



## Exploring the relationship between depressive symptoms, problematic smartphone use, and cumulative risk factors in nursing students: A cross sectional study

Ya-juan Yang<sup>a</sup>, Mats Granlund<sup>b</sup>, Fang-biao Tao<sup>c</sup>, Shu-man Tao<sup>d</sup>, Li-wei Zou<sup>d</sup>, Karin Enskar<sup>e</sup>, Xiao-yan Wu<sup>c,\*</sup>, Jing-fang Hong<sup>a,\*</sup>

<sup>a</sup> School of Nursing, Anhui Medical University, No. 81 Meishan Rd, Shushan District, Hefei, Anhui Province 230032, PR China

<sup>b</sup> CHILD, School of Health and Welfare, Jönköping University, Jönköping, Sweden

<sup>c</sup> Department of Maternal, Child and Adolescent Health, School of Public Health, Anhui Medical University, No. 81 Mei Shan Road, Shu Shan District, He Fei City 230032, Anhui Province, PR China

<sup>d</sup> The Second Affiliated Hospital of Anhui Medical University, No. 678 Fu Rong Road, Economic and Technological Development District, He Fei City 230601, Anhui Province, PR China

<sup>e</sup> Department of Women's and Children's Health, Uppsala University, Sweden

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### ABSTRACT

**Background:** No single risk factor is decisive in shaping an individual's healthy development. This study aimed to analyze the relationship between depressive symptoms and a cumulative risk index comprising individual, family, and social variables among nursing students.

**Methods:** We enrolled 1716 Chinese nursing students from three universities in a paperless survey that assessed a range of individual, family, and social risk factors associated with depressive symptoms. Multiple risk analysis was conducted to create a composite risk score for each individual. A test for trend was employed to assess the relationship between the multiple risk classification and depressive symptoms individually. Additionally, a 2-step cluster analysis and  $\chi^2$  tests were used to examine the relationship between the different clusters and the level of depressive symptoms.

**Results:** The mean scores of depressive symptoms increased significantly as the number of risk factors increased, regardless of their combination. As the number of risk factors increased, the proportion of nursing students in the normal group decreased, while the proportion in the group with depressive symptoms of varying severity tended to increase ( $P < 0.001$ ). A high-risk cluster characterized by poor sleep quality combined with problematic smartphone use was associated with higher levels of depressive symptoms ( $P < 0.001$ ).

**Conclusion:** Based on these findings that cumulative exposure to multiple risk factors is more harmful than cumulative exposure to fewer risk factors, then interventions that isolate only one risk factor are less likely to be effective than those that are multifaceted.

### 1. Introduction

Depression, a pervasive mental health condition, affects individuals across diverse demographics, posing significant challenges globally (World Health Organization [WHO], 2023). Its impact is profound, with over 280 million people worldwide affected, demonstrating a higher prevalence among women (WHO, 2023). The repercussions of depression extend beyond mental health, contributing to difficulties in various

life domains, increased illness rates, and heightened mortality and suicide risks (Rotenstein et al., 2016). Among university students, the transitional phase characterized by substantial physiological and psychological changes often predisposes them to depressive symptoms (Arnett et al., 2014). Nursing students (Cheung et al., 2016). In particular, nursing students face numerous stressors, including academic demands, interpersonal challenges, the emotional toll of patient care and the potential influence of social prejudice. (Cheung et al., 2016).

\* Corresponding authors.

E-mail addresses: [yajuanyang2024@126.com](mailto:yajuanyang2024@126.com) (Y.-j. Yang), [mats.granlund@ju.se](mailto:mats.granlund@ju.se) (M. Granlund), [fangbiaotao2024@126.com](mailto:fangbiaotao2024@126.com) (F.-b. Tao), [shumantao@126.com](mailto:shumantao@126.com) (S.-m. Tao), [lwzou\\_2010@sina.com](mailto:lwzou_2010@sina.com) (L.-w. Zou), [karin.enskar@uu.se](mailto:karin.enskar@uu.se) (K. Enskar), [xywu@ahmu.edu.cn](mailto:xywu@ahmu.edu.cn) (X.-y. Wu), [jingfanghong2024@126.com](mailto:jingfanghong2024@126.com) (J.-f. Hong).

