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Incidence and trajectory of ideal cardiovascular health markers in workers

Incidência e trajetória de marcadores ideais de saúde cardiovascular em trabalhadores

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Abstract – Cardiovascular diseases are the leading causes of death worldwide. Risk factors for these diseases have a high prevalence in the global population. Thus, this study aimed to assess the incidence and trajectory of risk factors associated with ideal cardiovascular health in workers. This retrospective study followed 417 employees from a teaching hospital. Sociodemographic interviews and assessments of weight, height, body mass index (BMI), blood pressure, glucose, and lipid profile were conducted in 2012, 2014, and 2016. A discrete mixture modeling was used to determine the trajectories of cardiovascular risk over a five-year follow-up period. High prevalence and incidence of cardiovascular risk factors were found. The cardiovascular risk trajectories identified by the model showed a stable pattern and were associated with ideal cardiovascular health, with unfavorable trajectories increasing the risk of inadequate cardiovascular health. The assessments revealed high prevalence and incidence of cardiovascular risk factors. The trajectory model demonstrated stable variables associated with inadequate cardiovascular health, highlighting the need for investigations into lifestyle and the trajectory of risk factors associated with ideal cardiovascular health.

Key words: Adult, Heart Disease Risk Factors; Cardiovascular Health; Longitudinal Studies; Workers.

Resumo – *Doenças cardiovasculares são as principais causas de morte no mundo. Os fatores de risco para essas doenças têm alta prevalência na população global. Assim, o objetivo deste estudo foi avaliar a incidência e a trajetória dos fatores de risco associados à saúde cardiovascular ideal em trabalhadores. Este estudo retrospectivo acompanhou 417 funcionários de um hospital de ensino. Entrevistas sociodemográficas e avaliações de peso, altura, índice de massa corporal (IMC), pressão arterial, glicemia e perfil lipídico foram conduzidas em três momentos: 2012, 2014 e 2016. Uma modelagem de mistura discreta foi usada para determinar as trajetórias de risco cardiovascular ao longo de um período de acompanhamento de cinco anos. Foram encontradas altas prevalência e incidência de fatores de risco cardiovascular. As trajetórias de risco cardiovascular identificadas pelo modelo mostraram um padrão estável e foram associadas à saúde cardiovascular ideal, com trajetórias desfavoráveis aumentando o risco de saúde cardiovascular inadequada. As avaliações revelaram alta prevalência e incidência de fatores de risco cardiovascular. O modelo de trajetória demonstrou variáveis estáveis associadas à saúde cardiovascular inadequada, destacando a necessidade de investigações sobre o estilo de vida e a trajetória dos fatores de risco associados à saúde cardiovascular ideal.*

Palavras-chave: *Adulto; Fatores de Risco de Doenças Cardíacas; Saúde cardiovascular; Estudos Longitudinais; Trabalhadores.*

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INTRODUCTION

Degenerative chronic diseases, especially cardiovascular diseases, are the leading cause of death worldwide[1]. The risk factors for these diseases have a high prevalence in the global population, making them a public health priority, particularly among adults[1,2]. Therefore, the American Heart Association has developed the concept of ideal cardiovascular health (CVH), aimed at reducing the incidence and mortality of cardiovascular diseases[3].

Among the seven components that form the concept of CVH, the study covering the Brazilian population[4] found higher prevalences of risk factors related to body mass, blood pressure, glucose, and cholesterol. These findings have also been observed in different populations[5]. Given that these are silent risk factors, often neglected in treatment adherence[1], we must not only understand the prevalence of these factors but also their trajectory over the years for us to learn the potential risks of each altered component to CVH.

The literature on cardiovascular risk factors and ideal CVH typically determines prevalence from start to end without intermediate measurements, often using clinical cutoff points to classify the data. Meanwhile, trajectory modeling describes the behavior of the variable over the years, which can enhance prevention strategies against the development of diseases[6]. Therefore, identifying these trajectories can reveal both the stratification and the intensification of preventive care, providing health promotion with a new perspective. This study aims to examine the incidence and trajectory of risk factors related to ideal CVH among workers of a teaching hospital.

METHODS

Study participants

The retrospective cohort study included employees of a teaching hospital. The hospital had a total of 797 permanent employees, distributed across a Superintendent Office (n=39) and five directorates: Administrative Directorate (n=238); Nursing Directorate (n=247); Pharmaceutical/Laboratory Directorate (n=68); Blood Center Directorate (n=58); and Medical Directorate (n=147)(Figure 1). These directorates oversee 35 different roles responsible for providing healthcare services in the hospital seven days a week, with work shifts ranging from six to 12 hours per day.

