Sexual orientation and sleep problem among Chinese college students: Mediating roles of interpersonal problems and depressive symptoms

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1. Introduction

Sleep disorder among college students has seen a global uprise (Tarokh et al., 2016). High prevalence of poor sleep quality (19.7-62.0%) (Becker et al., 2018; Lemma et al., 2012; Li et al., 2020) and shorter sleep duration(<7h) (Becker et al., 2018; Li et al., 2018) in college students were reported for developed and developing countries alike. Sleep problems of college students are connected with adverse health outcomes, such as fatigue (Herring et al., 2018), mood disturbance (Ablin et al., 2013), poor health status (Li et al., 2018), poor academic performance (Mirghani et al., 2015), depression and anxiety (Nyer et al., 2013) and even suicidal behaviors (Becker et al., 2018). Sexual minorities (e.g., lesbian, gay and bisexual) are at a greater risk of physical and mental health disparities (Frost et al., 2015; Russell, 2003), evident through growing literature that focused on this topic in the past five years (Chen and Shiu, 2017; Kann et al., 2016; Li et al., 2017; Patterson and Potter, 2020, 2019). In contrast, there is currently limited evidence on sleep problems for Chinese sexual minorities, let alone sexual minority college students during the stage of emerging adulthood (ages 18–29 years), which is considered a "sensitive period" for mental health(Arnett, 2014).

Many studies are also focusing on psychosocial factors (i.g., interpersonal problems and depressive symptoms), which contribute to the differences in sleep disorders between sexual minorities and heterosexuals and further provide timely prevention and intervention. Being in a stressful environment caused by stigma, prejudice and discrimination, sexual minorities are more likely to have mental health problems(Meyer, 2003**).** As the increase of stress exposure resulting from stigma, sexual minorities confront elevated interpersonal problems from this stigma-related stress(Hatzenbuehler, 2009**).** Several investigators found that interpersonal problems such as poorer relationship with family members, and those with teachers and classmates were more commonly found in sexual minorities compared to their heterosexual counterparts (Hank and Salzburger, 2015; Huang et al., 2018; Needham

and Austin, 2010; Patterson et al., 2018). Both family relationship issues (Ailshire and Burgard, 2012) and friendship quality (Tavernier and Willoughby, 2014) were also associated with college students' sleep quality. Therefore, interpersonal relationships may play an intermediary role in the association between sexual orientation and sleep disorders (Patterson et al., 2018). However, there is currently no such research on the Chinese population.

Additionally, poor psychological health such as depressive symptoms may theoretically contribute to potential sleep difficulties among sexual minority youth(Lucassen et al., 2017; Marshal et al., 2011)**.** Although the direction of influence between depression and sleep disorders is not fully understood, there is a robust association between them(Goldman-Mellor et al., 2014; Nutt et al., 2008)**.** Depression symptoms were uniquely related to most Pittsburgh Sleep Quality Index(PSQI) component domains (Becker et al., 2018) and there is evidence that sexual minority individuals across the different population are at higher rates of depressive symptomatology compared to their heterosexual counterparts (Argyriou et al., 2020; Scott et al., 2016; Wise et al., 2019). Two studies on adolescents and adults in the United States suggested that depressive symptoms may mediate the relationship between sexual orientation and sleep difficulties (Luk et al., 2018; Patterson and Potter, 2020). Since Chinese people are deeply influenced by traditional mainstream cultures of Confucian ideology and filial piety (Kwok and Wu, 2015), the general population has relatively low acceptance toward sexual minority groups; filial piety in particular, has been found to be associated with internalized homophobia (Liu et al., 2021). Therefore, sexual minorities in China may face more tremendous stress and higher depressive symptoms than their counterparts in Western countries (Kwok and Wu, 2015; Liu et al., 2018). To date, no one has explored whether the depression disparities may help explain the increased rates of poor sleep quality in sexual minorities in China.

Although interpersonal relationships and depressive symptoms may independently play a mediating role in the sleep disparities of sexual minorities, research suggested that interpersonal problems faced by sexual minorities may also indirectly affect sleep quality through depressive symptoms. A study found that the relationship between sexual minority status and attempted suicide was independently and sequentially mediated by social support and emotional regulation (Chang et al., 2020). Importantly, cross-sectional and longitudinal studies provided good support for the mediating roles of parental rejection, social and peer support, family relationships and satisfaction in the relationship between sexual orientation and depression (Argyriou et al., 2020; Hu et al., 2020; la Roi et al., 2016; Luk et al., 2018). Moreover, mental health was found to mediate the relationship between interpersonal problems and sleep quality among college students (Won and Shin, 2019). These findings indicate that sexual minorities have more interpersonal problems, and in turn, higher levels of depressive symptoms, and thus more inferior sleep quality. Although ongoing comprehensive investigations are being conducted for sleep qualities of sexual minorities, the same could not be said for the current research climate in China. The combined roles of interpersonal relationships and depressive symptoms on the association between sexual orientation and sleep quality is a vital interest and we set to fill in this void.

