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ORIGINAL

The Influence of Shift Work on Sociodemographic Characteristics, Anthropometric Parameters, Lifestyle Behaviors, and Its Relationship with Cardiovascular Risk Factors

Influencia del trabajo por turnos en las características sociodemográficas, los parámetros antropométricos, los hábitos de vida y su relación con los factores de riesgo cardiovascular

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Abstract

Introduction: Cardiovascular diseases are recognized as a major public health problem worldwide due to the high morbidity and mortality they cause. Their development is influenced by various risk factors, including dyslipidemia, arterial hypertension (HTN), and hyperglycemia.
Objective: This study assesses the association between sociodemographic variables, health habits, and shift work with the aforementioned cardiovascular risk factors (CRFs).
Methods: A cross-sectional, observational, and descriptive study was conducted, involving 53,053 workers from various occupational sectors across several regions of Spain. The sample included 31,753 men (17,527 of whom worked shifts) and 21,300 women (11,281 worked shifts). The relationship between shift work and CRFs was examined, along with its association with sex, age, social class, educational level, smoking, alcohol consumption, sedentary behavior, and an unhealthy diet.
Results: The three CRFs were more prevalent among shift workers. All variables related to unhealthy lifestyles showed a significantly higher prevalence among shift workers, with high statistical significance (p<0.001). Additionally, all variables, particularly age and physical activity, were associated with the prevalence of CRFs. Men had a higher risk than women, with odds ratios (OR) ranging from 1.47 (95% CI 1.41-1.52) for dyslipidemia to 2.42 (95% CI 2.30-2.45) for HTN.
Conclusions: The profile of a worker at the highest risk of developing these CRFs is a shift worker, male, older, of low socioeconomic status, a smoker, sedentary, with low adherence to the Mediterranean diet, and a regular alcohol intake.

Key words: Cardiovascular risk factors, shift work, physical activity, Mediterranean diet, alcohol consumption, tobacco use.

Resumen

Introducción: Las enfermedades cardiovasculares son consideradas como un enorme problema de salud pública a nivel mundial debido a la elevada morbimortalidad que ocasionan. En su génesis se encuentran diferentes factores de riesgo entre los que destacaríamos la dislipemia, la hipertensión arterial (HTA) y la hiperglucemia.
Objetivo: Este estudio valora la asociación entre variables sociodemográficas, hábitos de salud y trabajo a turnos con los factores de riesgo cardiovascular (FRCV) antes mencionados.
Metodología: Se realizó un estudio observacional, transversal y descriptivo en el que participaron 53.053 trabajadores de diversos sectores laborales de varias comunidades autónomas españolas. Se incluyeron 31.753 hombres (17.527 de ellos trabajaban a turnos) y 21.300 mujeres (11.281 trabajaban a turnos). Se examinó la relación entre el trabajo a turnos y los FRCV, así como su asociación con el sexo, la edad, la clase social, el nivel educativo, el tabaquismo, el consumo de alcohol, el comportamiento sedentario y la dieta poco saludable.
Resultados: Los tres FRCV mostraron una mayor prevalencia entre los trabajadores por turnos. Todas las variables relacionadas con hábitos de vida poco saludables revelaron una prevalencia significativamente mayor entre los trabajadores por turnos, con alta significación estadística (p<0,001). Igualmente todas las variables, pero especialmente la edad y la actividad física se asociaron con la prevalencia de los FRCV. Los hombres presentaban un riesgo mayor que las mujeres, con una OR que oscilaba entre 1,47 (IC 95% 1,41-1,52) para dislipemia y 2,42 (IC 95% 2,30-2,45) para HTA.
Conclusiones: El perfil de trabajador con mayor riesgo de presentar estos FRCV es un trabajador a turnos, varón, con edad avanzada, de estatus socioeconómico bajo, fumador, sedentario, con baja adherencia a la dieta mediterránea y consumidor habitual de alcohol.

Palabras clave: Factores de riesgo cardiovascular, trabajo a turnos, actividad física, dieta mediterránea, consumo de alcohol, consumo de tabaco.

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Introduction

Cardiovascular diseases are the leading cause of mortality worldwide[1], accounting for an extremely high number of deaths each year globally, a figure that continues to rise[2]. Among the most important modifiable risk factors are dyslipidemia, hypertension, and hyperglycemia, which are key components of metabolic syndrome[4] and significantly contribute to the development of atherosclerosis[5] and other vascular disorders[6].

