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Associations of fruit and vegetable intake with sleep quality and stress among Hong Kong female nurses with different working status: a cross-sectional study

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Abstract

Background The relationships of fruit and vegetable (FV) intake with sleep quality and stress among nurses with different working status are largely unknown. This study aimed to assess the FV intake among Hong Kong female nurses with varying working status and evaluate its associations with sleep quality and stress levels.

Methods A cross-sectional survey named "Hong Kong Women's Health Study" was conducted between 2019 and 2020. Systematic sampling was adopted to recruit eligible nurses from a local Nurses Association. Email invitations followed by mailed questionnaires were used for data collection. FV servings consumed every day with detailed descriptions. The Chinese version of the Pittsburgh Sleep Quality Index and Perceived Stress Scale-14 items were employed to evaluate sleep quality and stress level, respectively. Nurses' work status was classified as employed/retired and day work/shift work. Multivariate linear regression was applied.

Results A total of 1,270 female nurses were included in the data analysis. The average FV intake was 2.91 servings/day, 88.7% of the participants consumed less than 5 servings/day. Nurses who were aged 45 and above, obese (BMI ≥ 25 kg/m^2), post-menopause, with a higher monthly family income, day work schedule, or retired, were more likely to have higher VF intake (all $P < .05$). The mean PSQI score was 6.14 (SD = 3.41), 53.7% nurses reported poor sleep quality. The mean PSS score was 24.8 (SD = 7.62), with 79.5% of nurses having moderate to high levels of stress. The multiple linear regression analysis revealed that 1-serving increase in FV intake was associated with 0.150 (95% *CI*: -0.279, -0.021) units and 0.656 (95% *CI*: -0.932, -0.380) units decrease in sleep and stress scores (both $P < .05$), respectively. Among retired nurses and routine day-working nurses, consuming more FV servings predicted higher decline in stress levels than those employed and shift-working nurses.

Conclusion Increased FV intake was associated with better sleep quality and lower stress levels among Hong Kong female nurses. The FV intake-stress relationship was strengthened in employed nurses and those working routine day shifts.

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Keywords Fruit and vegetable intake, Sleep, Stress, Nurse

Background

Fruit and vegetable (FV) intake is widely recognized for its benefits in promoting health and reducing risk of common disease, and premature mortality [1]. Recently, a growing body of evidence highlights the positive effects of consuming FV on sleep quality. For instance, more FV intake was associated with better sleep quality [2], fewer insomnia symptoms, and sufficient sleep duration [3]. In contrast, inadequate FV consumption was associated with short sleep duration [4] and insomnia-related sleep difficulties [5]. However, there were still some studies found that FV consumption was not associated with sleep quality [4, 6, 7], which indicated that the FV-sleep relationship needs more insightful exploration.

Sleep quality, as measured by the Pittsburgh Sleep Quality Index (PSQI) score, encompasses seven components: subjective sleep quality, sleep latency, sleep efficiency, sleep duration, sleep disturbances, use of sleep medication, and daytime dysfunction. Poor sleep quality, indicated by PSQI score greater than 5, is a prominent issue among nurses worldwide [8]. Compared with the prevalence of sleep disorders (dissatisfaction with sleep quality and quantity) of the general population (20-48%), nurses across different countries had a higher percentage (about 65-78%) of sleep problems [9, 10]. It is recommended for adults to consistently obtain a minimum of 7 h or more of sleep per night in order to uphold optimal health [11]. In Hong Kong, 64.3% of nurses reported experiencing reduced sleep duration, with less than 7–8 h of sleep (3–4 times a week) [12], which indicated a significant prevalence of sleep deprivation among the nursing population. Moreover, female nurses exhibited a higher propensity for poor sleep quality than males. This aligned with the results of a review, which indicated that women have a 40% higher risk of experiencing insomnia compared to men across different age groups, likely due to fluctuations in sex steroids [13]. Limited evidence exists on the relationship between sleep and FV intake specifically among nurses, a unique population with distinct professional characteristics. Therefore, it is essential to evaluate nurses' FV consumption and its relationship with sleep quality.

