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# Risk Score for Detecting Dysglycemia: A Cross-Sectional Study of a Working-Age Population in an Oil Field in China

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Data Interpretation D  
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**Background:** Dysglycemia (pre-diabetes or diabetes) in young adults has increased rapidly. However, the risk scores for detecting dysglycemia in oil field staff and workers in China are limited. This study developed a risk score for the early identification of dysglycemia based on epidemiological and health examination data in an oil field working-age population with increased risk of diabetes.





**Material/Methods:** Multivariable logistic regression was used to develop the risk score model in a population-based, cross-sectional study. All subjects completed the questionnaires and underwent physical examination and oral glucose tolerance tests. The performance of the risk score models was evaluated using the area under the receiver operating characteristic curve (AUC).

**Results:** The study population consisted of 1995 participants, 20–64 years old (49.4% males), with undiagnosed diabetes or pre-diabetes who underwent periodic health examinations from March 2014 to June 2015 in Dagang oil field, Tianjin, China. Age, sex, body mass index, history of high blood glucose, smoking, triglyceride, and fasting plasma glucose (FPG) constituted the Dagang dysglycemia risk score (Dagang DRS) model. The performance of Dagang DRS was superior to m-FINDRISC (AUC: 0.791; 95% confidence interval (CI), 0.773–0.809 vs. 0.633; 95% CI, 0.611–0.654). At the cut-off value of 5.6 mmol/L, the Dagang DRS (AUC: 0.616; 95% CI, 0.592–0.641) was better than the FPG value alone (AUC: 0.571; 95% CI, 0.546–0.596) in participants with FPG <6.1 mmol/L (n=1545, P=0.028).

**Conclusions:** Dagang DRS is a valuable tool for detecting dysglycemia, especially when FPG <6.1 mmol/L, in oil field workers in China.

**MeSH Keywords:** **Diabetes Mellitus • Oil and Gas Fields • Physical Examination • Primary Prevention**

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## Background

According to the data from the International Diabetes Federation (IDF), worldwide, approximately 415 million adults aged 20–79 years are estimated to have diabetes, 320.5 million (77.23%) of which are in the working-age (20–64 years) population [1]. The diabetes epidemic is accelerating in young adults [2]. The IDF Diabetes Atlas (7<sup>th</sup> edition) predicts a 35% increase in the number of adults with type 2 diabetes mellitus (DM2) from 2015 to 2040 [1]. In China, a large epidemiological survey indicated a sustained growth in prevalence of diabetes, from 9% in 2007–2008 [3] to 11.6% in 2010 [4]. Surprisingly, the prevalence of pre-diabetes was estimated to be 50.1% [4]. Recent studies suggested that dysglycemia, including pre-diabetes and diabetes, affects the brain structure and cognition, as well as the lifespan of the elderly [5]. Moreover, dysglycemia is also associated with increased cardiovascular disease morbidity and mortality [6]. Tanner has systematically evaluated the importance of treating dysglycemia to delay onset of diabetes [7].

A recent study found several type 2 diabetes genetic susceptibility variants, such as KCNQ1 (rs2237892) and AP3S1 (rs3756555), in the northern Han Chinese population [8]. Benzene, a major pollutant affecting oil field workers, is closely related to the occurrence of diabetes [9]. Therefore, the risk of diabetes may be higher for oil field workers than for the general population. Furthermore, decreased insulin sensitivity not only occurs in patients with diabetes and pre-diabetes, but also in people with high-normal fasting glucose (high-NFG), compared to the low-normal fasting glucose group, which represents earlier glucoregulatory perturbations [10]. Taken together, these factors necessitate the early screening of dysglycemia in oil field workers.

The risk scores for diabetes that have been widely tested in 32 countries around the world are practical, feasible, and cost-effective [1]. Among these methods, the Finnish diabetes risk score (FINDRISC) and its modified version (m-FINDRISC) are well-known and have been widely validated in various countries and regions [11–14]. However, there are few score systems specifically designed for detecting dysglycemia in oil fields workers.