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Research underscores the prevalence of depressive symptoms among nursing students globally, with a meta-analysis revealing an average prevalence of 34.0 % across 27 cross-sectional studies (Tung et al., 2018). Asian nursing students, notably, exhibit the highest prevalence at 43.0 %, emphasizing the urgency for targeted interventions (Tung et al., 2018). Moreover, Chinese nursing students and nurses demonstrate significant rates of depressive symptoms, necessitating further exploration of contributing risk factors (Xie et al., 2020).

The etiology of depression is multifaceted, involving a complex interplay of social, psychological, and biological factors. Challenges encountered in academic or professional environments can exacerbate depressive symptoms (WHO, 2023). Given the pervasive influence of digital technology, recent research has increasingly directed attention towards the relationship between problematic smartphone use (PSU) and depressive symptoms among university students (Demir et al., 2015; Elhai et al., 2017). PSU, also referred to as smartphone dependence or addiction, manifests as excessive and compulsive smartphone use, leading to persistent cravings, dependency, and impairments in psychological and social functioning (Elhai et al., 2018). Previous studies consistently demonstrate a positive correlation between problematic smartphone use (PSU) and depressive symptoms among college students (Ge et al., 2023; Mohamed & Mostafa, 2020). Nevertheless, the exact role of PSU in precipitating depressive symptoms remains elusive, leaving open the possibility of its interaction with various personal, familial, and social factors among smartphone users. To advance current knowledge, it is imperative to delve into the potential association between PSU and depressive symptoms, while also exploring the collective influence of PSU and other detrimental personal, familial, and social factors on individuals. These endeavors are crucial for enhancing comprehension of the complex pathways leading to depression and for formulating precise interventions to promote the mental wellness of nursing students.

The primary objective of this study was to explore the correlation between individual, family, and social risk factors associated with depression, including PSU, among a cohort of 1716 nursing freshmen enrolled in three medical universities in Anhui Province, China. After conducting a comprehensive literature review, several key risk factors were identified. Individual risk factors included age (Long et al., 2016), gender (Assari, 2017; Long et al., 2016; Ngasa et al., 2017), level of physical activity (Hosen et al., 2021), quality of sleep (Awasthi et al., 2020), and exposure to major adverse events in the preceding year (e.g., family conflicts, hospitalization, academic setbacks, relationship breakdown) (Guang et al., 2017). Family-related risk factors comprised residence (Mojs et al., 2012), family depression history (Koly et al., 2021), and economic level (Assari, 2017; Mojs et al., 2012). Additionally, peer support (Horgan et al., 2016) is a very important social risk factor for the college population. Employing multiple risk analysis methods, the study aimed to ascertain whether depressive symptoms within the Chinese nursing students could be most effectively elucidated by a single factor or by a composite score derived from the amalgamation of individual, family, and social risk factors. Further elaboration on the specifics of these variables and their measurement procedures can be found within the method section.

## 2. Methods

### 2.1. Study design and participants

This cross-sectional study is based on the initial data wave from a longitudinal study of nursing students conducted at three medical universities in Anhui, China. Permission was obtained from the management of the universities, and information documents were provided to student counselors, including study descriptions, questionnaire guidance, consent forms, and a QR code for paperless questionnaires. Volunteers from each class were recruited to assist in promoting the project. The estimated time needed to complete the questionnaire was 10 to 20

min.

