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Cardiovascular risk behavior among industrial workers in the Northeast of Brazil: a cluster analysis

Comportamento de risco cardiovascular entre trabalhadores industriais no nordeste do Brasil: uma análise de cluster

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Abstract *This research aimed to investigate the occurrence of clusters of cardiovascular risk behaviors and their association with social demographic and occupational characteristics in a population of industrial workers in the metropolitan area of Recife, Brazil. It was a transversal study with 727 workers of both genders. We identified cluster distribution from the variables: smoking, alcohol consumption, physical activity and waist circumference, by a combination of hierarchical and non-hierarchical analysis. We later tested the association with the social demographic and occupational variables with a multi-varied analysis. We have identified a protection cluster (sufficient physical activity, moderate alcohol consumption) and a risk cluster (high waist circumference, sedentarism, smoking, excessive alcohol consumption). The protection cluster was positively associated with night shift or variable shift work (RP: 1.66, IC95%: 1.26-2.17), and the risk cluster was associated with women (RP: 1.15, IC95%: 1.01-1.31). Cluster analysis allowed to identify that, for day shift workers and women, the shortest daytime outside the work environment can influence the adoption of cardiovascular risk behaviors.*

Key words *Occupational health, Cluster analysis, Shift work, Health behaviors*

Resumo *Esta pesquisa teve como objetivo investigar a ocorrência de clusters de comportamentos de risco cardiovascular e sua associação com características sociodemográficas e ocupacionais em uma população de trabalhadores da indústria da região metropolitana de Recife, Brasil. Trata-se de um estudo transversal com 727 trabalhadores de ambos os gêneros. Identificou-se a distribuição do cluster a partir das variáveis: tabagismo, etilismo, atividade física e circunferência da cintura, por meio de uma combinação de análise hierárquica e não hierárquica. Posteriormente, testamos a associação às variáveis sociodemográficas e ocupacionais com uma análise multivariada. Identificamos a formação consistente de um cluster de proteção (atividade física suficiente, consumo moderado de álcool) e de um cluster de risco (circunferência da cintura elevada, sedentarismo, tabagismo, consumo excessivo de álcool). O cluster de proteção associou-se positivamente ao turno noturno ou turnos variáveis (RP: 1,66, IC95%: 1,26-2,17) e o cluster de risco esteve associado às mulheres (RP: 1,15, IC95%: 1,01-1,31). A análise de cluster permitiu identificar que, para trabalhadores diurnos e mulheres, a menor jornada diurna fora do trabalho pode influenciar na adoção de comportamentos de risco cardiovascular.*

Palavras-chave *Saúde ocupacional, Análise por conglomerados, Trabalho em turnos, Comportamento de saúde*

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Introduction

The main factors for cardiovascular risk that are considered to be modifiable are related to life behaviors adopted by individuals, and the main five are smoking, excess weight, high blood pressure, diabetes, and high cholesterol[1]. Although they are responsive to behavioral changes, the prevalence of these factors has increased in Brazil and worldwide[2,3].

The occurrence of these risk factors is influenced by social demographic characteristics such as gender, age, education, social class and cultural aspects of the individual and population groups[1,4-6]. In addition to that, studies in occupational health have pointed to the place of work[7,8], position[9], social capital[10], and the shift of work[11-14] as contributing factors to the increase in the occurrence of non-communicable chronic diseases, cardiovascular disease, and metabolic disturbances, due to their influence in the adoption of risk behaviors related to health. This highlights the importance of studies that can investigate the association between occupational variables and cardiovascular risk behaviors.

Also, the occurrence of these behaviors and risk factors has been studied in isolation, both in the general population[15] and among workers[16]. The risk factors studied including smoking[1,5,15,16-18], alcohol[5,15,16,18], physical activity[5,15,16,18], diet[5,15,16,18], overweight[1,15,16], diabetes[1,15,16], dyslipidemia[1,15,16], hypertension[1,15] and stress[16]. However, this approach seems to be insufficient, since most of the time, a positive or negative health behavior happens in association to other behaviors[5] revealing a synergic effect in the simultaneous presentation of behaviors and consequently in a heightened risk of cardiovascular diseases and general morbidity[1,18]. An in-depth analysis of how behaviors are distributed and associated with the construction of life habits for individuals might better show cardiovascular risk and its associated factors[17].

The use of cluster analysis has intensified in the past decade as an advanced statistical technique that may be able to identify the underlying associations among health behaviors demonstrating the increased risk associated with combined behavioral exposure[5,7] and even to find the existence of a common causal chain[19]. Some studies have described cluster cardiovascular risk of combination between alcohol, smoking and sedentarism[5,20-22], other clusters compound of smoking, abdominal fat and sedentarism[22-24].

