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Cardiovascular risk factors in immigrants: an intersectional real world data approach to understand health inequalities

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Abstract

Background Cardiovascular risk factors (CVRFs) are shaped by social determinants of health. Lower CVRFs frequency in immigrants, as reported in the literature, may oversimplify a group affected by multiple and intersecting social inequities. Using the framework of intersectionality, we aim to analyse the prevalence of CVRFs using Real-World Data (RWD), in immigrants to better understand how overlapping social identities shape health outcomes.

Methods A cross-sectional observational study was conducted in the immigrant population of the CARhES cohort (45,861) a population cohort of RWD of CVRFs' patients. In order to characterise the most privileged and oppressed immigrant groups, we considered the impact of country of origin, age group, gender, income level and place of residence on the prevalence of CVRFs. Logistic regression models were used to estimate the effect of socioeconomic characteristics on the presence of three CVRFs. To explore intersectionality, logistic regression models with interactions assessed how sociodemographic variables jointly influenced the presence of three CVRFs. Coefficients were tested for significance using the Wald test, and odds ratios (ORs) were calculated with their 95% confidence intervals (CI).

Results The prevalence of CVRFs was higher in immigrant men, living in urban areas, and increased with aging and low income. The strongest association between socioeconomic variables and the presence of three CVRFs was found in people 65–79 years and among Europeans. This association was independent of their time in the country. Intersectional strata with more CVRFs included individuals aged 65–79 in urban areas, Latin American and Caribbean men and African women. Intersectional analyses showed that African immigrants from urban areas had a higher probability of having the three CVRFs (OR: 1.66, CI = 1.30–2.11), as did African women (OR: 1.40, CI = 1.15–1.69). Females in the most oppressed axes of inequality showed a higher frequency of CVRFs than males.

Conclusions Intersectional approach reveals that the most disadvantaged groups regarding CVRFs include older Latin American and Caribbean men and African women in urban areas. Women facing multiple layers of social oppression are particularly at risk. This RWD-based approach enables the identification of at-risk groups and supports the design of equitable, data-driven health interventions.

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Keywords Immigrants, Cardiovascular risk factors, Intersectionality, Real world data

Introduction

Cardiovascular disease (CVD) is one of the most common chronic diseases and has a major impact on individuals, society and healthcare systems. It is one of the leading causes of death worldwide, resulting in disability and a significant reduction in the quality of life of those affected [1, 2]. The high prevalence of cardiovascular risk factors (CVRFs) such as smoking, dyslipidaemia, high body mass index, hyperglycemia or hypertension (HTA) [3, 4], together with the significant ageing of the population, is expected to increase morbidity and mortality in certain groups [3, 5].

Like the Spanish native population, immigrants are also affected by CVRFs [6–8]. A recurring idea in the scientific literature is that the cardiovascular health of immigrants is generally better than that of the Spanish native population, especially during the first years of residence in the country. This seems to be related to the age of arrival in the host country, as most arrive between the ages of 25 and 39, and morbidity such as CVRFs is low during these life stages [9, 10].

Nonetheless, some studies present a much more complex reality, showing that the immigrant population also has behavioral and biological cardiometabolic risk factors [11–13]. So, immigrants have a high prevalence of obesity and sedentary lifestyles, especially women, but lower tobacco consumption and cardiovascular mortality, compared to the Spanish native population [13]. Regarding region of origin, most studies suggest that immigrants from Latin America accumulate a high number of CVRFs, overtaking natives in some cases with increasing length of stay [9, 11]. Latin American origin is associated with a high prevalence of obesity, although they have fewer macrovascular complications than natives and it has also been shown that diabetic migrants are younger [14]. Other studies suggest that migrants from Eastern Europe are more likely to accumulate more CVRFs than the Spanish native population, and that older adults from South Asia have a higher prevalence of diabetes and dyslipidaemia than the native population [15]. Finally, studies focusing on migrants from North West Africa show that women from this region have a higher prevalence of CVRFs than men [7]. Therefore, social determinants of health affect immigrant populations in different ways. This social group is at a higher risk of poverty than the native population. Many remain in an irregular situation, lacking rights and facing precarious employment and economic conditions. This results in higher rates of occupational diseases. All these factors worsen health outcomes [16]. This heterogeneity requires a more comprehensive approach to understanding their cardiovascular health.

