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Personal, occupational and cardiovascular risk factors associated with elevated blood pressure in Brazilian firefighters: a cross-sectional study

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ABSTRACT

Objective Our study evaluated the prevalence of hypertension in a population of Brazilian firefighters and the association of elevated blood pressure (BP) with personal, occupational, and cardiovascular risk factors.

Design This was a cross-sectional study.

Setting Our study was based on health inspections of the Military Fire Brigade of the Espírito Santo State, Brazil, performed in 2019.

Participants The study participants were 859 male Brazilian firefighters.

Outcome measures Data collected included sociodemographic (age, ethnicity, educational level, health insurance coverage), occupational (city of work, type of current activity, main operational activity), lifestyle (smoking and alcohol consumption), and health status (fasting glucose, total cholesterol and triglycerides, blood pressure, and anthropometric composition). All firefighters in the pre-hypertension and hypertension range and/or using antihypertensive medication were considered as having BP above normal, and the association of this outcome with sociodemographic, occupational, lifestyle, and health status variables was analysed by a logistic regression model.

Results We found that 45.6% of firefighters presented elevated BP levels. A higher chance of elevated BP was observed for firefighters with high school (1.5; 95% confidence interval (CI) 1.02 to 2.19) and postgraduate (1.54; 95% CI 1.03 to 2.30) educational levels, those self-declared as black (1.98; 95% CI 1.03 to 3.78), those working in countryside cities (ie, locations outside the metropolitan circuit; 2.32; 95% CI 1.14 to 4.71), and those with hypertriglyceridemia (1.92; 95% CI 1.19 to 3.11), hyperglycaemia (1.5; 95% CI 1.01 to 2.22), and central obesity (2.34; 95% CI 1.47 to 3.70).

Conclusion We found an association between elevated BP and personal, occupational, and cardiovascular risk factors. Awareness of risk factors may grant implementation of more effective intervention and prevention strategies.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Strengths of the study include the large sample size analysed.
⇒ The hierarchical logistic regression model used accounts for the data structure and provides high accuracy while retaining individual estimates.
⇒ The cross-sectional design of the study prevents us from drawing conclusions regarding causality.
⇒ Our study is a secondary analysis of existing data, and the researchers were not involved in the original data collection.
⇒ Generalisability may be limited, as the study evaluated firefighters from one specific state of Brazil.

INTRODUCTION

The development of cardiovascular disease (CVD) is dependent on a complex set of risk factors determined by genetic, socio-environmental, and lifestyle influences, among others.[1] Some factors may not have predictive power individually but can do so when treated with other related factors, such as work-related activities, which may often be neglected in medical assessment.[2 3] Public health policies focus on counteracting metabolic and behavioural risk factors to reduce morbidity and mortality caused by CVD. Still, occupational factors can also be associated with these outcomes, contributing to the development of diseases such as hypertension, obesity, and atherosclerosis.[4–6] Not surprisingly, a recent study suggests that including work-related characteristics in clinical evaluation can more accurately predict hypertension onset.[3]

Firefighters perform several hazardous and risky activities to preserve lives and property, like fighting fires, rescuing accident and natural disaster victims, water rescues, and emergency medical calls.[7 8] These activities significantly strain the cardiovascular system, such as wearing heavy equipment, dragging heavy hoses, accessing difficult locations, exposure to extreme heat and environmental

pollutants, and great emotional stress, among other stressors.[7 8] Consequently, the combination of these hazardous and stressful occupational activities has been shown to increase the risk of CVD in these workers.[9] In fact, over the last decade, sudden cardiac events have been the leading cause of on-duty deaths among American firefighters,[10] particularly among volunteers.[11] Recently, the most prevalent CVD risk factor, arterial hypertension (AH), has been identified in 71% of American male firefighters in a large-scale study, reaching higher levels than the general population.[12] The same study also observed that hypertension prevalence was nearly 33% higher among older male firefighters (50–59 years old) than in younger ages (20–29 years old). In addition to this, 88% of the male firefighters analysed were classified as overweight or obese.[12] These data point to a high prevalence of hypertension and other CVD factors in this occupational group, particularly when ageing, highlighting that screening for high blood pressure among firefighters is of utmost importance to prevent fatal cardiac outcomes.