This article is part of a longitudinal study, "Profile of Risk Factors for Non-Communicable Chronic Diseases and Physical Exercise Program in Public Servants of a Teaching Hospital in Southern Brazil", approved by the Research Ethics Committee of the State University of Maringá under protocol number 1,766,685, following the National Health Council's guidelines for research involving human subjects. The following inclusion criteria were considered: not being on leave from the department at the time of the study; a work schedule of more than 30 hours per week at the hospital; having undergone medical consultation; and having been submitted to periodic examinations in 2012, 2014, and 2016.

After obtaining authorization from the hospital superintendent, the researchers received a comprehensive list of employees separated according to their respective directorates. As the hospital operates 24 hours a day, the employees are organized into work schedules based on daily and weekly shifts.

The researchers requested the work schedule from each directorate manager, which included the names of the employees, their respective departments, and their workdays and shifts. Subsequently, the research was shared with the employees via email and through posters displayed in the hospital. Based on the work schedules, the researchers visited all the departments to conduct interviews and perform blood pressure measurements and anthropometric assessments. In cases where an employee was not present in the department, a new visit was scheduled, with a maximum of three attempts.

A total of 58 employees were on leave, absent, on vacation, or relocated, 64 employees declined to participate, and 43 employees who were not present in their respective departments at any of the three attempts.

Out of the 485 medical records from the Occupational Medicine Department of the university, 68 were incomplete and could not be included in the study. The final sample consisted of 417 interviewed employees who had complete medical records for the years 2012, 2014, and 2016, as shown in the flowchart below.

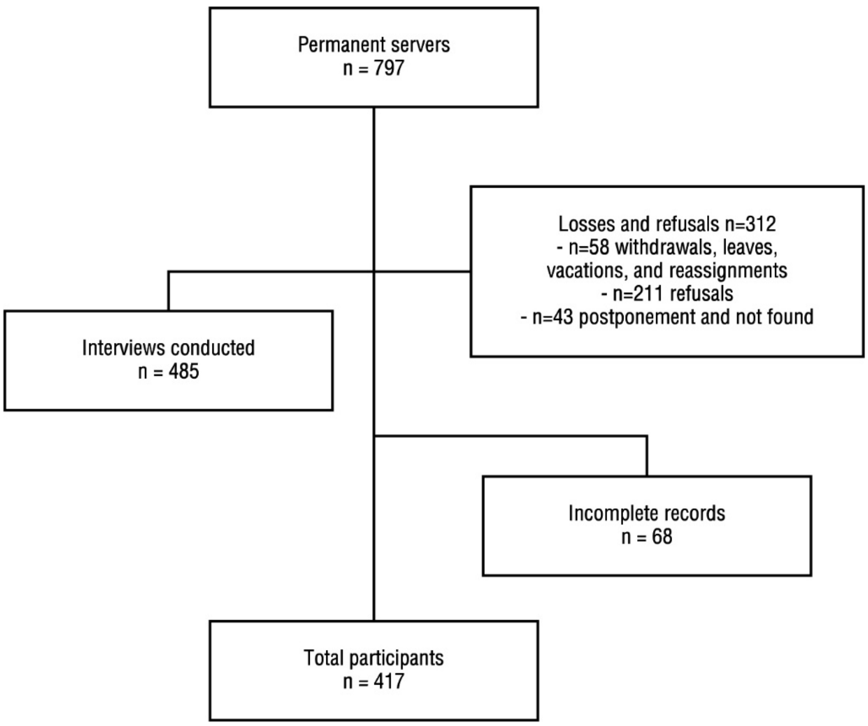

Figure 1. Participant selection process.

Study variables

The data were collected by a team of five interviewers who were familiarized and trained to apply the research instruments in a standardized manner. For this purpose, a 40-hour training was conducted to standardize the administration of questionnaires and anthropometric measurements. Information regarding age, gender, education, and skin color was collected through self-reporting. The classification of education level consisted of completed primary education, high school, and completed higher education. Body mass assessment was performed using a digital scale (Welmy) with a precision of 100 grams, while height was measured using a portable stadiometer with a precision of 0.1 centimeters[7].

