

Cardiovascular Risk Assessment among Agro-Textile Workers in Benin

Mênonli Adjobimey^{1,2,3*}, Ibrahim Mama Cissé⁴, Conchéta Tchibozo²,
Nayéton Rose Mikponhoué¹, Paul Ayélo¹, Dismand Houinato²,
Vikkey Antoine Hinson¹

¹Unité de Recherche et d'Enseignement en Santé au Travail et Environnement, Faculté des Sciences de la Santé Cotonou, Université d'Abomey-Calavi, Abomey-Calavi, Benin

²Laboratoire d'Epidémiologie des Maladies Chroniques et Neurologiques, Cotonou, Benin

³Centre National Hospitalier et Universitaire de Pneumo-Phtisiologie de Cotonou, Cotonou, Benin

⁴Unité de Formation et de Recherche en Santé au Travail, Ecole de Médecine de Parakou, Parakou, Benin

Email: *menoladjobi@yahoo.fr

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Abstract

Introduction: Global cardiovascular risk (CVR) reflects the probability of developing a cardiovascular event within a specified period, usually 10 years. Workers in industrial settings are exposed to multiple occupational and behavioural risk factors that may increase their cardiovascular risk. The objective of the study was to assess cardiovascular risk and identify associated factors among permanent workers in cotton-ginning factories in Benin. **Methods:** A cross-sectional analytical study was conducted in 2019 among permanent workers aged 40 years and older employed in cotton-ginning factories in Benin. Data were collected using a standardized digital questionnaire, physical examination, and biological testing. The absolute 10-year cardiovascular risk was assessed using the WHO/ISH AFR-D risk prediction charts and the Framingham cardiovascular risk model. A Framingham-based risk difference was also calculated as the difference between each worker's estimated cardiovascular risk and the corresponding ideal cardiovascular risk. Bivariate analyses were performed using R software. **Results:** A total of 170 workers were included. According to the WHO/ISH risk prediction charts, 6 workers (3.5%) had a 10-year cardiovascular risk $\geq 10\%$. Using the Framingham model, 14 workers (8.2%) had an estimated 10-year cardiovascular risk $\geq 10\%$, while 29 workers (17.1%) had a Framingham-based risk difference $> 5\%$. No statistically significant association was found between the investigated sociodemographic, occupational, behavioural, or biological factors and a Framingham-based risk difference $> 5\%$. **Conclusion:** Cardiovascular risk assessment among permanent workers in cotton-ginning factories in Benin showed differences

according to the assessment method used. Although no investigated factor was significantly associated with a Framingham-based risk difference > 5%, these findings support the importance of regular occupational health surveillance, cardiovascular risk screening, and preventive interventions in this workforce.

Keywords

Cardiovascular Risk, Framingham Risk Difference, Cotton Industry, Occupational Health, Benin

1. Introduction

Cardiovascular diseases (CVDs) are a major public health concern, particularly in developing countries where the epidemiological transition is accompanied by an increasing prevalence of cardiovascular risk factors. According to the World Health Organization (WHO), the workplace directly influences the physical, mental, economic, and social well-being of workers, as well as the health of their families, communities, and society as a whole [1].

Long considered a feature of developed countries, industrialization is rapidly expanding in sub-Saharan Africa. In Benin, the agro-textile industry is one of the pillars of the national economy. Between 2017 and 2018, the cotton sector contributed approximately 12% - 13% of Benin's Gross Domestic Product (GDP). This rapidly growing sector exposes workers to physical, chemical, and psychosocial conditions that may contribute to the development of cardiovascular diseases.

Cardiovascular diseases are the leading cause of death among non-communicable diseases (NCDs), accounting for an estimated 17.9 million deaths annually worldwide [2] [3]. The occupational setting is not exempt from this burden. To improve the prevention of CVDs in the workplace, it is essential to focus on the prediction of global cardiovascular risk (CVR). Global CVR is defined as the probability of developing a symptomatic cardiovascular disease within a specified period, usually 10 years [4] [5]. Global CVR prediction, therefore, targets individuals without clinically manifest cardiovascular disease, for whom the identification and management of risk factors may prevent, reduce, or delay the onset of cardiovascular disease [5]. Depending on the context, several tools can be used to assess global cardiovascular risk [6]-[8].