In previous work, we investigated the prevalence of obesity, another critical CVD risk factor, in a population of Brazilian firefighters.[13] In this population, the fire department institutionalised annual health inspections in a programme called "*Bom-Estar*" which in English translates to "*Wellness*", where they collect biochemical and anthropometric measurements from the whole troop and data on sociodemographic, occupational, and lifestyle habits. We observed a high prevalence of firefighters with overweight and/or obesity and a strong association of this outcome with ageing and cardiovascular risk factors.[13]

Given the substantial body of evidence of morbid cardiovascular outcomes, the high prevalence of CVD risk factors among firefighters, and the dearth of initiatives in Brazil focusing on the assessment and control of these risk factors, in our study we investigated the prevalence of hypertension in this occupational group and factors associated with this outcome.

METHODS

Study design

We conducted a secondary data analysis of cross-sectional data from the health inspections of the "*Bom-Estar*" programme of the Fire Department of the Espírito Santo state (CBMES) in 2019. During the inspections, all firefighters completed forms with the following data: sociodemographic (age, ethnicity, family income, education level, loan payment, and access to health insurance), occupational (city of work, type of current activity, and main operational function) and lifestyle (alcohol consumption and smoking). Data on health status obtained by direct measurements or biochemical analysis included blood pressure (BP), body weight, height, waist circumference (WC), blood glucose, total cholesterol, and triglycerides. Measurements were conducted within the firehouse by trained personnel, including nurses, pharmacists, and physical educators. The CBMES authorised access to the data. The research was approved by the ethics committee for human research of the Federal University of Espírito Santo (CEP-UFES), registered under the number 80483117.1.0000.5060.

Inclusion and exclusion criteria

All male firefighters with complete forms participating in the check-up in 2019 were included in the analyses. Firefighters who failed to attend the inspection or had incomplete data were excluded.

Sociodemographic variables

Age was grouped into four categories: below 30 years old, from 30 to 39, 40 to 49, or above 50 years old. Data on the educational level was available as complete high school, undergraduate (College/University degree), or postgraduate (Master of Science or PhD degree). Monthly income, corresponding to all family members' salary, was reported in Brazilian currency (BRL) in predetermined categories: R$ 2000.00 to R$ 3,999.99; R$ 4000.00 to R$ 5999. 99, R$ 6000.00 to R$ 7,999.99, R$ 8000.00 to R$ 9999.99 or above R$ 10 000.00. Ethnicity was self-declared according to the Brazilian Institute of Geography and Statistics,[14] and data collected were categorised as white, mixed heritage (brown), or black. Questions regarding health insurance coverage, monthly health expenses (including medical and dental coverage costs), and bank loan payments were also available. For analysis, the presence/absence of health insurance coverage and loan payment were categorised as yes or no, and the monthly amount spent on health expenses was analysed as a continuous variable.

Occupational variables

The Fire Department Unit where the firefighter was currently working was reported. The city of work was derived from this information and categorised into the following locations: Vitória, the capital of the state; the main metropolitan cities surrounding the capital, named Vila Velha, Cariacica, and Serra, and all the other cities located outside the metropolitan circuit and by the countryside as Countryside cities. Brazilian firefighters change their occupational status within the Fire Department during their careers. Thus, when filling out the forms, firefighters also reported the main activity performed during their career and current activity. The main activities reported were grouped as Rescue (paramedic service), ABTS – an acronym for the Portuguese (Auto-Busca Tanque e Salvamento), encompassing activities of firefighting and automobile accident victims' extrication, and Other activities corresponding to diving service, disaster surveillance, and civilians' protection. The current activity was reported as operational activity, including firefighters working in shifts and performing activities such as firefighting and paramedic service, and administrative activity, firefighters working during business hours in office activities. As the admission to the fire service date was available, the total length of service was also calculated and presented as a continuous variable.

Lifestyle variables

Questions regarding smoking and alcohol drinking habits were also available. Firefighters reported if they were current smokers or not and the number of cigarettes smoked per day. For alcohol consumption, the firefighters reported whether they frequently used alcohol or not. These variables, that is, smoking and alcohol drinking, were categorised as yes and no. Firefighters were considered smokers regardless of the smoking frequency reported.

Health status variables

Obesity was estimated using body mass index (BMI) and WC. BMI was obtained from the ratio between body weight and height squared (kg/m^2). A weighing scale, 150 kg capacity and 0.1 kg precision (TANITA, model UM-080), was used for body weight measurements. An inextensible tape (Microlife), 1 cm wide and 1 mm accurate, fixed in the vertical position with a rigid ruler, was used for height estimation. BMI data were grouped into the following categories: normal weight (BMI <25 kg/m^2), overweight (25 ≤BMI <30 kg/m^2) or obese (BMI ≥30 kg/m^2). Central obesity (CO) was determined by the WC measurement using a Microlife inextensible tape (1 cm wide and accurate to 1 mm). WC measurement was performed with the firefighter standing, with the feet together and arms kept at a 90 degree angle to the chest. WC was taken from the smallest measurement between the iliac crest and the last costal arch. Data obtained were grouped into no risk (WC <94 cm) and at risk (WC ≥94 cm), according to the cut-off points established for men by the International Diabetes Federation.[15]