An intersectional approach can be useful in understanding the apparent contradictions observed in relation to migrant cardiovascular health. This is a powerful approach for examining how social characteristics intersect to produce health inequalities [17, 18]. This approach allows the complexity of people and human experiences to be analysed, as they are shaped by many interacting factors [19]. Health inequalities are therefore not determined by a single axis of social division, be it gender, class or skin color, but by many interacting axes. From a theoretical and empirical point of view, the use of the intersectional approach in the study of migration-related phenomena is relevant. This approach aims to expose forms of oppression and false universalisms, and to highlight their impact on people's lives [20]. It acknowledges that inequalities do not exist in isolation, but rather in an additive way that creates new vulnerabilities within certain social groups. In terms of cardiovascular health, the status of immigrants is influenced by characteristics such as gender, socioeconomic status, age and region of origin, among others, which can have a major impact on the cardiovascular health of this group. Also, while it is true that quantitative research on health inequalities has increasingly used intersectionality as a theoretical tool [21, 22], there is a gap in the intersectional approach through the use of Real- World Data (RWD) in this field. Therefore, the aim of this study is to analyse the burden of CVRFs in immigrants from an intersectional perspective in a RWD cohort.

Methods

Design and data source

A cross-sectional observational study was conducted in the CArdiovascular Risk factors for Health Services research cohort (CARhES), a prospective RWD cohort designed to study the use of health services and to identify health care inequalities in patients with CVRFs. CARhES is an open population-based dynamic cohort whose clinical and administrative data are collected regularly from the Aragonese Health Service. It includes all residents of Aragón (Spain) aged 16 years and older with CVRFs (HTA, Diabetes Mellitus and/or dyslipidaemia). Data collection for this cohort began in 2017 and is updated annually [23]. The CARhES cohort protocol was approved by the Ethics Committee for Clinical Research in Aragon (CEICA PI21/148).

Population and study variables

From the CARhES cohort (2017 to 2022), we selected people born in European countries other than Spain, in Latin America and the Caribbean and in Africa. Following the classification used in Global Migration Reports, we considered people from Latin America and the Caribbean together. Also, the small size of the Caribbean population in the cohort meant that it could not be analysed separately. The remaining potential regions (Asia, North America and Oceania) were excluded from the study due to low number of patients. In order to compare the cardiovascular health of the most privileged and oppressed social strata, we examined people with only one cardiovascular risk factor (CVRF), the lowest number in our population, and compared them with those who had three CVRFs (hypertension, diabetes mellitus and dyslipidaemia). The purpose of these inclusion criteria was to compare the effects of different variables on groups with fewer or more CVRFs. For this reason, those with two CVRFs were excluded. This only influenced the total number of immigrants with CVRFs analysed, and did not impact the evaluation of possible effect modifiers among the independent variables of gender, age group, region of origin, place of residence, income level and presence of three CVRF. These diagnoses were identified through the medical diagnoses and/or the presence of a prescription for an antidiabetic or lipid-lowering drug. Finally, people aged 80 years or more were excluded from the study, due to the low number of immigrants in this age group, as well as those with some missing values for the variables of analyses. The flowchart of the study can be consulted in Fig. 1.

To delimit the axes of oppression and privilege, the 14 axes of inequality defined by Hill Collins P. et al. in her intersectionality diagram [19] were taken into account. We also considered the area of residence (rural or urban) as an axis of inequality. Therefore, to analyse the role of gender, age, income level, area of residence and region of origin on cardiovascular health, the following variables were considered: gender was divided into male or female; three age groups were defined: 16 to 44, 45 to 64 and 65 to 79 years old; income level was stratified into 2 groups: income less than 18 K € per year (low) and those with income equal to or greater than 18 K € per year (medium and high) on the basis of pharmacy copayment levels in Spain [24]; areas of residence were categorized into rural or urban according to the classification followed by the Aragón government [25]; finally, with regard to the