Blood pressure measurements were taken after the individual had been seated for more than ten minutes. The measurements were taken twice, and the lower value was used. An automatic digital device was used for blood pressure monitor, the OMRON model HEM-742INT, validated by[8], with a mean ± standard deviation of the difference between observer and device measurements of -1.15 ± 5.7 mmHg for systolic pressure and -1.61 ± 4.7 mmHg for diastolic pressure. The device was calibrated and compared with other devices once a week, as recommended by the manufacturer. The measurement procedures followed the recommendations[9].

The information collected from the medical records included name, medical record number, weight, height, systolic blood pressure, and diastolic blood pressure from the appointments in the years 2012 and 2014; total cholesterol, HDL-c, LDL-c, triglycerides, and glucose from the tests conducted in the years 2012, 2014, and 2016. Samples were excluded from the study upon confirming surgery, pregnancy, or a diagnosis of neoplasia. The biochemical parameters of the participants were evaluated following a fasting period from ten to 12 hours. Blood samples were collected in anticoagulant tubes and stored for a maximum period of 48 hours. The samples underwent a centrifugation process for evaluation by the colorimetric method.

Ideal cardiovascular health

Ideal CVH was assessed according to the criteria proposed by the American Heart Association[3], based on body mass index (BMI), blood pressure, total cholesterol, and glucose levels. BMI was assessed based on the weight/height2 equation, where: inadequate CVH: BMI greater than or equal to 30 kg/m2; intermediate CVH: BMI between 25 kg/m2 and 29.9 kg/m2; and ideal CVH: BMI below 25 kg/m2[3].

Systolic blood pressure equal to or above 140 mmHg, or diastolic blood pressure greater than or equal to 90 mmHg, is considered inadequate CVH. Systolic blood pressure between 120 mmHg and 139 mmHg, or diastolic blood pressure between 80 mmHg and 89 mmHg, or receiving pharmacological treatment, is classified as intermediate CVH. Values below 120 mmHg for systolic blood pressure and 80 mmHg for diastolic blood pressure are considered ideal CVH[3].

Total cholesterol equal to or above 240 mg/dL is considered inadequate CHV, while between 200 mg/dL and 239 mg/dL, or receiving pharmacological treatment, is classified as intermediate CVH. In turn, total cholesterol below 200 mg/dL is considered ideal CVH[3]. For glucose, a value equal to or above 126 mg/dL is considered inadequate CVH. Values between 100 mg/dL and 125 mg/dL, or receiving treatment, are classified as intermediate CVH. Finally, ideal CVH is set as fasting glucose levels below 100 mg/dL[3].

Scores of 0, 1, or 2 were assigned to represent inadequate CVH, intermediate CVH, and ideal CVH, respectively. A cardiovascular health score ranging from 0 to 8 was calculated individually and classified as inadequate CVH (0 to 4), intermediate CVH (5 and 6), and ideal CVH (7 and 8), being adapted for this study. For better model fitting, the distribution of the ideal CVH and intermediate CVH groups was designated as the reference group, while the inadequate CVH group was established as the contrast group.

Data analysis

Different statistical methods were applied for data analysis. A criterion of statistical significance was established for all hypothesis tests. Population was characterized based on the mean values and a 95% confidence interval. The calculated prevalence was determined by dividing the number of individuals with the outcome of interest by the total number of study participants. Incidence was calculated as the number of new cases per thousand individuals.

The relative risk (RR) for inadequate CVH was obtained by taking the exponential of the regression coefficient, along with its 95% confidence interval through Poisson regression with robust variance, both in unadjusted and adjusted models. The first model was adjusted for sex and age, while the second model was adjusted for sex, age, education, and skin color, considering potential confounding variables.

Follow-up analysis (longitudinal trajectory of variables)

To characterize the longitudinal trajectory of the theoretical variables proposed in this study, an analysis of group-based trajectory modeling (GBTM) using STATA TRAJ was conducted to identify subgroups within each variable of interest (BMI, systolic and diastolic blood pressure, glucose, HDL-c, LDL-c, total cholesterol, and triglycerides).

Initially, a quadratic model was considered for all groups. However, the final number of groups was determined based on the Bayesian Information Criterion (BIC), trajectory shapes for similarity, and the proportion of cohort members in each class[10]. After identifying the optimal number of groups, the polynomial level for each group was reduced until a higher parameter estimate had a p-value less than 0.01. This final model allowed each participant to be assigned to one of the subgroups based on the maximum posterior probability.