A nationwide study was used to evaluate the sleep disparities between Chinese sexual minority college students and their heterosexual counterparts. Based on existing research on intermediary variables (Luk et al., 2018; Patterson et al., 2018; Patterson and Potter, 2020), we further explored the series of psychosocial (i.e., interpersonal problems and depressive symptoms) mediating mechanisms that are implicated in these disparities. In addition, considering that only a few studies have explored sex differences in mediation pathways from sexual orientation to sleep problems, and presented mixed results (Luk et al., 2019; Patterson et al., 2018), we further investigated the moderating role of sex in the mediation relationships.

2. Method

2.1. Participants

Data from the 2019 School-Based Chinese College Students Health Survey (SCCSHS) was used, which is a large-scale health-related behavior survey among Chinese college students. In the 2019 SCCSHS, college students were selected via a four-stage, stratified cluster, random sampling method. In stage 1, according to the economic status, all 34 province-level regions in China were divided into three stratifications (the municipality has a single stratification), three provinces were randomly selected in each stratification, and one municipality was randomly selected. The final ten provinces included Guangdong, Shandong, Hunan, Inner Mongolia, Guangxi, Heilongjiang, Yunnan, Guizhou, Xinjiang, and Chongqing. In stage 2, universities from each selected province were divided into: undergraduate and vocational colleges. Then three undergraduate universities (two public and one private) and three vocational colleges (two public and one private) were selected in each province/municipality using the random sampling method. A total of 60 universities were eventually selected. In stage 3, four (4-year and above) or six (3-year) majors were randomly selected from all selected universities for investigation. In stage 4, once the major was determined, one class was randomly selected from the selected grades 1-3 (4 years and above) or grade 1-2 (3 years) within the selected major for investigation. A total of 30,296 college students completed the survey, and the response rate was 98.6%. In the SCCSHS study, sexual orientation was assessed with the use of a single item. As we were mainly interested in the sleep problems of students who acknowledged sexual minorities, and considering the possible information bias(Saewyc et al., 2004), those who answered “unsure” (n = 3,231) to the sexual orientation question were not included in the analysis. Therefore, a total of 27,065 students were finally included in the present analysis.

2.2. Ethical statement

This study was approved by the Sun Yat-Sen University, School of Public Health Institutional Review Board. Written informed consent was obtained from each

participating student.

2.3. Assessment instruments

2.3.1. Sexual orientation

Sexual orientation was measured by the question "Which of the following best describes you?" Responses to the question included "heterosexual"(n=25,927), "gay or lesbian"(n=248), "bisexual"(n=890), "not sure"(n=3,231) (Mueller et al., 2015; Shields et al., 2012). Students who reported "gay or lesbian" and "bisexual" were combined to define the sexual minority group(n=1,138) whilst the "heterosexual" responses defined the heterosexual group (Argyriou et al., 2020).

2.3.2. Depressive symptoms

Depressive symptoms were measured with the Chinese version of the Center for Epidemiology Scale for Depression (CES-D), which has been validated and extensively utilized among adolescents and the young adult population in China (Chen et al., 2009). The CES-D contains 20 items measured on a Likert-type scale. Participants were asked to report past week symptoms on a 0 ("rarely or none of the time") to 3 ("most or all of the time") scale. The total score was computed with higher scores indicating more severe depressive symptoms. The Cronbach's α has been found to be 0.88 (Chen et al., 2009).

2.3.3. Sleep quality

The Chinese Version of the Pittsburgh Sleep Quality Index (CPSQI) is a self-rated questionnaire used to measure the students' sleep quality and disturbances over the previous month. The CPSQI contains 19 items that can be grouped into seven subscales: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medications, and daytime dysfunction. The scores for each subscale ranges from 0 to 3 points. The CPSQI total score range from

0 to 21, with higher scores indicating worse sleep quality (Buysse et al., 1989; Tsai et al., 2005). The CPSQI has been demonstrated to be reliable with an overall reliability coefficient of 0.82–0.83. In the Chinese population, a total CPSQI score greater than 7 points indicates poor sleep quality or sleep disturbance (Tsai et al., 2005).