All equipment used to measure biochemical parameters and BP was registered at the Brazilian National Health Surveillance Agency (ANVISA), which certifies its use, safety, quality, and accuracy for health assessment.[16] Blood glucose was measured after a 12-hour fast and assessed with a portable blood glucose metre (INFORM II Roche, SP, Brazil, ANVISA registration N° 10287410863), designed for hospital use and validated.[17] The values obtained were categorised as <100 mg/dL or ≥100 mg/dL.[15] Fasting total cholesterol and triglycerides were measured with strips using Accutrend Plus equipment (Roche, SP, Brazil, ANVISA registration N° 10287410740) validated for cardiovascular screening.[18] Total cholesterol data were categorised as <190 mg/dL or ≥190 mg/dL, while triglyceride data were grouped as <150 mg/dL or ≥150 mg/dL, according to international guidelines.[19]

BP was non-invasively measured with digital equipment (Non-Invasive Professional Blood Pressure Monitor HBP-1100 OMRON, Kyoto, Japan, ANVISA registration N° 81952070008) validated and calibrated as indicated.[20] Systolic (SBP) and diastolic (DBP) blood pressure measurements were performed on the firefighters while seated, facing the examiner, with the right arm semi-flexed and resting on a table, with both feet on the floor, legs uncrossed, bladder empty and in a comfortable position. The cuff was adjusted on the arm and faced the brachial artery, in the position indicated by the manufacturer. The patient was instructed to breathe normally and not to speak during the measurements. The first measurement started after 5 minutes of rest and was repeated twice, with a 2 minute interval between measurements. After the measurements, the simple mean of the three measurements was taken to obtain the SBP/DBP. In addition to BP measurements, firefighters reported taking or not taking medication to control BP. BP data were analysed quantitatively by mean and SD. Based on the Brazilian Hypertension Guideline, BP values of firefighters were categorised into four levels: 1) optimal, if SBP <120 mmHg and DBP <80 mmHg; 2) normal, if SBP 120–129 mmHg and DBP 80–84 mmHg; 3) pre-hypertension if SBP 130–139 mmHg and/or DBP 85–89 mmHg and 4) hypertension if SBP ≥140 mmHg and/or DBP ≥90 mmHg and/or users of antihypertensive medication.[1] All information regarding how biochemical, BP, and anthropometric measurements were performed, as well as the apparatus used for measurements, was provided by the CBMES team.

Statistical analysis

Statistical analyses were performed using Statistical Package for Social Sciences (SPSS Inc., V.25, 2017). Descriptive analysis was used to characterise variables. Continuous variables were described as mean± standard deviation (SD) of the mean. Categorical variables were presented as absolute and relative frequencies. For the analysis regarding the altered BP outcome, firefighters in the pre-hypertension and hypertension range and/or using antihypertensive medication were grouped as 'above normal', and firefighters in the normal+optimal range were grouped as 'normal'. The association between the outcome (dependent variable) and a set of independent variables (age, sex, type of current activity, etc.) was analysed by Chi-squared test (X^2), with the significance

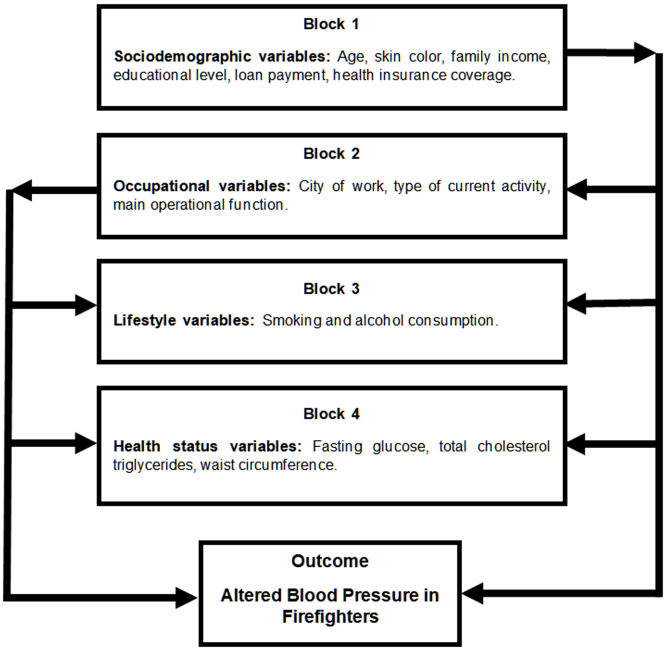

Figure 1 Theoretical model of variables associations with altered blood pressure.