### 2.2. Measurements

#### 2.2.1. Depressive symptoms

Depressive symptoms were assessed using the Depression Anxiety Stress Scale 21 (DASS 21), a validated Chinese version (Gong et al., 2010). The scale comprises 21 items across three subscales (depression, anxiety, and stress), each scored on a 4-point scale from "0" (does not meet) to "3" (always meet). A cutoff score of  $\geq 10$  on the depression subscale of the DASS-21 was used to identify individuals with depressive symptoms among nursing students (Chen et al., 2015; Zhang et al., 2019). The sum of depression scores was categorized into five severity levels: normal (0–9), mild (10–13), moderate (14–20), severe (21–27), and extremely severe (28+) (Lovibond & Lovibond, 1995). The reliability of the depression subscale within the DASS-21 among nursing students was supported by a Cronbach's alpha of 0.87 in previous research (Chen et al., 2015), and in the current study, the Cronbach's alpha coefficient for the Depression subscale was 0.89.

#### 2.2.2. Individual, family and social risk factors

Eight potential risk factors considered in this study were previously identified in a study conducted by our team (Yang et al., 2023), including number of friends ( $< 3$  /  $3-5$  /  $> 5$ ), household income (low/medium/high), academic performance (poor/medium/excellent), and exposure to major adverse events in the preceding year (e.g., hospitalization [yes/no], relationship breakdown [yes/no]). Physical activity was evaluated using the International Physical Activity Scale (IPAQ), sleep quality was measured using the Chinese version of the Pittsburgh Sleep Quality Index (PSQI), while PSU was assessed using the Self-rating Questionnaire for Adolescent Problematic Mobile Phone Use (SQAPMPU).

Physical activity was classified into three categories: walking, moderate intensity (e.g., lifting lighter objects, swimming, cycling), and high intensity (e.g., lifting heavier objects, running), with metabolic equivalents (METs) assigned values of 3.3, 4.0, and 8.0, respectively, using IPAQ. The total METs were computed as the sum of the three intensity METs (Nolan et al., 2016). High physical activity was defined as engaging in high-intensity physical activity for  $\geq 3$  days a week, with a weekly total of  $\geq 1500$  METs, or engaging in all three types of high-intensity activity for  $\geq 7$  days a week, with a weekly total of  $\geq 3000$  METs. Moderate physical activity was defined as meeting the criteria of engaging in high-intensity activity for  $\geq 3$  days a week for at least 20 min per day, or engaging in moderate-intensity or walking activity for  $\geq 5$  days a week for at least 30 min per day, or engaging in all three types of high-intensity activity for  $\geq 5$  days a week with a weekly total of  $\geq 600$  METs. Low physical activity was characterized by either reporting no activity or not meeting the criteria for moderate and high activity groups (Puciato et al., 2017). The Cronbach's alpha coefficient was 0.89 in the present study.

The Chinese version of the Pittsburgh Sleep Quality Index (PSQI) (Liu & Tang, 1996) was used to evaluate the sleep quality of university students over the past month. It consists of 19 items assessing various aspects of sleep, including sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each dimension is scored from 0 to 3. The total score ranges from 0 to 21, with a score of  $\geq 8$  indicating poor sleep quality (Liu & Tang, 1996). In the present study, the Cronbach's alpha coefficient for the PSQI was 0.87.

The SQAPMPU is a standardized questionnaire designed for assessing PSU in adolescents (Tao et al., 2017). It focuses on capturing feelings and attitudes associated with mobile phone use, with each item describing a potential problem. It consists of 13 items in total, covering three dimensions: withdrawal symptoms, craving, and physical and mental health status. For example, some items include statements such as 'I feel anxious if I have not checked for messages or switched on my

mobile phone for some time', 'I need to spend more time on my mobile phone to feel satisfied', and 'My productivity has decreased as a direct result of the time I spend on the mobile phone'. Participants rated each item on a five-point Likert scale ranging from 1 (not true at all) to 5 (extremely true). The total scores on the questionnaire ranged from 13 to 65, with the cutoff point set at the 75th percentile (Tao et al., 2017). Therefore, scores  $\geq 28$  were defined as indicative of PSU, and the Cronbach's coefficient was 0.92 in the present study.

