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Rotating shift and BMI increase among healthcare workers in a military hospital: pre- and post-pandemic analysis in Taiwan

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Abbreviations
BMI: body mass index; COVID-19: coronavirus disease 2019; GEE: generalized estimating equations; IQR: interquartile range; OR: odds ratio; RR: risk ratio; SD: standard deviation; TOCC: travel, occupation, contact, cluster.

ABSTRACT

Background: The increasing prevalence of high body mass index (BMI) emphasizes the need for action. Understanding of BMI factors among military hospital healthcare workers remains limited. This study aims to address this gap by analyzing BMI risk factors and changes pre- and post-coronavirus 2019 pandemic among military hospital healthcare workers in central Taiwan from 2019 to 2021.
Methods: Conducted at a military hospital in central Taiwan, this study analyzed anonymized health examination data from 2019 to 2021 for 483 healthcare workers. We performed generalized estimating equations to investigate trends in BMI and its association with various factors, including age, sex, job titles, military status, job tenure, work shifts, and lifestyle habits.
Results: The risk of increased BMI was higher in 2021 compared to 2019 (risk ratio [RR]: 1.008, 95% confidence interval [CI]: 1.001–1.014). Individuals on rotating shifts had a higher risk of increased BMI compared to day shift workers (RR: 1.021; 95% CI: 1.008–1.035) and higher odds of obesity (odds ratio: 1.546; 95% CI: 1.099–2.175). Among obese individuals, BMI in soldiers was approximately 4.9% lower than in non-soldiers (RR: 0.951; 95% CI: 0.915–0.988).
Conclusions: This study identified a significant post-pandemic increase in BMI among healthcare workers in a Taiwanese military hospital, with rotating shifts being a key risk factor for both increased BMI and obesity. Work-related factors influenced BMI changes among obese individuals, while non-work-related factors were significant for non-obese individuals. These findings highlight the broader effects of the pandemic and the specific impact of work-related factors on obese healthcare workers.

Keywords: Shift work; Rotating shift; BMI; Pandemic; Healthcare workers; Military hospital

BACKGROUND

Nearly 5 million individuals globally died from diseases associated with obesity, defined as having a body mass index (BMI) exceeding 25 kg/m^2.[1] Excessive BMI increases the risks of numerous health problems, such as high blood pressure, type 2 diabetes, metabolic syndrome, cardiovascular disease, and cancer, resulting in substantial healthcare expenses

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and productivity declines.[2] The increasing prevalence of BMI exceeding the standard underscores the need for collaborative action to tackle this global health issue.[3]

High BMI of healthcare workers is of specific concern, as it affects their ability to provide high-quality care.[4] Despite advising patients on health matters, many healthcare workers overlook their own well-being due to prolonged working hours and elevated stress levels, leading to the adoption of unhealthy habits.[5] Previous research reveals a higher prevalence of healthcare workers exceeding the standard BMI compared to the general population in (54% vs. 50% in Malaysia).[6,7] In contrast, the UK and Taiwan exhibit lower percentages of healthcare workers with elevated BMIs compared to the general population (19% vs. 26% in nurses in South Korea, 36% vs. 39% in Taiwan, and 49% vs. 60% in UK respectively).[5,8,9] Addressing healthcare workers' BMI facilitates the fulfillment of their duties effectively and sets positive examples for patients.[10]

Soldiers are typically expected to maintain a certain level of physical fitness, often resulting in a lower average BMI compared to the general population. However, several studies have revealed higher percentages of soldiers exceeding the standard BMI in several countries: Czech Republic (53% vs. 26%), Taiwan (57%–63% vs. 44%–51%), and the United States (65% vs. 35%).[11-14] In contrast, South Korea demonstrated lower percentages among soldiers compared to the general population (21% vs. 29%).[15]

