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Research Article

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Metabolic Syndrome and Pre-Metabolic Syndrome Among Health Care Workers in Yemen: Prevalence and Associated Risk Factors

Abdul-Kafi Shujaa[1*], Adnan Ali Alradhi[1], Abdulhafeedh Al-Habeet[2] and Ekram Al-Eryani[3]

[1]*Department of Internal Medicine, Sanaa University, Yemen*

[2]*Department of Epidemiology and Biostatistics, Al-Razi University, Yemen*

[3]*Biochemistry and Molecular Biology, Sanaa University, Yemen*

[*]Corresponding Author:
Abdul-Kafi Shujaa, Department of Internal Medicine, Sanaa University, Yemen.

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Abstract

Background

There is an increased prevalence of Metabolic Syndrome (MetS) and its risk factors among Health Care Workers (HCWs), which in turn contribute to the development of cardiovascular diseases. This increased prevalence reached alarming levels of global health and socioeconomic concern. This study was conducted to determine the prevalence of MetS and pre-Metabolic Syndrome (pre-MetS), as well as their components, among HCWs in Sana'a City, Yemen.

Materials and Methods

This is an observational, cross-sectional study conducted between February and June 2021. Two hospitals were randomly selected, one public (Al-Kuwait University Hospital) and one private (the University of Science and Technology Hospital). The study sample consisted of 282 HCWs. Body Mass Index (BMI) and body fat percentage were calculated. All participants underwent physical examinations at baseline. Fasting plasma glucose, uric acid, urea, creatinine, and lipid profile levels were measured. MetS was defined according to the International Diabetes Federation.

Results

The 282 HCWs included in our study, 158 (56.0%) were females, and the remaining 124 (44.0%) were males. Their ages ranged from 20 to 59 years, with a mean of 31.8 ± 7.2 years. The majority of subjects were non- smokers (85.1%). The prevalence of pre-MetS and MetS was 26.2% and 16.3%, respectively. HCWs aged 40 or older and smokers had 6.5 and 4.3 times more risk of having MetS than those less than 40 years old and nonsmokers, respectively. The presence of both pre-MetS and MetS was positively associated with BMI, LDL-c/HDL-c, TC/ HDL-c, and non-HDL-c ratios.

Conclusion

This study revealed an alarming prevalence of MetS among HCWs. Both pre- MetS and MetS were present only in overweight individuals and associated with a wide range of adiposity and lipid profile measures, underscoring the urgent need for targeted interventions in this high-risk population.

Keywords: Metabolic Syndrome, Health Care Workers, Health Personnel, Yemen

1. Introduction

During the last decades, the world's population has experienced substantial changes in health, lifestyle, and eating behavior [1,2]. These changes are observed in the increasing consumption of sugary beverages and high-calorie foods, a marked decrease in physical activity, and a more sedentary lifestyle [3,4]. As a result, the global prevalence of overweight and obesity has been rising steadily and has already reached epidemic levels [5-7]. Concurrently with this progression, there has been a rise in the occurrence of obesity-related health consequences such as Cardiovascular Diseases (CVDs) and Type 2 Diabetes (T2DM) [8,9]. A common term used to characterize the pathophysiological relationship between these patterns is the Metabolic Syndrome (MetS). MetS is complex, and its etiology is unclear [10,11]. However, this syndrome is indirectly affected by genetic factors such as age, dementia, pro-inflammatory factors, and hormonal changes. In addition, central obesity and insulin resistance are two significant contributors to its incidence, and insulin resistance is sometimes recognized as the basis for it [12,13]. In its last review, the American Heart Association (AHA) defined MetS as a cluster of conditions that occur together, raising an individual's risk for heart disease, T2DM, stroke, and other health issues [14]. Recently, it was demonstrated that MetS is independently associated with CVD risk, cardiovascular, and all-cause mortality. Components of the MetS were associated with a similar magnitude of increased CVD, which suggests that MetS was not in excess of the level explained by the presence of its single components [15]. Furthermore, there is evidence that MetS, when linked to polycystic ovary syndrome, is associated with various clinical conditions, including CVDs, T2DM, infertility, and anxiety [16].