Table 1 Frequencies of sociodemographic, occupational, lifestyle, and health status variables of male firefighters from the Military Fire Brigade of the State of Espírito Santo (CBMES) (n=859)

	Category	N	%
Sociodemographic variables			
Age range (years)	under 30	98	11.4%
	30 to 39	483	56.2%
	40 to 49	237	27.6%
	over 50	33	3.8%
Ethnicity	White	159	18.5%
	Mixed	635	73.9%
	Black	63	7.3%
Family month income (in BRL)	2000.00 to 3999.99	80	9.3%
	4000.00 to 5999. 99	262	30.5%
	6000.00 to 7999.99	222	25.8%
	8000.00 to 9999.99	142	16.5%
	>10 0000.00	151	17.6%
Educational level	High school	297	34.6%
	Undergraduate	330	38.4%
	Postgraduate	226	26.3%
Loan payment	Yes	564	65.7%
	No	291	33.9%
Health insurance	Yes	518	60.3%
	No	339	39.5%
Occupational Variables			
City of work	Vitória	278	32.4%
	Vila Velha	50	5.8%
	Cariacica	63	7.3%
	Serra	53	6.2%
	Countryside cities	413	48.1%
Type of current activity	Administrative	361	42.0%
	Operational	496	57.7%
Main operational function	Rescue	151	17.6%
	ABTS	483	56.2%
	Other	72	8.4%
Lifestyle Variables			
Smoking habit	Yes	25	2.9%
	No	831	96.7%
Alcohol drinking	Yes	458	53.3%
	No	399	46.4%
Health Status Variables			
Glucose (mg/dL)	<100	676	78.7%
	≥100	182	21.2%
Total cholesterol (mg/dL)	<190	630	73.3%
	≥190	226	26.3%
Triglycerides (mg/dL)	<150	717	83.5%
	≥150	139	16.2%
Central obesity (cm)	<94	709	82.5%
	≥94	146	17.0%
Body mass index (BMI, kg/m^2)	Normal Weight	313	36.4%
	Overweight	431	50.2%
	Obese	107	12.5%
Blood Pressure	Optimal	175	20.4%
	Normal	293	34.1%
	Prehypertension	235	27.4%
	Hypertension	156	18.2%

ABTS, abbreviation from the Portuguese '*Auto-Busca Tanque e Salvamento*'; BRL, Brazilian currency Real; Other, activities corresponding to diving service, disaster surveillance, and civilians' protection.

level set as p<0.05. A hierarchical binary logistic regression was performed to obtain the adjusted odds ratio (OR) with a 95% confidence interval (95% CI). A theoretical model was used for the hierarchical regression (figure 1), with variables distributed in four Blocks: 1. sociodemographic variables; 2. occupational variables; 3. lifestyle variables; 4. health status variables. As some factors/variables have more power of association with the outcome than others, we chose to use the hierarchical model to allow an analysis of the effects and interaction of factors related to the individual in the outcome analysed, seeking to reduce distortions in the estimation of the effects of distal determinants and enabling a broader interpretation of the data.[2] Only variables with p≤0.20 in the Chi-squared test were included in the multivariate analysis, and to avoid collinearity between BMI and CO, only CO was considered in the final analysis. Variables inclusion in the model followed the method *'enter'*. In the final model, only variables with p<0.05 were considered statistically significant.

Patient and public involvement

It was not possible to involve the individuals in the design, conducting, reporting, or dissemination plans of our research as we only analysed secondary data that the Military Fire Brigade had already collected, and therefore, there was no direct contact with the individuals. The results will be available for the Military Fire Brigade and the general population through the publication of the data.

RESULTS

In 2019, 859 out of 1001 male firefighters from the whole Fire Department participated in the annual inspection, with an effective response rate of 86% (ie, 859/1001).