Stress is a psychological and physiological response to perceived challenges in one's environment, and it is a complex state that involves emotional, cognitive, and behavioral responses. Stress is a most prevalent suffering that perplexes nurses' work performance and psychological health due to their challenging work. A cross-sectional study including 2,895 nurses in 115 tertiary hospitals demonstrated that 78.4% reported experiencing moderate to high levels of job-related stress [14]. Preliminary studies revealed that FV intake may be correlated with stress levels. For instance, a population-based cohort study among Australian adults indicated that higher FV intake was correlated with lower perceived stress, particularly in middle-aged adults [15]. However, most of the previous cross-sectional or prospective studies were conducted among university students or general adults. Furthermore, there were inconsistent and inconclusive results regarding the correlation between FV intake and stress levels [15, 16]. Hence, it is essential to conduct further evaluation to examine the relationship between FV intake and stress levels among nurses.

In summary, the current status of female nurses was still scarce and previous studies presented inconsistent findings regarding the associations between FV intake, sleep, and stress. Therefore, this study aimed to comprehensively assess the status of FV intake, sleep quality, and stress levels among female nurses in Hong Kong, with a specific focus on different subgroups of this population. The investigation into the correlation between nurses' work status and sleep, stress, and FV intake will contribute to a comprehensive understanding of the factors influencing nurses' health. Additionally, it will provide a scientific foundation for enhancing their quality of life and working environment.

Methods

Study design

Data were extracted from a regional, cross-sectional study: "Hong Kong Women's Health Study 2019" [17]. The study was conducted in Hong Kong and specifically focused on local female nurses as the target population.

Participants selection and setting

Systematic sampling was adopted. Female nurses were recruited from the Association of Hong Kong Nursing Staff's membership database, with an estimated 30,000 members, accounting for 60% of the overall nurses in Hong Kong. A unique code number was assigned to each nurse and arranged in ascending order. According to the formula $k = N/n$, where N represented the population size of 30,000 and n denoted the required sample size of 10,000, the sampling interval k was calculated to be 3. The starting point was selected randomly, and the first subject was chosen. Subjects were then selected every third interval until 10,000 samples were reached.

The inclusion criteria were as follows: (i) Chinese female nurses, (ii) Aged 30 years or older, individuals in this group tend to experience consistent levels of stress

and maintain regular sleep patterns due to the generally stable and regular nature of their employment, and (iii) Hong Kong residents. The exclusion criteria include: (i) Diagnosed with mental health diseases, (ii) With illness that significantly affected sleep quality, (iii) Individuals who were pregnant or had underlying medical conditions that substantially impacted their FV intake, such as irritable bowel syndrome, Crohn's disease, and other gastrointestinal disorders, (iv) Could not read Chinese. The sample size was calculated by PASS 2021 and based on the prevalence of stress symptoms among 850 Hong Kong nurses (41.1%) [12]. To achieve a 95% confidence level, 5% precision, and account for a 20% rate of no response and invalid responses (with missing data more than 10%), an estimated sample size of 460 participants was determined. To yield representative findings on this research topic for the Hong Kong nursing population, 1,270 participants were included.

Measures

FV intake

The average daily intake of FV servings was obtained via a predefined questionnaire based on information from the Centre for Health Protection, Department of Health, the Government of the Hong Kong Special Administrative Region. One serving of fruit was defined as ≥2 small-sized fresh fruits, 1 medium-sized fresh fruit, ½ large-sized fruit, ½ bowl of cut-up fruit, 1⁄2 bowl of mini-sized fruit, 1 tablespoon of dried fruit, or ¾ glass of pure fruit juice without added sugar or salt [18]. One serving of vegetables was referred to ½ bowl of cooked vegetables, sprouts, gourds, beans, or mushrooms or 1 bowl of uncooked vegetables [19]. Adequate consumption of FV was defined as ≥5 servings per day according to the WHO recommendation [20].

Sleep quality

The Chinese version of the PSQI, composed of 19 self-assessment items, was employed to assess the sleep quality within the past 30 days. There are 7 domains, including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medication use, and daytime dysfunction. Scores ranging from 0 (no difficulty) to 3 (severe difficulty) are assigned to each domain. The summation of all domains yields a global PSQI score, ranging from 0 to 21. A higher global PSQI score signifies inferior sleep quality, while a score above 5 is considered an indicator of clinically poor sleep quality. Previous study has shown that the PSQI has a good overall reliability, half-split reliability, test-retest reliability, and construct validity among medical students [21]. The Cronbach's alpha coefficient for the female nurses in this study is 0.721.