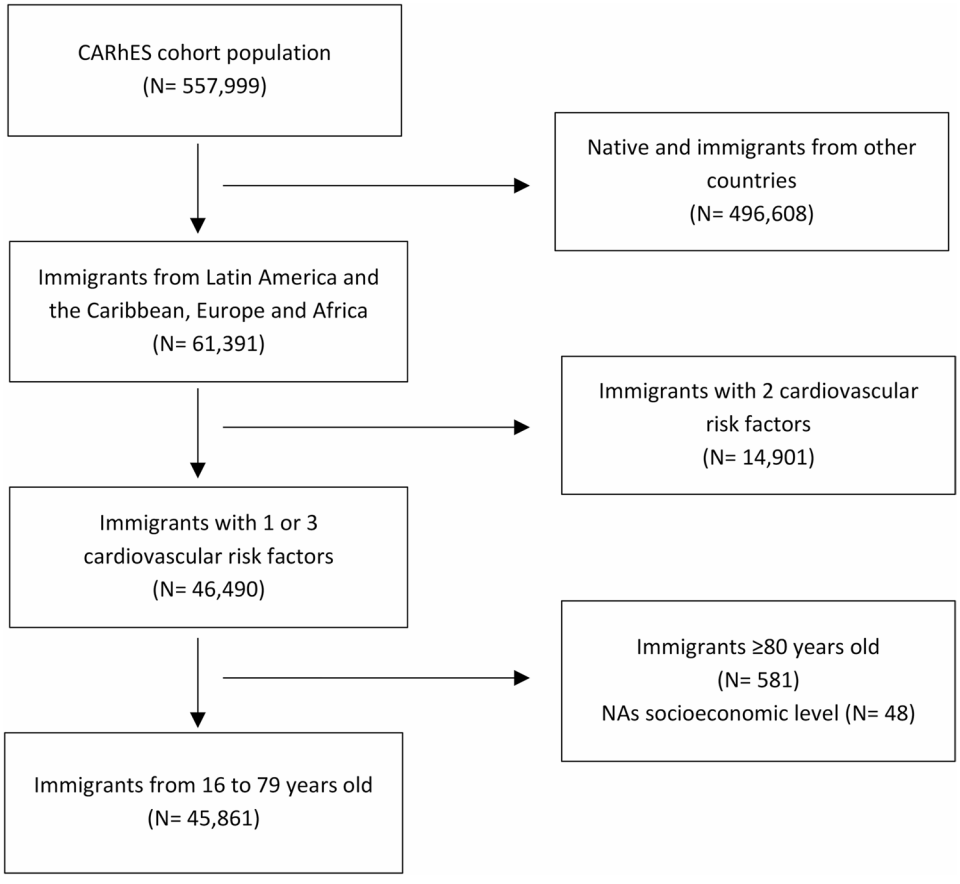

Fig. 1 Flowchart of the study population. N: number; NAs: missing values

country of birth, three strata were defined: European, African and Latin American and Caribbean.

The length of stay in the country was determined from the date of discharge from the health system. It was divided into two strata: those who had been in Aragón for less than 8 years and those with 8 years or more. This was defined on the basis of the literature consulted, in which a maximum health inflection point was observed at 8 years of stay in the country [11].

So, we can define our population with $n = 45{,}861$ as

$$\mathrm{Y} = \mathrm{CVRF} = \{1{,}3\}$$

$$\mathrm{X}_1 = \mathrm{Sex} = \{\mathrm{Male}, \mathrm{Female}\}$$

$$\mathrm{X}_2 = \mathrm{Region\ of\ origin} = \{\mathrm{LAC}, \mathrm{EU}, \mathrm{AF}\}$$

$$\mathrm{X}_3 = \mathrm{Place\ of\ residence} = \{\mathrm{Urban},\ \mathrm{Rural}\}$$

$$X_4 = Socioeconomic\ level = \{\geq 18K\ €, < 18K\ €\}$$

$$\mathrm{X}_5 = \mathrm{Age\ group} = \{16-44{,}45-64{,}65-79\}$$

Being LAC people from Latin America and the Caribbean, EU Europe and AF Africa.

Statistical analyses

Descriptive and stratified analyses were conducted. Categorical variables were summarized using absolute and relative frequencies. Percentages were calculated for each category based on having one or three CVRFs and by region of origin. Additionally, a variable was created to identify the specific stratum to which everyone belonged. This resulted in 72 strata, according to the intersectional categorical population variables.

For the regression models, univariate and multivariate models were fitted to estimate the effect of socioeconomic characteristics on the existence of 3 CVRFs. For the univariate logistic regression models, the probability of the occurrence of the event involving three CVRFs was modeled as:

$$\log\left(\frac{P(Y=1)}{P(Y=0)}\right) = \beta_o + \beta_i X_i$$

Being $Y = 1$ if the CVRF is 3, and $Y = 0$ if the CVRF is 1, X_i each intersectional variable and β_i are the coefficients associated to each i variable. These coefficients are typically estimated using maximum likelihood estimation [26], and results are presented as odds ratios (ORs) with 95% confidence intervals (95%CI).

In order to examine the effect of the relation between the study variables and cardiovascular health in immigrants, multivariate logistic regression models were fitted. These models allow for the adjustment of potential confounders, providing a more accurate estimation of the independent association between each predictor and the outcome compared to univariate models.

$$log\left(\frac{P(Y=1)}{P(Y=0)}\right) = \beta_o + \sum_{i=1}^{n} \beta_i X_i$$

The number of variables n corresponds to the number of categories minus one, which is used to represent the reference category, consisting of the Latin American and the Caribbean males, aged 16–44, living in rural areas, with an income equal or greater than 18 K €. This reference category corresponds to the most privileged group, based on the literature consulted and our results of the descriptive analyses of the sample. Additionally, a cross-classified variable was created to account for the combination of all possible categories derived from the categorical population variables.