However, studies that have used cluster analysis in the investigation of risk behaviors are concentrated on the general population[18,21,22,24] mainly in Asian countries[7,22,24] and in Europe[12,18,19,21]. A study among Chinese adults showed smoking, overweight and dyslipidemia as the main cardiovascular risk factors, and when evaluating them in clusters, they observed that combinations occurred frequently among dyslipidemia, overweight, hypertension and smoking. Revealing a synergistic effect in the simultaneous presentation of factors and an increased risk of cardiovascular events, cardiovascular diseases and general mortality[1].

In this context, despite several studies investigating occupational variables associated with the occurrence of cardiovascular risk behaviors in Brazilian industry workers[5,10,11,20,25-27], as far as we can tell, this is the first study to identify a behavioral cluster in Brazilian workers and its association with occupational characteristics. Therefore, this study investigates the occurrence of clusters of cardiovascular risk behavior and their association with sociodemographic and occupational characteristics in the population of factory workers in the metropolitan area of Northeast - Brazil.

Methods

This was a transversal study with adult subjects (≥18 years old) of both genders from factories in the metropolitan area of Recife – Pernambuco, Brazil – a region composed of 15 cities all closely linked together.

For the formation of the sample, we have considered variables such as being overweight, obesity, glycemia, cholesterol, triglycerides, and high blood pressure as indicators of non-communicable chronic diseases in the State of Pernambuco[28]. We considered a confidence level of 95%, a maximum sample error of 4% and a design effect of 1.5; with a 20% increase for possible losses, resulting in a sample size of around 630 subjects. Following the rule proposed by Hair *et al.*[29] for cluster analysis, it is necessary a sample larger than 100 subjects.

Sample building happened in two stages; first, an invitation was sent to factories in the metropolitan area with more than a hundred employees and who are part of the National Program for Workers Nutrition [*Programa de Alimentação do Trabalhador* - PAT]. From the 66 companies invited, 16 factories from 7 cities agreed to participate in the study. A proportional sample of workers was established, varying from 4.5 to 8%

of the total number of employees in each factory. In the end, the total sample size was 727.

Data collection happened between January and June 2015. Standardized questionnaires pre-coded and previously tested in a pilot study. The current project followed all applicable laws of ethics in research with human subjects. It was approved by the Committee of Ethics in Research in the Center for Health Sciences at the Federal University of Pernambuco (UFPE) (CAAE nº 37098814.0.0000.5208). Each participant signed a form of free consent.

Social demographic variables were: gender (male/female), age (≤27 years-old; 28 to 34 years-old; 35 to 44 years-old; >44 years-old), and schooling (<12 years of education; 12 years of education; >12 years of education); occupational: shift (day shift - from 6 am to 2 pm; night shift or rotating shift - from 2 pm to 6 am or rotating 8 hours/day); position (director/management; engineering administrative assistants and auxiliaries; production coordination and technicians; production; others (receptionists and nursing staff), and time of employment at the same factory (<2 years; 2 to 4 years; 5 to 9 years; ≥10 years).

The following behavioral variables were considered: smoking (yes or no); alcohol consumption (excessive consumption in men was 5 or more doses in a single occasion at least once in the past 30 days; for women, it was 4 or more doses – any amount smaller than that was considered as a moderate consumption. For determining the level of physical activity, participants stated the kind, the frequency and duration of any physical activity practiced in their free time in the week prior to the interview, being classified as sedentary (<10 minutes per week of moderate physical activity), insufficiently active (10 to 149 minutes per week of moderate physical activity), and sufficiently active (≥150 minutes per week of moderate physical activity)[30].

For waist circumference measurements, we have used the mean figure from two measurement takings, using a non-elastic measuring tape (brand: Seca®) with 200 cm in length and 1 mm precision, positioned in the middle point between the last rib arch and the iliac. When the difference between the two measurement takings was over 0.5 mm a third measurement was taken, and the two closest measurements were considered, and the most dissonant one was discarded. A regular waist circumference was <80 cm for women and <94 cm for men; a high waist circumference was from ≥80 to <88 cm for women and from ≥94 to <102 cm for men, and an extremely high waist circumference was ≥88 cm for women and ≥102 for men[31].

Data were entered in a double-entry method and checked with VALIDATE, a module of the software Epi-info version 3.5.2, to assure consistency and validity. Statistical analysis was done with the Statistical Package for Social Sciences (SPSS version 17) and Stata (version 15).