Perceived stress level

The perceived stress of female nurses was measured by the Chinese version of the Perceived Stress Scale-14 items (PSS-14). It consists of 14 items that are rated on a 5-point Likert scale, ranging from 0 (never) to 4 (very often). The total score ranges from 0 to 56, with higher scores indicating higher levels of stress. The levels of stress can be classified into three categories based on score: low stress level (0–18), moderate stress level (19–37), and high stress level (38–56). A preliminary study evaluated the psychometric properties of this scale and suggested satisfactory reliability and validity [22]. The Cronbach's alpha coefficient obtained in this study is 0.858.

Data collection

We employed a hybrid approach, utilizing both email and traditional mail methods to collect data. The Association of Hong Kong Nursing Staff assisted in sending two rounds of emails to potential participants at a one-month interval. These emails included an invitation letter and the hyperlink to the online questionnaires hosted on Qualtrics. A month after the second round of email correspondence, we sent regular emails including an invitation letter, the questionnaires, a research leaflet, and a prepaid return envelope. Only those who didn't respond online need to send back their reply through mail. The participation was voluntary. Throughout the process, participants were sent two reminder emails to notify them of the opportunity to receive a $100 coupon as a token of appreciation for their time and effort.

Data analysis

Independent t-test and analysis of variance (ANOVA) were performed to compare mean differences of the sum of FV servings, global PSQI score, and PSS total score among different nurse groups according to demographics characteristics. Pearson tests were computed to investigate the associations among FV consumption, sleep quality, and stress level. Multiple linear regression was employed to examine the predictive roles of FV servings in the changes of global PSQI score and total PSS score.

Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB) of The Hong Kong Polytechnic University, named as Human Subject Ethics Subcommittee (HSESC). The reference number was HSEARS20190514003. Female nurses were invited to participate voluntarily. Participants received a detailed information sheet with the questionnaires, and completion of the questionnaires indicated informed consent. All questionnaires were completed anonymously, ensuring that no connection could be established between the

participants' identities and their responses. All procedures in this study were implemented in accordance with the Declaration of Helsinki.

Results

Demographic characteristics of the Hong Kong female nurses

A total of 1,270 eligible female nurses were included in this analysis. Their mean age was 46.3 years (SD = 10.79), with over half (n = 683, 53.8%) being older than 45 years. Most of them were married or cohabiting (n = 922, 72.6%), and 92.4% (n = 1,173) of them were living with others. The majority of the participants held undergraduate or associated degrees (n = 677, 53.3%), or postgraduate degrees and above (n = 458, 36.1%). Most of the nurses were non-obesity (n = 1,044, 82.2%) and non-menopause (n = 792, 62.4%). Nearly 88% (n = 1,114, 87.7%) of nurses were actively employed. Among those employed nurses, more than half of them (n = 604, 54.2%) were engaged in day work schedules (nursing management, outpatient clinics, community/nursing home), and 45.8% were assigned to shift work (inpatient wards, emergency department, intensive care unit, operating room, and other specialist care wards). Table 1 presents a detailed comparison of the nurses' characteristics based on employed and working status.

FV intake, sleep quality, and stress levels of female nurses

The mean serving of FV intake was 2.91 (SD = 1.47) with 88.7% of them reported consuming less than 5 servings of FV per day. The median servings of FV intake was 3 servings. Specifically, the median serving for fruit, cooked vegetables, and uncooked vegetables was 1, 1, and 0, respectively. Table 2 summarized the results of FV intake of the participants based on various demographic factors. Hong Kong female nurses over the age of 45, with a higher family income, retired status, day work schedule, BMI ≥ 25 kg/m^2, and post-menopause stage, were more likely to report a higher intake of FV servings (all $p < .05$).