Table 1 presents the sociodemographic, occupational, lifestyle, and health status data obtained from the population of firefighters. The average age of firefighters was

Table 2 Association of sociodemographic, occupational, lifestyle, and health status variables with altered blood pressure in male firefighters from the Military Fire Brigade of the State of Espírito Santo (CBMES) (n=859)

		Blood pressure				
		Normal		Above normal		
Variable		N	%	N	%	P value
Age range (years)	under 30	54	55.10%	44	44.90%	0.337
	30 to 39	260	53.80%	223	46.20%	
	40 to 49	119	50.20%	118	49.80%	
	over 50	13	39.40%	20	60.60%	
Ethnicity	White	83	52.20%	76	47.80%	**0.005**
	Mixed	347	54.60%	288	45.40%	
	Black	21	33.30%	42	66.70%	
Family month income (in BRL)	2000.00 to 3999.99	41	51.20%	39	48.80%	0.403
	4000.00 to 5999. 99	139	53.10%	123	46.90%	
	6000.00 to 7999.99	106	47.70%	116	52.30%	
	8000.00 to 9999.99	82	57.70%	60	42.30%	
	>10 0000.00	83	55.00%	68	45.00%	
Educational level	High school	150	50.50%	147	49.50%	**0.023**
	Undergraduate	192	58.20%	138	41.80%	
	Postgraduate	106	46.90%	120	53.10%	
Loan payment	Yes	284	50.40%	280	49.60%	0.063
	No	166	57.00%	125	43.00%	
Health insurance	Yes	281	54.20%	237	45.80%	0.24
	No	170	50.10%	169	49.90%	
City of work	Vitória	160	57.60%	118	42.40%	**0.014**
	Vila Velha	30	60.00%	20	40.00%	
	Cariacica	36	57.10%	27	42.90%	
	Serra	33	62.30%	20	37.70%	
	Countryside cities	192	46.50%	221	53.50%	
Type of current activity	Administrative	198	54.80%	163	45.20%	0.266
	Operational	253	51.00%	243	49.00%	
Main operational function	Rescue	69	45.70%	82	54.30%	0.127
	ABTS	253	52.40%	230	47.60%	
	Other	43	59.70%	29	40.30%	
Smoking habit	Yes	10	40.00%	15	60.00%	0.197
	No	441	53.10%	390	46.90%	
Alcohol drinking	Yes	229	50.00%	229	50.00%	0.085
	No	223	55.90%	176	44.10%	
Glucose (mg/dL)	<100	375	55.5%	301	44.5%	**<0.001**
	≥100	77	42.3%	105	57.7%	
Total cholesterol (mg/dL)	<190	350	55.60%	280	44.40%	**0.003**
	≥190	100	44.20%	126	55.80%	
Triglycerides (mg/dL)	<150	402	56.10%	315	43.90%	**<0.001**
	≥150	49	35.30%	90	64.70%	
Central obesity (cm)	<94	403	56.80%	306	43.20%	**<0.001**
	≥94	46	31.50%	100	68.50%	

Continued

Table 2 Continued

Variable		Blood pressure				P value
		Normal		Above normal		
		N	%	N	%	
Body mass index (BMI, kg/m^2)	Normal Weight	217	69.30%	96	30.70%	**<0.001**
	Overweight	202	46.90%	229	53.10%	
	Obese	28	26.20%	79	73.80%	

ABTS, abbreviation from the Portuguese '*Auto-Busca Tanque e Salvamento*'; BRL, Brazilian currency Real; Other, activities corresponding to diving service, disaster surveillance, and civilians' protection.

36.7±6.93 years old, with most firefighters between 30 and 39 years old and the minority over 50 years old. Most firefighters self-reported being mixed (73.9%), with the lowest percentage observed for blacks (7.3%). The highest proportion of firefighters had a family income between 4000 to 8000 BRL monthly (56.3%). The prevalence of firefighters in the three educational levels was balanced, with 34.6% having only finished high school, 38.4% undergraduate, and 26.3% with postgraduate level. Most firefighters reported paying a loan and having insurance coverage, spending, on average, 654.92 BRL/month on health expenses. More than 52.1% of firefighters work in the main Metropolitan cities, with the highest prevalence observed for the capital of the state, Vitória (32.4%). The prevalence of firefighters working in countryside cities corresponded to 48.1%. More than half of the workforce currently works in operational activities (57.7%) and 42% in administrative activities. The main operational activity performed during their career was *ABTS*, encompassing firefighting and victims' rescue. On average, active service time is 13.23±7.21 years. More than 50% of firefighters reported consuming alcohol frequently, and nearly all reported not smoking (table 1).

A considerable percentage of firefighters had altered glucose levels (21.2%), with the mean blood glucose values being 94.2±13.86 mg/dL. Firefighters with above-normal levels of cholesterol and triglycerides were 26.3% and 16.2%, respectively. Considering the BMI, only 36.4% of firefighters were with normal weight. The mean BMI of the male firefighters was 26.4±3.31 kg/m^2. On the other hand, taking into account the CO, 17% of firefighters were considered at risk (mean WC 86.6±8.29 cm). According to the Brazilian Hypertension Guidelines, 54.5% of male firefighters were within the optimal/normal BP range. However, nearly 50% (45.6 %) had altered BP levels. The mean SBP was 128.6±11.54 mmHg and DBP was 75.06±8.87 mmHg (table 1).