In this study, we aimed to develop a risk score model and evaluate its performance. The model was based on the epidemiological and health examination data for detecting dysglycemia in an oil field working-age population with increased risk of diabetes. This new method was designed for early recognition and intervention in individuals who are still in the pre-diabetic stage or even pre-pre-diabetes.

## Material and Methods

### Study design and subjects

The present study was a cross-sectional survey of the Dagang oil field population, aged 20–64 years, from March 2014 to June 2015 in Tianjin, China. The sample was obtained by cluster random sampling technique to identify the study subjects from more than 30 companies and institutions encompassing various professions (e.g., geographical mapping, geological exploration, oil production, new energy production, water and electricity sector, logistic services, and medical care) in the Dagang oilfield. The subjects were requested to complete an m-FINDRISC questionnaire in the first interview. The monomial and general scores (Table 1) were obtained through their self-assessment at the Dagang Oil Field General Hospital Medical Examination Center with guidance from rigorously trained nurses. Those with a family history of diabetes, or without diabetes but who had a score  $\geq 5$  points, were defined as the increased-risk diabetes populations to be enrolled. Those enrolled were subjected to routine physical examination and completed anthropometric measurements and biochemical tests, including fasting plasma glucose (FPG). A second exam for oral glucose tolerance test (OGTT) was conducted according to the international criteria [15]. A 5-mL blood sample was withdrawn at 120 min from the beginning of the OGTT and tested for 2-h post-load plasma glucose (2h-PPG) at the earliest. From a total of 2373 subjects, those with incomplete baseline data ( $n=325$ ) for different parameters in various work units, males aged  $\geq 65$  years ( $n=7$ ), females aged  $\geq 55$  years ( $n=44$ ), and pregnant women ( $n=2$ ) were excluded. Finally, 1995 subjects were selected and classified into normal a glucose tolerance (NGT) group and a dysglycemia group according to OGTT. Data collected from each participant included m-FINDRISC risk parameters, anthropometric estimations, and laboratory measurements. The Ethics Committee of the Dagang Oil Field General Hospital (Tianjin, China) approved the study and written informed consent was obtained from all participants.

### Variables and data collection

#### *m-FINDRISC*

The present study used the m-FINDRISC questionnaire, which was modified according to the Finnish DRS [16], assessing only 6 variables that are clearly correlated with the risk of DM2: age, body mass index (BMI), waist circumference (WC), hypertension history and current antihypertensive medication, personal history of high blood glucose, and family history of DM2. The frequency of fruit and vegetable consumption, as well as physical activity, were not included owing to the uncertainty of not being a controlled prospective study. The variables were

**Table 1.** Characteristics of the study population stratified by OGTT and points assigned by the modified Finnish diabetes risk score in Da Gang oil field, Tianjin, North China (2014.3–2015.6).