The mean global PSQI score was 6.14 (SD = 3.41) with 682 nurses (53.7%) reporting overall poor sleep quality, indicated by a global PSQI score above 5. Regarding the subjective sleep quality domain, less than half of the nurses reported good subjective sleep quality (n = 573, 45.1%). A significant portion of participants experienced poor sleep quality(n = 446, 35.1%), with 4.6% of them describing it as "very bad". Nurses who were single, divorced, separate or widowed, lived alone, had a lower education level, were on shift, and non-menopause

Table 1 Different characteristics of working status and shift work of nurses

Variables	Employed status (n, %)			Working status (n, %)		
	Employed (n = 1,114)	Retired (n = 156)	p	Day worker (n = 604)	On shift (n = 510)	p
Age (years)			< 0.001			0.002
30–34	246 (22.1)	0 (0)		119 (19.7)	127 (22.1)	
35–44	338 (30.3)	3 (1.9)		169 (28.0)	169 (33.1)	
≥ 45	530 (47.6)	153 (98.1)		316 (52.3)	214 (42.0)	
Marital status			0.039			0.067
Married or cohabiting	820 (73.6)	102 (65.4)		458 (75.8)	362 (71.0)	
Single, divorced, separated or widow	294 (26.4)	54 (34.6)		146 (24.2)	148 (29.0)	
Living status			< 0.001			0.565
Living alone	65 (5.8)	32 (20.5)		33 (5.5)	32 (6.3)	
Living with others	1049 (94.2)	124 (79.5)		571 (94.5)	478 (93.7)	
Educational level			< 0.001			0.973
High school	98 (8.8)	37 (23.7)		54 (8.9)	44 (8.6)	
Undergraduate and associated degree	589 (52.9)	88 (56.4)		320 (53.0)	269 (52.7)	
Postgraduate or above	427 (38.3)	31 (19.9)		230 (38.1)	197 (38.6)	
Family income (HK$/month)			< 0.001			0.003
$0 - $50,000	222 (19.9)	99 (63.5)		135 (22.4)	87 (17.1)	
$50,001 - $100,000	752 (67.5)	54 (34.6)		381 (63.1)	371 (72.7)	
>$100,000	140 (12.6)	3 (1.9)		88 (14.6)	52 (10.2)	
BMI (kg/m2)						
< 25.0	918 (82.4)	126 (80.8)	0.617	508 (84.1)	410 (80.4)	0.105
≥ 25.0	196 (17.6)	30 (19.2)		96 (15.9)	100 (19.6)	
Menopause status			< 0.001			
Non-menopause	774 (70.0)	6 (4.0)		397 (66.3)	377 (74.4)	0.003
Post-menopause	332 (30.0)	146 (96.0)		202 (33.7)	130 (25.6)	

Note: Independent t-test and analysis of variance (ANOVA) were used for two or more groups comparison

Table 2 Demographics, FV servings, global PSQI score and PSS total score situations

Variables	Sum of FV Servings		Global PSQI Score		PSS Score	
	Mean (SD)	*p*	Mean (SD)	*p*	Mean (SD)	*p*
Age(years)		< 0.001		0.297		< 0.001
30–34	2.69 (1.39)		6.33 (3.16)		27.2 (7.49)	
35–44	2.64 (1.27)		6.28 (3.31)		26.8 (7.20)	
≥ 45	3.13 (1.56)		6.00 (3.54)		22.9 (7.37)	
Marital status		0.800		< 0.001		0.001
Married or cohabiting	2.91 (1.43)		5.93 (3.32)		24.4 (7.54)	
Single, divorced, separated or widow	2.93 (1.58)		6.71 (3.58)		26.0 (7.71)	
Living status		0.935		0.004		0.668
Living alone	2.90 (1.42)		7.09 (3.39)		24.5 (8.09)	
Living with others	2.92 (1.47)		6.06 (3.39)		24.8 (7.58)	
Educational level		0.076		0.005		0.534
High school	3.17 (1.39)		6.58 (3.60)		24.1 (7.27)	
Undergraduate and associated degree	2.92 (1.47)		6.33 (3.41)		24.8 (7.57)	
Postgraduate or above	2.84 (1.48)		5.74 (3.30)		25.0 (7.80)	
Family income (HK$/month)		0.018		0.441		0.022
$0 - $50,000	3.04 (1.50)		6.05 (3.44)		24.1 (8.37)	
$50,001 - $100,000	2.83 (1.42)		6.23 (3.39)		25.3 (7.26)	
>$100,000	3.12 (1.61)		5.87 (3.41)		24.1 (7.68)	
Employed status		< 0.001		0.113		< 0.001
Employed	2.85 (1.43)		6.20 (3.33)		25.5 (7.37)	
Retired	3.37 (1.65)		5.74 (3.88)		20.1 (7.69)	
Working status(n = 1,114)		0.001		< 0.001		0.001
Day worker	2.98 (1.44)		5.84 (3.20)		24.8 (7.59)	
On shift worker	2.69 (1.40)		6.63 (3.43)		26.3 (7.03)	
BMI(kg/m^2)		0.042		0.204		0.250
< 25	2.88 (1.44)		6.09 (3.34)		24.7 (7.53)	
≥ 25.0	3.10 (1.59)		6.40 (3.71)		25.3 (7.99)	
Menopause status		< 0.001		0.030		< 0.001
Non-menopause	2.73 (1.39)		6.30 (3.29)		26.4 (7.30)	
Post-menopause	3.23 (1.53)		5.87 (3.58)		22.3 (7.50)	