2.3. Data analysis

Data cleaning was conducted prior to the data analysis, incorporating both range and consistency checks. Statistical analyses were performed using a standard software package (SPSS 23 for Windows, SPSS Inc.® headquarters, Chicago, USA).

- For the current study, each of the eight risk variables was classified into high-risk and low-risk groups based on predefined criteria from prior research, rather than through statistical sampling of relative exposure frequency (e.g., upper quartile) (Evans et al., 2013). Binary logistic regression was used to identify significant risk factors for depressive symptoms in this study.
- A multiple risk analysis (Wade et al., 2015) was conducted with the significant factors related to depressive symptoms, creating a composite risk score for each individual based on the total number of high-risk factors they possessed. This score allowed for easy interpretation and facilitated grouping of participants for comparison regarding the level of depressive symptoms. A test for trend was used to examine the relationship between the multiple risk classification and depressive symptoms. Additionally, 2-step cluster analysis was conducted using the Jaccard method (Everitt et al., 2010) to evaluate similarities within and dissimilarities between clusters using a log-likelihood distance measure. The optimal number of clusters were automatically determined based on statistical metrics like BIC (Bayesian Information Criterion) or AIC (Akaike Information Criterion) to ensure model interpretability and reliability. Chi-square tests were used to analyze the association between different clusters and levels of depressive symptoms.

2.4. Ethical considerations

The study followed the guidelines of the Helsinki Declaration and received ethical approval from the Ethics Committee of Anhui Medical University(Approval Number: 20170219). Participants were informed of the voluntary nature of their participation, confidentiality of information, and the option to withdraw from the study at any time. All participants provided informed consent before the study.

3. Results

3.1. Characteristics of the sample and the number of risk factors

The study included participants with an age range of 16 to 26 years, with a mean age of  $18.90 \pm 1.39$ . Among the participants, there were 292 males (17.0 %) and 1424 females (83.0 %). The overall prevalence of mild and above depressive symptoms (score of 10 and above) was 18.4 %.

Table 1 outlines the high-risk groups for each variables. Among these variables, those classified as high risk included household economic level (low), number of friends (<3), academic performance (poor), sleep quality (bad), physical activity level (low), PSU (yes), experience of hospitalization (yes), and experience of relationship breakdown (yes). The remaining categories were deemed low risk for each respective factor.

The results of binary logistic regression analyses conclusively confirmed the association of six risk factors with depressive symptoms in

**Table 1**  
Variables used for calculating cumulative risk scores for participants.

Risk factors	Low risk, n(%)	High risk, n (%)
Household income	Medium and above, 1292 (75.3)	Low, 424 (24.7)
Numbers of friends	$\geq 3$ ,1504(87.6)	<3, 212 (12.4)
Academic performance	Medium and above, 1449 (84.4)	Poor, 267 (15.6)
Sleeping quality	Good, 1538(89.6)	Bad, 178 (10.4)
Physical activity level	Medium and above, 1178 (68.6)	Low, 538 (31.4)
PSU	No, 1247(72.7)	Yes, 469(27.3)
Experience of hospitalization	No, 1550(90.3)	Yes, 166(9.7)
Experience of relationship breakdown	No, 1370(79.8)	Yes, 346(20.2)

this study(see Table 2). The findings revealed that physical activity level and recent hospitalization were not significantly associated with depressive symptoms.

3.2. The relationship between number of risk factors and depressive symptoms

In the binary logistic regression analysis conducted, a multiple risk score was calculated for each individual, representing the cumulative number of high-risk factors. Scores ranged from 0 to 5, with distribution well spread between scores of 0 and 4. Only 6 individuals (0.3 %) had a multiple risk score of 5, and they were grouped with those scoring 4 in all analyses. The largest group consisted of 607 participants who had no risk factors, while the smallest group included 44 participants with 4–5 risk factors.