	All		NGT		Dysglycemia		P-value	m-FINDRISC
Total (n/score)	1995		1219		776			21
Sex: Female	1,010	(50.6%)	697	(57.2%)	313	(40.3%)	<0.001	–
FHD: Yes	1,268	(63.6%)	811	(66.5%)	457	(58.9%)	0.001	4
HHT: Yes	128	(6.4%)	53	(4.3%)	75	(9.7%)	<0.001	2
HHBG: Yes	153	(7.7%)	65	(5.3%)	88	(11.3%)	<0.001	5
Smoking: Yes	559	(28.0%)	273	(22.4%)	286	(36.9%)	<0.001	–
Age (years)							<0.001	
<45	1,097	(55.0%)	744	(61.0%)	353	(45.5%)		0
45–54	739	(37.0%)	424	(34.8%)	315	(40.6%)		2
55–64	159	(8.0%)	51	(4.2%)	108	(13.9%)		3
WC (cm)								
Male							<0.001	
<90	300	(30.5%)	184	(35.2%)	116	(25.1%)		0
≥90, <102	521	(52.9%)	266	(51.0%)	255	(55.1%)		3
≥102	164	(16.6%)	72	(13.8%)	92	(19.9%)		4
Female							<0.001	
<80	448	(44.4%)	345	(49.5%)	103	(32.9%)		0
≥80, <90	338	(33.5%)	225	(32.3%)	113	(36.1%)		3
≥90	224	(22.2%)	127	(18.2%)	97	(31.0%)		4
BMI (kg/m <sup>2</sup> )							<0.001	
≤25	1,001	(50.2%)	685	(56.2%)	316	(40.7%)		0
>25, ≤30	793	(39.7%)	440	(36.1%)	353	(45.5%)		1
>30	201	(10.1%)	94	(7.7%)	107	(13.8%)		3
FPG (mmol/L)	5.73±1.18		5.29±0.44		6.43±1.58		<0.001	
2H-PG (mmol/L)	7.37±3.00		5.86±1.12		9.74±3.47		<0.001	
ALT (U/L): ≤40	1,720	(86.2%)	1,086	(89.1%)	634	(81.7%)	<0.001	
AST (U/L): ≤35	1,883	(94.4%)	1,169	(95.9%)	714	(92.0%)	<0.001	
TG (mmol/L): <1.70	1,252	(62.8%)	865	(71.0%)	387	(49.9%)	<0.001	
TC (mmol/L): <5.18	1,221	(61.2%)	785	(64.4%)	436	(56.2%)	<0.001	
BUN (U/L): ≤7.5	1,931	(96.8%)	1,188	(97.5%)	743	(95.7%)	0.035	

Numerical variables are presented as mean ±SD for normal distribution and frequency (rate) for categorical variables. OGTT – oral glucose tolerance test used for grouping; NGT – normal glucose tolerance; FHD – family history of diabetes defined as first or second degree relatives having diabetes; HHT – history of hypertension defined as systolic blood pressure of ≥140 mmHg, diastolic blood pressure of ≥90 mmHg one year ago and use of antihypertensive medication; HHBG – history of high blood glucose; smoking was defined as “yes” including currently or previously smoking and “no” as never smoker (≤100 cigarettes in a subject’s lifetime); WC – waist circumference; BMI – body mass index; FPG – fasting plasma glucose; ALT – alanine aminotransferase; AST – aspartate aminotransferase; TG – triglyceride; TC – total cholesterol; BUN – blood urea nitrogen; m-FINDRISC – modified Finnish diabetes risk score.

scored according to the risk conferred, resulting in a score in the range of 0–21 total points.

### *Anthropometric measurements*

Body height and weight were measured with light clothes and without shoes, using the high-weight platform balance ZT-120 (Wuxi Instrument Factory, China), which possesses the capacity to measure the height up to 2 m with precision of 1 mm and weight up to 120 kg with precision of 0.1 kg. The BMI was calculated as weight (kg) divided by the squared height (m). The WC was measured by placing the tape around the bare abdomen just above the upper hip bone, with precision of 1 mm.

All measurements were conducted by a trained nurse at the Dagang Oil Field General Hospital Medical Examination Center.

### *Laboratory measurements*

A fasting venous blood sample for glucose and biochemical indicators was withdrawn after the participant had fasted for a minimum of 8–12 h. FPG and 2h-PPG were estimated using the glucose oxidase method. The levels of serum triglyceride (TG), total cholesterol (TC), alanine aminotransferase (ALT), aspartate transaminase (AST), and blood urea nitrogen (BUN) were measured immediately after 15-mL venous blood samples were collected in separate Vacutainer tubes. Data were obtained through an Automatic Biochemical Analyzer Hitachi 7180 (Hitachi Ltd., Japan) device in the Dagang Oil Field General Hospital Medical Laboratory Center.