A significant association between BP above normal was observed for ethnicity (p<0.005), educational level (p<0.023), and city of work (p<0.014). For health status variables, there was an association between altered BP and elevated glucose levels (p<0.001), total cholesterol (p<0.003), triglycerides (p<0.001), central obesity (p<0.001), and BMI (p<0.001). For all other variables, no statistical significance was observed (p>0.05) (table 2).

After adjustments, there was a greater chance of BP above normal in black firefighters (1.98; 95% CI 1.03 to 3.78; p<0.04), with only high school (1.5; 95% CI 1.02 to 2.19; p<0.04) and postgraduate level (1.54; 95% CI 1.03 to 2.30; p<0.04), in firefighters working in Inner cities (2.32; 95% CI 1.14 to 4.71; p<0.02) and with elevated levels of blood glucose (1.5; 95% CI 1.01 to 2.22; p<0.05) and triglycerides (1.92; 95% CI 1.19 to 3.11; p<0.01) and with central obesity (2.34; 95% CI 1.47 to 3.70; p<0.01) (table 3).

DISCUSSION

In this study, we sought to evaluate the prevalence of hypertension in a population of Brazilian firefighters and the association of elevated BP with sociodemographic, occupational, lifestyle, and health status factors in this occupational population. We identified that 45.6% of individuals were in the elevated BP range, with greater odds of altered BP among black firefighters, those with higher or lower educational levels, working in countryside cities, and with hyperglycaemia, hypertriglyceridemia, and central obesity.

According to the most recent Brazilian Guidelines on Hypertension[1] stratification criteria, in our study, 18.2% of firefighters were considered hypertensive, and 27.4% were in the pre-hypertension range, that is, almost 50% of the firefighter population had altered BP. The only study addressing the health status of Brazilian firefighters reported a 5% prevalence of systemic hypertension among firefighters from Paraná, a state in the South of Brazil.[21] The levels observed were much lower than our present data. However, in their study, pre-hypertension levels were not accessed. In addition, differences in economic status and ethnic heritage among the population between Brazilian states may also affect the prevalence of burden diseases, highlighting the need for more studies to better capture the true prevalence. In contrast, in a large-scale study among American firefighters, a 71% prevalence of hypertension was observed.[12] Although this study did not also describe the prevalence of firefighters in the pre-hypertension range, the most recent criteria of the ACC/AHA for framing the pressure category levels considered hypertension levels greater than or equal to 130/80 mmHg.[22] Thus, the prevalence of hypertensive individuals found in this study reflects, at least in part, the

Table 3 Crude and adjusted OR of altered blood pressure in male firefighters from the Military Fire Brigade of the State of Espírito Santo (CBMES)

		Crude OR				Adjusted OR			
Variable	**Category**	**P value**	**OR**	**IL 95%**	**UL 95%**	**P value**	**OR**	**IL 95%**	**UL 95%**
Ethnicity	Mixed		1.00				1.00		
	White	0.58	1.1	0.78	1.56	0.29	1.25	0.83	1.88
	Black	**0.002**	**2.41**	**1.39**	**4.16**	**0.04**	**1.98**	**1.03**	**3.78**
Education	Graduate		1.00				1.00		
	High school	0.054	1.36	0.99	1.87	**0.04**	**1.5**	**1.02**	**2.19**
	Postgraduate	**0.009**	**1.58**	**1.12**	**2.21**	**0.04**	**1.54**	**1.03**	**2.3**
Loan payment	No		1.00				1.00		
	Yes	0.064	1.31	0.98	1.74	0.78	1.05	0.74	1.48
City of work	Serra		1.00				1.00		
	Vila Velha	0.814	1.1	0.5	2.43	0.86	1.09	0.43	2.78
	Vitória	0.524	1.22	0.67	2.23	0.4	1.36	0.66	2.8
	Cariacica	0.576	1.24	0.59	2.61	0.49	1.37	0.56	3.33
	Countryside cities	**0.033**	**1.9**	**1.05**	**3.42**	**0.02**	**2.32**	**1.14**	**4.71**
Main operational function	Other		1.00				1.00		
	ABTS	0.245	1.35	0.81	2.23	0.33	1.32	0.76	2.32
	Rescue	**0.051**	**1.76**	**1.00**	**3.11**	0.2	1.52	0.81	2.85
Smoking habit	No		1.00				1.00		
	Yes	0.202	1.7	0.75	3.82	0.68	1.25	0.43	3.65
Alcohol drinking	No		1.00				1.00		
	Yes	0.085	1.27	0.97	1.66	0.66	1.08	0.78	1.49
Glucose (mg/dL)	<100		1.00				1.00		
	≥100	**0.002**	**1.7**	**1.22**	**2.37**	**0.05**	**1.5**	**1.01**	**2.22**
Total cholesterol (mg/dL)	<190		1.00				1.00		
	≥190	**0.004**	**1.58**	**1.16**	**2.14**	0.15	1.32	0.91	1.92
Triglycerides (mg/dL)	<150		1.00				1.00		
	≥150	**0.001**	**2.34**	**1.61**	**3.42**	**0.01**	**1.92**	**1.19**	**3.11**
Central obesity (cm)	<94		1.00				1.00		
	≥94	**0.001**	**2.86**	**1.96**	**4.18**	**0.01**	**2.34**	**1.47**	**3.7**

