

Nomogram for predicting major depression and suicidal ideation in medical residents: A multi-center cross-sectional study

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Abstract

Background: Few studies have addressed major depression and suicidal ideation in medical residents, yet the high incidence rate and low attendance rate highlight suggest the need for a greater focus on mental health. To our knowledge, there is no model for predicting major depression and suicidal ideation in medical residents. Thus, we developed and validated a model for predicting major depression and suicidal ideation in this specific subpopulation of medical professionals.

Design: The development cohort included 938 medical residents from six centers between January 1, 2017 and December 31, 2018. A total of 405 consecutive medical residents from two other centers met the inclusion and exclusion criteria and participated in the validation cohort. Lasso regression was utilized for data dimension reduction and feature selection. Multivariable logistic regression was then used to develop a predictive model. The efficacy of this predictive model was assessed with respect to its clinical usefulness, calibration, and discrimination.

Results: We identified four shared predictive factors for both major depression and suicidal ideation: sleep quality, Masrah Burnout Inventory personal accomplishment, Masrah Burnout Inventory depersonalization, and optimism of Psychological Capital. Furthermore, we identified two predictors that affect major depression exclusively: working duration and Masrah Burnout Inventory emotional exhaustion. Of the study participants, 44.90% (603/1343) experienced depressive symptoms, 12.90% (173/1343) experienced major depressive symptoms, and 9.70% (130/1343) experienced suicidal ideation. In the validation cohort, our model showed good discrimination, with an AUROC (Area under the receiver operating characteristic curves) of 0.906 (95% CI: 0.872–0.940) and good calibration (unreliability test, $P = 0.836$). Decision curve analysis showed that the model was clinically useful.

Conclusion: This study provides a reliable nomogram to facilitate the individualized prediction of major depression and suicidal ideation among medical residents, allowing for the early diagnosis and treatment of mental disorders in this specific subpopulation of medical professionals. The findings of our study are conducive to expanding the knowledge of mental disorders and improving the development of public health.

Background

Depression is the most common type of mood disorder, clinically characterized by a prominent and persistent depressed mood out of proportion to the situation. Suicidal ideation and behavior can occur in severe depressive cases. Globally, nearly 16% of the population is affected by depressive symptoms, and almost 300 million people have experienced depression in the last decade (Abdallah et al., 2016; Millan, 2006). Depression can lead to a series of problems, such as undesirable health sequelae (mental or physical), social consequences, substantial financial burden, and even suicide.

In previous studies, the incidence of depression among physicians was reported to range from 7–65%, which is substantially higher than the rate of 4–16% found in the general population (Millan, 2006; Schernhammer & Colditz, 2004). Similarly, in a survey from Australia, medical students and physicians were twice as likely to suffer from severe psychological distress and suicidal ideation compared to the general population (Lawrence, 2013). The prevalence of medical residents with depressive symptoms ranged from 20.9–50.8%, with prevalence of suicidal ideation reaching 8% (Becker, Milad, Magdy, Klock, & Susan; Dyrbye et al., 2014; Lin et al., 2017) (Mata et al., 2015). Similarly, a meta-analysis found that the rate of suicide among physicians was 130% and 40% higher in women and in men, respectively, compared to the general population (Schernhammer & Colditz, 2004).

Although the prevalence of depression is high, the rate at which professional help is sought remains low. A multi-stage stratified random sampling method study in China included 63,004 individuals and found that only one-third of Chinese adults who were diagnosed with moderate and severe psychiatric disorders sought professional help (Phillips et al., 2009). Furthermore, a cross-sectional survey that randomly selected 377 people in the United Arab Emirates found that approximately 70% of patients with mental illness failed to seek professional help (Crowe, Averett, Glass, & Prevention, 2016). A global review

reported that less than 50% of physicians with mental illness visited a psychological clinic for professional help(Kohn, Saxena, Levav, & Saraceno, 2004).

In China, the physician residency system is an indispensable period for training doctors that has been in place since 2014. Medical residents endure the burden of clinical work as well as stress related to finance, relationships (with colleagues, patients, supervisors, and others), dissertations, examinations, and graduation(Mansukhani, Kolla, Surani, Varon, & Ramar, 2012). Mental health issues, such as depression and anxiety, have been linked to the frequency of medical errors, self-disability, and poor performance on patient outcomes(Barger et al., 2006; Landrigan et al., 2004; Lockley et al., 2004).

The Patient Health Questionnaire (PHQ-9) is a nine-item self-administered questionnaire that is used to screen the presence and severity of depressive symptoms. Moderate and severe levels of depression (PHQ9 score ≥ 10) are described as major depression, which is more dangerous to the patient compared to mild depression(Kroenke, Spitzer, & Williams, 2001). There are limited studies on the mental health of medical residents, and there is no model for predicting depressive symptoms in this specific subpopulation of medical professionals. Thus, in this study, we developed a predictive model to screen for major depression and suicidal ideation in medical residents based on a multi-center cross-sectional study using PHQ-9.

Methods

Study design

This multi-center cross-sectional study was conducted from December 2019 to February 2020, there was 1533 medical residents from eight hospitals in China enrolled in this study. The study was sponsored by the Post-Graduation Committee and participated by all medical residents of eight hospitals. Finally, a total of 1343 valid responses were acquired. (86.48% effective response rate). Nine hundred and thirty-eight medical residents from six centers take part in the development cohort. A total of 405 consecutive medical residents from another two centers that are in line with the same inclusion and exclusion criteria participated in the validation cohort. The detailed flow chart of the cohort is shown in Figure 1.

The institutional research and ethics committee of Shengjing Hospital Affiliated to China Medical University provided ethical approval on November 14, 2019 (Ethics Committee No.: 2019PS647K). All centers meet this ethical standard. All eligible subjects obtained informed consent. The clinical study registration number is CHICTR1900027707. The research program is in line with the ethical guidelines of the 1975 Declaration of Helsinki.

Inclusion And Exclusion Criteria

The inclusion criteria was shown: occupational active residents. The following was exclusion criteria: medical residents who had worked less than 3 months and didn't finish the questionnaires.