### **Definitions**

In the present study, NGT was defined as FPG <6.1 mmol/L and 2h-PPG <7.8 mmol/L. Dysglycemia was defined as the presence of pre-diabetes (FPG 6.1–6.9 mmol/L, or 2-h PG 7.8–11.0 mmol/L) or DM (FPG ≥7.0 mmol/L, or 2-hPG ≥11.1 mmol/L) [15]. Smoking was defined as “no” (≤100 cigarettes in the lifetime of the subject) or “yes” including currently or previously smoking. History of hypertension (HHT) was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg before 1 year, and use of antihypertensive medication. History of high blood glucose (HHBG) was defined as those patients who were once assessed to have the disorder by a health care professional, but the assessment was not yet confirmed. The stratifications of age, WC, and BMI are shown in Table 1. The normal cut-off values of TG, TC, ALT, AST, and BUN were 1.7 mmol/L, 5.18 mmol/L, 40 U/L, 35 U/L, and 7.5 mmol/L, respectively. The cut-off value for FPG was defined as 5.6 mmol/L for increased risk of diabetes (pre-diabetes) according to the guideline of the Standards of Medical Care in Diabetes (USA), 2013 edition.

### **Data analyses and construction of risk scores**

The descriptive statistical values were expressed as mean ±SD for normal continuous variables and frequency (rate) for categorical variables. Chi-square and independent-samples *t* test were used for categorical variables.

We used a multivariable logistic regression model to explore the risk of dysglycemia and produce a new diabetes risk score, termed the Dagang dysglycemia risk score (Dagang DRS). The score is derived by multiplying the β-coefficients of the significant variable by 10 and approximating to the closest integer. To compare the performance of the Dagang DRS for detecting dysglycemia with respect to m-FINDRISC value and FPG value, the receiver operating characteristic (ROC) curves, sensitivity, specificity, positive likelihood ratios (PL+), negative likelihood ratios (PL-), and area under the curve (AUC) were calculated. Youden's index was used as a criterion for selecting the optimum cut-off points. C-statistics were used to compare the AUC of ROC curves.

All the statistical analyses were carried out using SPSS 21.0 (SPSS Inc., Chicago, IL, USA) and MedCalc 15.8 (MedCalc Software bvba, Ostend, Belgium). Two-sided P-values <0.05 were regarded as statistically significant.

## **Results**

### **Characteristics of the research subjects**

A total of 1995 subjects (38.9% dysglycemia), aged 20–64 years, were suitable for the study, of which 1010 (50.6%) were females and 1545 (77.4%) presented FPG <6.1 mmol/L.

As expected, compared to the NGT group, the percentage ratio of the subjects with dysglycemia showed an increased trend with higher body mass index and a rise in age, WC, and TG. Subjects with dysglycemia also encompassed a higher percentage of individuals with a history of hypertension, high blood glucose, or smoking than those subjects with NGT (all *P*<0.05, Table 1).

Nevertheless, compared to the NGT group, the percentage ratio of positive family history of diabetes in the dysglycemia group was not observed to be elevated (Table 1).

### **Risk factors of Dagang DRS**

A multivariate logistic model was built with all the characteristics considered in Table 1, except that WC was entered into the model alone or together with BMI; however, no significant difference was observed for 2 variables with respect

to the interaction between them ( $P>0.05$ ). Thus, in the multivariate logistic regression model, only sex, age, BMI, HHBG, smoking, TG, and FPG were independently associated with dysglycemia and constituted the Dagang DRS system, with the coefficients transformed into score points in a range of 0–55 (Table 2). However, contrary to the conventional viewpoint, the dysglycemia risk of females was higher than in males (OR: 1.33; 95% CI, 1.00–1.76).

In addition, the family history of diabetes did not show statistical significance in logistic regression analysis.

### Performance of 3 dysglycemia-detecting models: Dagang DRS, m-FINDRISC, and FPG value

The ROC curves of each risk model in detecting dysglycemia are shown in Figure 1.