Multivariate logistic regression models with interactions were explored to assess potential effect modifiers [27] between the independent variables: sex, age group, region of origin, place of residence and income level. In these models, interaction terms between selected variables were included, formulated as follows:

$$\log\left(\frac{\mathrm{P(Y=1)}}{\mathrm{P(Y=0)}}\right) = \beta_o + \sum_{i=1}^{n} \beta_i \mathrm{X_i} + \beta_{n+1}(\mathrm{X_1} \times \mathrm{X_2}) + \ldots \beta_m (\mathrm{X_{i-1}} \times \mathrm{X_i})$$

Where β_0 represents the intercept, β_i are the coefficients for individual predictor variables, and β_{n+1} to β_m correspond to the coefficients for interaction terms between pairs of variables, capturing their joint effects on the outcome. All possible two-way interaction combinations among the categorical variables were considered. No variables were included solely as confounders; rather, all variables and interactions included in the final multivariate model were selected based on their relevance as main effects or effect-modifying terms. The exact values of the estimated coefficients (β), including interaction terms, are presented [28].

For the statistical analyses, R version 4.4.1 (2024-06-14 ucrt) was used.

Results

A total of 45,861 immigrants from Europe, Latin America and the Caribbean and Africa were included in the study. Women with three CVRFs accounted for 4.29% of the whole sample analysed and men for 4.57%. The age group most frequently affected by three CVRFs were those with 45 to 64 years old. Regarding origin, the most frequent group in our sample with three CVRFs were those born in Europe. Almost 90% of the sample had an income of

Table 1 Description of the immigrant population in the CARhES cohort by number of cardiovascular risk factors

		1 cardiovascular risk factor		3 cardiovascular risk factors	
		N	**%**	***N***	**%**
Gender	Male	20,129	43.89	2096	4.57
	Female	21,667	47.24	1969	4.29
Age group	16–44	18,592	40.54	523	1.14
	45–64	20,788	45.33	2728	5.95
	65–79	2416	5.27	814	1.77
Origin	Latin America and the Caribbean	17,001	37.07	1364	2.97
	Europe	16,833	36.70	1864	4.06
	Africa	7962	17.36	837	1.83
Income level	< 18 K € per year	37,241	81.20	3687	8.04
	≥ 18 K € per year	4555	9.93	378	0.82
Area of residence	Rural	11,429	24.92	1073	2.34
	Urban	30,367	66.22	2992	6.52