Military hospitals play a critical role in safeguarding soldiers' health during peacetime and supporting healthcare needs during wartime.[16] Amidst the coronavirus 2019 (COVID-19) pandemic, healthcare workers continued to provide essential services, including polymerase chain reaction testing.[17] Given the dual responsibilities of preparing for national emergencies like the COVID-19 pandemic while delivering routine healthcare, military hospitals face unique challenges compared to civilian facilities.[18] Numerous studies have explored BMI risk factors among hospital healthcare workers and military personnel. In summary, these studies have found that soldiers tend to have a higher BMI than non-soldiers,[11-14] nurses have a higher BMI than non-nurses (e.g., physicians, technicians, and administrators),[6] and shift workers have a higher BMI than day workers.[9,19] However, there remains a gap in understanding these factors specifically among military hospital healthcare workers. This study aims to bridge this gap by analyzing BMI risk factors and changes before and after the COVID-19 pandemic among military hospital healthcare workers.

METHODS

Study design and setting
This retrospective study utilized data from 2019 to 2021 to compare BMI changes before and after the COVID-19 pandemic. The study was conducted at a military hospital in central Taiwan. Data were exported from the hospital's health examination databank, delinked, and anonymized for analysis.

Participants
The estimated sample size for this study was 376 participants, based on a prior national study reporting a prevalence of exceeded standard BMI among 64,356 Taiwan military personnel at 57.4%, with a precision (absolute error) of 5% and a type I error of 5%.[13,20] In our investigation, we identified 834 healthcare workers who had undergone health
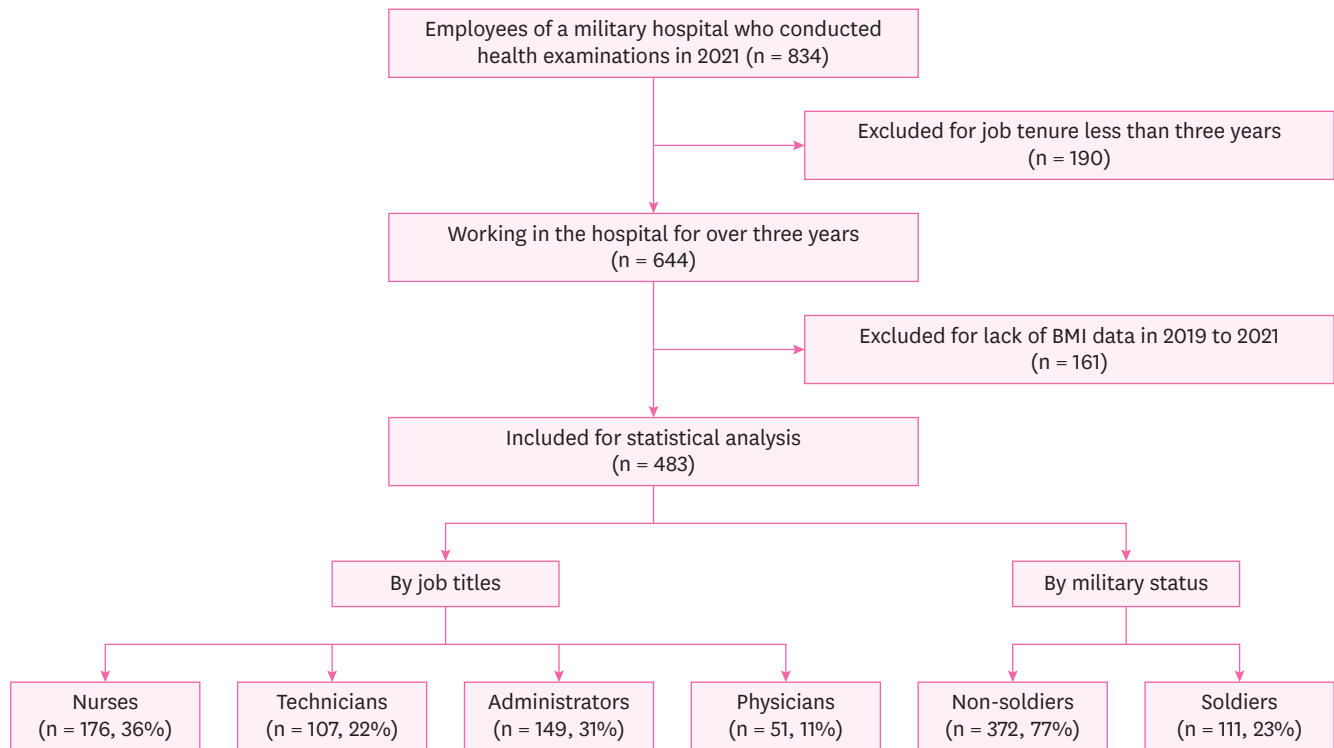
Fig. 1. Study flow and number of subjects in each stage.