Dyslipidemia, defined as abnormal blood lipid levels, affects a large proportion of the adult population, with variations depending on region, age, and sex[7]. This condition, particularly elevated levels of LDL-C and triglycerides, accelerates the formation of atherosclerotic plaques[8] by promoting endothelial dysfunction[9] and vascular inflammation[10].

Hypertension affects millions of people worldwide[11]. Its prevalence increases with age[12] and is linked to factors such as excessive sodium intake[13], obesity[14], and physical inactivity[15]. This "silent killer"[16] contributes to the development of cardiovascular diseases by damaging the endothelium[17] and increasing arterial stiffness[18].

Hyperglycemia, often associated with type 2 diabetes, also affects a significant portion of the global adult population[19]. Its impact includes accelerating vascular damage —both microvascular and macrovascular[20]— through mechanisms such as oxidative stress[21], chronic inflammation[22], and the formation of advanced glycation end-products[23].

These three factors are deeply interconnected, and their interaction amplifies cardiovascular risk. For instance, insulin resistance in hyperglycemia often coexists with hypertension and dyslipidemia, highlighting the need to address these factors comprehensively rather than in isolation[24].

Managing these conditions requires a multifaceted approach that combines lifestyle modifications[25] and pharmacological treatments. Dietary interventions, such as adopting the Mediterranean diet[26], and regular physical activity[27] have been shown to reduce cardiovascular risk. Similarly, pharmacological advancements, including PCSK9 inhibitors[28], GLP-1 receptor agonists[29], and SGLT2 inhibitors[30], have revolutionized the treatment of these pathologies.

Despite progress, significant challenges persist in the diagnosis and management of these conditions, particularly in vulnerable population.

This study aims to evaluate the associations between shift work, sociodemographic variables such as age, sex, social class, and educational level, as well as health-related behaviors like smoking, physical activity, adherence to the Mediterranean diet, and alcohol consumption, with different cardiovascular risk factors, including dyslipidemia, hypertension, and hyperglycemia.

Methods

Participants

This study was an observational, cross-sectional, descriptive analysis involving 53,053 workers from nearly all labor sectors across various regions of Spain. The sample comprised 31,753 men (17,527 of whom were shift workers) and 21,300 women (11,281 of whom were shift workers). Participants were selected from among those undergoing annual periodic medical examinations as part of occupational health assessments conducted by the participating companies. The selection period extended from January 2019 to June 2020.

Inclusion Criteria:

- Age between 18 and 69 years.
- Employment under a formal contract with one of the participating companies.
- Provision of informed consent to participate in the study.
- Authorization for the use of their data for epidemiological research purposes.

Figure 1 presents the flowchart outlining the selection process and the distribution of workers after applying the inclusion criteria.

Determination of Variables

The data required for this investigation were collected by personnel working in the occupational health departments of the participating companies. Data collection methods included a detailed anamnesis. Information on sociodemographic characteristics (such as age, sex, socioeconomic status, and education level) as well as lifestyle habits (including tobacco use, alcohol consumption, adherence to the Mediterranean diet, and physical activity) was obtained through comprehensive clinical history assessments.

- Clinical and Anthropometric Measurements: These included height, weight, waist circumference, and systolic and diastolic blood pressure.
- Analytical Measurements: These comprised blood glucose levels and lipid profiles.