The prevalence of MetS is not limited to a specific region but is a global concern. It was high in South America (6.2% in Colombia as classified by the Cook definition and 9.5% in Chile by the IDF) [17,18], in the United States of America (10.1% by the Ford et al. classification) [19], and in the Middle East countries (13 and 6% in Iran [20,21], and almost 5% in Saudi Arabia according to the Cook definition) [22]. Among employees of a Taiwanese hospital, the hospital employees had a moderate prevalence of MetS (12.0%). Physicians and administrative staff members had a higher prevalence of MetS than the other populations [23]. A recent cross-sectional study revealed that the prevalence of MetS among young Tunisian healthcare professionals was 8.8%, with a distribution of 13.8% in men and 5.1% in women [24]. Among Yemeni school-aged children, Saeed et al. [25] found that the prevalence of MetS was 0.5%, according to the International Diabetes Federation (IDF). Saeed et al. [25] also concluded that Yemeni school-aged children are at a potential risk of MetS despite its low prevalence.

There is an increased prevalence of MetS and its risk factors among Health Care Workers (HCWs), which in turn contribute to the development of CVD. This increased prevalence reached alarming global health and socioeconomic concerns [26,27]. HCWs are subjected to life-and-death duality in their work shifts, as well as to inappropriate working conditions, work overload, and stress; in addition, they are exposed to extra working shifts, occupational hazards, physical wear, and other unfavorable conditions that promote the development of various diseases [28-32]. Several studies have demonstrated that the risk of developing MetS is strongly associated with night-shift work [33,34]. According to a recent meta-analysis, compared to day HCWs, shift workers showed a more than twofold increase in the risk of developing MetS [35]. Another study found a significant correlation between the development of MetS and anxiety and stress [36]. A survey conducted in 2008 demonstrated that the prevalence of MetS among Yemeni physicians was similar to that of Western populations [37]. Therefore, the present study was conducted to determine the prevalence of MetS and pre-MetS and their components among HCWs in Sana'a City, Yemen.

2. Material and Methods

2.1 Study Design and Participants

This is an observational, cross-sectional study conducted between February and June 2021. Medical staff (doctors, dentists, nurses, pharmacists, psychologists, physiotherapists, physical trainers, biochemists, and nutritionists) and those who work in the hospital, including paramedics, ambulance drivers, assistants, clerks, cleaners, receptionists, and managing personnel inside the hospital, were considered. Diverse recruitment channels (hospital administration, professional societies) were utilized to avoid overrepresenting specific groups. Moreover, a plan was developed to reach a representative sample of HCWs from different specialties and levels of experience. Two hospitals in Sana'a City, Yemen, were randomly selected, one public (Al-Kuwait University Hospital) and one private (The University of Science and Technology Hospital). A total of 282 participants were randomly enrolled. Individuals with malignant diseases, any chronic or acute diseases, inflammation, women who were pregnant or breastfeeding, and those who were on regular medication during the study were excluded. All enrolled subjects attended an interview, during which a pre-designed questionnaire was completed, assessing the following socioeconomic data: age, gender, marital status, smoking, and education level. The study was conducted in accordance with the Declaration of Helsinki by including basic principles of ensuring the study subject's privacy, risk, and benefit, being undertaken by trained professionals, obtaining written informed consent, and even allowing the right to withdraw if the study participants requested it.

2.2 Clinical and Anthropometric Assessments

All participants underwent physical examinations at baseline. Before the measurements, they were instructed to refrain from smoking or consuming tea or coffee for at least 30 minutes. After 5–10 minutes of rest, BP was twice measured in the sitting position using a standardized mercury column sphygmomanometer and stethoscope while supporting the arm on a firm surface. A second reading was taken after 1-2 minutes, and the mean of the two measurements was recorded. Height was measured to the nearest 0.1 cm using a portable Shortboards. Weight was determined with the participants wearing light clothing and without shoes. A Balance Non-Digital Scale (SCOEHNLE-CERTIFIED classic XL) was used to measure the weight to the nearest 0.1 kg. The Body Mass Index (BMI) was calculated by dividing the body weight in kilograms by the square of the height in meters. Participants were classified according to the World Health Organization criteria as having normal weight (BMI<25 kg/m^2), overweight (25–29.9 kg/m^2), or obese ($\geq$ 30 kg/m^2) [38]. The Body Fat Percentage (BFP) was calculated in women by the formula (1.20 × BMI) + (0.23 × Age)-5.4, while in men by (1.20 × BMI) + (0.23 × Age)-16.2. Waist Circumference (WC) was measured in the abdominal region while the participant was standing, breathing normally, and without clothing. The waist was measured midway between the costal margin and the iliac crest using a 1.50-meter flexible, non-stretch tape measure with 0.5 cm divisions.