examinations in 2021 and were eligible for inclusion. Health examinations were conducted at the physical examination center of the hospital. Following screening for eligibility criteria, 190 participants were excluded due to less than three years of employment, and an additional 161 were excluded due to lack of BMI data from 2019 to 2021. Finally, 483 healthcare workers were included for statistical analysis, categorized into four groups based on job titles and two groups based on military status. The study flowchart is presented in **Fig. 1**.

Risk of estimated BMI assessment

We collected data on BMI, age, sex and work-related factors. We followed the Ministry of Health's definition of obesity, classifying individuals as obese if their BMI was ≥ 27 kg/m² and as non-obese if their BMI was < 27 kg/m².[21] Work-related factors include job titles, job tenure, military status, work shift, and weekly working hours. Job titles were categorized into physicians, nurses, technicians, and administrators. Military status was classified as soldiers and non-soldiers. Work shift was categorized based on shift rotation or not (yes vs. no). Non-shift rotation workers followed a fixed day schedule starting at 08:00 and ending at 17:30, defined as day work. Shift rotation included various schedules (i.e., 08:00–17:30, 08:00–16:00, 07:00–15:00, 16:00–24:00, and 24:00–08:00), with rotations occurring on average once a month across these schedules, defined as rotating shift. Weekly working hours were classified into two categories: ≤ 40 hours vs. > 40 hours per week over the past month.

In addition to work-related factors, data on lifestyle-related factors of BMI were collected. These included weekly exercise hours (defined as physical activity exceeding 30 minutes at a time within the past month), cigarette smoking habits (defined as self-reported regular cigarette smoking: yes vs. no), and alcohol drinking habits (defined as self-reported alcohol consumption: yes vs. no).

Statistical analysis

We used Kruskal-Wallis tests to compare BMI, age, and work tenure among four groups (physicians, nurses, technicians, and administrators), given the non-normal distributions of these variables. Fisher's exact test was performed to compare proportions of sex, military status, work shift, weekly working hours, weekly exercising hours, cigarette smoking, alcohol drinking, as well as obesity across these groups.

In this study, we utilized generalized estimating equations (GEE) to account for multiple covariates and repeated measures. Given that BMI is not normally distributed and is slightly skewed to the right, we log-transformed BMI and treated it as the dependent continuous variable in the GEE model with a normal distribution and identity link function to analyze trends in BMI over the 3-year period and associations with identified risk factors. The covariates included in the model were time-varying variables (i.e., year, age, job tenure, work shift, average weekly working hours, average weekly exercising hours, cigarette smoking habits, and alcohol drinking habits) and time-invariant variables (i.e., sex, job title, and military status). The GEE method accounts for the correlation within repeated measures for each subject by using an autoregressive correlation structure.

We performed subgroup analyses for individuals with and without obesity using the aforementioned GEE model with a normal distribution and identity link, with log-transformed BMI as the dependent continuous variable, adjusting for covariates. Finally, we treated obesity as a binary dependent variable and used a GEE model with a binomial distribution and logit link function, adjusting for covariates, to estimate the odds of obesity.

All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA), with a significance level set at $p < 0.05$.

Ethics statement

The request to waive informed consent was reviewed and approved by the Institutional Review Board (IRB) of the Tri-Service General Hospital (TSGH IRB No. A202205037).