Measurement Of Characteristics

Characteristics of medical residents were classified into five dimensions, including demographic characteristics, dietary habits, life related factors, profession related factors and psychological characteristics. Demographic characteristics comprised of BMI (body mass index, kg/m^2), age and gender. Dietary habits included coffee habits, alcohol habit, and smoking status, which all range from current, never or former. (current status means the habit $\geq 1/\text{day}$, and last ≥ 6 months; former habit means cessation ≥ 6 months). Life related factors comprised of sleep quality (PSQI, Pittsburgh sleep quality index scores)(Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), religious beliefs (yes vs. no), marital status (married/cohabitation vs. single/separated/divorced/widows), have siblings (yes vs. no), physical activity (IPAQ, international physical activity questionnaire, $\text{Mets}\times\text{Hours}/\text{week}$)(Craig et al., 2003), household income/month (RMB, yuan) was sorted as < 5000 , ≥ 5000 , < 10000 , ≥ 10000 , experienced major life events (yes vs. no) which include divorce/separation, severe illness of close relatives or death, severe injuries/unemployment or income reduction/debt, traffic accidents, natural disasters, violence, serious conflicts

with families, medical disputes, death or severe illness of partners, history of chronic disease (yes vs. no) (including Guillain Barré syndrome, physician-diagnosed diseases (including metabolic syndrome, hypertension and diabetes), rhinitis, hypothyroidism, gallstones, systemic lupus erythematosus, sinusitis, polycystic ovary syndrome, hyperthyroidism, facial neuritis, synovitis of joint, chronic gastritis, arrhythmias and pulmonary tuberculosis, chronic glomerulonephritis and rheumatoid arthritis, visiting friend constantly (yes vs. no). Worked related factors contained residency program year (1st vs. 2nd vs. 3rd year), academic degree (PhD vs. Master vs. Bachelor), specialized subject (pediatrics vs. gynaecology vs. internal medicine and others vs. surgery), night shifts (times/month) and work duration per week (< 40 hours vs. 40-60 hours vs. > 60 hours). The Chinese edition of the Perceived Organization Support Questionnaire (POS)(Eisenberger & Stinglhamber, 2011) was used to gauge the organizational support level. PsyCap was assessed by the Chinese edition of the 24-item Psychological Capital Questionnaire (PCQ)(Luthans, Avolio, Avey, & Norman, 2007; Zhang, Zhang, Dong, & Behavior, 2010). This survey utilized Masrah Burnout Inventory-General Survey (MBI-GS)(Chaoping, Shi, & Luo, 2003) to evaluate burnout. The scale is composed of three dimensions: personal accomplishment (PA), depersonalization (DP) and emotional exhaustion (EE). Clinically validated scales for PHQ09 was used to measure depressive symptoms(Millan, 2006). Major depression was considered to be present when the PHQ09 score was ≥ 10 . The ninth question score of PH09 ≥ 1 defined as suicidal ideation. (considering you're going to die better or somehow hurt yourself). The level of depression (mild, moderate and severe) is distinguished by the scores of PHQ9 (≥ 5 , ≥ 10 and ≥ 15).

Statistical analysis

SPSS 22.0 for windows (IBM), R software (version 3.0.1; <http://www.R-project.org>) and stata 15.0 (Stata Corp.) was utilized to analyze the data. The packages 'rms' and 'glmnet' in R were used in this research. The reported level of statistical significance is two-sided, with a $P < 0.05$ designated as the level of significance.

The Kolmogorov-Smirnov test was used to determine the normality of continuous variables. Normally distributed and non-normally continuous variables were showed as the mean \pm standard deviation (SD) and the median (interquartile range) respectively. Independent-sample Student's t tests and the Mann-Whitney U test were used to contrast the means of two continuous normally and two continuous non-normally distributed variables respectively. Categorical variables were expressed as a number (percentage) and compared by Chi-squared and Fisher's exact tests.

In this study, the least absolute shrinkage selection operator (LASSO) method is used to select the most useful predictive features from the original data set, which is appropriate for the decrease of high-dimensional data. Using LASSO binary logistic regression model, all variables were classified as limited potential predictors based on 938 development cohort participants. When the penalization coefficient lambda (λ) is large, it makes no difference to the estimated regression parameters. however, some coefficients become smaller as λ gets smaller, up to zero. Then, the optimum λ in the LASSO model was selected by 10-fold cross-validation of the minimum criterion and one standard error of the minimum criteria (the 1-SE criterion). Finally, all non-zero coefficients selected by LASSO method are used to modify the model.

An independent external validation cohort was used to examine the performance of this model. The logistic regression formula calculated in the development cohort was applied to the external validation cohort, including residents from two centers, and probabilities were calculated for each participant. The area under the receiver operating characteristic (AUROC) curve was counted to determine the discriminative performance of the model. AUROC 1.0 means perfect discrimination, yet means no discrimination as $AUROC < 0.50$. Calibration plots, the unreliability test and Hosmer-Lemeshow (H-L) chi-square statistics ($P > 0.05$ means better calibration) were altogether utilized to estimate the calibration of this model. Perfect calibration is indicated by the slope on the 45-degree line. Decision curve analysis was applied to determine the clinical utility of the model by quantifying the net benefit at various threshold probabilities in the external validation cohort.

Results

There were 938 medical residents from six centers included in the development cohort and 405 medical residents from another two centers included in the validation cohort after utilizing the same inclusion and exclusion criteria. Dietary habits,

demographic characteristics, life and work-related factors and psychological characteristics are shown in Table 1, in which 44.90% (603/1343) experienced depressive symptoms, 12.90% (173/1343) experienced major depressive symptoms and 9.70% (130/1343) experienced suicidal ideation.