N number, % percentage

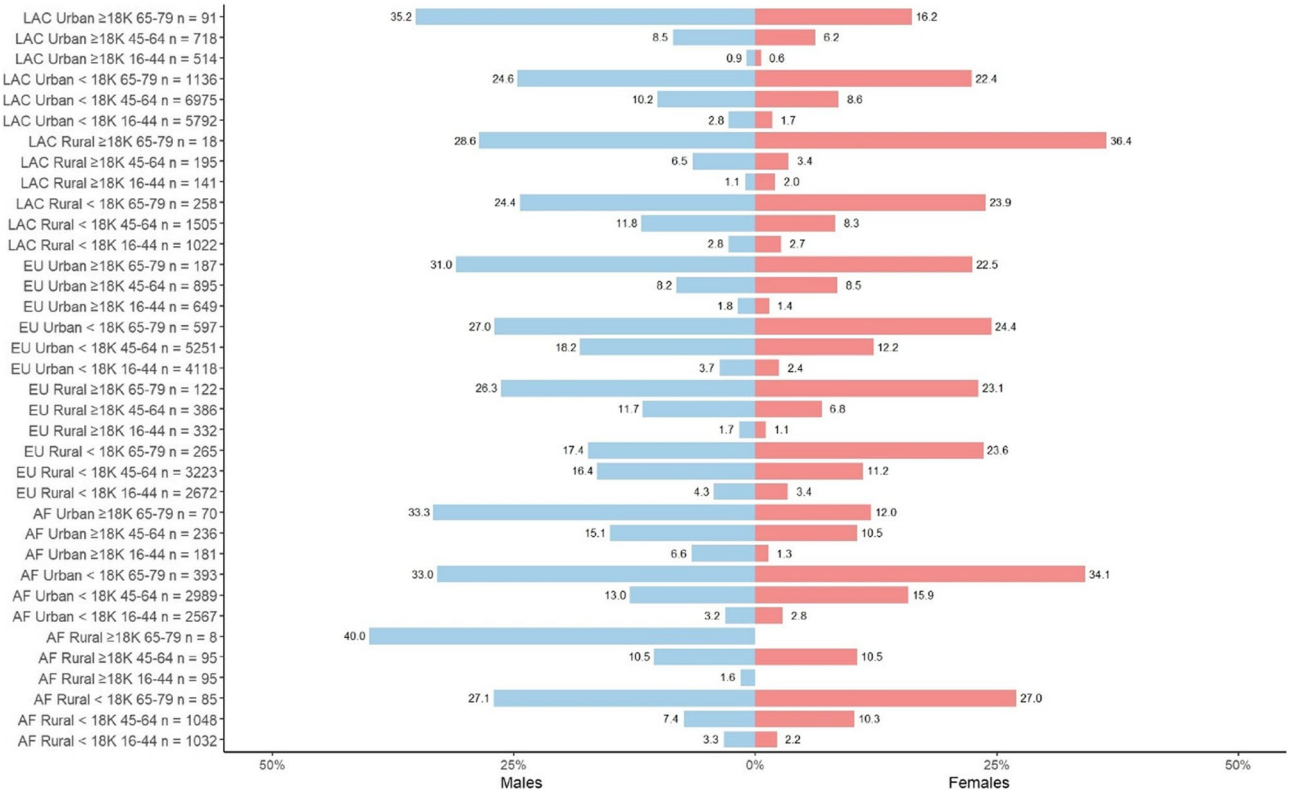

Fig. 2 Frequency of 3 cardiovascular risk factors in immigrants by axes of privilege and oppression. Results stratified by sex. LAC: Latin America and the Caribbean; EU: Europe; AF: Africa; n: number of people for each intersectional stratum

less than 18 K € per year. The majority of the sample lived in urban areas. The description of the sample can be consulted in Table 1. The description of the sample stratified by region of origin can be found in Annex 1.

In Fig. 2 the frequency of three CVRFs for the different intersectional strata can be observed for men and women. The percentage shown for each stratum and sex corresponds to the proportion of individuals with three CVRFs relative to the total number of individuals of the same sex within that stratum. In the group of Latin American and Caribbean men the group with the highest percentage of three CVRFs were those aged 65–79, middle and high income and from urban areas (35.2%). On the contrary, those with the best cardiovascular health were those aged 16–44, middle and high income and living in urban areas (0.9%). Regarding women, those aged 65–79 with high income and from rural areas have the highest percentage of three CVRFs (36.4%), while the

lowest frequency was in those aged 16–44, middle and high income and living in urban areas (0.6%).

Among European men, those in the 65–79 age group with high income and from urban areas were the most affected by the three CVRFs (31.0%). The best cardiovascular health was observed in the 16–44 age group, with middle and high income and living in rural areas (1.7%). In women, those aged 65–79 low income and living in urban areas stand out with 24.4%. The 16–44 age group, with middle and high income and residents in rural areas presented the lowest percentage of three CVRFs (1.1%).

Finally, among the immigrants from Africa, the group of men with the highest prevalence of three CVRFs were those aged 65–79, with high income and in rural areas (40.0%). On the contrary, those aged 16–44, with middle and high income and living in rural areas showed the lowest frequency of three CVRFs. Among African women, those aged 65–79, with low income and living in urban areas had three CVRFs more frequently (34.1%). No women with three CVRFs were found in two groups of African women: middle- and high-income, residents in rural areas and aged 16–44 or 65–79.

The association of the different socioeconomic variables with having 3 CVRFs can be observed in Table 2. In the multivariate model all the variables analysed showed a statistically significant association. The strongest association was found for the age group between 65 and 79 years (OR: 13.05, CI = 11.59–14.70), compared to those from 16 to 44. The immigrants from the European region had a higher association of having the 3 CVRFs than the people from Latin American region (OR: 1.49, CI = 1.38–1.61), as well as those from Africa (OR: 1.35, CI = 1.23–1.49). Low income immigrants had a 43% higher association of having poorer cardiovascular health than the high income group, while people living in urban areas had an OR of 1.10 (CI = 1.02–1.19) respect to those living in rural areas. Finally, being female was a protective factor compared to being male.

The association between having three CVRFs in each of the intersectional strata, with respect to the reference group (male, from Latin America and the Caribbean, aged 16–44, middle and high-income and living in a rural area) can be observed in Table 3 (only statistically significant results shown, $p < 0.05$). Among men, Africans aged 65–79, with middle high-income and living in rural areas standed out as having the highest association (OR: 60.67, CI = 4.66–1558.84). Among women, Latin American and the Caribbean women aged 65–79, with medium and high income and living in rural areas had the highest association, compared to the reference group (OR: 52.0, CI = 6.65–1095.84).