Note: Independent t-test and analysis of variance (ANOVA) were used for two or more groups comparison

Table 3 Seven PSQI components and difference based on employed and working status

Variable	Overall	Employed status (n = 1,270)			Working status (n = 1,114)		
		Employed	Retired	*p*	Day worker	Shift worker	*p*
Subjective sleep quality	1.20 ± 0.81	1.23 ± 0.79	0.98 ± 0.85	< 0.001	1.17 ± 0.80	1.30 ± 0.79	0.009
Sleep latency	0.85 ± 0.83	0.82 ± 0.81	1.03 ± 0.93	0.004	0.76 ± 0.77	0.90 ± 0.86	0.005
Sleep efficiency	0.87 ± 0.91	0.89 ± 0.92	0.78 ± 0.88	0.184	0.82 ± 0.88	0.96 ± 0.95	0.012
Sleep duration	0.45 ± 0.82	0.43 ± 0.80	0.60 ± 0.93	0.016	0.33 ± 0.72	0.56 ± 0.88	< 0.001
Sleep disturbance	1.06 ± 0.54	1.06 ± 0.55	1.08 ± 0.47	0.573	1.06 ± 0.54	1.06 ± 0.50	0.939
Use of sleep medication	0.15 ± 0.56	0.14 ± 0.55	0.21 ± 0.68	0.128	0.11 ± 0.50	0.18 ± 0.59	0.031
Daytime dysfunction	1.56 ± 1.06	1.63 ± 1.04	1.05 ± 1.05	< 0.001	1.59 ± 1.03	1.68 ± 1.05	0.155

exhibited a higher mean Global PSQI score (indicating poor sleep quality, all $p < .05$) (Table 2). The scores and differences of the seven PSQI components according to different employed and working status were shown in Table 3. Among people in different employed status, the PSQI of employed nurses in subjective sleep quality and daytime dysfunction were 1.23 (SD = 0.79) and 1.63 (SD = 1.04), while the scores of retirees in the above two dimensions were 0.98 (SD = 0.85) and 1.05 (SD = 1.05). But their PSQI in sleep latency and sleep duration was lower than that of the retried nurses. Regarding different working statuses, shift workers had statistically higher scores in subjective sleep quality, sleep latency, sleep efficiency, and use of sleep medication compared to day workers.

Table 4 Association between FV, sleep, and stress

Dependent Variables	Model 1		Model 2*				Model 3**			
	All nurses		Employed nurses		Retired nurses		Day workers		On shift	
	β(95% CI)	*p*	β(95% CI)	*p*	β(95% CI)	*p*	β(95% CI)	*p*	β(95% CI)	*p*
Sleep	-0.150 (-0.279,-0.021)	0.023	-0.116 (-0.253,-0.021)	0.097	-0.374 (-0.742,-0.006)	0.047	-0.098 (-0.277,0.082)	0.286	-0.141 (-0.354,0.073)	0.197
Stress	-0.656 (-0.932,-0.380)	< 0.001	-0.605 (-0.903,-0.308)	< 0.001	-1.035 (-1.765,-0.305)	0.006	-0.635 (-1.049,-0.222)	0.003	-0.590 (-1.021,-0.159)	0.007

Abbreviations: CI, confidence interval

*Model 2 was adjusted for age, marriage, educational level, menopause, living status, and working units

**Model 3 was adjusted for age, marriage, education level, menopause, and living status

Regarding perceived stress levels, the mean PSS score was 24.8 (SD = 7.62) with only 20.5% of the nurses ($n = 260$) reporting a low level of stress. The majority of participants ($n = 943$, 74.3%) stated a moderate level of stress, while 5.3% of them indicated a high level of stress. This study found that age group, marital status, family income, employed status, working unit, and menopause status were significantly associated with PSS scores (all $p < .05$) (Table 2).