In Benin, studies on global CVR prediction have been conducted in the general population, vulnerable groups, and workers in the tertiary sector, but very few have focused on industrial workers. However, previous studies have reported associations between global CVR and occupational factors [9]-[11] such as noise exposure [12] [13], shift work atypical working hours [10] [14] [15], and occupational stress [16] [17], all of which are common exposures in the agro-textile industry. Therefore, this study aimed to determine the prevalence of global CVR and

its associated factors among workers in Benin's agro-textile industry in 2019, thereby addressing an important gap in the existing literature.

2. Patients and Methods

2.1. Study Design and Period

A cross-sectional study with prospective data collection was conducted from January 31 to April 11, 2019.

2.2. Study Setting

The study was carried out in 15 agro-textile factories. The factories were organized into two sectors: production and administration. Production workers were mainly exposed to cotton dust, noise, prolonged standing, shift work, and night work. Administrative workers were primarily exposed to prolonged sitting and work-related pressure. Each factory had a functional occupational health unit and an Occupational Health and Safety Committee.

2.3. Study Population

The study population consisted of permanent workers aged 40 years and above, with at least one year of job seniority, who were present at the workplace during the 2019 annual medical examination campaign. Workers with clinically confirmed cardiovascular disease at the time of the study were excluded.

2.4. Sampling

An exhaustive recruitment of all eligible permanent workers was performed in each factory.

2.5. Study Variables

Cardiovascular Risk Assessment: Cardiovascular risk was assessed using two complementary approaches: the WHO/ISH cardiovascular risk prediction charts for the AFR-D epidemiological subregion and the Framingham risk model.

2.6. Assessment Using the WHO/ISH Risk Prediction Charts

The absolute 10-year cardiovascular risk was assessed using the WHO/ISH cardiovascular risk prediction charts developed for WHO epidemiological subregions. The present study used the chart corresponding to the AFR-D subregion, to which Benin belonged, in its version incorporating total cholesterol measurement [18].

This chart estimates the 10-year risk of a fatal or non-fatal cardiovascular event among individuals without clinically established cardiovascular disease. Risk estimation is based on age, sex, systolic blood pressure, smoking status, diabetes status, and total cholesterol level.

The absolute 10-year cardiovascular risk was classified into five categories: low (<10%), moderate (10% to <20%), high (20% to <30%), very high (30% to <40%), and extremely high ($\geq 40\%$).

2.7. Assessment Using the Framingham Risk Model

The Framingham model was used as a complementary approach to the WHO/ISH risk prediction charts. The general cardiovascular risk prediction model developed by D'Agostino *et al.* [19] was applied using the Excel-based calculator provided by the Framingham Heart Study. No population-specific recalibration was performed for the present study.

The absolute 10-year cardiovascular risk was estimated using age, sex, total cholesterol, HDL cholesterol, systolic blood pressure, antihypertensive treatment status, and smoking status. The absolute 10-year risk was classified as low (<10%), moderate (10% to <20%), or high ($\geq 20\%$).

The calculator also provided, for each worker, an ideal risk estimate corresponding to the expected risk for an individual of the same age and sex with optimal levels of the modifiable cardiovascular risk factors included in the model.

The risk difference (RD) was defined as the difference between the worker's estimated cardiovascular risk and the corresponding ideal cardiovascular risk:

$$\text{RD} = \text{estimated cardiovascular risk} - \text{ideal cardiovascular risk}.$$

In the present study, RD was categorized as $\leq 5\%$ or $> 5\%$. The 5% threshold was used for the analysis of risk difference, without considering an RD $> 5\%$ as equivalent to a high absolute cardiovascular risk. The Framingham-estimated absolute 10-year cardiovascular risk and the risk difference were therefore analyzed and reported as two distinct measures.