The fit of the trajectory model was assessed based on the following four diagnostic measures were used to assess, as suggested by[11]: i) an average posterior probability of assignment for each group of 0.7 or higher; ii) probabilities of correct classification of 0.5 or higher; iii) the proportion of a sample assigned to a particular group is close to the proportion estimated from the model; and iv) reasonably narrow 99% confidence intervals of the estimated proportion.

To estimate the association between the exposure and the outcome, the focus shifted towards conducting a dual trajectory model that summarizes the dynamic interplay between two longitudinal variables across multiple trajectory groups, rather than a traditional association analysis that estimates the overall association between two variables in heterogeneous subpopulations. All models included in the dual trajectory converged, and all parameters had reasonably small standard errors (standard errors divided by the means were less than 0.3). Therefore, initial values could not be specified, and default initial values were used.

RESULTS

The data collected from the medical records of the years 2012, 2014, and 2016 indicate that out of 417 employees, 65.50% (273) are female. The average age is 48.43 ± 7.55 years, and the average duration of employment at the hospital is 18.67 ± 7.08 years. Table 1 shows the prevalence and incidence of cardiovascular risk factors and inadequate cardiovascular health during the years 2012, 2014, and 2016.

Table 1. Prevalence, total incidence, and 95% confidence interval of cardiovascular risk factors in workers followed from 2012 to 2016.

Risk factors	2012 Prevalence % (CI 95%) n=417	Total incidence/1000 (95% CI)
Body mass index ≥ 30kg/m2	26.38 (22.38-30.81)	157 (135.8-180.9)
Systolic blood pressure ≥ 140 mmHg	06.00 (04.09-08.70)	178 (155.5-202.9)
Diastolic blood pressure ≥ 90 mmHg	07.92 (05.69-10.91)	159 (137.6-183.0)
Total cholesterol ≥ 240mg/dL	13.67 (10.70-17.30)	100 (082.9-120.2)
HDL-c cholesterol <40♂ <50♀ mg/dL	36.21 (31.51-40.69)	170 (148.0-194.5)
LDL-c cholesterol ≥ 160mg/dL	11.03 (08.37-14.40)	85 (069.3-103.9)
Triglyceride ≥ 200mg/dL	09.11 (06.71-12.26)	128 (108.7-150.1)
Glucose ≥ 126 mg/dL	07.19 (05.09-10.08)	15 (009.1-024.6)
Cardiovascular health – inadequate	22.54 (18.79-36.60)	198 (174.5-223.8)

Note. CI: confidence interval.

The year 2012 shows a high prevalence of risk factors, particularly for BMI ≥ 30kg/m2, HDL-c <40♂ <50♀ mg/dL, as well as inadequate CVH. In the analysis of total incidence, the same prevalent factors showed high incidence, with systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, and triglycerides ≥ 200 mg/dL also standing out. To identify the trajectory model, the first step was to model the trajectory of cardiovascular risk factor scores in the years 2012, 2014, and 2016. Each cardiovascular risk factor was categorized into two to three groups based on the longitudinal characteristics observed (Table 2).

In the BMI analysis, three stable groups were identified: "stable normal", "stable overweight", and "stable obesity". In the analysis of glucose and total cholesterol, three stable groups were also found: "stable normal", "stable moderate", and "stable high". For HDL-c, three stable groups were identified: "stable high", "Stable Moderate", and "Stable Low". In the analysis of systolic blood pressure, diastolic blood pressure, LDL-c, and triglycerides, two groups were discovered: "stable normal" and "stable high".

From the evaluated sample, 32.85% (n=137) showed inadequate cardiovascular health. The developed cardiovascular risk trajectory model showed a higher prevalence of the risk variables. In trajectory models with three variables, the prevalence increased linearly, except for HDL-c cholesterol, where the "stable moderate" trajectory showed a lower prevalence of inadequate cardiovascular health (Table 3).

Table 4 describes the magnitude of these prevalences through the relative risk calculated in crude analysis and in two adjustment models, with model 01 adjusted for sex and age, and model 02 adjusted for sex, age, education, and skin color. According to the data analysis, all variables in the trajectory increased the relative risk of inadequate CVH, regardless of the adjustment models for sex, age, education, or skin color. It is also worth noting that in the trajectory models with three variables, the moderate or overweight categories showed a significantly higher relative risk compared to the reference.