3. Biochemical Analysis

Standard laboratory methods were used to measure serum parameters. All participants were instructed not to exercise vigorously 24 hours before blood sample collection. After an 8-hour fasting period, the lipid profile and Fasting Plasma Glucose (FPG) were evaluated. The lipid profile was assessed by measuring Triglycerides (TGs), Total Cholesterol (TC), High-density Lipoprotein cholesterol (HDL-c), and Low-Density Lipoprotein cholesterol (LDL-c). Roche COBAS5001 analyzer (Germany) was used in all laboratory assessments.

4. Definitions of Metabolic Syndrome and Pre-Metabolic Syndrome

MetShas been defined as having three or more of the five risk factors that are

- Raised FPG (≥ 100 mg/dL or hypoglycemic medication use).
- Abdominal obesity (WC ≥ 80 cm in women and≥ 90 cm in men).
- Raised TGs (≥ 150 mg/dL or use of medications to lower triglycerides).
- Reduced HDL-c (<50 mg/dL in women and <40 mg/dL in men or specific treatment for this lipid abnormality).
- Raised BP (Systolic BP (SBP) ≥130 mm Hg and/or Diastolic BP (DBP) ≥ 85 mm Hg or on anti-hypertensive treatment) [39].

Pre-MetS has been defined as the presence of at least two components of MetS without fulfilling diagnostic criteria for MetS [40].

5. Statistical Analyzes

All data was collected in a database, and obvious errors and non-plausible data were cleaned. The Kolmogorov-Smirnov test was used to check the normality of continuous data. Accordingly, the normally distributed continuous variables were presented as the means and Standard Deviations (SD), and the nonparametric data as the medians and ranges (minimum and maximum). HCWs were dichotomized into two groups (with MetS or without MetS). The prevalence of MetS and pre-MetS was reported in percents with 95% Confidence Intervals (CIs). The Chi-square or Fisher's exact test was used to compare both cohorts as appropriate. Depending on the distribution pattern, the student t-test or the Mann-Whitney U test was used to analyze the differences between two groups of continuous variables. After that, HCWs were reclassified into three analytic groups based on the number of MetS components (0-1, 2, or ≥ 3). For comparison of means, analysis of Variance (ANOVA) with a post hoc Tukey test was used for normally distributed variables. Kruskal-Wallis H with a post hoc Dunn's test was used for nonparametric variables. Using simple logistic regression analysis, Odds Ratios (ORs) and their 95% CIs were calculated to assess the association between the variables studied and the MetS. All statistical analysis was conducted using the Statistical Package for Social Science Analysis (SPSS, Inc., Chicago, Illinois, USA) version 28.0, adopting a significance level of 5% for all hypothesis tests.

6. Results

The present study recruited 282 HCWs, with 158 (56.0%) female and the remaining 124 (44.0%) male. Their ages ranged from 20 to 59 years, with a mean of 31.8 ± 7.2 years. Most subjects were non- smokers (85.1%) and married (71.6%). Table 1 shows the sociodemographic and behavioral data of all enrolled subjects. As the age of HCWs increased, so did the prevalence of MetS. The prevalence of MetS was significantly higher in smokers than in nonsmokers (38.1% vs. 12.5%, respectively).

Both anthropometric parameters (BMI and WC), BFP, DBP, SBP, and FPG were significantly higher among HCWs with MetS. Likewise, HCWs with MetS had higher TGs, TC, LDL-c, non-HDL-c, TC/HDL-c, LDL-c/HDL-c, and lower HDL-c than those without MetS. Heart Rate (HR), Uric Acid (UA) concentrations, urea levels, and creatinine levels did not differ between groups (Table 2).

Table 3 demonstrates the prevalence of MetS and itscomponents. The prevalence of MetS was 16.3% (95% CI: 12.2-21.2) among HCWs, with no significant difference between the genders (p=0.565). Low HDL-c was the most prevalent component of MetS in both genders, with 48.4% of men and 54.4% of women having it. The other two most common components of MetS in men were hypertriglyceridemia (46.8%), followed by high BP (24.2%), and in women, abdominal obesity (23.2%) and hypertriglyceridemia (13.9%). The presence of hypertriglyceridemia, high FBG, and high BP MetS components was higher among men. Conversely, abdominal obesity was more frequent among women.