Because the Framingham model was developed in a population different from the Beninese population and has not been specifically validated or recalibrated for Beninese workers, its estimates were interpreted with caution. The model was therefore used as a complementary approach to the WHO/ISH AFR-D risk prediction charts.

Sociodemographic variables included marital status and educational level.

Behavioral variables included alcohol consumption and level of physical activity, defined and assessed according to the WHO STEPS surveillance manual [20].

Occupational variables included job position, shift work, job tenure, duration of employment in the cotton industry, exposure to noise, exposure to chemical agents, and psychosocial and organizational work factors. Occupational exposure to noise and chemical agents was classified according to job characteristics and the tasks routinely performed. These classifications were based on job-level information; individual quantitative measures of exposure duration or intensity were not used in the present analysis. Psychosocial and organizational work factors were psychological demand (low/high); decision latitude (low/high), defined according to the Karasek model [21]; social support (low/high), and reward at work (low/high), defined according to the Siegrist model [22]. Detailed information on psychosocial factors among permanent and temporary agro-textile workers has been published elsewhere [23].

3. Data Collection

Data collection was conducted in five stages:

First, face-to-face interviews were conducted using a smartphone-based digital questionnaire implemented through KoBoCollect software. The questionnaire was adapted from the WHO STEPwise instruments for non-communicable disease surveillance. Data were recorded electronically using tablets equipped with the KoBoCollect application.

Second, participants underwent a physical examination performed by occupational physicians, following anthropometric measurements conducted by trained nurses. Weight, height, and waist circumference were measured using calibrated mechanical scales (SECA model 761), portable stadiometers, and flexible measuring tapes, respectively.

Blood pressure was measured using an automated electronic sphygmomanometer (SPENGLER®) with an appropriately sized cuff. Measurements were taken with participants seated after at least 15 minutes of rest. The cuff was placed on the bare left arm, with the arm supported on a table and the palm facing upward. Three consecutive measurements were obtained at three-minute intervals, and the mean of the last two readings was used for analysis.

Third, fasting blood samples were collected after a minimum fasting period of 12 hours. Venous blood samples were drawn by a laboratory technician at the workplace into plain and ethylenediaminetetraacetic acid (EDTA) tubes.

Fourth, biochemical analyses were performed in the clinic, which is routinely responsible for employee health monitoring. All laboratory measurements were standardized according to the laboratory's routine procedures and validated by the supervising clinical biologist.

Finally, the WHO/ISH cardiovascular risk prediction charts for the AFR-D sub-region [18] and the D'Agostino *et al.*'s Framingham cardiovascular risk model [19] were used to estimate cardiovascular risk.

3.1. Statistical Analysis

Data were analyzed using R software version 4.0.4. Qualitative variables were described using frequencies, percentages, and corresponding 95% confidence intervals. Quantitative variables were summarized using means and standard deviations. The normality of continuous variables was assessed using the Shapiro-Wilk test.

Bivariate analyses were performed to explore associations between workers' characteristics and a Framingham-based risk difference > 5%. Group comparisons were conducted using Pearson's chi-square test when expected cell counts were sufficient and Fisher's exact test when appropriate. Crude odds ratios (ORs) and their 95% confidence intervals (95% CIs) were calculated as measures of association. Statistical significance was set at $p < 0.05$.

3.2. Ethical Considerations

Ethical approval was obtained from the Ethics Committee of the University of

Parakou (Approval No. 0194/CLERB-UP/P/SP/R/SA). Administrative authorization was obtained from the participating company (Authorization No. 529/2019/-DG/DAF/DAFA/CSRH). Written informed consent was obtained from each participant prior to enrolment. All data were collected and processed in accordance with confidentiality requirements and the principles of respect for fundamental human rights.