ABTS, abbreviation from the Portuguese '*Auto-Busca Tanque e Salvamento*'; IL, Inferior Limit; OR, overall response; Other, activities corresponding to diving service, disaster surveillance, and civilians' protection; UL, Upper Limit.

equivalent of the sum of pre-hypertensive and hypertensive individuals adopted in the Brazilian guideline.

In addition to work-related stress, the firefighter's duties involve exhausting physical activity, inhalation of smoke and particles, exposure to high temperatures, sleep deprivation, and job strain, among many other factors that can interact with and result in different types of cardiovascular events.[9–11] Evidence points to a higher risk of morbid cardiovascular outcomes in firefighters, particularly when AH is not controlled.[7 23]

Our study pointed to a higher chance of BP above normal among black firefighters. The prevalence of BP above normal was 66.70% in firefighters who self-reported as being black against 45.40% of mixed heritage. It has been previously described that hypertension is highly prevalent among black people and that this condition greatly contributes to the health disadvantages experienced by these individuals.[24] Racial differences in renal physiology and sociodemographic influences such as socioeconomic status appear to be the primary candidates for BP differences.[25] Also, higher sympathetic activity and/or changes in peripheral vasoconstriction significantly contribute to the pathophysiology of hypertension and chronic kidney disease in black individuals compared with white individuals.[26] Noteworthy, in Brazil, although self-declaration of race is important data for epidemiological investigation, most individuals share European, African, and local Native ancestries, making self-reported race a very subjective data.[27] Other studies also indicate that even though ethnicity is an important

risk factor for AH, socioeconomic conditions and lifestyle habits seem to be more relevant factors for differences in the prevalence of AH than the ethnic factor itself.[28]

We observed a higher chance of altered BP among firefighters with only high school or postgraduate degrees. Higher education levels among firefighters usually coincide with higher-ranking job positions, which may involve higher stress and/or sedentary work activities. Job strain is often associated with higher total cholesterol levels, triglycerides, and SBP.[29] It has been shown that mental stress induces sympathovagal imbalance and increases heart rate, BP, and plasma homocysteine levels, an independent risk marker for CVD.[30] A large population cross-sectional study encompassing 14 422 Chinese adults also found that having a higher educational level was one factor associated with increased risk of AH and diabetes.[31] Among Europeans, there is also evidence of a higher prevalence of hypertension among individuals with high educational levels and working in sedentary jobs.[32] The Brazilian Ministry of Health notes that certain job activities may be risk factors for the development of circulatory system diseases, including hypertension.[33] Although the cross-sectional design employed in our study does not allow us to state a causality between factors, the higher chance of hypertension observed in certain educational levels may well be related to some of these factors.

Our study found a higher prevalence of altered BP in firefighters working in countryside cities, which are geographically outside the main complex encompassing the most populous cities (Vila Velha, Cariacica, Serra) and the capital of the state (Vitória). The higher chance of altered BP in countryside cities could be related to unhealthy life habits with an eating culture favouring predilection for foods rich in simple carbohydrates and saturated fats, usually in generous portions, as pointed out in other studies in firefighters.[34 35] Another factor could be related to the less frequent physical activity of firefighters in these locations due to inferior local infrastructure and lack of gymnastics facilities, as observed in the fire department units of the main cities. Inadequate physical activity makes firefighters prone to increased body fat, metabolic syndrome[23] and cardiovascular disease.[9] Indeed, adequate facilities for on-duty physical activity are of pivotal importance for firefighters' health, as it has been shown that training while on duty can reduce obesity prevalence and physical inactivity among firefighters.[36] Of note is that many firefighters working in countryside cities live in the state capital or the surrounding towns (n=164). This fact points to long commuting hours between home and the workplace, which can be a stressor. Additionally, to reduce the frequency of travel, some firefighters carry out extensive work shifts of up to 72 hours, increasing sleep deprivation and consumption of fast food.