The area under the ROC (AUC) of the Dagang DRS was superior to the m-FINDRISC (AUC: 0.791; 95% confidence interval (CI) 0.773–0.809 vs. 0.633; 95% CI, 0.611–0.654) in all participants ( $n=1995$ ). However, the Dagang DRS did not exhibit a perfect performance relative to the FPG value alone (AUC: 0.820; 95% CI, 0.802–0.836). Although the AUC of the Dagang DRS was higher than that of the m-FINDRISC in participants with FPG  $<6.1$  mmol/L (AUC: 0.616; 95% CI, 0.592–0.641 vs. 0.583; 95% CI, 0.558–0.608), the difference did not reach statistical significance. At the cut-off value of 5.6 mmol/L, the performance of the Dagang DRS was superior to that of the FPG value alone (AUC: 0.571; 95% CI, 0.546–0.596) in participants with FPG  $<6.1$  mmol/L ( $n=1545$ ,  $P=0.031$ , Table 3).

Moreover, compared to the m-FINDRISC and FPG models, the Dagang DRS exhibited relatively optimal performance with respect to sensitivity, specificity, PL+, and NL–, when used in different populations (Table 3).

## Discussion

The current study is among the few in China that developed and evaluated a DRS to detect individuals at the stage of diabetes or pre-diabetes working in oil fields. The prevalence of dysglycemia (38.9%) in the oil field working-age population was lower than that of IDF ( $>50\%$ ) and the national epidemiological data in China (50.1%) [1,4]. Our DRS appeared to perform better than the existing scoring system, m-FINDRISC, and also better than only FPG value in FPG  $<6.1$  mmol/L populations. The goal of detecting both diabetes or pre-diabetes in our scoring system equally emphasized the prevention and control of pre-diabetes and diabetes. Simultaneously, early intervention in high-risk patients became increasingly possible. Although the glucose tests for the high-risk individual is well-accepted,

data (2007–2012) showed that only approximately half the population in the USA, eligible by the US Preventive Services Task Force or Diabetes Association Guidelines criteria, undertook glucose tolerance testing as recommended [17], which may be much worse than that in developing countries. In addition, another study showed that postprandial hyperglycemia is common among Asian populations due to a greater consumption of glucose and rice as compared to Europeans [18]. These studies make screening for dysglycemia in individuals with FPG  $<6.1$  mmol/L vital. Therefore, the Dagang DRS, as a comprehensive scoring system incorporating FPG, TG, BMI, and other risk factors, may assist early recognition and intervention for those still in pre-diabetes or even pre-pre-diabetes.

In this population-based cross-sectional study of 1995 participants, elderly females with higher BMI, HHBG, smoking, and increased FPG and TG face a much higher risk of diabetes. As reported, a high prevalence of hyperlipidemia in type 2 diabetes patients exists in China [19]. However, contrary to the conventional understanding, females are at higher risk of diabetes, which may be related to the increasing pressure on women in both work and life [20]. Another reason may be that the proportion of overweight/obesity and central obesity in women has been rising faster than in men (45.3 vs. 41.7% and 44.6 vs. 38.3%) [21]. In addition, according to IDF statistics, the incidence of diabetes in females will increase continually, and by 2040, the gap between males and females will be narrowed further worldwide [1]. Recently, another study of competing-risk-based DRS from Beijing displayed a significant difference in the univariate analysis of sex and blood lipid; however, the result was contrary in multivariate analysis [22]. Similar findings were also put forward by studies from the US and the UK [12,23]. Interestingly, a study from Spain found a high proportion of undiagnosed diabetes in females by HBA1c criteria and/or OGTT criteria [24], which was in agreement with our results. Altogether, these studies suggest that the distribution of diabetes by sex may be undergoing a steady shift.

The factor of family history of diabetes, which has been considered a risk factor for diabetes [25,26], was excluded from our scoring system. The selection bias in the inclusion criteria might have led to a relatively large number of participants in the study with a family history of the disease. Moreover, the effect of recall bias may also be one of the factors.