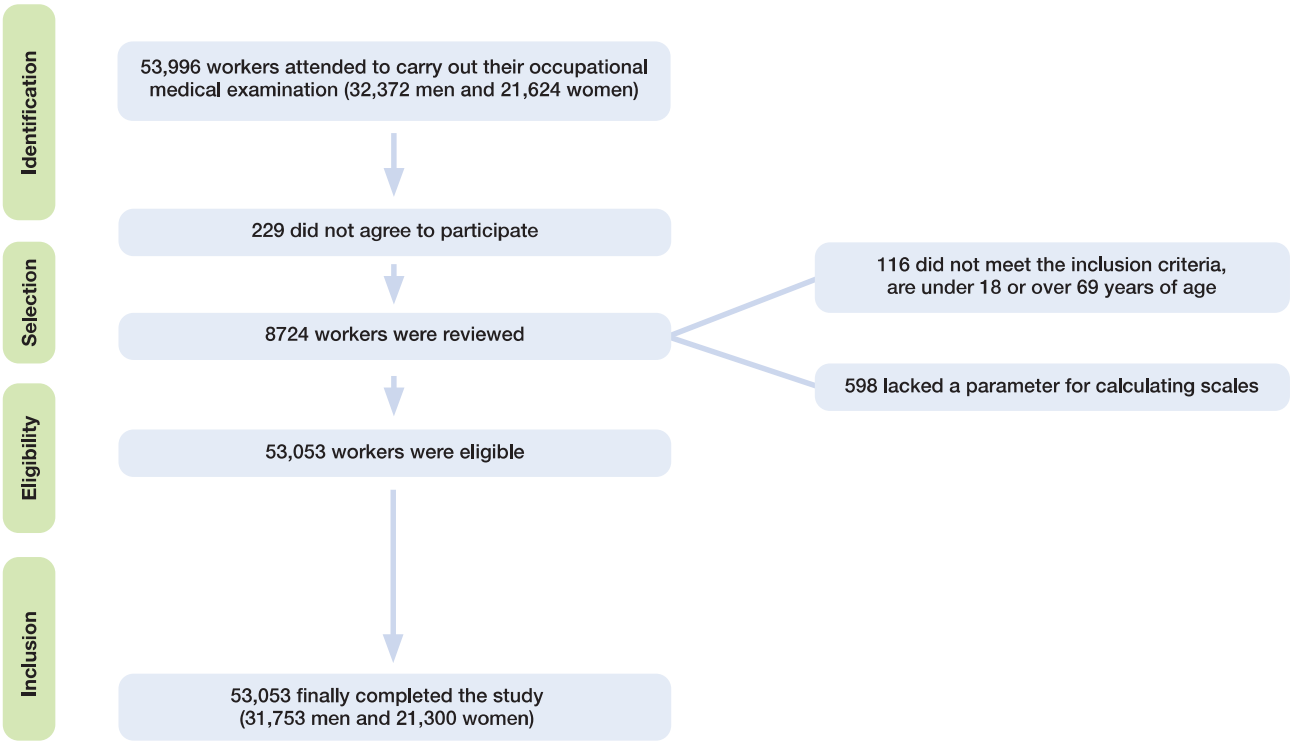
To minimize potential biases, measurement methodologies were standardized across all variables.

Anthropometric Measurements

Participants' height and weight were measured while standing upright, dressed only in undergarments, with arms relaxed at their sides and maintaining proper alignment of the head and chest. Measurements were recorded in kilograms and millimeters using a SECA-type scale and measuring device, adhering to international standards established for ISAK anthropometric evaluation.

Abdominal waist circumference was determined using a SECA model measuring tape, positioned horizontally

Figure 1: displays the data from the workers' flowchart after applying the inclusion criteria.



at the midpoint between the last rib and the iliac crest while participants stood in a relaxed posture. Similarly, hip circumference was measured at the widest part of the buttocks, ensuring the tape was parallel to the floor.

Clinical Measurements

Blood pressure was assessed using an OMROM-M3 blood pressure monitor. Participants were required to remain seated and at rest for at least ten minutes before measurements were taken. Appropriate cuff sizes were used to ensure accurate readings. Three consecutive blood pressure readings were recorded at one-minute intervals, and the average value was used for analysis. Individuals were classified as hypertensive if their systolic blood pressure exceeded 140 mmHg, their diastolic blood pressure exceeded 90 mmHg, or if they were undergoing antihypertensive treatment.

Analytical Measurements

Venous blood samples were collected following a 12-hour fasting period. Samples were processed and stored at refrigerated temperatures for no more than 48 to 72 hours before analysis, which was conducted in reference laboratories using standardized methodologies. Blood glucose, triglycerides, and total cholesterol levels were determined using enzymatic assays, while HDL cholesterol was measured using precipitation methods. LDL cholesterol levels were calculated using the Friedewald formula[31] when triglyceride levels were below 400 mg/dL. For triglyceride levels exceeding this threshold, LDL cholesterol was measured directly.

All analytical results were expressed in mg/dL. Participants were identified as dyslipidemic if their lipid levels exceeded the reference laboratory thresholds or if they were receiving treatment for dyslipidemia. Hyperglycemia was considered to be glycemia values above 100 mg/dL or if the person was under treatment.

Gender was classified into two binary categories: male and female. Age was calculated as the difference between the date of birth and the date of the medical examination. Educational attainment was categorized into three levels based on the highest level completed: primary education, secondary education, and university education.

Social class was determined following the guidelines of the Spanish Society of Epidemiology, which relies on occupational categories outlined in the 2011 National Classification of Occupations (NCO-11)[32]. Participants were grouped into three social classes:

- Social Class I: University-educated professionals, executives, professional athletes, and artists.
- Social Class II: Intermediate-level professionals and skilled self-employed workers.
- Social Class III: Workers with lower levels of qualifications.