Table 1
 Characteristics of residents in development and validation cohort for this study

Variables	Development cohort 938 residents	Validation cohort 405 residents
Major depression (yes)	118 (12.60)	55 (13.60)
Suicide ideation (yes)	88 (9.40)	42 (10.40)
Demographic characteristics		
Age (years)	26 (25, 27)	26 (24, 27)
Sex (male vs. female)	300 (32.00) / 638 (68.00)	128 (31.60) / 277 (68.40)
BMI (kg/m ²)	22.17±3.59	22.31±3.64
Dietary habits		
Smoking habit		
Current	36 (3.80)	16 (4.00)
Never	876 (93.40)	383 (94.60)
Former	26 (2.80)	6 (1.50)
Alcohol habit		
Current	467 (49.80)	213 (52.60)
Never	460 (49.00)	188 (46.40)
Former	11 (1.20)	4 (1.00)
Coffee habit		
Current	680 (72.50)	312 (77.00)
Never	220 (23.50)	72 (17.80)
Former	38 (4.10)	21 (5.20)
Life related factors		
Sleep quality (PSQI scores)	5 (3, 7)	5 (4, 7)
Physical activity (IPAQ Mets×hour/week)	16.00 (9.90, 33.55)	15.42 (11.55, 32.63)
Have religions (yes)	36 (3.80)	15 (3.70)
Marital status		
Single/divorce/separation/widow	805 (85.80)	345 (85.20)
Married/cohabitation	133 (14.20)	60 (14.80)
Have siblings (yes)	70 (7.50)	30 (7.4)
Household income (Yuan/month)		
< 5,000	80 (8.50)	38 (9.40)
≥5,000, <10,000	189 (20.10)	77 (19.00)

Continuous variables were reported median (interquartile range), categorical variables were reported as number (percentage). P value was analyzed by univariate binary logistic regression.

Variables	Development cohort	Validation cohort
	938 residents	405 residents
≥10,000	669 (71.30)	290 (71.60)
Experienced major events (yes)	261 (27.80)	136 (33.60)
History of chronic disease (yes)	88 (9.40)	42 (10.4)
Visiting friend constantly (yes)	468 (49.90)	209 (51.60)
Work related factors		
Post graduation year		
PGY1	283 (30.20)	120 (29.60)
PGY2	320 (34.10)	153 (37.80)
PGY3	335 (35.70)	132 (32.60)
Academic degree		
Bachelor	133 (14.20)	66 (16.30)
Master	735 (78.40)	311 (76.80)
Doctor	70 (7.5)	28 (6.90)
Speciality		
Surgery	183 (19.50)	80 (19.80)
Internal medicine and others	647 (69.00)	268 (66.20)
Obstetrics and Gynecology	54 (5.80)	37 (9.10)
Pediatrics	54 (5.80)	20 (4.90)
Working duration (hours/week)		
40-60 hours	744 (79.30)	326 (80.50)
< 40 hours	43 (4.60)	16 (4.00)
> 60 hours	151 (16.10)	63 (15.60)
Night shifts (times/month)	4 (0, 6)	4 (0, 7)
Psychological characteristics		
POS (scores)	43 (37, 49)	43 (36, 47)
PsyCap-efficacy (scores)	28 (24, 30)	28 (24, 30)
PsyCap-hope (scores)	27 (24, 30)	27 (24, 30)
PsyCap-resiliency (scores)	27 (23, 30)	27 (23, 30)
PsyCap-optimism (scores)	26 (23, 29)	26 (23, 29)
MBI-EE (scores)	8 (3, 13)	8 (4, 13)
MBI-DP (scores)	6 (3, 10)	6 (3, 10)

Continuous variables were reported median (interquartile range), categorical variables were reported as number (percentage). P value was analyzed by univariate binary logistic regression.

Variables	Development cohort	Validation cohort
	938 residents	405 residents
MBI-PA (scores)	24 (17, 32)	24 (17, 30)
Continuous variables were reported median (interquartile range), categorical variables were reported as number (percentage). P value was analyzed by univariate binary logistic regression.		

We used LASSO binary logistic regression to construct a model. The λ value was 0.015 and 0.006 in major depression and suicide ideations model respectively. Twenty-eight features were reduced to six and four potential predictors in view of development cohort for major depression and suicidal ideation (Table 1) respectively. The six variables with non-zero coefficients were showed in the final model of major depression (sleep quality, working duration, MBI-PA, MBI-DP, MBI-EE and optimism of PsyCap). We established a prediction model on these results, from which we generated a nomogram predicting the incidence of major depression. Meanwhile, four variables with non-zero coefficients were showed in the final model of suicide ideations (sleep quality, MBI-PA, MBI-DP and optimism of PsyCap). We established a predictive model on these results, from which we generated a nomogram predicting the incidence of suicidal ideation (Table 3 and Figure 2).

Table 2
Univariate analysis of the risk factors for major depression of residents in development and validation cohort

Variables	Development cohort 938 residents			Validation cohort 405 residents		
	Major depression 118 residents	Without major depression 820 residents	p	Major depression 55residents	Without major depression 350 residents	p
Demographic characteristics						
Age (years)	25 (24, 27)	26 (25, 27)	0.237	26 (25, 28)	26 (24, 27)	0.178
Sex (male vs.female)	39 (33.10)/79 (66.90)	261 (31.80)/559 (68.20)	0.790	14 (25.50)/41 (74.50)	114 (32.60)/236 (67.40)	0.293
BMI (kg/m ²)	22.378±3.592	22.138±3.589	0.497	23.503±4.905	22.120±3.367	0.010
Dietary habits						
Smoking habit			0.210			0.100
Current	3 (2.50)	33 (4.00)		4 (7.30)	12 (3.40)	
Never	110 (93.20)	766 (93.40)		51 (92.70)	332 (94.90)	
Former	5 (4.20)	21 (2.60)		0 (0.00)	6 (1.70)	
Alcohol habit			0.905			0.119
Current	62 (52.50)	405 (49.40)		34 (61.80)	179 (51.10)	
Never	52 (44.10)	408 (49.80)		21 (38.20)	167 (47.70)	
Former	4 (3.40)	7 (0.90)		0 (0.00)	4 (1.10)	
Coffee habit			0.750			0.095
Current	84 (71.20)	596 (72.70)		48 (87.30)	264 (75.40)	
Never	29 (24.60)	191 (23.30)		5 (9.10)	67 (19.10)	
Former	5 (4.20)	33 (4.0)		2 (3.60)	19 (5.40)	
Life related factors						
Sleep quality (PSQI scores)	7 (6, 10)	5 (3, 6)	<0.001	7 (7, 10)	5 (3, 7)	<0.001
Physical activity (IPAQ Mets×hour/week)	15.3510.25 (32.63,)	16.00 (9.90, 33.55)	0.770	11.55 (8.25, 23.10)	16.38 (11.55, 34.65)	0.193
Have religions (yes)	9 (7.60)	27 (3.30)	0.026	3 (5.50)	12 (3.40)	0.464
Marital status			0.294			0.728
Single/divorce/separation/widow	105 (89.00)	700 (85.40)		46 (83.60)	299 (85.40)	
Married/cohabitation	13 (11.00)	120 (14.60)		9 (16.40)	51 (14.60)	

Continuous variables were expressed as median (interquartile range); categorical variables were reported as number (percentage). P value was analyzed by univariate binary logistic regression. **Abbreviations:** PSM, propensity score matching; BMI, body mass index; PSQI, Pittsburgh sleep quality index, IPAQ, International Physical Activity Questionnaire; PGY, Post graduation year; International Physical Activity Questionnaires; POS, Perceived Organization Support; PsyCap, Psychological Capital; MBI-GS, Maslach Burnout Inventory-General Survey; EE, Emotional Exhaustion; DP, Depersonalization; PA, Personal Accomplishment.