Table 2. Mean and confidence interval according to the analysis of cardiovascular risk factor trajectories (n=417).

Trajectories	2012	2014	2016
	mean (95%CI)	mean (95%CI)	mean (95%CI)
BMI			
Normal stable (n=189)	23.57 (23.26-23.87)	23.96 (23.64-24.27)	24.26 (23.91-24.61)
Stable overweight (n=197)	29.43 (29.12-29.74)	30.04 (29.73-30.36)	29.89 (29.55-30.22)
Stable obesity (n=31)	37.85 (36.47-39.22)	38.19 (37.02-39.36)	38.29 (37.12-39.45)
Systolic pressure			
Normal stable (n=247)	101.1 (99.9-102.4)	102.4 (101.1-103.8)	115.2 (113.8-116.6)
High stable (n=170)	121.1 (119.0-123.2)	122.4 (120.3-124.5)	134.8 (133.0-136.6)
Diastolic pressure			
Normal stable (n=141)	63.2 (61.8-64.5)	64.1 (62.6-65.5)	69.0 (67.7-70.4)
High stable (n=276)	77.8 (76.9-78.8)	77.8 (76.8-78.8)	81.5 (80.4-82.6)
Glucose			
Normal stable (n=390)	89.9 (89.0-90.8)	89.2 (88.2-90.1)	91.81 (90.8-92.8)
Moderate stable n= (21)	120.8 (107.7-133.9)	121.1 (107.6-134.6)	138.5 (124.7-152.4)
High stable (n=06)	244.2 (156.0-332.3)	228.5 (150.2-306.8)	256.0 (155.3-356.7)
HDL-c			
High stable (n=40)	75.1 (71.7-78.5)	78.2 (75.3-81.0)	72.1 (69.1-75.1)
Moderate stable (n=177)	55.8 (54.7-57.0)	59.0 (57.9-60.2)	58.9 (57.7-60.2)
Low stable (n=200)	42.2 (41.3-43.1)	44.1 (43.2-45.1)	43.5 (42.6-44.5)
LDL-c			
Normal stable (n=247)	91.31 (88.77-93.8)	93.9 (91.45-96.4)	98.83 (96.20-101.4)
High stable (n=170)	134.3 (130.5-138.2)	136.6 (133.2-140.0)	140.4 (136.4-144.3)
Total cholesterol			
Normal stable (n=68)	134.5 (129.8-139.2)	141.0 (135.5-146.5)	149.0 (144.6-153.4)
Moderate stable (n=272)	181.6 (178.8-184.3)	187.6 (184.8-190.4)	191.5 (188.5-194.6)
High stable (n=77)	235.8 (229.4-242.1)	235.9 (231.0-240.8)	241.1 (234.1-248.2)
Triglyceride			
Normal stable (n=379)	100.4 (95.9-104.9)	108.4 (103.4-113.5)	112.0 (106.8-117.1)
High stable (n=38)	259.1 (229.6-288.6)	280.8 (251.8-309.7)	309.4 (268.7-350.2)

Note. CI: confidence interval.

Table 3. Prevalence of inadequate cardiovascular health according to the trajectory of cardiovascular risk factors from 2012 to 2016 (n=417).

	N (%)	**Inadequate cardiovascular health (n=137) % (CI 95%)**
BMI		BMI ≥ 30 kg/m2
Normal stable	189 (45.32)	11.64 (07.81-16.99)
Stable overweight	197 (47.24)	48.22 (41.35-55.17)
Stable obesity	31 (07.43)	64.52 (46.95-78.88)
Systolic pressure		SP ≥ 140mmHg
Normal stable	247 (59.23)	12.95 (09.33-17.72)
High stable	170 (40.77)	61.76 (54.28-68.73)
Diastolic pressure		DP ≥ 90 mmHg
Normal stable	141 (33.81)	06.38 (03.39-11.69)
High stable	276 (66.19)	46.38 (40.58-52.28)
Glucose		GLU ≥ 126 mg/dL
Normal stable	390 (93.52)	28.72 (24.45-33.40)
Moderate stable	21 (05.04)	90.48 (71.09-97.35)
High stable	06 (01.44)	100.0 (60.97-100.0)
Total cholesterol		TC ≥ 240 mg/dL
Normal stable	68 (16.31)	11.76 (06.08-21.53)
Moderate stable	272 (65.23)	29.78 (24.66-35.46)
High stable	77 (18.47)	62.34 (51.17-72.33)
HDL-c		s/c
High stable	40 (09.59)	27.50 (16.11-42.83)
Moderate stable	177 (42.45)	26.55 (20.60-33.51)
Low stable	200 (47.96)	39.50 (32.98-86.61)
LDL-c		s/c
Normal stable	247 (59.23)	22.67 (17.89-28.29)
High stable	170 (40.77)	47.65 (40.27-55.12)
Triglyceride		s/c
Normal stable	379 (90.89)	28.50 (24.19-33.24)
High stable	38 (09.11)	76.31 (60.79-87.01)