4. Results

4.1. Sociodemographic Characteristics of Workers

Of the 259 permanent workers employed in the participating agro-textile factories, 223 participated in the occupational health screening. Among them, 170 workers aged ≥ 40 years were included in the cardiovascular risk assessment (**Figure 1**).

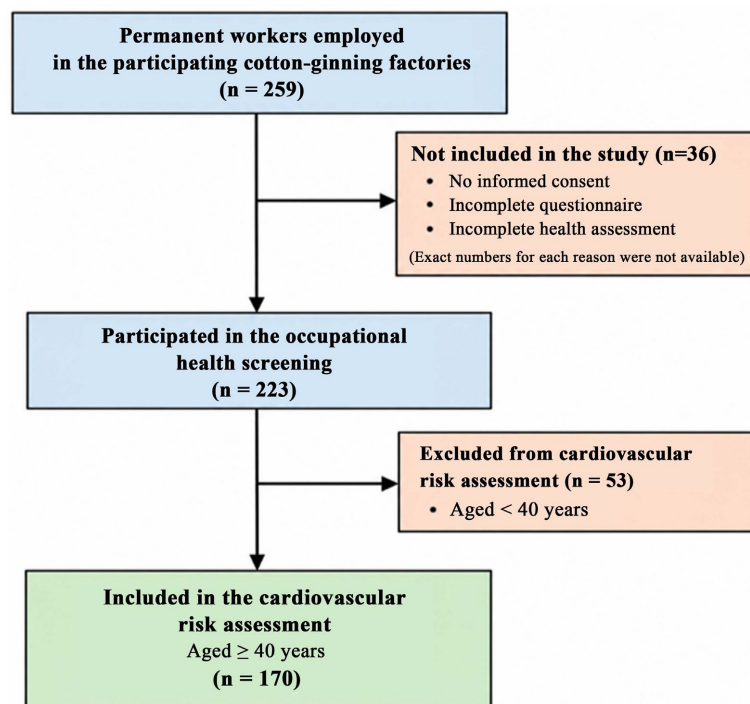


Figure 1. Flow diagram of permanent workers from agro-textile factories included in the cardiovascular risk assessment.

Of the 170 workers included in the cardiovascular risk assessment, 159 (93.53%) were men and 11 (6.47%) were women, yielding a male-to-female ratio of 14.45.

The median age was 52 years (interquartile range [IQR]: 51 - 55 years). Participants were aged 40 - 49 years (29.41%), 50 - 59 years (68.24%), or ≥ 60 years (2.35%).

Regarding ethnicity, 86 workers (50.59%) belonged to the Fon and related ethnic groups.

Regarding marital status, 2 workers (1.18%) were single, 164 (96.47%) were living with a partner, and 4 (2.35%) were divorced.

Educational attainment was distributed as follows: primary education or less, 11 (6.47%); secondary education, 117 (68.82%); and higher education, 42 (24.71%).

Occupational, Behavioral, and Biological Characteristics of Workers

Among the workers, 126 (74.12%) had more than 10 years of occupational seniority, 117 (68.82%) were exposed to occupational noise, and 63 (37.06%) experienced occupational stress.

Twenty-four workers (14.12%) were tobacco users, 155 (91.18%) reported insufficient fruit and vegetable consumption, and 122 (71.76%) had no occupational physical activity.

Among the participants, 41 (24.12%) reported a previous diagnosis of hypertension. The biological and clinical characteristics were as follows: hypertension, 35 (20.59%); elevated systolic blood pressure, 35 (20.59%); diabetes mellitus, 16 (9.41%); hypercholesterolemia, 10 (5.88%); and overweight/obesity, 105 (61.76%). **Table 1** presents the occupational, behavioral, and biological characteristics of the workers.

Table 1. Occupational, behavioural, and biological characteristics of permanent workers in agro-textile factories in Benin, 2019 (n = 170).