2.3.4. Interpersonal problems

The students' self-perception of family, peers, and teacher-student relationship was evaluated by the following three questions: "how do you judge the quality of relationship with your family members?"; "how do you judge the quality of relationship with your classmates?"; "how do you judge the quality of relationship with your teachers?" The response options were 3-point scale: good = 1, average = 2, poor = 3. Similar questions have been previously used in other studies (Chen et al., 2020; Guo et al., 2015; Huang et al., 2018). We aggregate the scores from these three questions. Higher scores indicated a higher level of interpersonal relationships.

2.3.5 Control variables

Control variables were included due to their known relations to sleep difficulties among sexual minorities, including sex (1=males and 2=females), age, household socioeconomic status (HSS), ethnicity, academic pressure, smoking, and drinking (Butler et al., 2020; Fricke and Sironi, 2017; Li et al., 2017). HSS was measured by asking students' perceptions of their own family economic situation (Response categories: 1=excellent or very good, 2=good, and 3=fair or poor). Ethnicity was determined based on student self-report (1=Han and 2=other ethnics). Academic pressure was assessed by asking about the student's perceptions about their school work (Response categories: 1=below average, 2=average, 3=above average). Smoking was measured by the question the item, "Have you smoked at least one cigarette during your lifetime?" (1=yes and 2=no). Drinking was assessed by the item, "Have you used at least one drink during your lifetime?" (1=yes and 2=no).

2.4. Statistical analyses

First, descriptive statistics were used to describe demographic characteristics (sex, age, HSS, ethnicity, academic pressure, smoking, and drinking) and prevalence of studied variables (sleep quality, interpersonal relationships, and depressive symptoms) in both heterosexual and sexual minority groups, t-tests or chi-square tests were conducted to make comparisons between the groups. Second, Spearman correlation analyses of the four studied variables were conducted. Third, multiple linear regression analyses assessed associations between sexual orientation, interpersonal relationships, depressive symptoms, and sleep quality. The unadjusted model was firstly tested for a bivariate association for the three explanatory variables and the dependent variable. The adjusted models then controlled all covariates including age, sex, ethnictiy, HSS, academic pression, smoking, and alcohol use. Fourth, the model SPSS PROCESS macros version 3 (Hayes and Montoya, 2017) was used to test the serial multiple mediating roles of interpersonal relationships and depressive symptoms. Specifically, we examined regression coefficients of the association 1) between sexual orientation and interpersonal relationship (a_1 path),2) between sexual orientation and depressive symptoms (a_2 path); between interpersonal relationships and depressive symptoms (d path),3) between sexual orientation (c' path/direct effect), interpersonal relationships (b_1 path) and depressive symptoms (b_2 path) respectively and sleep quality (Fig 1). All the above models controlled for sex, age, HSS, ethnicity, academic pressure, smoking, and drinking. A significant effect was considered if the 95% bootstrap confidence interval (CI) calculated with 10,000 bootstrapping samples does not include a zero. Finally, a moderated mediation analysis was conducted with the SPSS PROCESS macro to test whether the indirect effects of sexual orientation on sleep quality through interpersonal relationships, depressive symptoms, or both differed by sex (Fig 1). An index of moderated mediation suggested by Hayes (Hayes, 2015) was used to judge the significance of the moderated mediation effects. This index is a measure of the association between an indirect effect and a moderator. Significance of the index of moderated mediation is determined when the bootstrap confidence interval does not include zero(Hayes, 2015). The percentage of missing data was less than 2.1% for all relevant variables, and missing data were eliminated in

multiple linear regression analyses, serial multiple mediating analyses and moderated mediation analyses. All analyses were conducted on IBM SPSS Statistics 23.0. *P*-values < 0.05 were considered statistically significant (2-sided tests).

3. Results

3.1. Descriptive and correlation analyses

In the current sample, 4.2% self-reported as sexual minorities, and 95.8% self-reported as heterosexual. These college students consisted of 42.8% males and 57.2% females, with a mean (SD) age of 19.9 (1.3) years. Table 1 shows the differences in demographic and clinical characteristics between the sexual minorities and heterosexuals. Compared with the heterosexual, the sexual minorities had significantly higher subjective scores in sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medications, daytime dysfunction, and CPSQI global ($P < 0.0001$ for all). The mean depressive symptoms score of the sexual minorities was significantly higher than that of the heterosexual college students ($P < 0.0001$). Compared with their heterosexual peers, sexual minority college students were more likely to report average and poor perceived family relationships ($P < 0.001$), teacher relationships ($P < 0.001$) and peer relationships ($P < 0.001$). Additionally, sexual minority college students were more likely to report smoking, alcohol use, good HSS, and above-average academic pressure than their heterosexual peers. Bivariate correlation analyses showed that sleep quality was related to sexual orientation (r =0.074, $P < 0.01$), interpersonal problems (r=0.211, $P < 0.01$), and depressive symptoms (r=0.389, $P < 0.01$) (see Supplemental Table s1).