To efficiently screen for diabetes or pre-diabetes, several risk scores have been developed for different countries and races based on demographic, anthropometric, lifestyle, and clinical information [23,27–30]. However, only a few DRSs were established for working-age individuals, especially for detecting dysglycemia, and few DRSs have been designed for people engaged in a specialized occupation, such as oil field staff and workers. For example, a Spanish study found that at the optimum



**Table 2.** Multivariate logistic regression analysis evaluating the dysglycemia risk factor of the Dagang model.

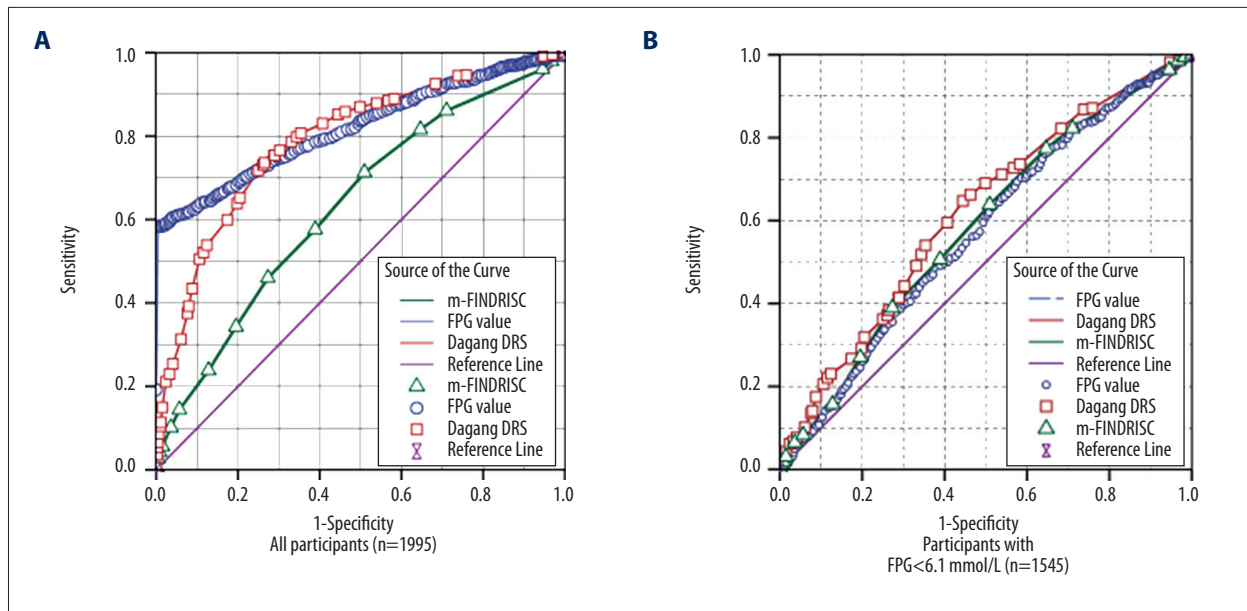
Variables	$\beta$ -Coefficient (95% CI)	OR (95% CI)	P-value	Dagang DRS
Sex				55 (total)
Female	0.29 (0.00–0.57)	1.33 (1.00–1.76)	0.046	3
Male	0	1.00		0
Age				
<45	0	1.00		0
45–54	0.30 (0.07–0.53)	1.35 (1.08–1.70)	0.010	3
55–64	1.04 (0.60–1.47)	2.82 (1.83–4.36)	<0.001	10
HHBG				
Yes	0.57 (0.18–0.96)	1.77 (1.20–2.62)	0.040	6
No	0	1.00		0
FHD				
Yes	0.08 (–0.15–0.30)	1.08 (0.86–1.36)	0.522	–
No	0	1.00		–
Smoking				
Yes	0.43 (0.14–0.71)	1.53 (1.15–2.04)	0.003	4
No	0	1.00		0
BMI				
<25	0	1.00		0
≥25, <30	0.19 (–0.06–0.43)	1.20 (0.95–1.53)	0.131	2
≥30	0.60 (0.22–0.98)	1.82 (1.24–2.65)	0.002	6
FPG				
<5.6	0	1.00		0
≥5.6	1.89 (1.68–2.10)	6.61 (5.34–8.19)	<0.001	19
TG				
<1.70	0	1.00		0
≥1.70	0.66 (0.42–0.89)	1.93 (1.52–2.44)	<0.001	7