In Table 4 the role of gender, age group, region of origin, socioeconomic status and area of residence and their interactions in the association of having 3 CVRFs were

Table 2 Association between socioeconomic variables and the risk of having 3 cardiovascular risk factors in immigrant population. Main effect analyses

	Univariate models								Multivariate model	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
45–64 years-old	4.67*	4.24–5.14							4.75*	4.32–5.23
65–79 years-old	11.98*	10.65–13.48							13.05*	11.59–14.70
Female			0.87*	0.82–0.93					0.79*	0.74–0.85
Urban					1.05	0.98–1.13			1.10*	1.02–1.19
European							1.38*	1.28–1.48	1.49*	1.38–1.61
African							1.31*	1.20–1.43	1.35*	1.23–1.49
< 18 K € per year									1.43*	1.28–1.61
								1.19*	1.07–1.33	

OR odds Ratios, *95%CI* 95% Confidence interval

Reference categories; 16 to 44 years of age (age); male (gender); rural area (place of residence); Latin America and the Caribbean (region of origin); ≥18 K € per year (income level)

The number of variables *n* corresponds to the number of categories minus one, which is used to represent the reference category, consisting of the Latin American and the Caribbean males, aged 16–44, living in rural areas, with an income equal or greater than 18 K €

Table 3 Association of having three cardiovascular risk factors for each intersectional stratum. Multivariate logistic regression models. Only stratum with statistically significant results showed

Predictors	Odds Ratios	95% CI	*p*
EU-Male-45–64-rural ≥ 18	12.02	2.51–215.89	0.015
AF-Male-45–64-Rural ≥ 18	10.71	1.90–200.99	0.027
LAC-Male-65–79-Rural ≥ 18	36.40	3.02–869.20	0.006
EU -Male-65–79-Rural ≥ 18	32.50	6.27–597.42	0.001
AF-Male-65–79-Rural ≥ 18	60.67	4.66–1558.84	0.003
LAC- Female-65–79-Rural ≥ 18	52.00	6.65–1095.84	0.001
EU- Female-65–79-Rural ≥ 18	27.30	5.30–500.93	0.002
LAC-Male–45–64-Urban ≥ 18	8.47	1.79–151.51	0.036
EU-Male-45–64-Urban ≥ 18	8.08	1.73–144.00	0.040
AF-Male-45–64-Urban ≥ 18	16.16	3.35–290.79	0.007
EU- Female-45–64-Urban ≥ 18	8.40	1.76–150.78	0.038
AF- Female-45–64-Urban ≥ 18	10.71	1.76–205.19	0.030
LAC-Male–65–79-Urban ≥ 18	49.40	9.69–904.42	< 0.001
EU-Male–65–79-Urban ≥ 18	40.95	8.03–749.44	< 0.001
AF-Male-65–79-Urban ≥ 18	45.50	8.67–840.16	< 0.001
LAC -Female – 65–79-Urban ≥ 18	17.61	2.86–339.64	0.009
EU- Female-65–79-Urban ≥ 18	26.39	5.47–474.95	0.001
AF- Female-65–79-Urban ≥ 18	12.41	1.51–257.54	0.033
LAC-Male–45–64-Rural < 18 K	12.22	2.65–217.20	0.014
EU-Male-45–64-Rural < 18 K	17.84	3.95–315.21	0.004
AF-Male-45–64 -Rural < 18 K	7.28	1.57–129.49	0.050
LAC- Female- 45–64-Rural < 18 K	8.20	1.79–145.44	0.038
EU- Female-45–64-Rural < 18 K	11.42	2.52–201.87	0.016
AF- Female-45–64-Rural < 18 K	10.42	2.18–186.89	0.022
LAC-Male-65–79-Rural < 18 K	29.35	5.88–533.64	0.001
EU-Male-65–79-Rural < 18 K	19.11	3.88–345.99	0.004
AF-Male-65–79-Rural < 18 K	33.80	6.38–625.54	0.001
LAC- Female-65–79-Rural < 18 K	28.52	6.04–510.21	0.001
EU- Female-65–79 -Rural < 18 K	28.13	5.89–504.83	0.001
AF- Female-65–79-Rural < 18 K	33.70	6.06–632.56	0.001
LAC-Male-45–64-Urban < 18 K	10.34	2.29–182.63	0.020
EU-Male-45–64-Urban < 18 K	20.18	4.48–356.20	0.003
AF-Male-45–64-Urban < 18 K	13.63	3.02–240.84	0.010
LAC-Female-45–64-Urban < 18 K	8.59	1.91–151.70	0.033
EU-Female-45–64-Urban < 18 K	12.69	2.81–223.99	0.012
AF- Female-45–64-Urban < 18 K	17.15	3.78–303.36	0.005
LAC-Male-65–79-Urban < 18 K	29.74	6.46–528.13	0.001
EU-Male-65–79-Urban < 18 K	33.66	7.25–599.43	0.001
AF-Male-65–79-Urban < 18 K	44.74	9.57–798.12	< 0.001
LAC- Female-65–79-Urban < 18 K	26.27	5.79–464.69	0.001
EU- Female-65–79-Urban < 18 K	29.44	6.40–522.66	0.001
AF- Female-65–79-Urban < 18 K	47.11	10.15–838.66	< 0.001
Observations	45,861		
R^2 Tjur	0.057		