The relationship between the multiple risk classification and depressive symptom scores is graphically depicted in Fig. 1. A significant linear trend analysis ( $F = 322.229$ ,  $df = 1$ ,  $P < 0.001$ ) indicated that as the number of risk factors increased, so did the scores of depressive symptoms for the participants.

The individual effects of multiple risks were obscured by the overall trend in the mean depressive symptom score. To gain a more nuanced understanding of these effects, the data was reanalyzed based on the

**Table 2**  
Binary logistic regression analysis among variables influencing depressive symptoms.

	$\beta$	Standard error	Wald $\chi^2$	OR(95%CI) <sup>a</sup>
Constant	-1.84	1.06	3.01	0.16
Household income	0.47	0.15	9.92	1.60 (1.20–2.15)**
Numbers of friends	0.68	0.18	13.62	1.97 (1.38–2.83)***
Academic performance	0.63	0.17	14.30	1.88 (1.36–2.61)***
Sleep quality	1.35	0.18	55.79	3.87 (2.71–5.51)***
Physical activity level	0.21	0.14	2.04	1.23(0.93–1.63)
PSU	1.30	0.14	85.34	3.65 (2.78–4.81)***
Experience of hospitalization	-0.36	0.21	3.00	0.70(0.46–1.05)
Experience of relationship breakdown	0.37	0.16	5.32	1.45(1.06–1.98)*

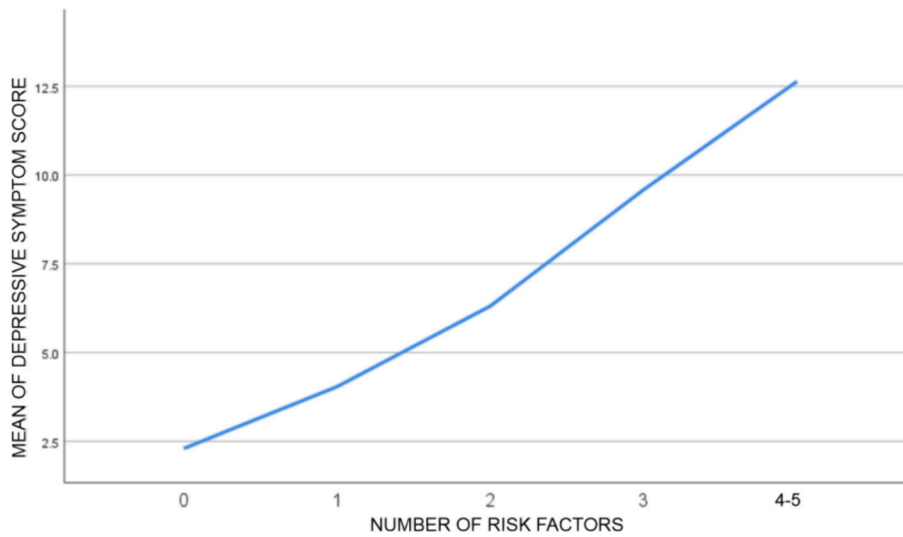
Abbreviations: PSU, problematic smartphone use.

<sup>a</sup> Adjusted for gender and age.

\*  $P < 0.05$ .

\*\*  $P < 0.01$ .

\*\*\*  $P < 0.001$ .



**Fig. 1.** Means of participants' depressive symptom score for each cumulative risk score in whole sample (color should be used for figures in print, single column fitting image).

prevalence of different levels of depressive symptoms. The results of this analysis are presented in Fig. 2. It was noted that irrespective of the combination of factors, as the number of risk factors increased, the proportion of individuals in the normal group decreased, while the proportion of individuals in the other three levels of depressive symptoms exhibited an increasing trend.