Odds ratios and P-values are from multiple logistic regression model (OR – odds ratio; CI – confidence interval).

cut-off value of 13, the power of FINDRISC to detect dysglycemia was poor, with AUC 0.69 (95% CI, 0.66–0.71), sensitivity 0.543 (95% CI, 0.489–0.596), and specificity 0.687 (95% CI, 0.658–0.715) [24]. These observations were similar to our results using m-FINDRISC at a cut-off of 6 points with AUC 0.633 (95% CI, 0.611–0.654), sensitivity 0.713 (95% CI, 0.679–0.744), and specificity 0.491 (95% CI, 0.462–0.519). In Leicester, UK another risk scoring system for detecting dysglycemia has AUC 0.69 (95% CI, 0.68–0.71), sensitivity 0.721 (95% CI, 0.796–0.746), and specificity 0.541 (95% CI, 0.527–0.555) [14]. On the other hand, the Dagang DRS, designed to detect dysglycemia in the oil field

working-age population, exhibited good overall performance, with AUC 0.791 (95% CI, 0.773–0.809), sensitivity 0.736 (95% CI, 0.703–0.767), and specificity 0.735 (95% CI, 0.709–0.760).

In recent years, most DRSs indicated a further improved overall performance after adding FPG and/or TG. For instance, studies from Japan [23], China (Beijing and Shanghai) [31], and Taiwan [28] agree with our results. However, some other studies, including diabetes scores from China (Nanjing) [32], demonstrated that when FBG and/or TG were added into the model together with or independent of other invasive factors,



**Figure 1.** Receiver operating characteristics (ROC) curves of each model for detecting dysglycemia in all participants (A) (n=1995) and the participants with FPG<6.1 mmol/L (B) (n=1545). Abbreviations: m-FINDRISC, modified Finnish diabetes risk score (AUC<sub>A</sub>: 0.633, 95% confidence interval (CI) [0.611–0.654]; AUC<sub>B</sub>: 0.583, 95%CI [0.558–0.608]); Dagang DRS, Dagang dysglycemia risk score (AUC<sub>A</sub>: 0.791, 95%CI [0.773–0.809]; AUC<sub>B</sub>: 0.616, 95%CI [0.592–0.641]); FPG value, fasting plasma glucose value (AUC<sub>A</sub>: 0.820, 95% CI [0.802–0.836]; AUC<sub>B</sub>: 0.571, 95% CI [0.546–0.641]).

**Table 3.** Comparison of performances of detecting dysglycemia by three models (m-FINDRISC, Dagang DRS, and FPG value) in all participants (n=1995) and the participants with FPG <6.1 mmol/L (n=1545).

	m-FINDRISC		Dagang DRS		FPG	
	EV	95% CI	EV	95% CI	EV	95% CI
<b>All participants</b>						
Cut-off value	>6 (points)		>19 (points)		>5.6 (mmol/L)	
Sen	0.713	(0.679–0.744)	0.736	(0.703–0.767)	0.722	(0.689–0.753)
Spec	0.491	(0.462–0.519)	0.735	(0.709–0.760)	0.746	(0.720–0.770)
PL+	1.4	(1.30–1.50)	2.78	(2.50–3.10)	2.84	(2.60–3.20)
PL–	0.59	(0.50–0.70)	0.36	(0.30–0.40)	0.37	(0.30–0.40)
AUC	0.633	(0.611–0.654)	0.791	(0.773–0.809)*	0.82	(0.802–0.836)#
<b>Participants with FPG &lt;6.1 mmol/L</b>						
Cut-off value	>6 (points)		>11 (points)		>5.6 (mmol/L)	
Sen	0.638	(0.583–0.690)	0.647	(0.593–0.699)	0.337	(0.286–0.392)
Spec	0.491	(0.462–0.519)	0.555	(0.527–0.584)	0.746	(0.720–0.770)
PL+	1.25	(1.10–1.40)	1.46	(1.30–1.60)	1.33	(1.10–1.60)
PL–	0.74	(0.60–0.90)	0.64	(0.50–0.70)	0.89	(0.80–1.00)
AUC	0.583	(0.558–0.608)	0.616	(0.592–0.641) <sup>§</sup> &	0.571	(0.546–0.596)