EU Europe, *AF* Africa, *LAC* Latin American and the Caribbean, 95%*CI* 95% Confidence interval, *p*: statistical significance

Reference group: Latin American and the Caribbean men aged 16–44 middle and high-income and living in rural area

Table 4 Association of having 3 CVRFs for the different socioeconomic variables. Interaction models with two interactions

Predictors	Odds Ratios	95% CI	*p*
(Intercept)	0.02*	0.01–0.03	< 0.001
Gender Female	0.62*	0.44–0.87	0.006
Age group 45–64	4.34*	2.81–6.88	< 0.001
Age group 65–79	19.83*	12.00–33.40	< 0.001
Origin Europe	1.09	0.77–1.56	0.623
Origin Africa	0.96	0.61–1.51	0.873
Urban Area	0.69*	0.49–0.97	0.032
Socio-economic level < 18 K	1.64*	1.05–2.62	0.034
Female Age group 45–64	1.12	0.92–1.37	0.259
Female Age group 65–79	1.28*	1.00–1.64	0.050
Female Origin Europe	0.89	0.76–1.04	0.146
Female Origin Africa	1.40*	1.15–1.69	0.001
Female Urban Area	0.97	0.83–1.14	0.746
Female Socio-economic level < 18 K	1.15	0.90–1.47	0.282
Age group 45–64 Origin Europe	1.16	0.92–1.46	0.196
Age group 65–79 Origin Europe	0.77	0.58–1.03	0.076
Age group 45–64 Origin Africa	1.03	0.79–1.36	0.810
Age group 65–79 Origin Africa	1.00	0.72–1.38	0.980
Age group 45–64 Area Urban	1.35*	1.09–1.67	0.006
Age group 65–79 Area Urban	1.34*	1.01–1.77	0.041
Age group 45–64 Socio-economic level < 18 K	0.78	0.51–1.14	0.217
Age group 65–79 Socio-economic level < 18 K	0.48*	0.30–0.73	0.001
Origin Europe Urban Area	1.12	0.94–1.34	0.209
Origin Africa Urban Area	1.66*	1.30–2.11	< 0.001
Origin Europe Socio-economic level < 18 K	1.24	0.94–1.62	0.125
Origin Africa Socio-economic level < 18 K	0.80	0.57–1.15	0.222
Urban area Socio-economic level < 18 K	1.09	0.84–1.42	0.499
Observations	45,861		
R^2 Tjur	0.055		

Reference categories; 16 to 44 years of age (age); male (gender); rural area (place of residence); Latin America and the Caribbean (region of origin); ≥18 K € per year (income level); 95%CI: 95% Confidence Intervals

analysed. Among individuals from Africa, residing in urban areas was associated with significantly higher odds of having all three CVRFs compared to those in rural areas (OR: 1.66, CI = 1.30–2.11). The association also increased for women from Africa (OR: 1.40, CI = 1.15–1.69) compared to other nationalities. The interaction of the 45–64 age group with the urban area of residence and the 65–79 age group with urban area also increased this association (OR: 1.35, CI = 1.09–1.67 and 1.34, CI = 1.01–1.77, respectively) compared to living in rural

areas. Being female in the 65–79 age group also increases the likelihood of having all 3 CVRFs (OR: 1.28, CI = 1.00–1.64). On the other hand, the association of having worse cardiovascular health decreased significantly with the interaction of age group 65–79 and income less than 18 K € per year, compared to those oldest immigrants with an income of 18 K € or higher.

Stratified analyses were performed to determine whether the associations described above were modified by length of stay. Main effects analyses were repeated for immigrants with less than 8 years in the Aragonese health system and for those with 8 years or more. The analyses (Appendix Tables 2 and 3) showed similar results for the two groups analysed. In relation to region of origin, the association of having the three CVRFs increases more for Europeans (OR:1.40, CI = 1.18–1.65), in relation to the group of Latin Americans and Caribbeans in the stratum with less than 8 years of entry into the health system. In the stratum of more than 8 years, this association significant increases even more for Europeans, followed by Africans (OR: 1.49, CI = 1.37–1.63 and 1.38, CI = 1.24–1.54, respectively). These results were also similar to those obtained for the population as a whole (Table 2), with the same variables showing a similar association.