Occupational Characteristics		Behavioural Characteristics		Biological Characteristics	
n (%)		n (%)		n (%)	
Work Sector		Alcohol Consumption		Known Hypertension	
Production	90 (52.94)	Yes	24 (14.12)	Yes	41 (24.12)
Administration	80 (47.06)	No	146 (85.88)	No	129 (75.88)
Length of Employment (years)		Smoking Status		Elevated Systolic Blood Pressure	
1 - 9	44 (25.88)	Non-smoker	146 (85.88)	Yes	35 (20.59)
10 - 19	46 (27.06)	Current smoker	6 (3.53)	No	135 (79.41)
20 - 29	74 (43.53)	Former smoker	10 (5.88)		
≥30	6 (3.53)	Passive smoker	8 (4.70)		
Shift Work		Fruit and Vegetable Intake		Diabetes	
Yes	40 (23.53)	Adequate	15 (8.82)	Yes	16 (9.41)
No	130 (76.47)	Inadequate	155 (91.18)	No	154 (90.59)
Noise Exposure		Physical Activity at Work		Elevated Total Cholesterol	
Yes	117 (68.82)	High	35 (20.59)	Yes	10 (5.88)
No	53 (31.18)	Moderate	13 (7.65)	No	160 (94.12)
		Light	122 (71.76)		
Chemical Exposure		Body Mass Index (BMI)			
Yes	44 (25.88)	Underweight		3 (1.76)	
No	126 (74.12)	Normal weight		62 (36.47)	
Occupational Stress (Karasek)		Overweight		71 (41.76)	
Yes	63 (37.06)	Obesity		34 (20.00)	
No	107 (62.94)				

4.2. Cardiovascular Risk Assessment among Workers

According to the WHO/ISH cardiovascular risk prediction charts, 6 workers (3.53%) had an absolute 10-year cardiovascular risk $\geq 10\%$. Using the Framingham cardiovascular risk model, 14 workers (8.24%) had an absolute 10-year cardiovascular risk $\geq 10\%$. In addition, 29 workers (17.06%) had a Framingham-based risk difference $> 5\%$. **Table 2** presents the distribution of workers according to WHO/ISH and Framingham 10-year cardiovascular risk categories and Framingham-based risk difference.

Table 2. Distribution of permanent workers in agro-textile factories in Benin according to WHO/ISH 10-year cardiovascular risk, Framingham 10-year cardiovascular risk, and Framingham-based risk difference, 2019 (n = 170).

	n	%
WHO/ISH 10-Year Cardiovascular Risk		
Low (<10%)	164	96.47
Moderate (10% - <20%)	2	1.18
High (20% - <30%)	2	1.18
Very high (30% - <40%)	2	1.18
Framingham 10-Year Cardiovascular Risk		
Low (<10%)	156	91.76
Moderate (10% - 20%)	14	8.24
Framingham-Based Risk Difference		
$\leq 5\%$	141	82.94
$> 5\%$	29	17.06

4.3. Factors Associated with Cardiovascular Risk

No statistically significant association was found between sociodemographic, occupational, behavioral, or biological characteristics and a Framingham-based risk difference $> 5\%$.

However, the prevalence of a Framingham-based risk difference $> 5\%$ was higher among workers experiencing occupational stress than among those who did not (22.20% vs. 14.00%), although the difference was not statistically significant (**Table 3**).

Table 3. Factors associated with a Framingham-based risk difference $> 5\%$ among permanent workers in agro-textile factories in Benin: bivariate analysis, 2019 (n = 170).