**3.3. The relationship between components of risk and depressive symptoms**

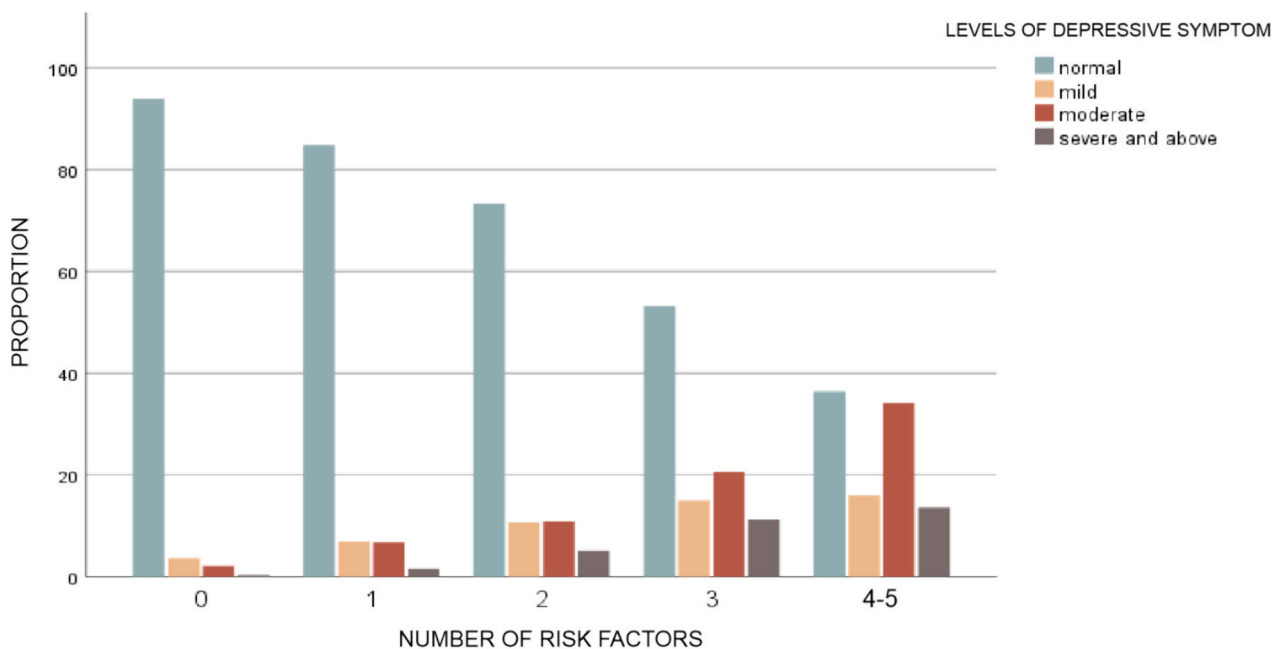
Participants were classified into seven clusters with distinct sets of high-risk factors, including 607 participants devoid of any risk factors (Table 3 provides a detailed enumeration of these clusters). The table displays all combinations of risk factors prevalent in >50 % of the individuals within each cluster, ranked in descending order of frequency within each cluster. Risk factors with a prevalence of <50 % are not

included in the table.

Furthermore, a chi-square analysis uncovered variations in the prevalence of depressive symptoms among individuals in the seven clusters. These disparities indicate that the coexistence of problematic smartphone use and sleep problems is a notable predictor of high risk for depressive symptoms among nursing students.

**4. Discussion**

To a certain extent, the focus of efforts to prevent mental illness in university students has shifted from primarily considering biological factors to adopting a broader perspective that encompasses specific behavioral characteristics of the students. Based on the findings of this study, it is our belief that further attention should be given to understanding the intricate interplay of individual, family, and social factors among university students. As the number of risk factors faced by an



**Fig. 2.** Percentages of participants who were normal and had different levels of depressive symptom in 5 risk categories (color should be used for figures in print, single column fitting image).