Table 4 describes the odds ratio for the association between age, smoking, adiposity indicators, and biochemical parameters in pre-MetS and MetS. The pre-MetS was associated with BMI, TC/HDL- c, and LDL-c/HDL-c ratios. For each increase of 1 kg/m^2 in BMI, there was a 7% increased risk of MetS. The investigation of biochemical markers showed that the risk of MetS went up by about 1.5 times for every unit increase in the TC/HDL-c or LDL-c/HDL-c ratios. Age, smoking, BMI, BFP, TC/HDL-c ratios, and LDL-c/ HDL-c positively increased the MetS risk. HCWs aged 40 or older had 6.5 times more risk of having MetS than those less than 40 years old (95% CI: 2.97–14.01). Smokers who work in health care were 4.3 times more likely to have MetS compared to their nonsmoker counterparts (95% CI: 2.07-8.95). For each 1 kg/m2 increase in BMI and 1% body fat, there was a 23% and 11% increased risk of MetS, respectively. The investigation of biochemical markers showed that the risk of MetS almost doubled for every unit increase in the TC/HDL

Variables	Total (n=282)	With MetS (n=46)	Without MetS (n=236)	p
Age, mean (SD)	31.8 (7.2)	37.6 (10.1)	30.7 (5.9)	<0.001
Marital status, n (%)				
Unmarried	80 (28.4)	10 (12.5)	70 (87.5)	0.276
Married	202 (71.6)	36 (17.8)	166 (82.2)	
Educational level, n (%)				
≤ Diploma	102 (36.2)	20 (19.6)	82 (80.4)	0.259
University/postgraduate	180 (63.8)	26 (14.4)	154 (85.6)	
Smoking, n (%)				
Yes	42 (14.9)	16 (38.1)	26 (61.9)	<0.001
No	240 (85.1)	30 (12.5)	210 (87.5)	
Note: MetS: Metabolic Syndrome; SD: Standard Deviation.				

Table 1: Sociodemographic and behavioral data of HCWs with MetS and without MetS (n=282).

Parameters	Total (n=282)	With MetS (n=46)	Without MetS (n=236)	p
Body weight (kg), mean (SD)	63.4 (14.0)	76.3 (17.1)	60.8 (11.8)	<0.001
Height (m), mean (SD)	1.62 (0.08)	1.65 (0.08)	1.62 (0.8)	0.020
BMI (kg/m2), mean (SD)	23.9 (4.7)	27.8 (6.3)	23.1 (3.9)	<0.001
WC (cm), mean (SD)	88.5 (13.5)	99.1 (15.9)	86.4 (11.9)	<0.001
BFP (%), mean (SD)	26.0 (8.1)	31.5 (8.6)	24.9 (7.5)	<0.001
SBP (mmHg), mean (SD)	105.5 (13.6)	116.5 (16.2)	103.6 (12.0)	<0.001
DBP (mmHg), mean (SD)	74.5 (17.6)	88.7 (27.9)	71.8 (13.2)	<0.001
HR (beats per minute), mean (SD)	81.2 (14.1)	86.8 (22.6)	80.1 (11.6)	0.229
FPG (mg/dL), mean (SD)	83.2 (25.0)	102.3 (43.5)	79.5 (11.1)	<0.001
TGs (mg/dL), median (range)	98.4 (27-377)	168.1 (73.2-329.3)	95.8 (27-377.1)	<0.001
TC (mg/dL), median (range)	183.6 (71-290)	205.1 (111-253.6)	179.8 (71.4-203.2)	0.001
LDL-c (mg/dL), mean (SD)	115.9 (31.5)	128.5 (27.3)	113.4 (31.8)	<0.001
HDL-c (mg/dL), median (range)	45.9 (21-127)	40.8 (26.3-59.6)	49.1 (31.7-127.1)	<0.001
Non-HDL-c (mg/dL), mean (SD)	138.8 (37.9)	157.3 (30.7)	135.3 (38.1)	<0.001
TC /HDL-c (mg/dL), mean (SD)	4.13 (1.2)	5.0 (1.3)	3.9 (1.1)	<0.001
LDL-c/HDL-c (mg/dL), mean (SD)	2.58 (0.92)	3.2 (0.8)	2.4 (0.8)	<0.001
UA (mg/dL), mean (SD)	3.0 (0.7)	3.0 (0.7)	3.2 (0.7)	0.502
Urea (mg/dL), mean (SD)	22.1 (5.8)	21.8 (5.8)	23.5 (5.5)	0.165
Creatinine (mg/dL), mean (SD)	0.84 (0.1)	0.86 (0.1)	0.88 (0.1)	0.136
Note: BFP: Body Fat Percentage; BMI: Body Mass Index; DBP: Diastolic Blood Pressure; FPG: Fasting Plasma Glucose; HDL-c: High-Density Lipoprotein cholesterol; HR: Heart Rate; LDL-c: Low-Density Lipoprotein cholesterol; TC: Total Cholesterol; TGs: Triglycerides; MetS: Metabolic Syndrome; SBP: Systolic Blood Pressure; SD: Standard Deviation; UA: Uric Acid; WC: Waist Circumference.				