To identify the behavioral clusters, we used a combination of hierarchical and non-hierarchical analysis. In the hierarchical cluster analysis, we used the method of Euclidian square distances for binary variables. The possible clusters found at this stage, considering the analysis of Dendrogram and Screen Plot, were used in the non-hierarchical analysis, when the k-mean procedure was used, based on the Euclidian square distances. As the seeds for the initial randomization, we used the clusters' centroids in the hierarchical analysis and 10,000 iterations to further refine the preliminary solution and to optimize the classification. The final cluster solution was selected based on its ability to interpret the data. Finally, each cluster generated was saved as dichotomy variable (0/1).

The associations between clusters of behavioral characteristics and independent variables were tested by Pearson's chi-square test and linear tendency. The prevalence ratios, crude and adjusted, with their respective intervals of 95% of confidence, were obtained by Poisson's regression method with a robust variation. The analysis followed a conceptual model (1st level: social-demographic variables; 2nd level: occupational variables). In the multi-varied analysis, only the exposition variables obtained $p<0.2$ in the bi-varied analysis were included. The same cut was applied to the other variables in the subsequent levels. Associations with $p\leq0.05$ were considered as statistically significant.

Results

There was a loss of 8 participants due to the absence of an answer to the variables physical activity (1) and waist circumference (7), so the final sample contained 719 workers. Of these workers, with a mean age of 36.4 (standard deviation 10.7), most were male (75,8%). Most of them declare to have 12 years of education (56.9%), followed by those who said they had more than 12 years (31.2%). The great majority of the subjects worked in a day shift (95.0%), predominantly in production positions (57.2%). The mean time of

employment at the same factory was 4.08 years (interquartile range 1.92:10).

Cluster analysis identified 2 behavioral clusters. Initially, they were named cluster 1 and cluster 2, and their distribution is shown in Table 1. Cluster 1 had an evident predominance of sufficient physical activity and a moderate alcohol consumption pattern, which are factors of cardiovascular protection. On the other hand, risky behaviors concentrated on Cluster 2, with the predominance of high waist circumference, sedentarism, smoking, and excessive alcohol consumption. Cluster 2 included the majority of the participants. According to each cluster's predominant behaviors, they were renamed as Protection Cluster and Risk Cluster, respectively.

In Table 2 we can observe both clusters according to social demographic and occupational variables. Only the shifts seemed to be associated with the behavior clusters, and for all the other social demographic and occupational variables, there was not a significant association to the composition of the clusters.

The multivariable analysis of the Protection cluster (Table 3) shows that women and older workers had a lower probability of being a part of the protection cluster; on the other hand, night shift workers had a higher probability of being a part of the same cluster compared to day workers. In Table 4, the multivariable analysis of the Risk cluster indicated a positive association of females, had more than 44 years old, and risk, while night shift or variable shift work was inversely associated with the Risk cluster.

Table 1. Distribution of cardiovascular risk behaviors among industrial workers in each cluster. Recife, Brazil, 2019.

Behaviors	Protection Cluster		Risk Cluster	
	N (288)	% (40.1)	N (431)	% (59.9)
High waist circumference	142	37	237	62.5
Sedentarism	0	0	350	100
Physical Activity ≥150 min per week	211	100	0	0
Smoking	20	40.8	29	59.2
Moderate Drinking	169	55	138	45
Excessive Drinking	16	40	24	60

Source: Authors.

Discussion

This study investigated the aggregate occurrence of cardiovascular risk behavior in a population of factory workers in the metropolitan area of Recife and identified the formation of two clusters associated with gender and the shift in which industrial employees work.

In the cluster analysis, there were a consistent determination of a group composed more frequently or protection behaviors (sufficient physical activity, moderate alcohol consumption) and another with behaviors that represent a risk for cardiovascular health (augmented waist circumference, sedentarism, smoking, excessive alcohol consumption) and the largest cluster was the second. These findings suggest that individuals may simultaneously adopt risk behaviors as well as protection behaviors, which reinforces the hypothesis that these behaviors happen together[5] and that there is a synergy in the basic mechanisms that lead to cardiovascular diseases[23].

Mawditt *et al.*[18] found similar cluster compositions in 21,019 adult subjects in Great Britain – a Conventional cluster (more frequent physical activity and lower alcohol consumption, as well as not smoking) and a Risk cluster (smoking and excessive alcohol consumption). Other studies have also found a combination of alcohol abuse, smoking and physical activity level in cardiovascular risk clusters[5,20-22]. In the same sense, other studies have found a significant association between smoking, abdominal fat and the higher probability of any combination of cardiovascular risk in sedentary individuals[22-24], suggesting that sedentarism is a risk behavior with a propensity to combine with others[1]. In this study, all sedentary participants presented behaviors that were distributed in the risk cluster.