Smoking status was defined as having used tobacco products within the previous 30 days or not having abstained from smoking for at least one year.

Adherence to the Mediterranean diet was assessed through a validated 14-item questionnaire. Each affirmative response was awarded one point, with a total score of nine or higher indicating strong adherence to the Mediterranean dietary pattern[33].

Physical activity levels were evaluated using the International Physical Activity Questionnaire (IPAQ), a self-reported tool designed to assess activity levels over the previous seven days[34].

Alcohol consumption was measured using standard drinking units (SDUs), which provide a widely accepted method for estimating alcohol intake across various care settings. One SDU in Spain corresponds to 10 grams of pure alcohol, equivalent to approximately one glass of wine (100 mL), champagne (100 mL), or beer (200 mL), or half a serving of spirits (25 mL). Weekly consumption thresholds for significant health risks were defined as more than 35 SDUs for men and more than 20 SDUs for women[35].

When workers are expected to work beyond the standard nine-to-five shift, this is known as shift work. Working evenings, splitting shifts, alternating shift patterns, and consistently working early or late hours could all be part of this[36].

Statistical Analysis

Quantitative variables were analyzed using Student's t-test to compare means and standard deviations. For prevalence rates of categorical variables, the Chi-square (χ^2) test was applied. Variables related to cardiovascular risk factors were examined using a multinomial logistic regression model, with goodness-of-fit assessed through the Hosmer-Lemeshow test. A stratified analysis was conducted to identify potential confounding factors, although none of the variables analyzed exhibited such effects. All analyses were performed using SPSS software, version 28.0. Statistical significance was set at a p-value less than 0.05.

Results

Table I summarizes the anthropometric, clinical, analytical, and sociodemographic characteristics of the participants, disaggregated by sex and shift work status. Across all parameters, individuals engaged in shift work displayed less favorable clinical, analytical, and anthropometric profiles compared to those without shifts. These adverse findings were more pronounced in men, with the exception of HDL cholesterol. Notably, all observed differences between shift and non-shift workers were statistically significant, except for height.

Table I: Characteristics of the population.

	Non shift work Men n=14226 Mean (SD)	Shift work Men n=17527 Mean (SD)	p-value	Non shift work Women n=10019 Mean (SD)	Shift work Women n=11281 Mean (SD)	p-value
Age (years)	41.2 (10.9)	41.3 (10.5)	0.089	40.0 (10.5)	40.2 (10.3)	0.199
Height (cm)	173.8 (7.1)	173.7 (7.1)	0.219	161.0 (6.6)	161.2 (6.6)	0.015
Weight (kg)	81.5 (14.6)	84.5 (14.4)	<0.001	63.6 (12.8)	68.6 (12.8)	<0.001
Waist (cm)	89.5 (10.5)	90.8 (10.2)	<0.001	74.7 (9.7)	77.6 (10.9)	<0.001
Systolic BP (mmHg)	125.3 (15.7)	126.9 (16.0)	<0.001	114.8 (15.5)	116.1 (15.6)	<0.001
Diastolic BP (mmHg)	75.9 (10.7)	77.2 (11.0)	<0.001	70.3 (10.6)	71.6 (10.8)	<0.001
Total cholesterol (mg/dL)	197.3 (38.4)	201.2 (38.6)	<0.001	192.3 (36.6)	196.9 (37.3)	<0.001
HDL-cholesterol (mg/dL)	50.4 (7.8)	49.7 (7.7)	<0.001	55.0 (9.1)	54.5 (9.2)	<0.001
LDL-cholesterol (mg/dL)	120.9 (37.3)	123.8 (37.6)	<0.001	119.6 (36.9)	123.5 (37.5)	<0.001
Triglycerides (mmHg)	129.3 (93.7)	136.8 (95.5)	<0.001	87.5 (46.8)	93.6 (51.7)	<0.001
Glucose (mg/dL)	91.9 (26.4)	93.3 (26.4)	<0.001	86.6 (19.0)	87.8 (17.6)	<0.001
	%	%	p-value	%	%	p-value
18-29 years	16.4	13.8	<0.001	18.6	17.5	0.135
30-39 years	29.3	29.8		31.0	31.3	
40-49 years	29.0	31.3		29.6	30.6	
50-59 years	20.9	20.9		17.9	17.5	
60-69 years	4.4	4.2		2.9	3.1	
Social class I	6.8	8.2	<0.001	11.6	14.6	<0.001
Social class II	20.7	26.6		27.6	37.0	
Social class III	72.5	65.2		60.8	48.4	
Elementary school	69.5	63.8	<0.001	53.7	43.2	<0.001
High school	24.4	28.9		36.2	44.2	
University	6.1	7.3		10.1	12.6	
Non-smokers	67.9	66.0	<0.001	66.3	69.1	<0.001
Smokers	32.1	34.0		33.7	30.9	
Non physical activity	55.2	67.9	<0.001	40.8	60.7	<0.001
Yes physical activity	44.8	32.1		59.2	39.3	
Non Mediterranean diet	58.2	71.5		42.0	63.1	
Yes Mediterranean diet	41.8	28.5		58.0	36.9	
Non alcohol consumption	70.4	63.2	<0.001	85.3	83.5	<0.001
Yes alcohol consumption	29.6	36.8		14.7	16.5	