Association between FV intake, sleep, and stress level

The Pearson test showed that FV intake was negatively correlated with sleep quality (r=-.179, $p = .005$) and stress level (r=-.391, $p < .001$). With FV intake as the independent variable and sleep quality and stress levels as the dependent variables, the multiple linear regression analysis was conducted. After controlling for various factors including age, marital status, educational level, menopause status, living status, employment status, and working units, the analysis revealed significant inverse relationships between FV intake, PSQI score, and PSS score (Model 1, Table 4). In concrete, for every 1-serving increase in FV intake, the PSQI score decreased by 0.150 units (β=-0.150, 95% *CI*: -0.279, -0.021, $p = .023$), and the PSS score reduced by 0.656 units (β=-0.656, 95% *CI*: -0.932, -0.380, $p < .001$).

Subgroup analyses were conducted based on the employed status (Model 2) and working status (Model 3) (Table 4). The results revealed that increasing the intake of FV by the same number of servings had a greater effect on improving sleep quality (β=-0.374, $p = .047$ vs. β=-0.116, $p = .097$), and reducing stress level (β=-1.035, $p = .006$ vs. β=-0.605, $p < .001$) among the retired nurses, compared to employed ones. The subgroup analysis conducted on day shift and night shift nurses revealed that the relationship between FV intake and sleep was not significant. However, an intriguing finding emerged regarding the association between FV intake and stress levels. Among nurses with equivalent FV intake, those working day shifts experienced a greater reduction in stress level (β=-0.635, $p = .003$) compared to their counterparts on night shifts (β=-0.590, $p = .007$).

The PSQI score was positively correlated with the PSS score ($r = .391$, $p < .001$), indicating that lower sleep quality was associated with higher stress levels. Further correlation analysis between sub-scales revealed that, with the exception of the sleep medication, all other sub-scales of sleep were positively correlated with stress (r ranged from 0.106 to 0.812, all $p < .001$).

Discussion

This study unveiled a substantial inadequacy in FV intake among Hong Kong female nurses. Nearly 90% of the participants reported consuming less than 5 servings of FV per day, which fell far below the recommended level set by WHO for the general population. Retired nurses were included in the study, taking into consideration the enduring impact of their occupation, comparable lifestyles, long-term health outcomes, and the robustness of the data. It also surpassed the percentages found among nurses in the Midwestern United States (63%) [23] and Brazil (71.2%) [24]. The inadequate consumption of FV worldwide may be attributed to the features of the nursing workplace environment, with barriers to maintaining a healthy diet, such as long working hours, shift work schedules, limited availability of fresh fruit, and inadequate access to keep FV fresh [25]. The time constraints and demanding nature of the nursing work also explained why employed nurses had a lower FV intake than retired nurses (2.85 vs. 3.37 servings/day). When comparing the difference in FV intake between day workers and nurses on shift (2.98 vs. 2.69 servings/day), day shift nurses had better eating and sleeping habits than night shift nurses for several reasons. Their work schedules aligned with the natural circadian rhythm, which supported regular sleep patterns and meal times, as well as consistent FV intake. In contrast, night shift work imposed physiological stress by requiring individuals to stay awake during natural rest periods, leading to poorer sleep quality and irregular eating habits, such as reduced consumption of FV. Those nurses working night shifts may opt for convenience foods or fast food choices during late nights or early mornings when restaurants or cafeterias were closed, resulting in limited availability of FV. Additionally,

the fatigue associated with night shifts could result in less healthy food choices and impaired decision-making, further complicating the maintenance of their healthy habits. Therefore, nursing managers are suggested to prioritize addressing the inadequate FV intake for nurses and take concrete steps to promote increased FV consumption, such as providing more convenient access by setting up small fruit baskets or vegetable trays in nurses' rest areas, and collaborating with food services by partnering with cafeteria or restaurant to ensure the availability of FV options specifically during night shifts.