Table 2: Anthropometric, Clinical, And Biochemical Parameters Among HCWs with MetS and without MetS (n=282)

	Total (n=282)	Males (n=124)	Females (n=158)	p
MetS, % (95% CI)	16.3 (12.2-21.2)	17.7 (11.5-25.6)	15.2 (10.0-21.8)	0.565
Pre-MetS, % (95% CI)	26.2 (21.2-31.8)	29.0 (21.2-37.9)	24.1 (17.6-31.5)	0.345
Components of MetS, % (95% CI)				
High BP	15.6 (11.6-20.4)	24.2 (17.0-32/7)	8.9 (4.9-14.4)	<0.001
Hypertriglyceridemia	28.4 (23.2-34.0)	46.8 (37.8-55.9)	13.9 (8.9-20.3)	<0.001
Abdominal obesity	15.6 (9.5-22.7)	8.1 (3.9-14.3)	23.2 (15.1-31.1)	<0.001
High FPG	8.50 (5.51-12.4)	12.9 (7.6-20.1)	5.1 (2.20-9.70)	0.019
Low HDL-c	51.8 (45.8-57.7)	48.4 (39.3-57.5)	54.4 (46.3-62.4)	0.313
Note: BP: Blood Pressure; CL: Confidence Interval; FPG: Fasting Plasma Glucose; HDL-c: High-Density Lipoprotein cholesterol; MetS: Metabolic Syndrome.				

Table 3: The Prevalence of Metabolic Syndrome, Pre-Metabolic Syndrome and their Components in Health Care Workers (n=282).

Variables	Pre-MetS OR (95% CI)	MetS
Age (≥ 40 years)	0.34 (0.12-0.99)*	6.45 (2.97-14.01)
Smokers	1.15 (0.55-2.38)*	4.31 (2.07-8.95)
BMI(kg/m2)	1.07 (1.02-1.14)	1.23 (1.14-1.33)
BFP (%)	1.02 (0.98-1.05)*	1.11 (1.06-1.16)
TC /HDL-c	1.64 (1.30-2.06)	1.96 (1.49-2.58)
LDL-c/HDL-c	1.66 (1.23-2.24)	2.58 (1.76-3.79)
Non-HDL-c	1.11 (1.01-1.24)	1.16 (1.01-1.21)
Note: BFP: Body Fat Percentage; BMI: Body Mass Index; BP: Blood Pressure; CL: Confidence Interval; HDL-c: High-Density Lipoprotein cholesterol; LDL-c: Low-Density Lipoprotein cholesterol; MetS: Metabolic Syndrome; TCL: Total Cholesterol; *Non-significant relationship.		

Table 4: Odds Ratio for the Association Between Age, Smoking, Adiposity Indicators and Biochemical Parameters in Pre-MetS and MetS.

7. Discussion

The prevalence of MetS was 16.3% in our study, with no significant difference between the genders based on the IDF criteria. Our study reported a lower prevalence of MetS than previously published among Yemeni physicians (16.3% vs. 23.8%, respectively), based on different criteria for defining MetS [37]. Conversely, our study's prevalence of MetS was remarkably higher than the 4.5% identified by the LATINMETS Brazil study [27]. Using the same criteria as our study, another LATINMETS study reported a comparable prevalence of 17.5% among Columbian health professionals [41]. A study in Germany found that 1.7% of HCWs had MetS [42]. In another study in Italy, on night shift HCWs, 9% of the population had MetS [33]. A study among HCWs in Iran reported a prevalence of MetS of 22.4% [13]. According to the criteria established by the IDF, the prevalence of MetS in the adult USA population decreased from 25.5% in 1999–2000 to 22.9% in 2009–2010, as indicated by the NHANES data [43]. In one of the most extensive meta-analyses to date of 59 studies in the Middle East, the pooled estimated prevalence of this syndrome was 25% in the adult population [44]. It is important to note that our entire sample consisted of HCWs and educated subjects, with none having an education level below high school, thereby ensuring homogeneity in educational attainment. Therefore, our findings are not comparable when considering the general population. Research comparing the prevalence of MetS among HCWs and non-HCWs shows mixed results. One study in Nigeria observed a similar prevalence of MetS in both groups (29.5% vs. 28.0%, respectively, p=0.789) [45]. Interestingly, while the prevalence was comparable in the above study, certain risk factors were more frequent in HCWs. In particular, abdominal obesity, high TC, and high LDL-c were more common in HCWs than in non-HCWs [45]. On the other hand, another study reported that the prevalence of MetS was higher in physicians and administrative personnel than in different populations [23]. These discrepancies highlight the need for further research to understand the true scope of MetS in this population. The fact that the previous Yemeni study was physician-based, suggesting a higher prevalence of MetS among physicians, could explain the relatively lower prevalence of MetS in our study. However, our findings are still alarming.