	Development cohort 938 residents			Validation cohort 405 residents		
Have siblings (yes)	7 (5.90)	63 (7.70)	0.500	3 (5.50)	27 (7.70)	0.554
Household income (Yuan/month)			0.160			0.620
< 5,000	11 (9.30)	69 (8.40)		8 (14.50)	30 (8.60)	
≥5,000, <10,000	31 (26.30)	158 (19.30)		7 (12.70)	70 (20.00)	
≥10,000	76 (64.40)	593 (72.30)		40 (72.70)	250 (71.40)	
Experienced major events (yes)	47 (39.80)	214 (26.10)	0.002	27 (31.10)	109 (31.10)	0.010
History of chronic disease (yes)	20 (16.90)	68 (8.30)	0.003	10 (18.20)	32 (9.10)	0.045
Visiting friend constantly (yes)	45 (38.10)	423 (51.60)	0.007	19 (34.50)	190 (54.30)	0.007
Work related factors						
Post graduation year			0.674			0.908
PGY1	34 (28.80)	249 (30.40)		14 (25.50)	106 (30.30)	
PGY2	40 (33.90)	280 (34.10)		26 (47.30)	127 (36.30)	
PGY3	44 (37.30)	291 (35.50)		15 (27.30)	117 (33.40)	
Academic degree			0.401			0.036
Bachelor	12 (10.20)	121 (14.80)		14 (25.50)	52 (14.90)	
Master	98 (83.10)	637 (77.70)		39 (70.90)	272 (77.70)	
Doctor	8 (6.80)	62 (7.60)		2 (3.60)	26 (7.40)	
Speciality			0.960			0.032
Surgery	27 (22.90)	156 (19.00)		8 (14.50)	72 (20.60)	
Internal medicine and others	77 (65.30)	570 (69.50)		34 (61.80)	234 (66.90)	
Obstetrics and Gynecology	4 (3.40)	50 (6.10)		8 (14.50)	29 (8.30)	
Pediatrics	10 (8.50)	44 (5.40)		5 (9.10)	15 (4.30)	
Working duration (hours/week)			<0.001			0.014
40-60 hours	73 (61.90)	671 (81.80)		38 (69.10)	288 (82.30)	
< 40 hours	8 (6.80)	35 (4.30)		2 (3.60)	14 (4.00)	
> 60 hours	37 (31.40)	114 (13.90)		15 (27.30)	48 (13.70)	
Night shifts (times/month)	4 (0, 8)	4 (0, 6)	0.002	4 (0, 8)	4 (0, 6)	0.352
Psychological characteristics						
POS (scores)	38 (32, 43)	43 (38, 50)	<0.001	36 (30, 42)	34 (37, 48)	<0.001
PsyCap-efficacy (scores)	24 (21, 28)	28 (24, 30)	<0.001	22 (20,25)	29 (24, 31)	<0.001

Continuous variables were expressed as median (interquartile range); categorical variables were reported as number (percentage). P value was analyzed by univariate binary logistic regression. **Abbreviations:** PSM, propensity score matching; BMI, body mass index; PSQI, Pittsburgh sleep quality index, IPAQ, International Physical Activity Questionnaire; PGY, Post graduation year; International Physical Activity Questionnaires; POS, Perceived Organization Support; PsyCap, Psychological Capital; MBI-GS, Maslach Burnout Inventory-General Survey; EE, Emotional Exhaustion; DP, Depersonalization; PA, Personal Accomplishment.

	Development cohort 938 residents			Validation cohort 405 residents		
PsyCap-hope (scores)	23 (20, 27)	28 (24, 30)	<0.001	22 (19, 25)	28 (24, 30)	<0.001
PsyCap-resiliency (scores)	24 (21, 27)	27 (24, 30)	<0.001	22 (19, 27)	27 (24, 30)	<0.001
PsyCap-optimism (scores)	23 (20, 25)	26 (24, 30)	<0.001	22 (19, 24)	26 (24, 29)	<0.001
MBI-EE (scores)	15 (11, 24)	7 (3, 11)	<0.001	16 (11, 24)	8 (4, 11)	<0.001
MBI-DP (scores)	12 (8, 18)	6 (3, 9)	<0.001	11 (8, 18)	6 (2, 9)	<0.001
MBI-PA (scores)	20 (13, 28)	25 (18, 32)	0.001	20 (15, 26)	25 (17, 31)	0.068

Continuous variables were expressed as median (interquartile range); categorical variables were reported as number (percentage). P value was analyzed by univariate binary logistic regression. **Abbreviations:** PSM, propensity score matching; BMI, body mass index; PSQI, Pittsburgh sleep quality index, IPAQ, International Physical Activity Questionnaire; PGY, Post graduation year; International Physical Activity Questionnaires; POS, Perceived Organization Support; PsyCap, Psychological Capital; MBI-GS, Maslach Burnout Inventory-General Survey; EE, Emotional Exhaustion; DP, Depersonalization; PA, Personal Accomplishment.

Table 3

Multivariate analysis of the risk factors for major depression and suicide ideations of residents in development cohort.