Variable	Framingham-Based Risk Difference $> 5\%$ n/N (%)	Crude OR (95% CI)	p-Value
Ethnicity			0.249
Other ethnic groups	11/84 (13.1)	1	
Fon and related ethnic groups	18/86 (20.9)	1.76 (0.78 - 4.09)	

Continued

Marital status			1.000
Living alone	1/6 (16.7)	1	
Living with a partner	28/164 (17.1)	1.03 (0.16 - 9.15)	
Educational level			0.645
≤Secondary education	23/128 (18.0)	1.31 (0.50 - 3.48)	
Higher education	6/42 (14.3)	1	
Work sector			0.449
Administration	16/80 (20.0)	1	
Production	13/90 (14.4)	0.68 (0.30 - 1.51)	
Length of employment in the company			1.000
<10 years	8/44 (18.2)	1	
≥10 years	21/126 (16.7)	0.90 (0.38 - 2.32)	
Job tenure			0.122
<10 years	12/47 (25.5)	1	
≥10 years	17/123 (13.8)	0.47 (0.20 - 1.09)	
Shift work			0.420
Yes	9/40 (22.5)	1.60 (0.64 - 3.78)	
No	20/130 (15.4)	1	
Noise exposure			0.128
Yes	16/117 (13.7)	0.49 (0.21 - 1.11)	
No	13/53 (24.5)	1	
Chemical exposure			0.163
Yes	11/44 (25.0)	2.00 (0.84 - 4.62)	
No	18/126 (14.3)	1	
Occupational stress			0.245
Yes	14/63 (22.2)	1.75 (0.78 - 3.94)	
No	15/107 (14.0)	1	
Harmful alcohol consumption			1.000
Yes	4/24 (16.7)	0.97 (0.26 - 2.83)	
No	25/146 (17.1)	1	
Fruit and vegetable consumption			1.000
Adequate	2/15 (13.3)	1	
Inadequate	27/155 (17.4)	1.37 (0.35 - 9.09)	
Physical activity			0.755
Adequate	5/19 (26.3)	1	
Inadequate	24/151 (15.9)	0.53 (0.17 - 1.79)	
BMI category			0.636
Underweight	0/3 (0.0)	-	
Normal weight	12/62 (19.4)	1	
Overweight/obesity	17/105 (16.2)	0.80 (0.36 - 1.86)	

5. Discussion

This study assessed cardiovascular risk and its associated factors among permanent workers in agro-textile factories in Benin. According to the WHO/ISH cardiovascular risk prediction charts, 6 workers (3.53%) had an absolute 10-year cardiovascular risk $\geq 10\%$. Using the Framingham cardiovascular risk model, 14 workers (8.24%) had an absolute 10-year cardiovascular risk $\geq 10\%$, while 29 workers (17.06%) had a Framingham-based risk difference $> 5\%$. No statistically significant association was observed between the investigated sociodemographic, occupational, behavioral, or biological factors and a Framingham-based risk difference $> 5\%$.

Comparison of our findings with those reported in the literature should be interpreted with caution because of differences in study populations, occupational settings, and cardiovascular risk assessment methods. In Spain, Chaparro *et al.* reported a prevalence of high cardiovascular risk of 5.59% among workers using the SCORE risk assessment tool [24]. Similarly, Vandersmissen *et al.* reported a prevalence of 7% among Belgian workers undergoing occupational health surveillance [25], while Strauss *et al.* reported a prevalence of 10.7% among German military officers in 2020 [26]. Differences in cardiovascular risk assessment methods, study populations, and occupational environments may partly explain the variation in cardiovascular risk estimates across studies.

In Algeria, Behlouli *et al.* reported no cases of high cardiovascular risk among workers in 2017 [27]. Differences between their findings and ours may be related to differences in the cardiovascular risk assessment methods and study populations, particularly as their study included only men. Similarly, Chebab *et al.* reported a prevalence of high cardiovascular risk of 13% among workers employed in an oil-sludge company in southern Algeria [28].

Higher prevalence estimates have been reported elsewhere. In Brazil, Bernhard *et al.* and Cezar-Vaz *et al.* reported prevalences of 22.3% [29] and 28.9% [30], respectively, among rural workers. These differences may reflect variations in cardiovascular risk assessment methods, occupational settings, working conditions, and population characteristics.