For the sleep quality of female nurses in Hong Kong, 53.7% of them reported experiencing overall poor sleep quality, which is lower than the 79.8% reported in a study conducted in an acute hospital in South Korea [26]. Meanwhile, the female nurses exhibited higher levels of stress, with 79.5% of them reporting moderate to high levels. This was higher than the 78.4% reported in a national survey of nurses in Iran [14]. This discrepancy may be attributed to differences in cultural contexts, the type of hospital setting (acute versus non-acute), and the characteristics of the nursing staff. Furthermore, nurses engaged in shift work exhibited poorer sleep quality compared to those who only had routine day works, and nurses who also worked rotating shifts experienced higher levels of mental stress. This was similar to previous study, indicating that night shift workload was the risk factor of shorten sleep duration, poor sleep quality, and sleep deprivation [27]. Shortened sleep duration and poor sleep quality could give rise to a range of health issues in individuals, including persistent fatigue, irritability, and other behavioral changes that contributed to alterations in mood and heightened mental stress levels [28]. The quality of sleep and fatigue were impacted by shift work, leading to disruption of a woman's circadian rhythm and subsequent alteration in hormone secretion, thereby exacerbating stress levels [29]. Additionally, the inverse relationship between sleep and stress was consistent with previous research [30], suggesting that enhancing sleep quality may be an essential strategy for reducing stress among nurses.

Taking FV intake as an independent variable, the results highlighted a significant association between inadequate FV intake and compromised sleep quality within the cohort of female nurses in Hong Kong. This was consistent with the results of the previous studies conducted across different populations. A study from the United States noted that young women with low FV intake may improve their sleep difficulties associated with insomnia by increasing their FV intake [31]. Relevant Canadian studies have indicated that women of reproductive age who consumed lower amounts of FV were more prone to experiencing shorter sleep duration or poorer quality sleep [32]. The findings of a cohort study conducted in the United Kingdom suggested that there was an association between fruit and vegetable intake, as well as its polyphenol content, and a reduction in sleep duration among a specific subgroup of British women [33]. However, there were also contradictory findings. For instance, a study involving 462 young adult women found no association between FV intake and PSQI scores [4]. This inconsistency may be attributed to variations in the different populations, and measurement tools used to assess FV intake, which differed in terms of capturing data on different types of foods consumed, overall diet quality, and eating habits. Furthermore, discrepancies in serving sizes of FV consumption across different studies may have also contributed to the observed disparities.

The reciprocal interplay between FV intake and sleep quality indicated that FV consumption may impact sleep through polyphenol via several potential pathways [34]. A study has demonstrated that incorporating fruits and vegetables into an anti-inflammatory diet significantly enhances sleep quality by stimulating the production of melatonin and other neurotransmitters involved in the initiation and maintenance of sleep [35]. Firstly, various commonly consumed FV, such as grapes, cherries, tomatoes, and peppers, contain melatonin, a well-established regulator of the circadian rhythm. Melatonin has the ability to modulate peripheral clocks and regulate the expression of circadian clock genes inversely, thereby contributing to the regulation of sleep [36]. Secondly, FV are abundant sources of micronutrients and antioxidants. The potential impact of FV intake, along with its polyphenols, on sleep indicators may lie in their ability to enhance mitochondrial function and energy metabolism through the reduction of adipose tissue mass. This could potentially lead to alterations in sleep patterns. Additionally, FV intake may contribute to a decrease in free radical production, thereby reducing the overall sleep requirements. These bioactive components could influence melatonin levels and other neurotransmitters involved in the complex sleep/wake processes, which have the potential to impact the initiation and maintenance of sleep [37].

A significant association was also observed between insufficient FV intake and higher stress levels among Hong Kong female nurses. This finding corroborated the results of previous studies in other populations. For instance, the bidirectional relationship between work-related stress and consumption of foods rich in sugar, fat, and salt concomitantly resulted in a reduced intake of FV [38]. Nurses under stress and negative affects were prone to choose food with high energy and sugar, rather than FV, to relieve the sense of fatigue, especially for female nurses on nighttime shift duty [39]. However, other studies also presented arguments that a heightened intake of FV may mitigate perceived stress, rather than elevated stress resulting in diminished FV consumption [15].

This notion is further bolstered by a short-term (14-day) randomized controlled trial among younger individuals (aged 18–25), wherein the provision of two additional daily servings of FV on top of their normal diet, exhibited enhanced psychological well-being [40].