Risk cluster was associated with women. Several studies done with cluster analysis have shown a higher number of risk behaviors in women[7,12,18,19,21,22,24]. The association of gender and these risk factors can be related in a certain measure by the stress and lack of leisure time generated by the accumulation of formal work and house work[32,33], as shown in the previous studies[7,33-35]. In addition to that, individuals who were a part of this cluster have the highest prevalence of sedentarism and abdominal obesity, in accordance with the literature that repeatedly suggests the association of sedentarism and the other risk behaviors, especially an increase in abdominal circumference in women[5,23,24,36-38].

Table 2. Clustering of cardiovascular risk behavior according to social demographic and occupational variables among industrial workers. Recife, Brazil, 2019.

Variables	Sample		Protection Cluster		Risk Cluster		p-value**
	N (727)*	%	N (288)	%	N (431)	%	
Gender							
Male	551	75,8	229	79,5	316	73,3	0.057
Female	176	24,2	59	20,5	115	26,7	
Age							
≤27 y.o.	167	23	75	26	92	109	0.206
28-34 y.o.	180	24.8	69	24	109	25.3	
35-44 y.o.	202	27.8	84	29.2	115	26.7	
>44 y.o.	178	24.5	60	20.8	115	26.7	
Schooling							
<12 years in school	86	11.8	32	11,1	54	12.5	0.719
12 years in school	414	56.9	168	58.3	239	55.5	
>12 years in school	227	31.2	88	30.6	138	32.0	
Shifts							
Day shift	691	95	265	92	418	97	0.003
Night shift or variable shift	36	5	23	8	13	3	
Position							
Director/manager	33	4.5	15	5.2	17	3.9	0.831
Engineering administrative auxiliaries and assistants	171	23.5	66	22.9	105	24.4	
Technicians and production coordinators	87	12	36	12.5	49	11.4	
Production	416	57.2	162	56.3	250	58	
Others (receptionists, nursing staff)	20	2.8	9	3.1	10	2.6	
Time of employment							
<2 years	182	25	70	24.3	112	26	0.965
2-4 years	204	28.1	83	28.8	120	27.8	
5-9 years	144	19.8	58	20.1	85	19.7	
≥10 years	197	27.1	77	26.7	114	26.5	

*From the final sample of 727 workers, 8 were excluded because of the absence of information about physical activity (1) and waist circumference (7). **Pearson chi-square; y.o.= years-old.

Source: Authors.

Population aging combined with metabolic risks is associated with an increased incidence of cardiovascular disease and mortality[39]. Aging was associated with the risk cluster in this study, probably due to abdominal obesity being part of that cluster. Central adiposity concentration over the years was observed among rural and urban workers, and among women aged >40 or in the menopausal period[40-42], corroborating our results.

In this study, the day shift was associated with the risk cluster. However, the literature has demonstrated consistent associations with night shift or variable shift work and metabolic diseases[13,14] and cardiovascular diseases[8], the causal mechanism of these associations still is controversial, and it would involve metabolic and behavioral changes. Metabolic changes could be explained by the fact that these workers are exposed to the physiological effects that the rupture in the circadian rhythm can trigger[14], either by hormonal changes brought about by the inversion of the sleep cycle and associated with the increase of abdominal fat[20,43-45], or by the lower production of melatonin triggered by the constant exposition to light, even if it is at night[13]. However, behavioral changes such as eating habits, smoking and physical activity may occur due to reorganize daily activities, since during the day, instead of being able to practice these common activities, the worker has to rest[11,46,47]. In

Table 3. Multivariable analysis of protection cluster according to social demographic and occupational variables among industrial workers. Recife, Brazil, 2019.

Variables	Crude analysis			Adjusted analysis*		
	RP	IC95%	p-value	RP	IC95%	p-value
Gender						
Male	1		0.067	1		0.045
Female	0.80	0.64-1.01		0.78	0.62-0.90	
Age						
≤27 y.o.	1		0.094	1		0.058
28-34 y.o.	0.86	0.67-1.10		0.85	0.66-1.09	
35-44 y.o.	0.94	0.74-1.18		0.92	0.73-1.17	
>44 y.o.	0.76	0.58-0.99		0.74	0.57 – 0.96	
Schooling						
<12 years in school	1		0.992			
12 years in school	1.11	0.82-1.49		-		
>12 years in school	1.04	0.76-1.44		-		
Shifts						
Day shift				1		
Night shift or variable shift	1.64	1.26-2,14	<0.001	1.66	1.26-2.17	<0.001
Position						
Director/manager			0.873			
Engineering administrative auxiliaries and assistants	0.82	0.54-1.24		-		
Technicians and production coordinators	0.90	0.58-1.40		-		
Production	0.83	0.57-1.23		-		
Others (receptionists, nursing staff)	1.01	0.55-1.84		-		
Time of employment						
<2 years			0.757			
2-4 years	1.06	0.83-1.36		-		
5-9 years	10.5	0.80-1.38		-		
≥10 years	1.05	0.81-1.35		-		

*For the adjusted analysis variables with p-value<0.20 in the crude analysis were included. First level of analysis: social demographic variables (gender, age and schooling); second level: first level + occupational variables; y.o.= years-old.