	Major depression			Suicide ideations		
Variables	β (95% CI)	OR (95% CI)	p	β (95% CI)	OR (95% CI)	p
Constant	-4.331 (-6.283, -2.379)	0.132 (0.002, 0.093)	<0.001	-0.357 (-2.222, 1.507)	0.699 (0.108, 4.515)	0.707
Life related factors						
Sleep quality (PSQI scores)	0.293 (0.196, 0.390)	1.340 (1.216, 1.476)	<0.001	0.897 (0.004, 0.176)	1.094 (1.004, 1.192)	0.041
Work related factors						
Working duration (hours/week)						
40-60 hours	reference	reference		N/A	N/A	N/A
< 40 hours vs.40-60 hours	1.416 (0.459, 2.373)	4.121 (1.583, 10.730)	0.004			
> 60 hours vs. 40-60 hours	0.250 (-0.328, 0.829)	1.284 (0.720, 2.290)	0.396			
Psychological characteristics						
PsyCap-optimism (scores)	-0.450 (-0.113, 0.023)	0.956 (0.894, 1.023)	0.192	-0.093 (-0.162, -0.024)	0.911 (0.851, 0.976)	0.008
MBI-EE (scores)	0.109 (0.062, 0.155)	1.115 (1.064, 1.168)	<0.001	N/A	N/A	N/A
MBI-DP (scores)	0.090 (0.040, 0.140)	1.095 (1.041, 1.151)	<0.001	0.091 (0.051, 0.130)	1.095 (1.053, 1.139)	<0.001
MBI-PA (scores)	-0.028 (-0.059, 0.004)	0.973 (0.943, 1.004)	0.083	-0.046 (-0.074, -0.018)	0.955 (0.929, 0.982)	0.001
Area under ROC curve						
Development cohort	0.892 (0.863, 0.922)			0.814 (0.770, 0.857)		
Validation cohort	0.906 (0.872, 0.940)			0.802 (0.740, 0.864)		
The β coefficient, odds ratio and 95% confidence interval were analyzed by multivariate binary logistic regression.						

Each feature corresponds to a specific point by drawing a straight line directed up the point axis. After summing the points located on the total points axis, the summation represents the probability of major depression and suicidal ideation by plotting directly down to the risk axis respectively. For instance, consider a resident with the following features: PSQI scores, 8 points (50 points); working duration, < 40 hours/week (30 points); MBI-PA, 20 points (12 points); MBI-DP,10 points (19 points); MBI-EE,15 points (35 points); and optimism of PsyCap,20 (15 points). The total point was 161, and the suspected probability of major depression was approximately 62.0%.

The AUROC was 0.892 and 0.906 in the development and validation cohorts of major depression respectively. In the model of major depression and suicidal ideation model, the cut-off value for risk probability was 10.20%, 8.80%, with a sensitivity of 87.29%,82.95% and specificity of 76.95%, 69.18% respectively (Table 2 and Figure 3A, B). The unreliability test statistic of calibration in validation was -0.004, the P value was 0.836, and the Emax and Eavg were 0.175 and 0.022, respectively (Figure 3C). The Hosmer-Lemeshow (H-L) chi-square statistic was 7.12,14.05, and the P value was 0.7138, 0.1707 respectively, which

showed that the model have good calibration. If the threshold probability of residents is between 0% and 65%, the incidence rate of major depression can be predicted by this nomogram on the base of the decision curve.

The AUROC was 0.814 and 0.802 in the development and validation cohorts of suicidal ideation respectively. The unreliability test statistic of calibration in validation was -0.004, the P value was 0.321, and the Emax and Eavg were 0.512 and 0.030, respectively (Figure 3C). If the threshold probability of medical residents is between 10% and 25%, the incidence rate of suicidal ideation can be predicted by this nomogram on the base of the decision curve.

The mean sleep duration was 6.68 (95% CI, 6.63, 6.73) hours, 43.3% (581/1343) and 86.3% (1159/1343) of the residents, slept less than 7 and 8 h respectively, and 44.80% (662/1343) of the residents experienced poor sleep quality. In the light of dysfunction of daytime sleep quality, 51.4% (690/1343) of the residents felt sleepy or sleepiness and 32.91% (442/1343) felt lack of energy.

The mean weekly working duration were 52.68 ± 13.91 hours, of which 79.70% (1070/1343) worked between 40 and 60 hours, 4.40% (59/1343) worked less than 40 hours and 15.90% (214/1343) worked longer than 60 hours.

Discussion

The prevalence of major depression and suicidal ideation in medical residents is much higher than that of the general population. It is also higher compared to other groups of medical professionals in Europe, America, and South Asia (Becker et al.; Dyrbye et al., 2014; Lin et al., 2017; Mata et al., 2015). Depression can adversely affect the mind, body, and family, but also may affect residency work performance, subsequently leading to increased medical mistakes and adverse treatment outcomes for patients. Only one-third of patients with psychological disorders were reported to seek professional help (Crowe et al., 2016; Kohn et al., 2004; Phillips et al., 2009; Schernhammer & Colditz, 2004). Therefore, we developed and validated a nomogram to predict major depression and suicidal ideation in medical residents based on a multicenter, cross-sectional survey that included comprehensive potential predictive factors.

We found that nearly half of medical residents experienced depressive symptoms, almost one-eighth experienced major depression, and one-tenth experienced suicidal ideation. A meta-analysis from the United States and Canada estimated the prevalence of depression to be 29% among resident physicians, and this number continued to rise in each subsequent year of training (Brunsberg et al., 2019). A review showed that 6% of 18–25-year-olds in the United States have experienced suicidal ideation (Harmer, Lee, Duong, & Saadabadi, 2021). Compared with these previously published studies, we found that Chinese medical residents experienced a higher rate of major depression and suicidal ideation. We identified four shared predictive factors (sleep quality, MBI-PA, MBI-DP, and optimism of PsyCap) that affected both major depression and suicidal ideation, along with another two predictive factors (working duration and MBI-EE) that exclusively affected major depression.

Our study suggests that poor sleep quality is closely associated with both major depression and suicidal ideation. Resident physicians reported a mean sleep duration of less than 7 h, and nearly half of the study subjects slept for less than 7 h per night. Furthermore, the medical residents in our study experienced poor sleep quality or felt sleepy during the day, and one-third reported a lack of energy. A joint consensus statement of the American Sleep Association recommends a minimum sleep duration of 7 h, utilizing a modified RAND appropriateness method (Watson et al., 2015). Poor sleep quality has a negative effect on mental health, physical health, and quality of life (Giorgi, Mattei, Notarnicola, Petrucci, & Lancia, 2018). In a review of seven prospective studies that included a total of 25,271 adults, poor sleep quality was found to be significantly associated with an increased risk of depression in adults (Zhai, Zhang, & Zhang, 2015). There are several possible mechanisms through which poor sleep quality affects depression. Sleep quality is associated with abnormal cortical activation patterns, including abnormalities in the anterior frontal, medial temporal, and parietal lobes. Furthermore, reduced hippocampal growth factor levels were observed following poor sleep quality (Drummond & Brown, 2001; Kandel, 2001), thereby exerting a crucial influence on major depression and suicidal ideation, in addition to learning and memory consolidation (Curcio, Ferrara, & De Gennaro, 2006). However, a cross-sectional study of 200 community-dwelling adults in the United States found that a history of

depression resulted in impaired quality of sleep(Motivala, Levin, Oxman, & Irwin, 2006). Therefore, there may be a bidirectional relationship between sleep and depressive symptoms.