EV – estimated value; CI – confidence interval; Spec – specificity; Sen – sensitivity; PL+ – positive likelihood ratios; PL– – negative likelihood ratios; AUC – area under the curve. \* Dagang DRS vs. m-FINDRISC, P<0.0001 (z=11.69); # FPG vs. Dagang DRS, P=0.0003 (z=3.61); § Dagang DRS vs. m-FINDRISC, P=0.101 (z=1.63); & Dagang DRS vs. FPG, P=0.028 (z=2.99).

further improvement did not occur. Given the crucial role of fasting blood glucose in the diagnosis of diabetes, as early as in 2002, the role of OGTT in the screening of high-risk diabetes was controversial [33]. A clinical study (including FPG and without 2-h glucose) showed a higher AUC than the model with only 2-h glucose ( $P < 0.001$ ) [33]. Similarly, the AUC of a simple score model from China (Nanjing), including age, height, WC, BMI, systolic blood pressure, pulse, hypertension, dyslipidemia, and family history, was less than the FPG alone [32]. These studies further emphasize the vital role of fasting blood glucose in the score. Thus, since 2013, the ADA diabetes guidelines recommend the use of OGTT in screening pre-diabetes in those with FPG  $> 5.6$  mmol/L.

Currently, owing to its cost-ineffectiveness and inconvenience, the OGTT has met with considerable resistance, and the actual acceptance proportion is around 50%. Those willing to undertake the glucose test were older, had a higher mean BMI, and larger WCs, or were more likely to be female as compared to those eligible but not tested in the whole population [17]. Among the patients with the highest rate of acceptance were those with pre-diabetes [17]. Therefore, screening for dysglycemia as a connecting supply and demand to slow the progressive incidences of diabetes [34] should be a long-term focus as a current and future goal for government and society.

In brief, the Dagang DRS, established on FPG and other risk factors, is suitable for early screening of dysglycemia in an oil field population, especially in those with FPG  $< 6.1$  mmol/L.

### Limitations and strengths

Our study has several limitations. Firstly, the participants were drawn from a unique oil field physical examination center in

Tianjin. Thus, the results may not apply to the rest of the oil field. Secondly, the study was a conditional cross-sectional survey rather than a cohort study based on strict criteria of recruitment. Thus, because exercise and diet were not stringently controlled, and because responses to the survey may have been biased by subjectivity, the monomial score was neither collected nor included in this scoring system. Therefore, the detection ability and components of this model need to be confirmed and improved in further prospective studies, especially with respect to factors such as lifestyle.

The strengths of the study are that the assessment of dysglycemia was conducted in oil field working-age (20–64 years) population; therefore, we speculate that the data reflects the risk factors for diabetes in populations engaged in oil extraction-related industries elsewhere. In addition, the scoring system can be used for self-assessment during the annual physical examination, with immediate results.

### Conclusions

We developed the Dagang DRS to detect dysglycemia based on the epidemiological and health examination data that included age, sex, BMI, HHBG, smoking, TG, and FPG for oil field working-age individuals, especially suitable for those with FPG  $< 6.1$  mmol/L. The Dagang DRS exhibited adequate performance, and may be valuable in early intervention based on lifestyle change or pharmacotherapy, as well as to promote prevention and control of pre-diabetes.

### Conflict of interests

The authors declare that they have no conflict of interests.

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