3.2. Multivariable regression analysis.

As shown in Table 2, the multiple linear regression analysis models were summarized, and the CPSQI total score for sleep quality was the dependent variable; sexual orientation, the total score for interpersonal relationships and CES-D were the

independent variables; students' age, sex, ethnicity, HSS, academic pressure, smoking, and alcohol use were control variables. There were significant associations between sexual orientation, interpersonal relationships, depression symptoms and sleep quality ($P < 0.001$). To be more specific, regardless of whether the covariates were controlled or not, sexual orientation, poor interpersonal relationships and depression symptoms were positively associated with poor sleep quality.

3.3. Serial multiple mediating analysis

Serial multiple mediation model results are presented in Table 3 and Fig 1, including three indirect effects (i.e., a_1b_1, a_2b_2, a_1db_2). Firstly, sexual orientation positively predicted interpersonal problems ($a_1 = 0.250$; 95% CI = 0.192~0.308), which, in turn, negatively predicted sleep quality ($b_1 = 0.107$; 95% CI = 0.095~0.118). The indirect effect of sexual orientation on sleep quality through interpersonal problems was significant ($a_1b_1 = 0.028$; 95% CI = 0.019~0.035), thus demonstrating that the association between sexual orientation and sleep quality was mediated by interpersonal problems.

Secondly, sexual orientation positively predicted depressive symptoms ($a_2 = 0.302$; 95% CI = 0.246~0.359), which, in turn, positively predicted worse sleep quality ($b_2 = 0.322$; 95% CI = 0.312~0.334). The indirect effect of sexual orientation on sleep quality through depressive symptoms was significant ($a_2b_2 = 0.097$; 95% CI = 0.075~0.119), thus demonstrating that the association between sexual orientation and sleep quality was mediated by depressive symptoms.

In addition, interpersonal problems positively predicted depressive symptoms (d = 0.161, 95% CI = 0.149~0.172). The serial indirect effect of sexual orientation on sleep quality through interpersonal problems and depressive symptoms was also significant ($a_1db_2 = 0.013$; 95% CI =0.009~0.018). The results suggest that the association between sexual orientation and sleep quality was mediated by interpersonal problems and depressive symptoms in sequence. After controlling for interpersonal problems

and depressive symptoms, sexual orientation still positively predicted worse sleep quality (c' = 0.162; 95% CI =0.108~0.706).

3.4. Moderated mediation analyses

As shown in Table 4, based on the Index of moderated mediation, the 95% bias-corrected bootstrap CIs for mediation through interpersonal problems only and mediation through depressive symptoms only both contained 0 (95% CI = -0.031~0.004 and 95% CI = -0.036~0.062, respectively). The pathway linking interpersonal problems and depressive symptoms was significantly moderated by sex (Fig 1) (interpersonal problems*sex: -0.062, P <0.0001); meanwhile, the 95% bias-corrected bootstrap CI for mediation through interpersonal problems and depressive symptoms in serial multiple mediation analysis did not contain 0, suggesting that the serial indirect effect of sexual orientation on sleep quality through interpersonal problems and depressive symptoms was stronger in males than females.

4. Discussion

The present study investigated the relationships among sexual orientation, interpersonal problems, depressive symptoms and sleep quality using a large sample of Chinese college students. The result showed that 4.2% of students self-reported sexual minorities and sexual orientation was associated with greater likelihood of poor interpersonal relationships, severe depressive symptoms and poor sleep quality. In the serial multiple mediation analysis, we found that 1) sexual orientation was directly associated with the risk for poor sleep quality, 2) interpersonal relationships mediated the relationship between sexual orientation and sleep quality, 3) depressive symptoms mediated the relationship between sexual orientation and sleep quality, 4) interpersonal relationships and depressive symptoms, in sequence, mediated the relationship between sexual orientation and sleep quality. Moreover, the serial indirect effect of sexual orientation on sleep quality through interpersonal problems and depressive symptoms was more robust in males than females.