SD Standard deviation.

The most prevalent age group for both sexes ranged between 30 and 49 years. A significant proportion of workers, regardless of shift status, belonged to the lowest socioeconomic strata (Social Class III) and had completed only elementary education. Smoking prevalence was higher among men with shift work and women without shifts. Greater adherence to the Mediterranean diet and higher physical activity levels were observed among non-shift workers of both sexes. Conversely, alcohol consumption was significantly elevated among shift workers.

Tables II and **III** present the prevalence of dyslipidemia, hypertension, and hyperglycemia in both male and female workers, stratified by shift work status and according to various sociodemographic variables (age, social class, and educational level) as well as health-related behaviors (smoking, physical activity, adherence to the Mediterranean diet, and alcohol consumption).

The prevalence of all three cardiovascular risk factors shows a progressive increase with advancing age and lower socioeconomic status. Higher prevalence rates are also observed among smokers, sedentary individuals, workers with low adherence to the Mediterranean diet, and those who regularly consume excessive amounts of alcohol. Across all risk factors analyzed, prevalence rates are consistently lower in women compared to men.

In all cases, the differences observed are statistically significant ($p < 0.001$).

Table II: Prevalence of cardiovascular risk factors according to shift or not shift work and according to different sociodemographic variables and healthy habits in men.

	Non shift work				Shift work			
Men	n	Dyslipidemia %	Hypertension %	Glucose high %	n	Dyslipidemia %	Hypertension %	Glucose high %
18-29 years	2329	26.8	9.0	7.6	2425	32.1	11.8	8.0
30-39 years	4174	48.0	12.4	13.4	5228	55.6	18.1	13.9
40-49 years	4130	68.4	24.7	22.7	5477	71.5	28.9	24.2
50-59 years	2972	75.6	37.7	34.9	3666	77.8	41.2	37.2
60-69 years	621	79.2	46.9	47.2	731	82.1	49.0	49.0
Social class I	972	51.5	15.5	17.2	1438	57.5	20.2	17.4
Social class II	2942	57.3	22.4	18.9	4669	62.8	26.9	19.3
Social class III	10312	60.6	23.7	22.9	11420	65.4	27.4	23.5
Elementary school	9874	61.0	25.1	23.1	11169	65.0	27.9	24.1
High school	3478	56.7	21.7	18.7	5070	62.7	26.9	19.5
University	874	54.2	16.1	17.3	1288	58.3	20.6	17.7
Non-smokers	9656	54.7	21.4	21.2	11567	62.8	25.8	21.8
Smokers	4570	59.0	22.6	22.7	5960	63.7	27.2	22.9
Non physical activity	7851	80.2	30.4	26.1	11899	77.8	33.2	29.9
Yes physical activity	6375	29.8	12.2	12.8	5628	32.0	13.0	13.9
Non Mediterranean diet	8275	78.5	29.4	25.4	12536	76.8	32.1	28.1
Yes Mediterranean diet	5951	28.5	12.3	12.7	4991	28.5	13.1	13.1
Non alcohol consumption	8996	46.6	15.7	12.7	12332	57.5	23.4	15.4
Yes alcohol consumption	5230	76.5	33.5	37.2	5195	77.3	34.5	37.3

p <0.001 in all cases.

Table III: Prevalence of cardiovascular risk factors according to shift or not shift work and according to different sociodemographic variables and healthy habits in women.