Note. CI: confidence interval. s/c = marker not used in the ideal CVS classification; BMI = body mass index; SB = systolic blood pressure; DP = diastolic blood pressure; GLI = glucose; TC = total cholesterol.

Table 4. Relative risk between inadequate cardiovascular health and trajectory models of cardiovascular risk factors in workers (n=417).

Trajectories	Gross analysis	Model 01	Model 02
BMI			
Normal stable	1	1	1
Stable overweight	1.442 (1.326-1.567)	1.395 (1.283-1.518)	1.392 (1.278-1.515)
Stable obesity	1.697 (1.425-2.020)	1.637 (1.379-1.943)	1.624 (1.365-1.932)
Systolic pressure			
Normal stable	1	1	1
High stable	1.629 (1.498-1.772)	1.569 (1.430-1.722)	1.564 (1.423-1.718)
Diastolic pressure			
Normal stable	1	1	1
High stable	1.492 (1.389-1.602)	1.417 (1.313-1.530)	1.408 (1.302-1.522)
Glucose			
Normal stable	1	1	1
Moderate stable	1.854 (1.623-2.119)	1.788 (1.559-2.051)	1.761 (1.520-2.041)
High stable	2.040 (1.950-2.133)	1.822 (1.657-2.005)	1.785 (1.609-1.980)
Total cholesterol			
Normal stable	1	1	1
Moderate stable	1.197 (1.090-1.315)	1.165 (1.064-1.275)	1.176 (1.077-1.284)
High stable	1.658 (1.452-1.893)	1.523 (1.320-1.758)	1.536 (1.332-1.771)
HDL-c			
Moderate stable	1	1	1
High stable	1.010 (0.866-1.176)	1.021 (0.882-1.181)	1.029 (0.890-1.190)
Low stable	1.138 (1.036-1.250)	1.070 (0.974-1.175)	1.048 (0.953-1.152)
LDL-c			
Normal stable	1	1	1
High stable	1.284 (1.172-1.407)	1.203 (1.091-1.326)	1.208 (1.096-1.332)
Triglyceride			
Normal stable	1	1	1
High stable	1.613 (1.399-1.860)	1.511 (1.303-1.752)	1.502 (1.290-1.749)

Note. CI: confidence interval. a = adjustment according to model; model 01 sex and age; model 02 sex, age, education, and skin color.

DISCUSSION

This study aimed to investigate the incidence and trajectory of risk factors associated with ideal cardiovascular health among 417 workers during the years 2012, 2014, and 2016. Compared to data from the Brazilian population[12] our findings indicate a high incidence of cardiovascular risk factors over the years of follow-up. Other studies have reported similar findings with higher incidences of risk factors related to obesity, blood pressure, and dyslipidemia[13].

According to the literature, there has been a decrease in the incidence of cardiovascular deaths both in Brazil and worldwide[14]. However, this decline in mortality has reached a plateau in the past five years, coinciding with an increase in the incidence of risk factors. This trend may result in an increase in the burden of cardiovascular diseases[15].

Risk factors for cardiovascular disease have been extensively studied. However, studies often employ cross-sectional assessment methods or measure prevalence only at the beginning and end of the study, without capturing intermediate measurements[6]. The trajectory model used in this study allows for a comprehensive understanding of the behavior of the variables over time, providing greater causal consistency to the results[16].

In our study, the trajectory model revealed a stable characteristic of the risk factors. Although in some studies, stable categories have also been found for BMI[16], it is common to observe trajectory models with categories characterized by progressive increase, progressive decrease, moderate increase, and increase and decrease[17], for BMI[18], systolic and diastolic blood pressure[19], and glucose assessment[20].