In this study, sexual orientation disparities were found in sleep disturbance and all the CPSQI sleep component domains. After controlling for social demographics, interpersonal relationships, depressive symptoms and sexual orientation was associated with sleep quality. These findings were consistent with previous results on Chinese adolescents from grades 7–12 (Huang et al., 2018; Li et al., 2017). Although most previous studies in western countries used a single item to evaluate sleep quality or sleep difficulties, the trend of increased risk of sleep problems among sexual minorities was in line with this study, regardless of whether for adolescents or adults (Caceres and Hickey, 2020; Crawford and Ridner, 2018; Duncan et al., 2018; Chen and Shiu, 2017; Dai et al., 2020; Blosnich et al., 2013). The current research conclusions on sleep time and sleep delay are still inconsistent (Luk et al., 2019), which may be caused by different evaluation indexes, grouping standards and statistical description methods. More research on sleep problems of sexual minorities is needed. Objective sleep measurements are recommended to evaluate the sleep differences between sexual minorities and heterosexuals.

Our mediation analyses uncovered significant mediating effects of interpersonal problems on the association between sexual orientation and sleep quality in this study. Similarly, Patterson et al. reported that the relationship between sexual orientation and sleep difficulties was significantly mediated by the relationship with parents and the stress associated with them in a national sample of adults in the United States (Patterson et al., 2018). In addition, during the transition period from adolescents to college students, the quality of one's interpersonal relationships has been linked to a host of outcomes (e.g., academic, emotional functioning, and depressive symptoms) (Holt et al., 2018). Moreover, due to stigma and discrimination, sexual minority individuals confront the higher level of poor relationships with parents, teachers, and classmates (Hatzenbuehler, 2009; Huang et al., 2018; Tate and Patterson, 2019). This is especially true in a Chinese society dominated by Confucian culture, where a large portion of the population still show intolerant attitudes towards sexual minorities (Kwok and Wu, 2015; Xie and Peng, 2018). Thus, they often hide their sexual

orientation and have minimal support from friends and family (Liu et al., 2018). Current research has found that sexual minority college students have worse interpersonal relationships than heterosexuals. These interpersonal difficulties have been related to perceived stress associated with sleep difficulties (Patterson et al., 2018). Our findings suggest that interventions for sleep difficulty of college students that target sexual minority individuals may benefit from incorporating strategies that improve interpersonal relationships with their family, peers, and teachers.

The current research found that depressive symptoms significantly mediated the effect of sexual orientation on sleep quality for Chinese college students, which is in line with two previous studies. Luk et al. found that higher depressive symptoms mediated the relationship between sexual orientation and increased daytime sleepiness (mediated 70.8% of total effect) among US female youth (Luk et al., 2019). Patterson and Potter also found that sexual orientation was associated with confirmed sleep difficulties through depressive symptoms among bisexual adults in the United States (Patterson and Potter, 2020). These studies suggest that depression may help explain disparities in overall sleep quality or a specific sleep behavior between sexual minorities and heterosexuals. Considering the complexity and multidimensional nature of sleep problems (Buysse, 2014), we can further explore the specific influence mechanism of depression on different sleep components in sexual minorities.

In this study, a higher level of interpersonal problems was associated with more depression symptoms, decreasing sleep quality. Sexual minority individuals experience multiple stressors due to their sexual orientation, such as prejudice, violence and discrimination (Meyer, 2003). These stigma-related stressors cause them to face more social/interpersonal and emotional disorders than heterosexuals, and these processes, in turn, play a mediating role in the relationship between stigma-related stressors and adverse mental outcomes. Past empirical studies have shown that sexual minorities experience more interpersonal problems, such as parental rejection, social and peer support, family relationships and satisfaction,

which lead to an increased risk of depressive symptoms (Argyriou et al., 2020; Hu et al., 2020; la Roi et al., 2016; Luk et al., 2018). We use a series of mediation analyses to further expand the mechanism of interpersonal problems and depression on the sleep problems of sexual minorities (Butler et al., 2020; Hatzenbuehler, 2009; Patterson and Potter, 2020). However, considering the complexity of the relationship between interpersonal relationships, depression, and sleep disorders, it is necessary to implement longitudinal research in the future to understand their interrelations better.

Consistent with previous research (Cheng et al., 2012; Madrid-Valero et al., 2017), females had a higher risk of poor sleep quality. This study found that the mediating effects of depressive symptoms in the association between sexual orientation and sleep quality were not moderated by sex, which is different from a longitudinal study resulting from that sexual minority status was associated with daytime sleepiness through depressive symptoms only found in female (Luk et al., 2019). However, our findings were similar to a previous study that reported no sex differences in the effects of sexual minority status on sleep quality through interpersonal problems (Patterson et al., 2018). Our findings further elaborate on these results by providing new evidence for a stronger serial indirect effect of sexual orientation on sleep quality through interpersonal problems and depressive symptoms in males than females. This suggests that reducing depression symptoms and further improving sleep quality by improving interpersonal relationships will produce better results for males, but the result needs to be confirmed.