RESULTS

Table 1 shows the baseline characteristics of 483 participants categorized by their job titles. Nurses constitute the largest group (36.4%), followed by administrators (30.8%), technicians (22.2%), and physicians (10.6%). The mean BMI for all participants was 24.1 ± 3.9, with physicians recording the highest mean BMI at 26.0 ± 3.4. The overall prevalence of obesity (BMI ≥ 27) was 20.7%, with the highest prevalence observed among physician at 31.4%. Administrators had the highest mean age and duration of work, at 46.9 years and 16.5 years, respectively, whereas nurses had the lowest mean age of 40.1 years, and physicians the fewest mean duration of work at 10.8 years. There was a significant gender difference, with the physician group being predominantly men (98.0%) compared to a higher percentage of women in the other categories (94.3% of nurses, 74.8% of technicians, and 73.2% of administrators). Regarding military status, the majority were non-soldiers (77.0%), with the exception of physicians, 92.2% of whom were soldiers. Over half (53.8%) of the study population worked in in rotating shifts, particularly among physicians (86.3%) and nurses (73.9%). Moreover, 95.2% of participants reported working 40 hours or fewer per week. Lifestyle habits, including weekly exercising hours, cigarette smoking, and alcohol drinking, showed minor variations across job titles.

Table 1. Baseline characteristics in 2019, by job titles

Characteristics	Job titles					p^a
	Total	Nurses	Technicians	Administrators	Physicians	
	483 (100.0)	176 (36.4)	107 (22.2)	149 (30.8)	51 (10.6)	
BMI (kg/m²)						< 0.001***
Mean ± SD	24.1 ± 3.9	23.6 ± 3.9	23.9 ± 3.9	24.2 ± 3.9	26.0 ± 3.4	
Median [IQR]	23.4 [5.0]	22.8 [4.8]	22.9 [4.4]	23.7 [4.9]	25.7 [4.1]	
Obesity (BMI ≥ 27)	100 (20.7)	33 (18.8)	21 (19.6)	30 (20.1)	16 (31.4)	0.275
Mean age (years)	43.3 ± 9.5	40.1 ± 9.0	44.2 ± 9.2	46.9 ± 10.1	42.5 ± 5.5	< 0.001***
Mean job tenure (years)	13.6 ± 9.4	11.2 ± 8.3	14.9 ± 9.4	16.5 ± 10.8	10.8 ± 4.9	< 0.001***
Sex						< 0.001***
Men	127 (26.3)	10 (5.7)	27 (25.2)	40 (26.8)	50 (98.0)	
Women	356 (73.7)	166 (94.3)	80 (74.8)	109 (73.2)	1 (2.0)	
Military status						< 0.001***
Soldiers	111 (23.0)	23 (13.1)	9 (8.4)	32 (21.5)	47 (92.2)	
Non-soldiers	372 (77.0)	153 (86.9)	98 (91.6)	117 (78.5)	4 (7.8)	
Work shift						< 0.001***
Day work	223 (46.2)	46 (26.1)	49 (45.8)	121 (81.2)	7 (13.7)	
Rotating shift	260 (53.8)	130 (73.9)	58 (54.2)	28 (18.8)	44 (86.3)	
Mean weekly working hours, past one month						< 0.001***
≤ 40 hours	460 (95.2)	159 (90.3)	106 (99.1)	147 (98.7)	48 (94.1)	
> 40 hours	23 (4.8)	17 (9.7)	1 (0.9)	2 (1.3)	3 (5.9)	
Mean weekly exercising hours, past one month						0.285
< 2 hours	395 (81.8)	148 (84.1)	81 (75.7)	122 (81.9)	44 (86.3)	
≥ 2 hours	88 (18.2)	28 (15.9)	26 (24.3)	27 (18.1)	7 (13.7)	
Cigarette smoking habits	18 (3.7)	2 (1.1)	5 (4.7)	11 (7.4)	0 (0.0)	0.010**
Alcohol drinking habits	122 (25.3)	42 (23.9)	31 (29.0)	40 (26.8)	9 (17.6)	0.443

Values are presented as mean ± standard deviation, median [interquartile range], or number (%).
BMI: body mass index; SD: standard deviation; IQR: interquartile range.
^{a} Kruskal-Wallis test was performed to compare the group differences for continuous variables and Fisher's exact test was performed to compare the group differences for binary variables.
*p < 0.05, **p < 0.01, ***p < 0.001.