In the present study, none of the factors investigated was significantly associated with a Framingham-based risk difference $> 5\%$. Nevertheless, several occupational factors have been identified as potential determinants of cardiovascular risk in previous studies. In particular, the association between occupational noise exposure and cardiovascular risk has been documented in several occupational settings. Studies conducted in Italy, as well as a meta-analysis from China, reported that workers exposed to occupational noise had an increased risk of cardiovascular disease and related outcomes, including hypertension and electrocardiographic abnormalities [31]–[33].

Evidence also suggests a dose-response relationship between prolonged occupational noise exposure and cardiovascular disease. Chronic exposure to noise may activate neuroendocrine stress pathways, resulting in elevated blood pressure

and an increased risk of cardiovascular disease.

Although job tenure was not associated with a Framingham-based risk difference > 5% in the present study, associations involving job tenure, job position, and occupational category have been reported in previous studies [27] [34]. Such relationships may reflect differences in occupational exposures across job categories and the cumulative effects of long-term exposure to occupational hazards.

In contrast to our findings, shift and night work have been identified as important determinants of cardiovascular risk in several occupational settings. Farha *et al.* reported an association between shift work and high cardiovascular risk among Jordanian workers [35]. Similarly, evidence from systematic reviews and meta-analyses supports a positive relationship between shift work and cardiovascular disease, with the risk increasing with longer durations of exposure [36].

This association may be explained by the disruption of circadian rhythms, which has been linked to neuroendocrine dysregulation, psychosocial stress, adverse dietary behaviors, and metabolic disturbances. These alterations may contribute to the development of obesity, hypertension, hyperglycemia, and dyslipidemia, thereby increasing cardiovascular risk [37].

No significant association was observed between occupational stress and a Framingham-based risk difference > 5% in the present study. However, previous studies have suggested that occupational stress, particularly job strain and long working hours, may increase the risk of cardiovascular disease [38] [39]. The absence of a statistically significant association in our study may be related to the characteristics of the study population, the relatively small sample size, or differences in the assessment of occupational stress and cardiovascular risk.

Similarly, although alcohol consumption has been associated with cardiovascular risk and mortality in previous studies [40]–[42], no significant association was observed between alcohol consumption and a Framingham-based risk difference > 5% in our study.

This study provides valuable insights into cardiovascular risk among permanent workers in agro-textile factories in Benin. Its main strengths include the recruitment of permanent workers across the participating factories and the incorporation of occupational factors into the analysis. However, the cross-sectional design precludes causal inference, and the limited number of workers with a Framingham-based risk difference > 5% may have reduced the statistical power to detect significant associations. Furthermore, occupational exposures were classified primarily based on job characteristics and routinely performed tasks, rather than on individual quantitative measures of exposure intensity. Further prospective studies involving larger populations and more detailed occupational exposure assessment are warranted to better identify the determinants of cardiovascular risk in this occupational setting.

6. Conclusion

This study provides one of the first assessments of cardiovascular risk among per-

manent workers in agro-textile factories in Benin. Cardiovascular risk estimates varied according to the assessment method used. Although no investigated factor was significantly associated with a Framingham-based risk difference > 5%, the findings highlight the importance of regular occupational health surveillance, cardiovascular risk screening, and preventive interventions in this workforce. Further studies involving larger populations are needed to better identify the determinants of cardiovascular risk in this occupational setting.

Author Contributions

Ménonli Adjobimey: Conceptualization, methodology, investigation, data collection, supervision, data analysis and statistical analysis, interpretation of results, and writing—original draft; **Mama Cissé Ibrahim:** Conceptualization, critical review and revision of the manuscript; **Conchéta Tchibozo:** Data analysis and statistical analysis; **Nayéton Rose Mikponhoué:** Critical review and revision of the manuscript; **Paul Ayélo:** Critical review and revision of the manuscript; **Dismand Houinato:** Conceptualization, critical review and revision of the manuscript; **Vikkey Antoine Hinson:** Conceptualization, critical review and revision of the manuscript. All authors: Read and approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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