Hyperglycaemia and hypertriglyceridemia, factors associated with a higher chance of BP above normal, are conditions that, like high BP and smoking, can lead to endothelial dysfunction and atherosclerosis plaque formation.[1 37 38] Hyperglycaemia, caused by insulin resistance, leads to hyperinsulinemia, which, in turn, stimulates sodium and water retention and activation of the sympathetic nervous system, contributing to the development of AH.[38] These factors may also be interconnected, as it is known that hyperglycaemia can also lead to the development of hypertriglyceridemia.[37 39] Although, in our study, the adjusted analysis did not demonstrate a greater chance of altered BP in firefighters who frequently use alcohol, alcohol consumption is another factor that can lead to hypertriglyceridemia.[40] Of note, alcohol consumption was self-reported in the evaluations performed, and the true prevalence may be underestimated. Furthermore, the questions used to assess lifestyle habits, such as alcohol intake, lacked the accuracy needed to measure their true impact on hypertension risk. Once more than 50% of firefighters declared frequent use of alcohol, this could also be a factor contributing to hypertriglyceridemia.

Obese firefighters also showed a higher chance of altered BP, and the straight association between these factors has been well described.[1 22] Obesity can change vascular homeostasis, leading to the development of hypertension through several mechanisms, including a reduction in renal natriuresis, activation of the renin-angiotensin-aldosterone system, decreasing parasympathetic tone, and increasing sympathetic nerve activity.[41] A previous study from our group evaluated the prevalence of obesity in the same population of Brazilian firefighters who participated in the "*Wellness*" programme in the year 2018, showing an association between this outcome and occupational and cardiovascular risk factors.[13] Although BP levels were not measured in this previous study, a higher chance of central obesity was observed in firefighters with hyperglycaemia and hypertriglyceridemia, which agrees with the present findings. Given the effect of obesity, particularly visceral adiposity, on the development of hypertension, it is not surprising that the same population previously studied concomitantly showed a high prevalence of altered BP.[13]

We must acknowledge some limitations of our study. First, generalisability is limited as the study evaluated firefighters from one specific state of Brazil, which may not reflect the same reality of the entire population of Brazilian firefighters. Second, the cross-sectional nature of the study prevents assuming causality between the risk factors and the outcome, and as the present work is a secondary analysis, it may have reduced intra- or inter-tester reliability, as the researchers were not involved in collecting the data. On the other hand, as health inspections were conducted by trained health personnel from the firehouse, part of the reliability limitation may have been overcome. Third, the absence of other biochemical markers in the health inspections prevented from establishment of a more accurate cardiovascular risk of the population. Fourth, as BP assessment was not measured on at least two different occasions, as recommended by the Brazilian Hypertension Guidelines for diagnosing persistent elevated BP, the true prevalence may have been under or overestimated. Finally, if firefighters excluded

from the analysis for missing the evaluations, were absent due to medical conditions, there may have been a health-based selection bias.

Given the high prevalence of elevated BP in this population of Brazilian firefighters and the higher chance of this outcome observed with certain ethnicities, educational levels, working locations, altered glycaemic and lipid profiles, and obesity, future research with different approaches is recommended. Conducting mortality studies, unravelling the leading causes of death and life expectancy of these workers, when compared with the general population, could indicate whether CVD has a major impact on morbidity and/or mortality among this population of firefighters. Monitoring the health status of this occupational group over time could provide strong evidence on how and if occupational activities are impacting cardiovascular health. Finally, endeavours toward multidisciplinary interventional programmes would benefit the health profile of this population and serve as exemplary models for other firefighter populations within the country.

CONCLUSION

Our study demonstrated associations between elevated BP and personal, occupational, and cardiovascular risk factors. Although the study's cross-sectional design does not allow determination of causality between the risk factors and elevated BP, better knowledge of occupational health can drive more effective preventative strategies. Some of these strategies may include risk communication to empower responsible authorities to take assertive occupational health assessment and intervention policies, multisectoral partnership for adequate screening, treatment, and early detection of risk factors, and educational activities promoting healthy lifestyle habits. The combination of these measures would have great power in preventing the progression of hypertension and CVD among these workers, directly impacting the excellence of the service provided to the population.

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Patient consent for publication Not applicable.

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Data availability statement Data are available upon reasonable request. The data supporting this study's findings are available from the CBMES. Still, restrictions apply to the availability of these data, which were used under license for the current research and are not publicly available. Data are, however, available from the authors upon reasonable request and with permission from the command of the CBMES.

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