	Non shift work				Shift work			
Women	n	Dyslipidemia %	Hypertension %	Glucose high %	n	Dyslipidemia %	Hypertension %	Glucose high %
18-29 years	1869	23.1	1.4	3.3	1975	28.7	3.0	4.0
30-39 years	3103	33.7	3.6	6.5	3530	38.2	4.8	7.0
40-49 years	2965	50.4	10.6	12.8	3450	57.4	13.1	13.9
50-59 years	1791	74.5	23.7	22.8	1974	78.5	24.5	23.5
60-69 years	291	79.0	31.3	33.8	352	83.2	32.7	39.8
Social class I	1164	33.2	2.0	6.6	1644	40.8	3.9	8.2
Social class II	2763	43.3	7.6	9.0	4175	49.5	9.6	9.9
Social class III	6092	48.4	12.1	14.3	5462	54.9	15.0	15.0
Elementary school	5377	49.7	12.6	13.7	4871	57.3	15.7	14.3
High school	3628	42.3	7.6	10.2	4984	47.6	9.3	11.7
University	1014	32.4	1.7	7.2	1426	40.2	4.0	8.2
Non-smokers	6638	42.9	8.0	10.7	7794	49.4	10.3	11.6
Smokers	3381	46.5	10.5	12.0	3487	51.2	11.8	12.8
Non physical activity	4090	66.8	16.4	15.8	6842	72.4	18.4	22.7
Yes physical activity	5929	26.2	3.4	5.0	4439	26.5	3.6	5.3
Non Mediterranean diet	4206	66.4	15.9	15.2	7115	71.5	18.0	21.9
Yes Mediterranean diet	5813	24.3	3.7	5.4	4166	26.3	3.7	5.5
Non alcohol consumption	8361	40.7	5.9	4.3	9619	47.6	8.3	4.5
Yes alcohol consumption	1658	68.5	28.9	45.9	1662	68.8	29.2	51.3

p <0.001 in all cases.

The multinomial logistic regression analysis (**Table IV**) establishes the following reference categories for independent variables: female sex, age below 30 years, Social Class I, university-level education, non-smoking status, regular physical activity, high adherence to the Mediterranean diet, and no habitual alcohol consumption. The results indicate that all the analyzed variables are significantly associated with the prevalence of the three cardiovascular risk factors. Among these, age, physical activity, and adherence to the Mediterranean diet demonstrate the strongest associations, as reflected by the highest odds ratio values. In all cases, the observed differences are statistically significant ($p < 0.001$).

Table IV: Multinomial logistic regression.

	Dyslipidemia OR (95% CI)	Hypertension OR (95% CI)	Glucose high OR (95% CI)
Women	1	1	1
Men	1.47 (1.41-1.53)	2.42 (2.30-2.55)	1.57 (1.48-1.66)
18-29 years	1	1	1
30-39 years	1.25 (1.10-1.41)	1.38 (1.24-1.52)	1.53 (1.37-1.70)
40-49 years	2.01 (1.77-2.26)	2.34 (2.11-2.58)	2.21 (1.99-2.44)
50-59 years	3.50 (3.09-3.92)	4.37 (3.92-4.83)	3.65 (3.27-4.04)
60-69 years	6.34 (5.55-7.13)	6.11 (5.37-6.86)	5.92 (5.17-6.67)
Social class I	1	1	1
Social class II	1.15 (1.12-1.18)	1.16 (1.11-1.22)	2.31 (2.14-2.49)
Social class III	1.39 (1.30-1.49)	1.64 (1.52-1.76)	3.10 (2.33-3.88)
University	1	1	1
High school	1.36 (1.30-1.43)	1.20 (1.14-1.26)	2.19 (2.01-2.37)
Elementary school	1.18 (1.14-1.23)	1.61 (1.50-1.73)	3.15 (2.40-3.91)
Non-smokers	1	1	1
Smokers	1.13 (1.10-1.17)	1.13 (1.10-1.17)	1.16 (1.11-1.22)
Yes physical activity	1	1	1
Non physical activity	2.93 (2.73-3.14)	1.97 (1.77-2.18)	3.88 (3.08-4.69)
Yes Mediterranean diet	1	1	1
Non Mediterranean diet	2.77 (2.58-2.97)	1.57 (1.43-1.71)	2.91 (2.22-3.61)
Non alcohol consumption	1	1	1
Yes alcohol consumption	1.40 (1.35-1.46)	1.27 (1.20-1.34)	4.46 (4.20-4.73)
Non shift work	1	1	1
Yes shift work	1.19 (1.16-1.23)	1.23 (1.18-1.29)	1.33 (1.20-1.46)

OR Odds ratio, p <0.001 in all cases.

Discussion

Both the prevalence of dyslipidemia, hypertension, and hyperglycemia have been associated with shift work, sociodemographic variables, and health habits in our study.