The findings cover the series effects of psychosocial factors on sleep disparities of sexual minority college students, which have important implications for preventions and clinical interventions. First, changing the stigmatized social environment of sexual minorities can effectively reduce health disparities(Matsick et al., 2020). The education and public health departments should formulate corresponding policies to reduce the sexual minority stressors, including discrimination, injustice and prejudice. Second, colleges and universities should develop teacher education and training

programs that provide support for sexual minorities to improve their teacher-student relationship, because teachers' sexual prejudices and discriminatory attitudes bring mental health risks to sexual minorities (Kwok, 2019). Third, knowledge related to sexual minorities (e.g., identity concepts and adverse mental health effects) could be delivered to parents and students through lectures or courses, which can help reduce parents' rejecting behaviors and promote affirmative attitudes of peers (Friedrich and Schlarb, 2018) to improve interpersonal problems of sexual minorities further, thereby reducing the risk of depression and sleep disorders. Fourth, it is essential to note that the path of reducing depression symptoms and further improving sleep problems by improving interpersonal relationships is even more important for male college students. Finally, school counselors, psychiatrists, and clinicians should adopt effective interventions (e.g., improving self-esteem and emotional regulation capacity) (Argyriou et al., 2020) and treatment measures (e.g., seven-module computerized cognitive behavioral therapy program) (Lucassen et al., 2015) for the sexual minority college students who have interpersonal difficulties, depression symptoms and other mental disorders to improve their sleep quality.

Some limitations of this study should be considered. First, given the cross-sectional design, all our data were collected at a single time point, which prevents the identification of causal relationships when conducting mediation analysis (Maxwell and Cole, 2007). In the future, the causal relationship between sexual orientation, interpersonal relationships, depression and sleep quality should be explored in a longitudinal design. Second, students may have difficulty recalling information about sleep quality measured by the CPSQI, introducing bias into this measure (Dietch et al., 2019). Third, the assessment of sexual orientation was based on a single question (Patterson and Potter, 2020); although this is common in current scientific practice, we were unable to evaluate the sleep quality of gender dysphoria or transgender groups. Fourth, considering the single item measurement, we did not distinguish between family relationships, teacher-student relationships, and classmate relationships. However, these may play different roles in the relationship between

sexual orientation and sleep problems. Fifth, our study sample did not include students in the graduation grade; poor sleep quality and depression symptoms may be more common among those students. Sixth, regarding the two covariates of smoking and drinking, more effective measurement is needed. Despite these limitations, one of the strengths of our research is that it uses a nationally large-scale sample of college students across China, which provides sufficient statistical power, particularly for the serial multiple mediation, and may avoid oversampling of the sexual minorities. In addition, although there are several studies on mediations of the relationship between sexual orientation and sleep quality, this study uses multiple serial mediation models for the first time to explore the mechanism of sleep disparities in sexual minorities. This methodology provides a better understanding of how mediators are related (Chang et al., 2020; Hatzenbuehler, 2009). Finally, the important constructs such as sleep quality were measured by widely used, reliable instruments (Tate and Patterson, 2019).

5. Conclusion

To conclude, evidence was provided that sexual minority college students have a higher risk of sleep disorders than their heterosexual peers. The relationship between sexual orientation and sleep quality was also found to be independently and in series mediated by interpersonal relationships and depressive symptoms, and the serial indirect effect was more robust in males than females. Our results call for more support and attention to be paid towards disparities in sleep quality in sexual minority college students in China. This could be achieved through incorporating prevention and intervention programs that target interpersonal problems and depression symptoms, rather than sleep disorders alone.