Source: Authors.

fact, some studies have suggested that night shift or variable shift work may not negatively influence healthy behaviors[8,11,14,48] and may even favor them, as shown in some studies that associated night shift or variable shift work to an increase of time available for regular physical activity[49,50]. However, it is important to consider some study limitations in interpreting these results: the work shift was not detail investigated, and the sample had a small number of shift workers compared to daytime workers.

From these findings, we hypothesized that for day shift workers, the shortest socially valuable time (daytime) out of a formal work environment can limit the adoption of a profile of cardiovascular protective behaviors, such as physical activity practice. Besides, for women, who also showed higher risk behavior, this can be intensified for the double shift imposed by domestic work. These hypotheses should be verified in further studies.

The present study has possibly been limited by its transversal design, which does not determine temporal or causal relationships in the association between social-demographic and behavioral factors, even if most of the interviewed workers have worked at the same factory for over 2 years. On the other hand, this study has cluster analysis as a strong point in identifying patterns of cardiovascular risk behavior in the workers, which allowed us to demonstrate how risk or protection behaviors can occur simultaneously.

Table 4. Multivariable analysis of risk cluster according to social demographic and occupational variables among industrial workers. Recife, Brazil, 2019.

Variables	Crude analysis			Adjusted analysis*		
	RP	IC95%	p-value	RP	IC95%	p-value
Gender						
Male	1		0.045	1		0.027
Female	1.4	1.0-1.29		1.15	1.01-1.31	
Age						
≤27 y.o.	1		0.095	1		0.060
28-34 y.o.	1.11	0.93-1.33		1.12	0.93-1.34	
35-44 y.o.	1.05	0.87-1.25		1.06	0.88-1.34	
>44 y.o.	1.19	1.00-1.42		1.22	1.2-1.45	
Schooling						
<12 years in school	1		0.992			
12 years in school	1.11	0.82-1.49		-		
>12 years in school	1.04	0.76-1.44		-		
Shifts						
Day shift	-		0.018	1		0.020
Night shift or variable shift	0.59	0.38-0.91		0.59	0.38-0.92	
Position						
Director/manager	1		0.873			
Engineering administrative auxiliaries and assistants	1.15	0.81-1.63		-		
Technicians and production coordinators	1.08	0.74-1.57		-		
Production	1.14	0.82-1.59		-		
Others (receptionists, nursing staff)	0.99	0.57-1.69		-		
Time of employment						
<2 years	1		0.757			
2-4 years	0.96	0.81-1.13		-		
5-9 years	0.96	0.81-1.15		-		
≥10 years	0.96	0.82-1.14		-		

*For the adjusted analysis variables with p-value<0.20 in the crude analysis were included. First level of analysis: social demographic variables (gender, age and schooling); second level: first level + occupational variables; y.o.= years-old.

Source: Authors.

Besides, considering the lack of evidence on this topic with data from workers who live in Latin America, the results of this study contributed to a better understanding of this issue and to assist public policy formulation aiming to change cardiovascular risk behaviors in this population.

Considering the great diversity of work environments, our results indicated the importance of future studies on the simultaneous occurrence of health behaviors in other worker places, and how these behaviors are associated with social demographic and occupational variables. Studies on this theme are essential for investigating possible iniquities involved in adopting health behaviors by workers and a deeper understanding of the factors that influence time management outside work, as demonstrated in this study. Also, the knowledge of the impact of simultaneous risk behaviors on the population's quality of life and their iniquities is essential for the implementation of worker's health public policies informed by evidence and socially referenced.

Collaborations

SGF Clark, RC Guilherme, PIC Lira and R Canuto conceived the work and designed analyses. SGF Clark, RC Guilherme, FN Vasconcelos and PIC Lira acquired the data for this work. SGF Clark and RC Guilherme conducted preliminary analyses. All authors contributed to the design of the final analysis plan. FR Motter conducted the final data analysis. All authors contributed to interpretation of the findings. SGF Clark and RC Guilherme drafted the manuscript. All authors reviewed, edited, and approved the manuscript.

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