A cross-sectional study of 281 adults in the United States reported that sleep disorders promoted the appearance of suicidal ideation. Insomnia was also reported to have an impact on suicidal risk(DeShong & Tucker, 2019). Additionally, a cross-sectional study of 434 suicide victims in Spain found that reduced sleep duration also promoted the development of suicidal ideation(Blasco-Fontecilla et al., 2011). Similar to previous reports, we found that sleep was a predictive factor of suicidal ideation in Chinese medical residents. This may be explained mechanistically by serotonin, which plays an important role in the induction, continuity, and formation of suicidal thoughts(Ursin, 2002).

Our study suggests that MBI-PA and MBI-DP are associated with both major depression and suicidal ideation, and that MBI-EE is associated with major depression exclusively. Burnout is a psychological syndrome that is a long-term response to chronic interpersonal stressors at work. Three key aspects of this response are a sense of PA, DP, and EE(Maslach & Leiter, 2016). A sense of PA is described as demoralization and reduced ability; DP is described as an inappropriate or negative attitude, irritability, withdrawal, and loss of idealism; and EE is described as a loss of energy accompanied by fatigue.

A longitudinal study of 2555 dentists in Finland found that burnout was an important predictor of depressive symptoms and a mediator between stress and depression(Ahola & Hakanen, 2007). A Danish repeated-measures time-to-event analysis of 2936 adults(Madsen, Lange, Borritz, & Rugulies, 2015) documented an increase in the frequency of antidepressant medication use with increasing burnout among patients. In addition, both EE and DP were independent risk factors for depressive symptoms in a longitudinal cohort study of 4287 medical students in the United States(Dyrbye et al., 2008). These conclusions are consistent with the results of our study. One potential mechanism to explain these findings is that epigenetic studies advocate for DNA methylation as a possible biomarker for stress-related mental disorders with co-expression in burnout, depression, and chronic stress(Koutsimani, Montgomery, & Georganta, 2019).

On the other hand, suicidal ideation is a severe manifestation of depressive symptoms. A longitudinal analysis of burnout in medical students in the United States concluded that DP and reduced PA were independent risk factors for suicidal ideation, and that this could not be alleviated by controlling burnout(Dyrbye et al., 2008). However, another cross-sectional study of 146 community nurses in Spain found different results; EE was reported to play an important role in the formation of suicidal ideation(Tomás-Sábado et al., 2010). The discrepancy may result from differences between subpopulations.

Optimism of PsyCap was a predictable factor for both major depression and suicidal ideation in this study. In line with our study, a cross-sectional study of 24,888 university teachers in China found that psychological capital was negatively correlated with depressive symptoms(Shen et al., 2014). Furthermore, optimism, resilience, and hope were negatively correlated with major depression in another cross-sectional survey of 2500 underground coal miners in China(Liu, Wen, Xu, & Wang, 2015). PsyCap played a mediating role for suicidal ideation and occupational stress in a stratified-cluster sampling of 2216 employees in China(Gao et al., 2020). Previous studies have suggested that optimism can affect immune function, regulating activity of natural killer cells (NKCs) and cytotoxic T-cells(Brydon, Walker, Wawrzyniak, Chart, & Steptoe, 2009). However, a prospective, repeated measurement study by Bakker(Bakker, Lyons, & Conlon, 2017) reported that self-efficacy and hope were negatively correlated with depression, while the other two elements of psychological capital had no clear relationship.

In this study, we found that medical residents were more likely to experience major depression if their work duration was greater than 60 h or less than 40 h. A cross-sectional survey of 24,922 surgeons in America demonstrated that working more than 60 h per week in a hospital was significantly negatively correlated to mental health(Shanafelt et al., 2009). Furthermore, a cross-sectional electronic survey of 976 physician trainees in the United States(Sharp et al., 2021) found that trainees completing more than 70 h of clinical work per week with heavy electronic documentation were more likely to suffer from burnout and depression. Working longer hours can lead to physical consequences (such as increased risk of stroke or coronary heart disease) and mental health problems, and the stress and subjective experience of disease plays an important role in mental disorders(Choi et al., 2021). Meanwhile, another cross-sectional study of 753 general surgery trainees in the United States(Elmore, Jeffe, Jin, Awad, & Turnbull, 2016) reported that shorter working hours and reduced receipt of superior physician

teaching hours resulted in a lower sense of personal accomplishment, and even led to major depression. Therefore, appropriate work intensity and opportunity to learn more are beneficial for reducing the risk of depression.

This study is not without limitations. First, this is a multicenter cross-sectional study and cannot assess causal relationships between variables. Therefore, longitudinal studies are needed to validate our conclusions. Second, the use of self-reporting questionnaires may lead to recall or reporting bias. Third, the PHQ-9 questionnaire was used to screen for depression, not to provide clinical diagnoses, and this may affect the true prevalence of depression. The confirmatory scale for diagnosing depression is too complex to assess using a survey, and psychological professionals are required to do so. Fourth, unmeasured confounders like genetic variants may have an impact on major depression and suicidal ideation. Fifth, the recruited participants were confined to northeastern China and additional subjects remain to be validated in other regions of China. Despite these limitations, this is the first nomogram for predicting major depression and suicidal ideation in Chinese medical residents based on a multi-center study with excellent external validation. In addition, we evaluated a large number of potentially predictive factors among psychological characteristics, work-related factors, and life-related factors, while excluding confounders.

Conclusion

This study provides a reliable nomogram to facilitate the individualized prediction of major depression and suicidal ideation among resident physicians, allowing for early diagnosis and treatment of mental disorders in this specific subpopulation of medical professionals. The findings of our study are conducive to expanding the knowledge of mental disorders and improving the development of public health.