Table 2 shows the association between BMI and various determinants. Compared with the baseline year of 2019, the risk of increased BMI was slightly higher in 2020 (risk ratio [RR]: 1.004; 95% confidence interval [CI]: 1.000–1.009; p = 0.059) and significantly higher in 2021 (RR: 1.008; 95% CI: 1.001–1.014; p = 0.017). A pronounced gender disparity was observed, with men exhibiting a significantly higher risk of increased BMI than women (RR: 1.077; 95% CI: 1.034–1.121; p < 0.001). Furthermore, those on rotating shifts had a greater risk of increased BMI compared to day shift workers (RR: 1.021; 95% CI: 1.008–1.035; p = 0.002). Although other work-related and lifestyle-factors presented varying levels of risk, these differences were not statistically significant. For example, when comparing different job titles to nurses, technicians, administrators, and physicians showed varying RRs (1.002–1.031; p > 0.05). Similarly, soldiers had slightly lower risks of increased BMI compared to compared to their counterparts but without statistical significance (RR: 0.994; p > 0.05).

Subgroup analyses were also conducted for obese and non-obese individuals (**Table 2**). Among the obese individuals, work-related variables showed statistically significant associations with BMI, including military status and work shift. Obese individuals on rotating shifts had a statistically significant increase in BMI by approximately 2.1% compared to those on day shifts (RR: 1.021; 95% CI: 1.003–1.040; p = 0.021). In contrast, BMI in soldiers was approximately 4.9% lower than in non-soldiers (RR: 0.951; 95% CI: 0.915–0.988; p = 0.010). Among the non-obese individuals, significant associations with increased BMI were found for non-work-related factors such as age (RR: 1.003; 95% CI: 1.001–1.005; p < 0.001) and sex, with men having a higher risk compared to women (RR: 1.062; 95% CI: 1.032–1.094; p < 0.001). These findings suggest that while overall trends in BMI increase were observed over the three-year period,

Table 2. Association between risk factors and BMI increase among total participants and by obesity status

Determinants	Total		Obese individuals		Non-obese individuals	
	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p
Year						
2019	1.000	-	1.000	-	1.000	-
2020	1.004 (1.000–1.009)	0.059	1.002 (0.993–1.011)	0.623	1.003 (0.999–1.007)	0.158
2021	1.008 (1.001–1.014)	0.017*	1.007 (0.996–1.019)	0.208	1.003 (0.998–1.009)	0.265
Age	1.002 (1.000–1.004)	0.096	0.998 (0.995–1.000)	0.068	1.003 (1.001–1.005)	< 0.001***
Job tenure	1.000 (0.997–1.002)	0.648	1.002 (1.000–1.005)	0.054	0.999 (0.997–1.001)	0.212
Sex						
Women	1.000	-	1.000	-	1.000	-
Men	1.077 (1.034–1.121)	< 0.001***	0.990 (0.954–1.028)	0.601	1.062 (1.032–1.094)	< 0.001***
Job title						
Nurses	1.000	-	1.000	-	1.000	-
Technicians	1.002 (0.965–1.039)	0.934	1.011 (0.972–1.051)	0.596	1.002 (0.977–1.027)	0.887
Administrators	1.017 (0.979–1.056)	0.378	1.013 (0.973–1.056)	0.525	1.009 (0.982–1.037)	0.510
Physicians	1.031 (0.976–1.090)	0.271	1.022 (0.971–1.074)	0.409	1.006 (0.967–1.047)	0.754
Military status						
Non-soldiers	1.000	-	1.000	-	1.000	-
Soldiers	0.994 (0.957–1.032)	0.751	0.951 (0.915–0.988)	0.010*	1.026 (0.999–1.055)	0.064
Work shift						
Day work	1.000	-	1.000	-	1.000	-
Rotating shift	1.021 (1.008–1.035)	0.002**	1.021 (1.003–1.040)	0.021*	1.012 (0.999–1.026)	0.073
Average weekly working hours, past one month						
≤ 40 hours	1.000	-	1.000	-	1.000	-
> 40 hours	0.993 (0.980–1.007)	0.309	0.994 (0.974–1.015)	0.577	1.006 (0.994–1.017)	0.359
Average weekly exercising hours, past one month						
< 2 hours	1.000	-	1.000	-	1.000	-
≥ 2 hours	1.009 (0.994–1.024)	0.259	1.013 (0.971–1.056)	0.553	1.004 (0.990–1.017)	0.590
Cigarette smoking habits						
No	1.000	-	1.000	-	1.000	-
Yes	1.000 (0.993–1.006)	0.906	0.994 (0.980–1.008)	0.374	1.002 (0.994–1.010)	0.590
Alcohol drinking habits						
No	1.000	-	1.000	-	1.000	-
Yes	0.989 (0.953–1.026)	0.542	0.983 (0.955–1.013)	0.260	0.996 (0.962–1.031)	0.830