As we will see, some authors align with our findings and have reported that the prevalence of dyslipidemia varies according to sociodemographic and behavioral factors. Aging is closely linked to an increase in total cholesterol and LDL levels due to physiological changes in lipid metabolism[37]. Reduced lipoprotein activity[38] and increased hepatic cholesterol synthesis in older individuals contribute to these changes[39]. Additionally, men tend to develop dyslipidemia at younger ages compared to women[40], who generally experience a rise in lipid levels post-menopause, likely due to the decline in estrogen levels[41]. These findings underscore the importance of addressing dyslipidemia differently based on sex and age.

Socioeconomic status plays a critical role in the prevalence of dyslipidemia, as suggested by our results. Similar findings have been reported by other researchers, who attribute this to individuals with lower educational and economic levels often consuming diets high in saturated and processed fats, which promote the development of dyslipidemia[42]. Moreover, the stress associated with economic insecurity may contribute to altered lipid profiles[43], promoting systemic inflammation and endothelial dysfunction[44]. In contrast, individuals with higher socioeconomic status generally have greater access to health information and nutritious foods, facilitating better lipid management.

According to our findings, smoking is a factor associated with the exacerbation of dyslipidemia. Other studies with similar results have observed that smoking increases triglyceride levels while reducing HDL cholesterol, fostering a pro-atherogenic environment[45]. This may be mediated by various mechanisms, including RNA-containing vesicles[46]. Conversely, we also observed that regular physical activity is associated with improvements in lipid profiles. As noted by some researchers, physical exercise increases HDL cholesterol levels and reduces triglycerides[47]. The Mediterranean diet, also associated in our study with a lower prevalence of dyslipidemia, may achieve this by improving LDL and HDL cholesterol levels, thereby reducing the risk of atherosclerosis[48].

Alcohol consumption, another parameter linked to dyslipidemia in our study, presents a complex relationship. While moderate alcohol intake has been

associated with higher HDL cholesterol levels[49], excessive consumption contributes to elevated triglycerides and dyslipidemia[50].

Hypertension was associated in our research with all the variables analyzed, including sociodemographic factors, health habits, and shift work.

Several authors have demonstrated that hypertension is more prevalent with aging, as arterial stiffness and endothelial dysfunction increase with age[51]. Men are at greater risk for hypertension at younger ages, but women surpass men in prevalence as they age, particularly after menopause, since sex hormones have a protective role in younger women, while their decline post-menopause elevates the risk of hypertension[52].

Socioeconomic status has also been linked to hypertension prevalence, consistent with our findings. Studies supporting our results explain that individuals with fewer economic resources often consume diets high in sodium and low in potassium, increasing their risk of developing hypertension[53]. Additionally, chronic stress associated with economic insecurity can contribute to elevated blood pressure[54].

Health habits showed a significant association with hypertension prevalence, as indicated by our findings. Excessive salt consumption[55] and physical inactivity[56] are widely recognized as key factors favoring hypertension. Conversely, regular physical activity, such as aerobic exercise, helps reduce blood pressure by improving cardiovascular function and reducing arterial stiffness[57]. The Mediterranean diet, with its low sodium and high potassium content, has been shown to be effective in preventing and managing hypertension[58]. Excessive alcohol consumption is strongly associated with hypertension, as it increases vascular resistance and promotes vasoconstriction[59].

Hyperglycemia, particularly in the context of type 2 diabetes, is a major risk factor for cardiovascular disease and, according to our findings, is associated with shift work as well as all the sociodemographic variables and health habits analyzed.

Our results align with previous research showing that the prevalence of type 2 diabetes increases significantly with age, largely due to reduced insulin sensitivity[60] and changes in glucose metabolism[61]. While both men and women can develop type 2 diabetes, men are at higher risk at younger ages, whereas women, particularly after menopause, experience a greater increase in risk[62].

Low socioeconomic status is associated with a higher risk of hyperglycemia and type 2 diabetes, as reflected in our results. Various researchers attribute this to factors such as limited access to healthy foods[63], chronic stress[64], and reduced availability of healthcare[65,66].

Healthy lifestyles, on the other hand, have been positively associated with reduced hyperglycemia prevalence, according to our data. Some studies have demonstrated that smoking decreases insulin sensitivity and increases the risk of insulin resistance[67]. Physical activity, conversely, enhances insulin sensitivity and helps maintain healthy glucose levels[68]. The Mediterranean diet, rich in antioxidants and healthy fats, has been shown to prevent and control type 2 diabetes[69]. Regarding alcohol consumption, excessive intake can disrupt glucose metabolism, while moderate amounts may have protective effects on insulin resistance in some studies[70].