Stress was found to be linked to biomarkers of inflammation and oxidative stress markers [41]. FV is rich in antioxidants including carotenoids, vitamins C and E, phytochemicals, and polyphenols, the antioxidant properties of these nutrients can act as a defense against oxidative stress, regulating inflammatory responses, and reducing cortisol levels [42]. Therefore, a FV-focused diet may be effective in regulating nurses' stress levels. However, future studies incorporating longitudinal data or rigorous randomized controlled trials on both FV consumption and stress levels are still imperative to elucidate the causal relationship between FV intake and stress.

This study had several strengths. Firstly, the analysis utilized data sourced from a regional survey with a large sample size, thereby enhancing the statistical power and robustness of the results. Secondly, the representativeness of the sample was commendable owning to the systematic sampling employed. In addition, the serving size for FV intake was precisely specified.

In terms of the implications for nursing practice, it is strongly recommended that nurses prioritize the daily consumption of an adequate amount of FV to meet the guideline-recommended servings. This recommendation holds significant academic and professional value for addressing the poor sleep quality and high level of stress faced by nurses in their demanding roles. Increasing FV intake among nurses, based on the associations found with sleep quality and stress levels, may further positively impact the quality of care and patient safety in nursing practices.

Our findings also suggest important policy implications, such as advocating for the enhancement of storage facilities for home-cooked food and the provision of a wide range of healthy, FV-rich diet choices in workplace canteens. Furthermore, targeted educational intervention programs involving nurses, hospital management personnel, and other stakeholders, should be developed to promote adequate FV consumption through knowledge dissemination and awareness campaigns.

Academically, our study makes a substantial contribution by addressing a crucial knowledge gap pertaining to the complex relationship between FV intake, sleep quality, and stress among female nurses in Hong Kong. Future research endeavors are suggested to focus on evaluating the efficacy of interventions designed to promote FV intake, specifically targeting sleep quality improvement and stress control.

However, there were also some limitations in our study. Firstly, as a cross-sectional study, the design only presented the association but not the causal relationship among variables. Longitudinal studies or rigorous randomized controlled trials are necessary to establish a clear cause-and-effect relationship. Secondly, the inclusion of only female nurses in this study may constrain the generalizability of the findings to the broader nursing population. Moreover, investigating the effects of specific types of FV on sleep quality and stress levels was important due to variations in micronutrient and antioxidant content. Similar to other self-reported assessments, the presence of self-reporting bias or recall bias of PSS and PQSI, should not be neglected, where individuals may inaccurately estimate FV intake and their sleep quality. To minimize these biases, future studies could employ a prospective design that includes daily FV intake diary records and utilize objective method to monitor sleep. Finally, participants' FV intake was collected through a questionnaire issued by the Hong Kong Special Administrative Region Government through the Centre for Health Protection of the Department of Health. This questionnaire employed the term "serving" to denote portions of food, rather than utilizing exact quantities of food.

Conclusion

In conclusion, working nurses reported inferior sleep quality and elevated levels of stress in comparison to retirees. Notably, day shift workers exhibited better sleep quality and lower stress levels compared to those shift nurses. Furthermore, there was a significant association between increased FV intake and improved sleep quality, as well as reduced stress levels, among Hong Kong female nurses. Particularly, the impact of increased FV intake on improving stress levels was more pronounced among day nurses and shift nurses. These findings hold crucial implications for nurse health and hospital policies, highlighting the need to improve FV intake to address issues of poor sleep and high stress among female nurses.

Abbreviations

ANOVA	Analysis of variance
FV	Fruit and vegetable
PSQI	Pittsburgh Sleep Quality Index
PSS	Perceived Stress Scale
SD	Standard deviation

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Author contributions

Yan Zhang: Methodology; Formal analysis; Writing-original draft; Writing-review & editing. Jiajun Ma: Methodology; Formal analysis; Writing- review & editing. Ka Po Wong: Writing-Review & Editing; Methodology. Harry Hx Wang: Writing-Review & Editing; Methodology. Lili Wei: Writing-Review & Editing; Supervision. Fei Wan Ngai: Methodology; Investigation; Validation; Supervision;

Writing-Review & Editing. Yao Jie Xie: Conceptualization; Methodology; Investigation; Validation; Supervision; Writing-Review & Editing; Project administration.

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Data availability
The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study received approval from the Institutional Review Board (IRB) of The Hong Kong Polytechnic University (reference number: HSEARS20190514003). Participants received a detailed information sheet with the questionnaires, and completion of the questionnaires indicated informed consent. All procedures adhered to the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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