The multivariate analysis was performed using generalized estimating equations, accounting for year, age, job tenure, sex, job title, military status, work shift, average weekly working hours, average weekly exercise hours, cigarette smoking habits, and alcohol consumption.
BMI: body mass index; RR: risk ratio; CI: confidence interval.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

specific determinants such as work-related factors played significant roles in influencing BMI changes among obese individuals, whereas non-work-related factors played significant roles in influencing BMI changes among non-obese individuals.

Table 3 presents the association between various risk factors and obesity, as presented using odds ratios (ORs). Sex and work shift are significant determinants of obesity, with men and individuals on rotating shifts showing higher odds of obesity. Men had significantly higher odds of obesity compared to women (OR: 2.004; 95% CI: 1.098–3.658; $p = 0.024$). Individuals on rotating shifts had significantly higher odds of obesity compared to those on day shifts (OR: 1.546; 95% CI: 1.099–2.175; $p = 0.012$). Other factors, such as age, job tenure, job title, military status, working hours, exercise, smoking, and drinking habits, did not show statistically significant associations with obesity in this study.

Table 3. Association between risk factors and obesity among total participants

Determinants	OR (95% CI)	p
Year		
2019	1.000	-
2020	1.085 (0.956–1.231)	0.207
2021	1.143 (0.997–1.310)	0.056
Age	0.998 (0.964–1.033)	0.911
Job tenure	0.998 (0.962–1.035)	0.911
Sex		
Women	1.000	-
Men	2.004 (1.098–3.658)	0.024*
Job title		
Nurses	1.000	-
Technicians	0.962 (0.512–1.807)	0.904
Administrators	1.382 (0.761–2.509)	0.288
Physicians	1.552 (0.640–3.760)	0.331
Military status		
Non-soldiers	1.000	-
Soldiers	0.716 (0.383–1.341)	0.297
Work shift		
Day work	1.000	-
Rotating shift	1.546 (1.099–2.175)	0.012*
Average weekly working hours, past one month		
≤ 40 hours	1.000	-
> 40 hours	0.716 (0.427–1.200)	0.205
Average weekly exercising hours, past one month		
< 2 hours	1.000	-
≥ 2 hours	1.082 (0.709–1.650)	0.715
Cigarette smoking habits		
No	1.000	-
Yes	0.950 (0.782–1.154)	0.605
Alcohol drinking habits		
No	1.000	-
Yes	0.888 (0.346–2.279)	0.804

The multivariate analysis was performed using generalized estimating equations, accounting for year, age, job tenure, sex, job title, military status, work shift, average weekly working hours, average weekly exercise hours, cigarette smoking habits, and alcohol consumption.
OR: odds ratio; CI: confidence interval.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

DISCUSSION

Our study investigated the risk factors for increased BMI and obesity among healthcare workers in a military hospital, finding significant associations with rotating shift work. Participants in 2021 had a higher risk of increased BMI compared to 2019 (RR: 1.008). Work-related factors (military status and work shift) played significant roles in influencing BMI changes among obese individuals, whereas non-work-related factors (age and sex) played significant roles in influencing BMI changes among non-obese individuals. These findings emphasize the importance of addressing both work-related and non-work-related factors in managing BMI and obesity among healthcare workers.