Declarations

Ethics approval and consent to participate

The institutional research and ethics committee of Shengjing Hospital Affiliated to China Medical University provided ethical approval on November 14, 2019 (Ethics Committee No.: 2019PS647K). All centers meet this ethical standard. All eligible subjects obtained informed consent. The clinical study registration number is CHICTR1900027707. The research program is in line with the ethical guidelines of the 1975 Declaration of Helsinki.

Conflict of interest

There is no conflict of interest.

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Consent for publication

Informed consent from all eligible patients was obtained.

Availability of data and materials

Not applicable

Competing interests

Shaolong E, Tianshu Ying and Song Bai declare that they have no competing interests.

Author contributions:

BS had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

BS: Protocol/project development

ESL, ZhYX, YTS and BS: Data collection or management

ESL, ZhYX and BS: Data analysis

ESL, ZhYX and BS: Manuscript writing/editing

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Figures

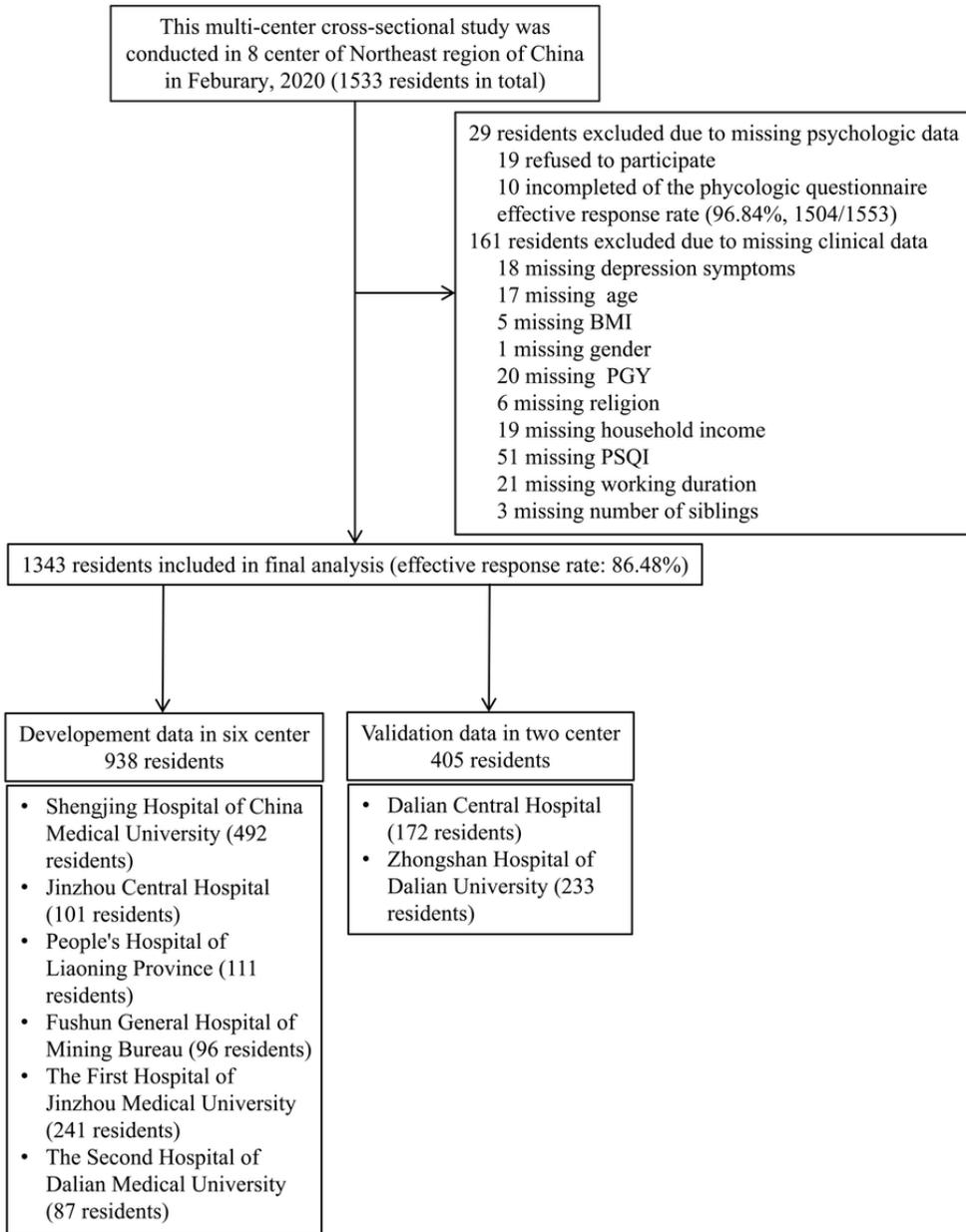


Figure 1

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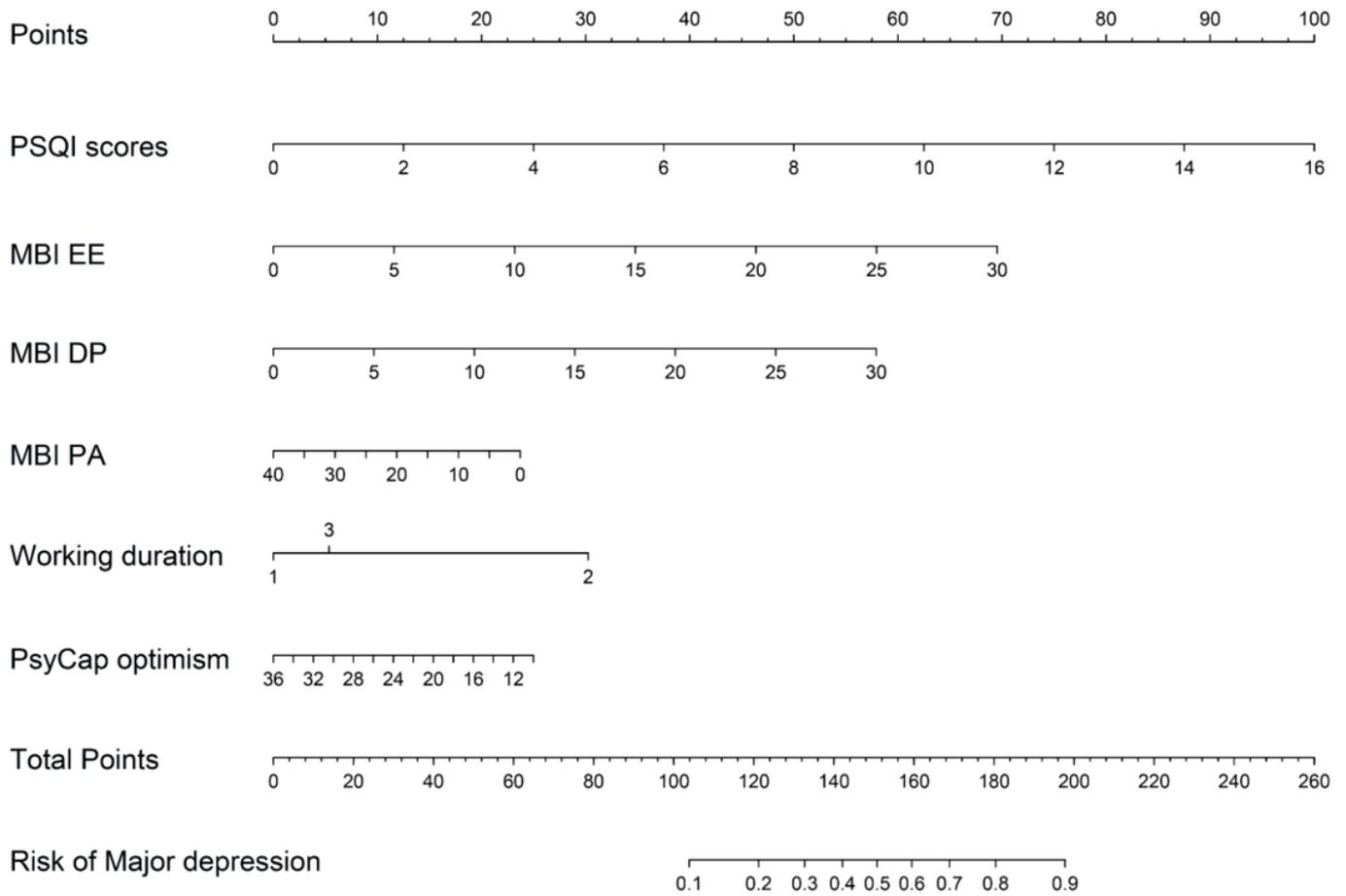


Figure 2

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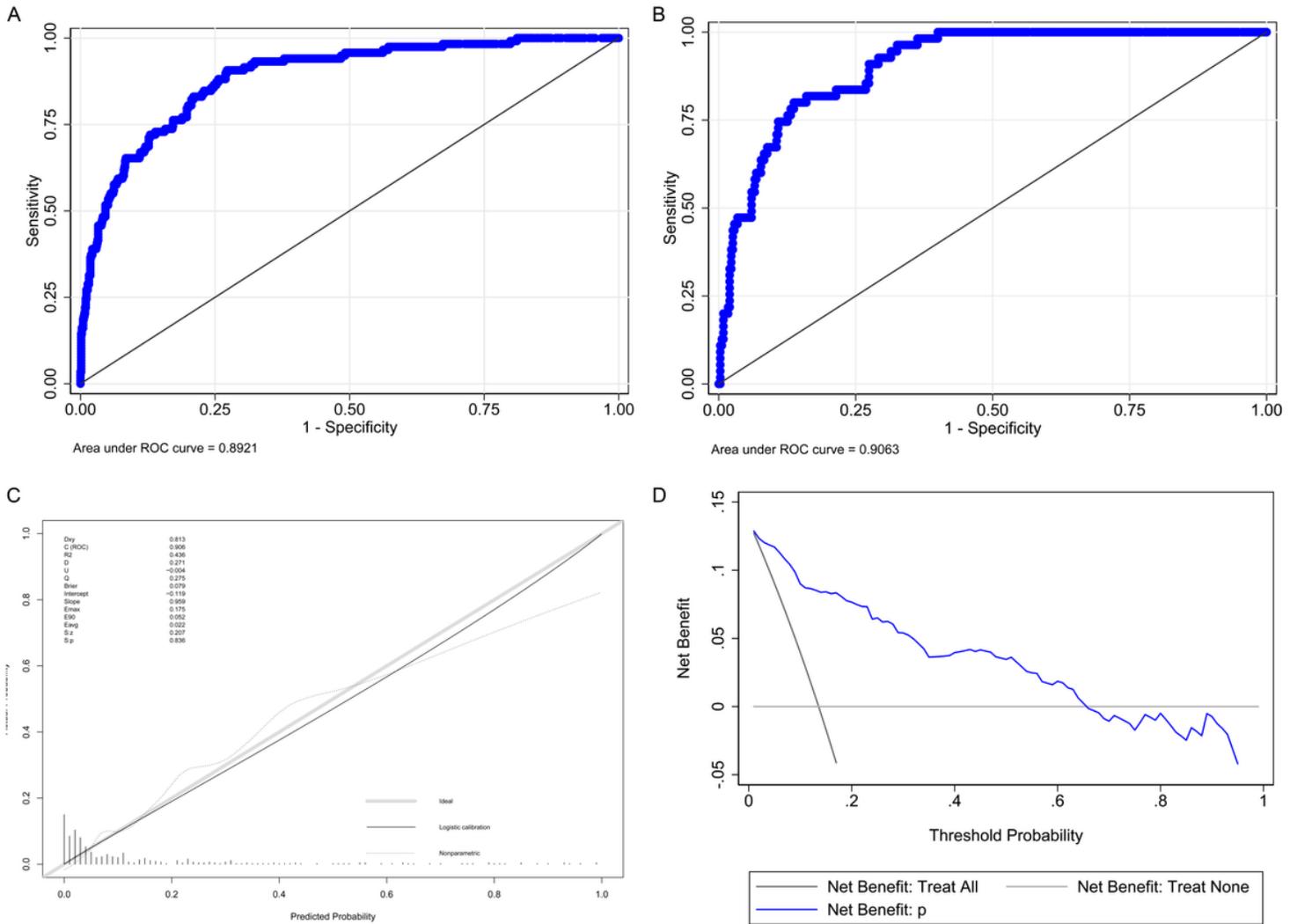


Figure 3

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