We also found that the prevalence of MetS increased with age, presenting as high in subjects over 40 years of age, which is in line with the results of the LATINMETS Brazil study [27]. Corroborating these findings, four other studies from different geographical regions also found an increased prevalence of MetS with age [13, 26,34,46]. In general, age significantly influences the prevalence of MetS among HCWs, yet the underlying reasons remain poorly understood. However, physiological changes and lifestyle factors can contribute to this age-related trend. In addition, age can influence the pattern of MetS components. In concordance with the results of the LATINMETS Brazil study [27], our study revealed no significant difference between the genders in the prevalence of MetS. One study suggested that men are more likely to develop MetS than women [46].

The authors have argued that this could be due to biological factors like hormonal influence and behavioral aspects, such as men being less likely to prioritize preventive healthcare [46]. On the other hand, a different study revealed that women were significantly more likely to have MetS than men, with 34.9% of women and 2.4% of men having the syndrome [47]. Additionally, another study noted that the prevalence of MetS among female HCWs was about three times that of male subjects [48]. These conflicting findings suggest a lack of clear consensus, with various factors such as work environment, lifestyle, and socioeconomic status influencing the likelihood of MetS. The presence of two MetS components appears to enhance atherogenic dyslipidemia and anthropometric indicators of obesity. Pre-MetS may be able to detect anthropometric indicators and metabolic abnormalities, suggesting that this early phase preceding the MetS is also marked by an elevated risk of insulin resistance and atherosclerosis complications [40,49]. A recent study has shown that Yemeni children are at potential risk for pre-MetS later in life [25].

Hyperuricemia individuals have a cardiometabolic risk factor, even in asymptomatic clinical manifestations. Research observed that concentrations of UA increased linearly with the increasing number of MetS components [27,49]. Studies in Asian populations (Japan, Thailand, South Korea, and China) also demonstrated a positive relationship between MetS and UA concentrations [50-53]. These findings seem to be in accordance with our study. Furthermore, research has shown that among obese individuals (10 to 15.9 years old), UA concentration is a reliable predictor of pre-MetS [49]. Finally, it should be mentioned that managing MetS involves lifestyle modifications and medication. It is crucial to prioritize lifestyle changes before considering medication [54]. Patients may need multiple medications to control dyslipidemia, hypertension, insulin resistance, and obesity [55]. In severe obesity cases, bariatric surgery may be considered [56].

8. Limitations

It must be acknowledged that this study has several potential limitations, and it is therefore essential to interpret its findings in the context of these limitations. First, due to the inherent characteristics of the cross-sectional design, causality between the syndrome and variables, as well as the temporal sequence between risk factors and the syndrome, cannot be established. Second, the relationship between the syndrome and long working hours and night shift work has not been investigated. Third, the study was based on data from HCWs at two hospitals and may not be generalizable to other populations or settings. Despite these limitations, this observational study provided valuable insights into the prevalence and associated risk factors of the syndrome, which, in the future, could inform interventions and might be a building block of input for longitudinal studies.

9. Conclusion

Unlike previous studies that primarily focused on the general population, our research specifically targeted a high-risk occupational group, HCWs. Our findings revealed an alarming prevalence of pre-MetS and MetS in this cohort. Moreover, both pre-MetS and MetS were present only in overweight individuals and associated with a wide range of adiposity and lipid profile measures, underscoring the urgent need for early screening and intervention to prevent the development of MetS and associated complications in this high-risk population.

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