Our study highlights that rotating shift workers face a significantly higher risk of elevated BMI and obesity compared to their day-working counterparts. The challenges for rotating shift workers stem from irregular working hours and the constant need to adjust their life rhythms, complicating the establishment of healthy habits such as consistent meal times, regular exercise, and adequate sleep.[22,23] In particular, the disruption caused by irregular working hours can lead to insufficient sleep, which has been shown to increase ghrelin

levels,[22] a hormone that stimulates appetite, thus potentially leading to overeating and weight gain.[24] Research indicates that for each hour of sleep lost relative to the standard seven hours, the risk of having a BMI above the standard increases by 9%.[25] Both insufficient sleep (less than 7 hours) and excessive daytime sleep have been linked with higher odds of surpassing the standard BMI.[25] Among rotating shift workers, night shift workers particularly show a stronger association with increased BMI, partly due to the significant "social jetlag" arising from the mismatch between their work schedules and natural rest periods.[26,27] This misalignment can increase the risk of increased BMI. In our study, workers on the 16:00–24:00 shift typically finish work at midnight, perform their personal routines (e.g., showers and dining), and go to bed usually after 3:00 am. Frequent shift rotations may exacerbate the problem, with weekly rotations associated with a 6%–8% higher risk of increased BMI compared to monthly rotations.[28] These findings underscore the potential impact of disrupted sleep patterns and irregular lifestyles on hormonal fluctuations and weight gain among rotating shift workers.

We found that among obese individuals, BMI in soldiers was approximately 4.9% lower than in non-soldiers (RR: 0.951; $p = 0.010$). Previous studies have indicated differences in BMI among soldiers compared to the non-soldiers, revealing varied effects across different groups.[11,45] Our finding of different effects in different populations aligns with this phenomenon. Specifically, in the obese group, soldiers had a lower BMI compared to non-soldiers, which is consistent with a previous South Korean study that showed soldiers had a lower average BMI.[15] Soldiers may have a slight advantage in maintaining lower BMI within the obese category, but this protective effect does not extend to the non-obese group. This indicates that military status may influence BMI differently depending on the baseline obesity status of individuals. These findings underscore the need for tailored interventions that consider both work-related and non-work-related factors in managing BMI and obesity, particularly among healthcare workers in military settings. Addressing these factors is crucial in ensuring the health and fitness of military personnel, which can have significant implications for their overall performance and readiness.

Our analysis revealed that male participants had a significantly higher risk of increased BMI and obesity than female participants, consistent with findings from previous research.[29,30] Men comprised 26.3% of our study cohort, with the majority (39.4%) being physicians. Physicians often spend extended hours seated during night shifts in consultation rooms, resulting in limited physical activity compared to nurses. Furthermore, the timing of night clinics, often commencing post-dinner, restricts opportunities for exercise, thereby accentuating the sedentary nature of their roles. This lifestyle significantly contributes to an increased obesity risk among male staffs.[31] Conversely, women, who represented 73.7% of participants, mainly filled nurses. Their position, inherently more physically demanding, coupled with a greater health consciousness,[30] likely contribute to their healthier BMI levels. Women's proactive approach to wellness and weight management, including careful attention to diet and physical activity, contrasts with the challenges faced by men, leading to a notable difference in obesity prevalence between genders. This divergence underscores the impact of occupational activity levels and health awareness on BMI differences. It also highlights the need for further investigation into sex-specific challenges and the development of targeted strategies to support healthy BMI maintenance across all professional roles in the healthcare sector.

Our analysis highlighted that participants experienced a significantly higher risk of elevated BMI after COVID-19 pandemic, compared to those in the preceding year, 2019, mirroring the

trend seen among US military members where obesity prevalence saw a modest increase of 0.43% during the COVID-19 pandemic.[32] The increase in BMI among healthcare workers at the military hospital we studied might be largely attributed to the intensified job demands throughout the two-year span of the pandemic. Following the pandemic's emergence in January 2020, hospitals introduced rigorous safety protocols, including temperature screenings, travel, occupation, contact, cluster (TOCC) evaluations, and checks on travel history at their entrances. Financial constraints necessitated the reliance on the hospital's current staff, who were scheduled into rotation shifts to enforce these precautions. Additionally, these workers were called upon to support vaccination drives and COVID-19 rapid antigen tests at military installations, assignments that extended until July 2021. This prolonged engagement with COVID-19 response efforts led to several adverse effects, notably dehydration from prolonged wear of sealed protective clothing and an increased reliance on fast, unhealthy food options owing to compressed eating schedules.[33] These elements significantly increased the risk for a higher BMI.[2] Thus, the cumulative effect of the overwhelming workload due to pandemic-related hospital activities not only placed an enormous strain on healthcare personnel but also contributed to a significant increase in BMI levels among this cohort in the post-pandemic period.