Shift work, particularly night shifts, has been linked to various health problems, including an increased risk of dyslipidemia, hypertension, and diabetes, as observed in this study. Circadian rhythm disruption, sleep disturbances, and occupational stress negatively impact metabolic regulation, promoting dyslipidemia[71], hypertension[72], and hyperglycemia[73]. Chronic exposure to shift work is also associated with increased risk of obesity and altered dietary patterns, which can contribute to the development of these risk factors[74].

Strengths and Limitations

One of the primary strengths of this study lies in its substantial sample size, encompassing over 53,000 participants. This extensive sample provides a robust basis for generalizing the findings to a broader population, significantly improving the statistical power and reliability of the results. Furthermore, the sample's diverse origin, including individuals from various autonomous communities and professional sectors, enhances its representativeness of the Spanish population. In the group of shift workers, all participants followed a rotating schedule that included day, evening, and night shifts. The consistency of the findings with those reported in studies from other countries supports the generalizability of our results to other populations and validates observations derived from smaller samples.

Another notable strength of this study is its investigation of multiple variables linking shift work to cardiovascular risk factors, such as dyslipidemia, hypertension, and hyperglycemia, with analyses stratified by sex. This approach addresses a significant gap in the literature, as few existing studies examine these associations comprehensively, and those that do often present contradictory findings.

However, the study's cross-sectional design constitutes its primary limitation. While associations between shift work and obesity-related variables can be identified, causal relationships cannot be established. Additionally, the "healthy worker effect" poses a methodological challenge in shift work research; individuals with cardiovascular risk factors may be less likely to engage in or remain in shift work, potentially leading to an underestimation of the observed associations. The lack of data on the duration

of shift work also precludes the ability to explore the relationship between exposure length and cardiovascular risk factors. Another limitation is the omission of workplace location as a variable, which might influence the findings due to differences across companies or job roles. Lastly, in assessing dietary habits, the study only considers adherence to the Mediterranean diet, lacking information on the consumption of fast food, snacks, pastries, and similar items, which could offer additional insights.

Conclusion

Dyslipidemia, hypertension, and hyperglycemia are key risk factors for cardiovascular diseases, with their prevalence and severity being influenced by various sociodemographic and lifestyle factors. Age, sex, and socioeconomic status are critical determinants of the risk for these conditions, alongside behaviors related to tobacco use, physical activity, diet, and alcohol consumption. Furthermore, shift work poses an additional challenge to metabolic health by disrupting biological rhythms and promoting unhealthy lifestyle patterns. It is essential to adopt comprehensive approaches that include interventions targeting these factors.

Author Contributions

Conceptualization: Á.A.L.-G. and J.I.R.-M.; Data collection and analysis: JT. and P.J.T.L Data curation: JT. Methodology: E.M.-A.R. and P.J.T.L. Validation: C.M.S.; Formal analysis: Á.A.L.-G.; Investigation: J.T.; Draft: JT; P.J.T.L., C.M.S and E.M.-A.R.; Revision: J.I.R.-M. and Á.A.L.-G. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The research team is dedicated to consistently adhering to the ethical guidelines for health sciences research established at both national and international levels, specifically following the Declaration of Helsinki. The primary focus is on ensuring participant anonymity and the confidentiality of their data. Ethical approval for the study was granted by the Ethics and Research Committee of the Balearic Islands (CEI-IB) under reference number IB 4383/20. Participation in the study was entirely voluntary, with participants providing both written and verbal consent after being thoroughly informed about the study's objectives. To facilitate this process, participants received an information sheet explaining the study's purpose, along with an informed consent form. To maintain confidentiality, the data collected were coded in such a way that only the project coordinator could link the data back to individual participants, making re-identification impossible. The identities of the participants will not be disclosed in any study report, nor will any identifying information be revealed by the researchers. The research team guarantees that all study participants have the right to access, correct, delete, and oppose their data as per their rights. The team also commits to full compliance with Organic Law 3/2018, of 5 December, on the Protection of Personal Data and Guarantee of Digital Rights and Regulation (EU) 2016/679 of the European Parliament and the Council of 27 April 2016 on Data Protection (RGPD).

Informed Consent Statement

Informed consent was obtained from all participants involved in this study.

Data Availability Statement

The study data are securely stored in a database that meets all security requirements at the ADEMA-Escuela Universitaria. The Data Protection Officer is Ángel Arturo López González.

Conflicts of Interest

The authors declare no conflicts of interest.

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