函数，差异有统计学意义（$P<0.001$）。

3　讨论

T2DM患病率呈现增长趋势，它具有不可痊愈的特征，会引起多种并发症，给医疗系统和社会带来巨大的经济负担[50]。因此有必要针对T2DM的危险因素采取预防措施。

随着社会经济的发展，行为生活方式等危险因素在人群中的暴露随时间而变化，本研究通过检索2010年之后的研究，基于40项队列研究对T2DM风险因素进行了Meta分析，扩大了样本量，提高了风险预测模型中各危险因素及其危险度的代表性。Meta分析共确定了10个危险因素，其中吸烟、BMI、腰围和运动可通过改变行为生活方式调节，提示健康行为生活方式和肥胖管理是预防T2DM的重要措施。

文江平等[7]构建的中国成年人T2DM预测模型所含的危险因素有年龄、BMI、腰围、糖尿病家族史、FPG和TG，与本研究通过Meta筛选的危险因素与之基本一致。肥胖存在明显的种族差异，有研究表明在给定的BMI下，亚洲人内脏脂肪率较欧洲人高[51]，且腹部脂肪堆积是造成代谢性疾病的独立危险因素[52-53]。在亚洲人群中，腹部脂肪与T2DM的风险联系更普遍[51, 54-55]。本研究将BMI和中心性肥胖两个肥胖指标在排除共线性的前提下，同时纳入预测模型，符合中国人群的肥胖指标的特征。吸烟在本研究中对T2DM没有单独预测作用，原因可能是本研究的预测模型未区分性别，但吸烟存在明显的性别差异[56]，本研究男性吸烟率为61.2%，女性吸烟率为2.2%，有研究表明女性吸烟糖尿病不存在显著关联[57]，从而在全人群中预测能力弱。胰岛素抵抗是T2DM发生的关键环节，综合了血糖和血脂的TYG指数是评估胰岛素抵抗的可靠指标[58-59]，本研究中该指标也呈现出对T2DM有较好的预测能力。

张红艳等[60]以年龄、睡眠时间、BMI、腰围和高血压作为预测因子构建的T2DM预测模型，在验证组的AUC为0.66，与之相比，本研究预测模型增加了部分基公卫体检指标，在验证人群中AUC为0.794，预测能力有所提升。Framingham的T2DM风险预测模型在欧洲人群中AUC为0.852[8]，但在本研究中国人群进行外部验证，ACU仅为0.733，原因可能是其危险因素截断值的划分及效应值与中国人群存在差异。

国家基本公共卫生服务项目开展以来，全国老年人健康体检的参与率在逐步增加[61]。本研究构建的T2DM预测模型紧密结合了基公卫老年健康体检条目和指标，提高了基公卫体检数据利用的及时性，可广泛应用于体检人群。区别于单一反馈体检报告异常指标，综合了多危险因素评估的T2DM风险，可帮助医务工作者综合了解体检者健康状况并提供精准化的健康指导，也可帮助中老年体检人群了解自身患病风险，根据危险因素阳性条目，采取精准防控措施。

该模型依然存在一些不足。首先，基公卫体检缺少饮食、睡眠等部分重要的预测因子。例如糖化血红蛋白（HbA1c）是监测总体血糖的黄金标准，但基公卫体检缺少该检查指标。后续研究可从卫生经济学等方面探索基公卫慢病和老年健康体检是否有必要扩展该血糖指标。其次，本研究T2DM诊断由临床诊断和疾病自报共同确定，可能与真实发病存在差异。在模型预测效能的评价方面，由于本研究的验证人群老年人口占比较大，在其他年龄层的预测效能研究待完善，模型的推广可能受限。最后，不同研究对同一危险因素的定义存在些许差异，如纳入的研究对缺乏运动的定义不同，但整体的量化方向一致，本研究为了便于模型在基层基公卫服务中的应用，采用《国家基本公共卫生服务服务规范（第三版）》的定义[62]。该模型若投入使用，还需规范地完善健康指导建议的具体内容。

总体而言，本研究基于Meta分析构建的T2DM风险预测模型具有较好的预测性能，在基公卫人群中应用可能性和覆盖面广泛，为中老年人群T2DM风险预测提供了一个实用的工具，可为T2DM的预防及干预措施的制定提供参考。

*　　*　　*

作者贡献声明　杨会芳负责论文构思、数据审编、正式分析、研究方法和初稿写作，袁璐和吴结凤负责提供资源和监督指导，李星月负责数据审编和正式分析，龙璐负责验证和审读与编辑写作，滕屹霖和冯琬婷负责调查研究和研究方法，吕良负责数据审编和调查研究，许彬负责研究项目管理，马天佩和肖金雨负责数据审编，周丁子负责经费获取、研究方法和审读与编辑写作，李佳圆负责论文构思、经费获取和审读与编辑写作。所有作者已经同意将文章提交给本刊，且对将要发表的版本进行最终定稿，并同意对工作的所有方面负责。

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editing. LI Jiayuan is responsible for conceptualization, funding acquisition, and writing--review and editing. All authors consented to the submission of the article to the Journal. All authors approved the final version to be published and agreed to take responsibility for all aspects of the work.

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