In our study, no statistically significant associations were observed between job titles, work hours, exercise duration, cigarette smoking, and alcohol intake, and the increase in BMI or obesity among healthcare workers at the studied military hospital. This could be partly attributed to the uneven distribution of sex and military status across different job titles; for instance, 98.0% of physicians were male, and 92.2% were soldiers, highlighting a substantial imbalance. Such disparities may explain the significant findings related to sex. The lack of a significant link between exercising hours and BMI could be due to the broad categorization of exercise duration without considering the intensity of activities, obscuring potential impacts of moderate to intense physical activities. Similarly, the standard categorization of working hours around a 40-hour week threshold may not have captured the nuanced BMI differences possibly present in those working extended hours, as suggested by literature indicating a threshold of 55 hours for notable BMI impact.[34] Additionally, the low prevalence of smoking (3.7%), attributable to hospital regulations, and a generalized approach to measuring alcohol consumption without detailing quantity or frequency, likely diluted the potential to discern their impact on BMI. Individuals who consumed even a small amount of alcohol may have been grouped together, leading to a larger proportion of participants falling under the "drinking" category, leading to non-significant association with the risk of increased BMI.

This study investigated BMI trends across various job titles, military statuses, rotating shifts, and sex before and after the COVID-19 pandemic in Taiwan, utilizing data collected from a military hospital spanning three years. However, several limitations warrant caution in interpreting the results. First, the reliance on BMI as a measure does not account for body composition differences, such as muscle mass in athletic individuals, potentially skewing results towards an overestimation of obesity.[35] Second, the evaluation of lifestyle factors like cigarette smoking, alcohol consumption, and physical activity was based on self-reports, which did not differentiate between levels of exposure, possibly leading to underestimations of these behaviors' impact. Notably, our study's question on alcohol drinking habits was designed dichotomously: those who consumed alcohol and those who did not, regardless of regularity. This design could lead to an overestimation of alcohol consumption, as individuals who drank a specific amount weekly or monthly could have selected "Yes." Questions with too few options can result in incomplete scales.[36] Third, our analysis of BMI

changes over time did not include individuals' disease conditions or clinical biomarkers, such as diabetes and hypertension. This omission is a potential limitation, as some conditions have a bidirectional relationship with BMI. For example, fasting glucose levels and BMI influence each other.[37] Not accounting for these factors could lead to an underestimation of BMI changes in populations with a high prevalence of these conditions and vice versa, potentially biasing the results towards the null. Fourth, we observed small effect sizes in our analysis of BMI change. However, the significant risk factors may still contribute to long-term health outcomes. Modest changes in BMI can accumulate over time, increasing the risk of chronic conditions such as cardiovascular disease, diabetes, and other obesity-related disorders. Furthermore, while individual factors might have limited impact, the combined influence of multiple factors can be substantial, emphasizing the need for comprehensive intervention strategies. Despite these limitations, the study offers valuable insights into the BMI trends among healthcare workers in a military setting, highlighting the need for cautious interpretation of its findings.

CONCLUSIONS

This study investigated the risk factors contributing to increased BMI among healthcare workers in a military hospital in Taiwan. We identified a significant increase in BMI among healthcare workers in the military hospital after the COVID-19 pandemic. Rotating shifts emerged as a significant risk factor for both increased BMI and obesity. The risk factors for BMI increase differed based on obesity status; work-related factors influenced BMI changes among obese individuals, while non-work-related factors were significant for non-obese individuals. These findings underscore the broader effects of the pandemic on the physical health of healthcare professionals, specifically highlights its impact of work-related factors among obese healthcare workers in military healthcare settings.

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