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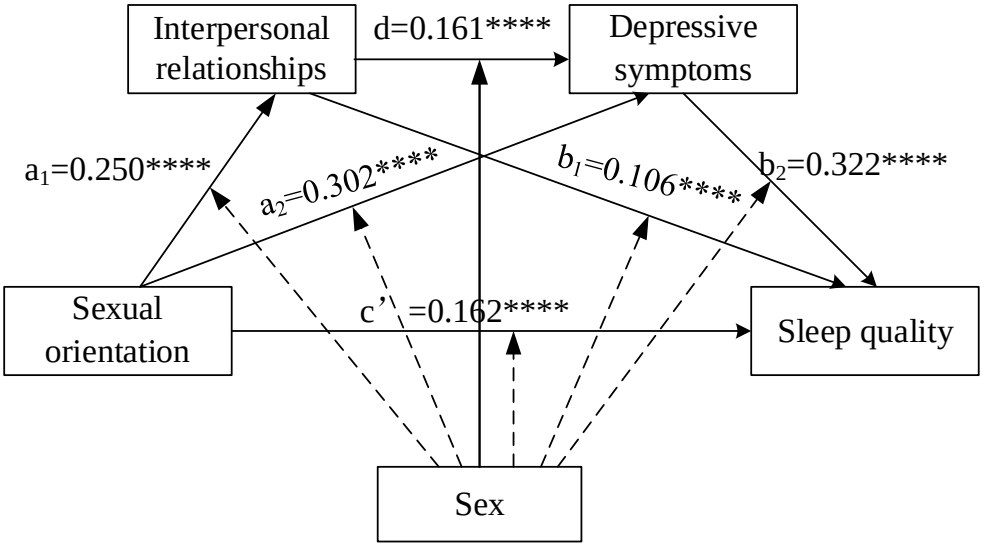

Fig.1 Serial multiple mediation model from sexual orientation to sleep quality and in which sex moderate the relation of sexual orientation to sleep quality. Values shown are standardized path coefficients. Solid lines indicate significant paths while broken lines indicate non-significant paths. ****P<0.0001.

Table 1. Demographic characteristics stratified by sexual orientation.

Characteristic	Total, n (%)	Sexual minorities [a], n (%)	Heterosexual, n (%)	χ^2 /*t*	*P*-value
Total	27,065(100)	1,138(4.2)	25,927(95.8)		
Sex				75.241	<0.001
Male	11,575(42.8)	345(30.3)	11,230(43.3)		
Female	154,90(57.2)	793(69.7)	14,697(56.7)		
Age [b]	19.9(1.3）	19.6(1.3)	19.9(1.3)	6.596	<0.001
Ethic					
Han	22,639(83.6)	964(85.0)	21,675(84.1)	0.645	0.425
other	4,260(15.7)	170(15.0)	4,090(15.9)		
Missing data	166(0.6)	-	-		
HSS				28.373	<0.001
Good	2,733(10.1)	168(14.9)	2,565(10.0)		
Average	14,878(55.0)	586(51.9)	14,292(55.8)		
Poor	9,152(33.8)	375(33.2)	8,777(34.2)		
Missing data	302(1.1)	-	-		
Academic pressure				14.830	0.001
Below average	7,966(29.4)	330(29.1)	7,636(29.6)		
Average	11,558(42.7)	437(38.6)	11,121(43.1)		
Above average	7,430(27.5)	366(32.3)	7,064(27.4)		
Missing data	111(0.4)	-	-		
Smoking				32.742	<0.001
No	19,896(73.5)	754(66.4)	19,142(74.1)		
Yes	7,083(26.2)	381(33.6)	6,702(25.9)		
Missing data	86(0.3)	-	-		
Alcohol use				26.984	<0.001

No	7,897(29.2)	254(22.4)	7,643(29.6)		
Yes	19,062(70.4)	879(77.6)	18,183(70.4)		
Missing data	106(0.4)	-	-		
Classmates relations				58.325	<0.001
Good	20,516(75.8)	783(68.8)	19,733(76.1)		
Average	6,363(23.5)	331(29.1)	6,032(23.3)		
Poor	186(0.7)	24(2.1)	162(0.6)		
Teacher-classmate relations					
Good	15,992(59.1)	581(51.0)	15,411(59.4)	43.915	<0.001
Average	10,774(39.8)	530(46.6)	10,244(39.5)		
Poor	299(1.1)	27(2.4)	272(1.1)		
Family relations				72.913	<0.001
Good	23,253(95.9)	885(77.8)	22,368(86.3)		
Average	2,945(10.9)	181(15.9)	2,764(10.7)		
Poor	867(3.2)	72(6.3)	795(3.1)		
CPSQI [b]					
CPSQI total score	5.36(2.82)	6.36(3.31)	5.31(2.79)	-10.459	<0.001
Subjective sleep quality	1.12(0.73)	1.28(0.82)	1.11(0.73)	-6.892	<0.001
Sleep latency	1.35(1.57)	1.70(1.78)	1.33(1.56)	-6.700	<0.001
Sleep duration	0.90(0.83)	1.10(0.94)	0.89(0.82)	-7.125	<0.001
Habitual sleep efficiency	0.25(0.60)	0.32(0.68)	0.24(0.60)	-3.532	<0.001
Sleep disturbance	0.78(0.54)	0.92(0.65)	0.78(0.54)	-8.567	<0.001
Use of sleeping medications	0.03(0.24)	0.12(0.50)	0.03(0.22)	-6.111	<0.001
Daytime dysfunction	1.47(0.86)	1.74(0.90)	1.46(0.85)	-10.885	<0.001
Depressive symptoms [b]	36.18(7.01)	38.92(8.41)	36.06(6.93)	-11.294	<0.001

[a] Sexual minorities include students who reported gay, lesbian and bisexual.