These differences may be related to the follow-up time of the study. The aforementioned studies cover a follow-up period of 20 years or more. When analyzing data from years 10 to 15 of these cohorts (with a similar mean age to our study), a more stable trajectory pattern emerges. The means of the categories in our study show a moderate increase in some variables, which, in the long term, could lead to an increased incidence of cardiovascular disease, cardiovascular mortality, dementia, and decreased psychological well-being, contributing to a higher trajectory of absenteeism and lower productivity[20-24].

Table 3 shows a prevalence of 32.85% of inadequate cardiovascular health (n=137). Considering the same cutoff points and risk factors such as total cholesterol, glucose, blood pressure, and BMI, the American population showed a prevalence of 21.07%[25]. Meanwhile, other studies found a prevalence of 16.82% in the American population[5], as well as a higher prevalence of 25.5% in the Brazilian population4. This difference may be linked to various risk factors associated with inadequate cardiovascular health, such as socioeconomic status, working hours, shift work, and depression[26].

The trajectories of unfavorable risk factors increase the relative risk for inadequate cardiovascular health, adjusted for sex, age, education, and skin color, compared to the reference trajectories (Table 4). The trajectories of high LDL-c and high triglycerides showed a significant relative risk compared to the reference categories, even though they are not part of the criteria for assessing ideal cardiovascular health. One study found an association between ideal cardiovascular health and the atherogenic index of plasma (AIP), a score that incorporates triglycerides and HDL-c in the equation[27]. This result highlights the importance of considering multiple markers that can affect cardiovascular health.

It is worth highlighting that the trajectory of overweight BMI, characterized by a consistent excess weight, showed a significant relative risk for inadequate cardiovascular health. These findings support the systematic review[28] that associates overweight with cardiovascular complications, as well as the study[29] that links obesity to type 2 diabetes, even in individuals considered metabolically healthy obese.

The "moderate glucose" trajectory showed a significant relative risk, similar to the "elevated glucose" trajectory, thus[19] supporting the data indicating the importance of maintaining stable glucose levels within the ideal range (<100mg/dL).

The trajectories of obesity and elevated glucose showed the highest relative risk for inadequate cardiovascular health. These results stem from a sedentary lifestyle and poor dietary habits, which can cause neuroendocrine alterations that affect the autonomic nervous system (ANS). This can potentially impair nutrient metabolism and energy expenditure, leading to complications in the aforementioned trajectories and triggering other chronic diseases, such as atherosclerosis[30].

Limitations of this study include a small and specific sample of hospital workers, which limits generalizability to the general population. Another limitation was the failure to assess all behavioral factors of ideal cardiovascular health. However, the developed trajectories of cardiovascular risk factors were associated with ideal cardiovascular health, indicating that the risk of cardiovascular diseases can accumulate and persist over many years. This highlights the need for primary prevention measures targeting all risk factors, such as promoting physical activity and healthy eating.

Further studies are important for understanding the trajectory of cardiovascular risk factors in workers, such as work schedule, work shift, socioeconomic status, mental health, and physical activity. Research must focus on the well-being of workers since, in addition to the economic and production demands, adult health is closely related to that of the worker, considering that a significant portion of adult life is spent in the workplace. Therefore, health promotion measures should be encouraged within companies, addressing factors that can impact cardiovascular health.

CONCLUSION

This study found high prevalence and incidence of cardiovascular risk factors. The analysis of the trajectory of these risk factors identified two to three categories that remained stable over the years. Unfavorable trajectories showed an increased relative risk compared to reference categories for cardiovascular health. It is worth noting that intermediate categories of BMI and glucose showed a significant relative risk for inadequate cardiovascular health, indicating the importance of maintaining BMI below 24.9 kg/m2 and glucose below 100 mg/dL. This underscores the need for further investigation into lifestyle and the trajectory of risk factors associated with ideal cardiovascular health.

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Compliance with ethical standards

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee – State University of Maringá, and the protocol (no. 1.766.685) was written following the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflicts of interest to declare.

Author Contributions

Conceived and designed the experiments: RMGE, ASDI, WR. Performed the experiments: RGME, JPF, DPV, WFF. Analyzed the data: RGME, ASDI, BROR, WR. Contributed reagents/materials/analysis tools: RGME, JPF, DPV, WFF, BROR, WR. Wrote the paper: RGME, ASDI, JPF.

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