**Table 3**  
2-Step Cluster Analyses of all Individuals, n(%), Only variables with high risk from the clusters are displayed in the table.\*

Cluster Description	Normal	Mild	Moderate	Severe and above
Cluster 1				
Sleep quality	61(55.0)	11(9.9)	21(18.9)	18(16.2)
PSU				
Cluster 2				
Number of friends	144 (71.6)	26 (12.9)	23(11.4)	6(4.0)
Cluster 3				
Academic performance	114 (76.0)	17 (11.3)	15(10.0)	4(2.7)
Cluster 4				
Experience of relationship breakdown	181 (75.7)	16(6.7)	33(13.8)	9(3.8)
Cluster 5				
Household income	210 (82.7)	21(8.3)	17(6.7)	6(2.4)
Cluster 6				
PSU	120 (77.9)	15(9.7)	14(9.1)	5(3.2)
Cluster 7				
No risk factors	570 (93.9)	22(3.6)	13(2.1)	2(0.3)

\* Chi-square analysis,  $\chi^2 = 188.16$ ,  $P < 0.001$

individual increases, the severity of their level of depressive symptoms also increases. This suggests that the number of risk factors may be an important factor influencing an individual's mental health. However, it is particularly crucial to pay attention to individuals exhibiting severe depressive symptoms. Notably, a distinctive pattern was observed when poor sleep quality coexisted with PSU (refer to Cluster 1).

Our findings are in line with previous research in various fields, indicating that the accumulation of risk factors, rather than the influence of specific factors, contributes to morbidity in multiple areas (Canto et al., 2011; Inoue et al., 2006). Past studies have identified mobile phone addiction as a significant risk factor for depression among university students (Ge et al., 2023; Mohamed & Mostafa, 2020). Hence, we aimed to determine the predictive value of individual, family, and social risk measures for depressive symptoms in university students, in addition to PSU. In our study, we observed a significant trend in the distribution of depressive symptoms across different levels. <10 % of students in the low multiple risk group exhibited depressive symptoms, whereas nearly 65 % of students in the high multiple risk group experienced varying levels of depressive symptoms, with 13.64 % displaying severe or higher symptoms. The results of this study are consistent with previous studies, again demonstrating the existence of a dose-response function - as the number of risk factors encountered increases, so does the severity of the effect (Evans et al., 2013).

This set of six risk variables can aid in identifying students with depressive symptoms and inform the development of targeted interventions and prevention strategies for at-risk students. Some of these risk factors, such as the number of friends, academic performance, and sleep quality, can be addressed early through interventions. University administrators are advised to provide group-level education on friendship, academic engagement, and establishing healthy routines at the outset of students' studies. However, household income and experiences of romantic breakups are more challenging to alter. For students facing these circumstances, early identification and personalized interventions at the individual level are necessary. In our study, we did not observe a significant association between physical activity and depressive symptoms, which contrasts with findings from previous research. The discrepancy may be attributed to differences in measurement tools and the method used to categorize high-risk factors. However, meta-analysis conducted by Guo et al. (2014) highlighted that Tai chi was identified as the most effective intervention for alleviating depressive symptoms,

followed by yoga and dance among depressed college students. Running, volleyball, basketball, and badminton were also noted to have varying degrees of effectiveness in improving depressive symptoms. This finding shows that lower level of physical activity is not necessarily a risk factor for depressive symptoms. We need to pay more attention to the selection and use of measurement tools in future studies investigating physical activity. Hospitalization experience was also not identified as a high risk factor for depressive symptoms. It may be related to the fact that illnesses in the college population are dominated by acute, easily curable illnesses, such as acute gastroenteritis, acute appendicitis, and acute trauma in China, which do not constitute a serious psychological shock.