[b] Age data, depressive symptoms score, CPSQI scores were presented as the mean (SD).

Abbreviations: -, Not available; n, number; SD, standard deviation; HSS, household socioeconomic status; CPSQI, Chinese Version of the Pittsburgh Sleep Quality Index.

Table 2. Multivariable regression analysis of sleep quality.

Variable	Model 1				Model 2			
	B	***β***	***t***	***P***	***B***	***β***	***t***	***P***
Sexual orientation [a]	0.181	0.036	6.488	<0.001	0.153	0.031	5.583	<0.001
Interpersonal relations	0.125	0.129	22.696	<0.001	0.103	0.107	18.639	<0.001
Depressive symptoms	0.051	0.353	61.748	<0.001	0.046	0.316	54.257	<0.001

B, non-standardized regression coefficient; *β*, standardized regression coefficient; [a] heterosexual coded as 1.

Model 1 is unadjusted.

Model 2 adjusted for age, sex, ethnicity, HSS, academic pressure, smoking, and alcohol use.

Table 3. The bootstrap results for the indirect effect of sexual orientation on sleep quality between interpersonal problems and depressive symptoms.

Effect/path	*b*	SE	95%CI(PC)	
			Lower	Upper
Direct effect				
Sexual orientation → interpersonal problems	0.250	0.030	0.192	0.308
Sexual orientation → depressive symptoms	0.302	0.029	0.246	0.359
Interpersonal problems → depressive symptoms	0.161	0.006	0.149	0.172
Sexual orientation → sleep quality	0.162	0.028	0.108	0.706
Interpersonal problems → sleep quality	0.107	0.006	0.095	0.118
Depressive symptoms → sleep quality	0.322	0.006	0.312	0.334
Indirect effect				
Indirect 1	0.028	0.004	0.019	0.035
Indirect 2	0.097	0.111	0.075	0.119
Indirect 3	0.013	0.002	0.009	0.018

Indirect 1, Sexual orientation → interpersonal problems → sleep quality; Indirect 2, Sexual orientation → depressive symptoms → sleep quality; Indirect 3, Sexual orientation → interpersonal problems → depressive symptoms → sleep quality.

All models controlled age, sex, ethnicity, HSS, academic pressure, smoking and alcohol use.

Abbreviations: SE, standard error; b, standardized regression coefficient; CI, confidence interval.

Table 4. Results testing whether indirect effects were moderated by sex.

	Interpersonal problems			**Depressive symptoms**			**Sleep quality**		
	b	**SE**	***P***	***b***	**SE**	***P***	***b***	**SE**	***P***
Sexual orientation	0.261	0.031	<0.0001	0.299	0.030	<0.0001	0.150	0.028	<0.0001
sex	0.210	0.013	<0.0001	0.197	0.013	<0.0001	0.066	0.013	<0.0001
Sexual orientation × sex	-0.095	0.064	0.1409	0.039	0.062	0.5352	0.096	0.060	0.1083
Interpersonal problems	-	-	-	0.162	0.006	<0.0001	0.107	0.006	<0.0001
Interpersonal problems × sex	-	-	-	-0.062	0.011	<0.0001	-0.012	0.012	0.3156
Depressive symptoms	-	-	-	-	-	-	0.322	0.006	<0.0001
Depressive symptoms × sex	-	-	-	-	-	-	0.003	0.011	0.8046
	R^2=0.066			R^2=0.114			R^2=0.201		
	F (9,26349) =208.08			F (11,26347) =308.25			F (13,26345) =508.30		
	P<0.0001			*P*<0.0001			*P*<0.0001		
	Index of moderated mediation and its 95% bootstrapped CI								
	-0.013			0.013			**-0.010**		
	(-0.031,0.004)			(-0.036,0.062)			**(-0.019,-0.002)**		

All models controlled age, ethnicity, HSS, academic pression, smoking, and alcohol use.

Abbreviations: CI, confidence interval; SE, standard error; -, not available.