While PSU problems alone do not explain a significant degree of variance, their occurrence alongside multiple risk indicators enhances predictive power, particularly for the development of severe depressive symptoms. As shown in Table 3, PSU combined with poor sleep quality primarily contributes to the explained variance in students with severe levels of depression. The proportion of students in this cluster who exhibit severe depressive symptoms is significantly higher than that of the other clusters. This result is consistent with a study from Nepalese undergraduate students (Bhandari et al., 2017). Alimoradi (2019) and Wong et al. (2020) have also summarized the evidence for a clear association between internet addiction (and its equivalents) and sleep quality. The underlying mechanisms contributing to these associations are likely multifaceted. The prevalence of PSU among university students is underscored, with a significant portion displaying signs of addiction. Research indicates that younger generations, whether engaging in activities for recreation, communication, or academic purposes, are particularly susceptible to smartphone addiction (Bhandari et al., 2017). Communication frequently continues late into the night among university students, even after retiring to bed (Dowdell & Clayton, 2019). This persistent engagement exacerbates disruptions to their circadian rhythms and sleep-wake cycles (Lam, 2014), particularly among university students who often experience sleep deprivation due to smartphone use. The blue light emitted by smartphone screens can further affect the quality of sleep (Randjelović et al., 2023), which can exacerbate depressive symptoms.

In summary, the integration of multifaceted intervention strategies, considering various risk factors simultaneously, presents a promising approach for preventing depressive symptoms among nursing students. Healthcare professionals can optimize outcomes for individuals affected by these risk factors by employing comprehensive methods encompassing psychological education, cognitive-behavioral interventions such as check smartphones less and exercising more, sleep hygiene promotion, and social support. Nevertheless, further research and evaluation are warranted to ascertain the effectiveness and long-term effects of multifaceted intervention.

#### Strength and limitations of the work

Our study encompasses a large and representative sample of nursing students. The data collection followed consistent protocols, and we achieved a high response rate. However, it is important to acknowledge the limitations of our research. Firstly, the sampling approach utilized in this study was a convenience sample of nursing students recruited from three selected universities, while practical and efficient, may not be representative of the entire population of nursing students in China and any other culture (Etikan et al., 2016). Cross-cultural comparisons or studies involving diverse healthcare student populations would be valuable to enhance the broader applicability of the multiple risk factor model (Heine et al., 2002). Furthermore, due to the cross-sectional study design, we cannot establish causal relationships between risk factors and students' depressive symptoms. Longitudinal studies would be necessary to better understand the temporal relationships and potential reciprocal influences among the multiple risk factors and depressive symptoms (Levin, 2006). Additionally, the current study relied on self-reported measures, which may be subject to various biases. The use of more

objective assessments, such as peer or faculty reports, clinical observations, or administrative data, could be used to provide a more comprehensive understanding of the multiple risk factors in the future (Podsakoff et al., 2003). Finally, despite including several risk factors for depressive symptoms, we cannot eliminate the possibility of residual confounding.

## 5. Conclusion

From our data, it becomes evident that a larger perspective involving individual, family, and social influences on students reveals a higher probability of depressive symptoms with an increased number of risk factors. Based on the findings that cumulative exposure to multiple risk factors is more harmful than cumulative exposure to fewer risk factors, then interventions that isolate only one risk factor are less likely to be effective than those that are multifaceted. Therefore, exploring the causal association of the interaction of PSU and sleep quality with depressive symptoms and developing individualised interventions is the next step in our study.

## Consent for publication

Consent for publication has been obtained from the participants.

## Research data for this article

Due to the sensitive nature of the questions asked in this study, survey respondents were assured raw data would remain confidential and would not be shared. To request the data, contact the corresponding author of the article.

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## CRediT authorship contribution statement

**Ya-juan Yang:** Writing – original draft, Investigation, Formal analysis. **Mats Granlund:** Validation, Supervision, Methodology. **Fang-biao Tao:** Supervision, Resources, Project administration, Conceptualization. **Shu-man Tao:** Investigation, Data curation. **Li-wei Zou:** Software, Investigation. **Karin Enskar:** Writing – review & editing, Supervision. **Xiao-yan Wu:** Resources, Project administration, Funding acquisition. **Jing-fang Hong:** Writing – review & editing, Supervision, Funding acquisition.

## Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Data availability

The data that has been used is confidential.

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