Discussion

In this study, which analyses the frequency of CVRFs in an immigrant population from an intersectional approach, the role of socioeconomic determinants in cardiovascular health and their interactions can be observed.

When we explored the role of social determinants on the burden of CVRFs on immigrant population separately, we observed that the group aged 65 to 79 years had the highest risk, followed by the group aged 45 to 64 years. The role of age in CVRFs has been widely confirmed: with increasing age, the risk of having more CVRFs increases proportionally [5]. Regarding the region of origin, those immigrants from European counties were more likely to have all 3 CVRFs than other regions. In our study, these immigrants are mainly from Eastern Europe (Romania and Bulgaria have the highest percentages). Other studies have also found that immigrants from Eastern Europe are more likely to have 3 CVRFs than those from Latin American and the Caribbean, Africa and even the indigenous Spanish population, and this seems to be associated with a low level of education [15, 29]. In our results, being from the African region also increases the risk compared to the Latin American and Caribbean region. These findings differ from previous studies, which have highlighted a higher risk for Latin Americans and the Caribbean population [11]. This could be related to factors such as country of origin, age and length of stay. A higher risk of 3 CVRFs was associated with urban areas. The literature shows that the prevalence of CVRFs, such as hypercholesterolemia and smoking, is lower in rural areas [30]. Finally, being a woman was a protective factor, which has been supported by other studies [31, 32].

Regarding the time of residence, we did not get significant differences whether immigrants have been in the Aragonese system for less than 8 years or more. In general terms, the results obtained were very similar to those for the whole population. Our results differ from other studies where a longer time of residence was associated with a higher risk of having 3 CVRFs [15]. These differences could be due to the fact that we considered the time of entry into the health system (only available data) and not the time of stay in the country, and we compared them with the studies that included the native population in the analysis. We also have no data on the health status of migrants in their country of origin or in other transit countries.

The analyses of the different intersectional strata revealed that the axes of greater oppression were associated with a higher frequency of CVRFs. It was the case of both men and women aged 65 to 79 years living in urban areas. Specifically, Latin American and Caribbean men with medium and high incomes and African women with low incomes. A study conducted in Latin American and Caribbean immigrant population found that alcohol, tobacco and illicit drug use was highly prevalent in the adult men [33]. The unhealthy lifestyles of this group could be associated with a worse cardiovascular health. This may also be interacting with genetic and environmental factors, typical of urban environments. In relation to the stratum of African women, it is widely endorsed in the literature that the addition of vulnerability factors may increase the likelihood of cardiovascular disease [34] A study in the United States of America found that black women >50 years of age, of African descent or origin, with low income, were more likely to develop CVD [35]. This may be due to the type of CVD and the economic and social factors of the destination country and their socio-cultural integration, which may affect their lifestyle. On the contrary, the privileged axes identified were mostly in the 16 to 44 age group, with medium and high incomes people.

A significant increase in the risk of having the three CVRFs was observed in the interaction between urban area and African region, followed by the interaction between female sex and African origin. In a study of an immigrant population in Catalonia, a higher prevalence of arterial hypertension and obesity was observed in women from sub-Saharan Africa compared with men and other immigrant groups [13]. Research focusing on migrant women from Maghreb has also found that women have a higher prevalence of CVRFs than men [7]. A study in the African context found a high prevalence of modifiable risk factors among black South Africans living

in urban areas [36]. This increase in CVRFs in immigrants of African origin in the urban context could be related with acculturation [37]. Another study found that African immigrants who experienced frequent discrimination were more likely to have an increased risk of CVD than those who experienced less discrimination [38]. All this evidence suggests that the results of our study could be motivated by the burden of CVRFs that African immigrants bring with them from their countries of origin, and that a probable low adherence to treatment and the adoption of new lifestyles in the host country, could lead to an increase in the prevalence of CVRFs. Nonetheless, other social factors, such as language barriers, lower income, poor housing or inequities in access to and quality of medical care, could be influencing the cardiovascular health of this group and should be considered in future studies.

The interaction between living in an urban area and the 45 to 64 and 65 to 79 age groups, compared with living in a rural area, increases the risk of having the three CVRFs analysed. A study by Niculita-Hirzel et al. found a significant association between the most severely affected built-up urban areas and the prevalence of CVD in older adults living in these areas [39]. Other epidemiological studies show strong associations between exposure to urban air pollutants and the incidence of CVD, with higher rates in more affluent areas [40, 41]. In addition to these findings, the continued growth of the urban environment has led to greater socioeconomic inequalities in health due to the existence of neighborhoods with high socioeconomic deprivation and concentrations of vulnerable populations [42, 43].

One of the main contributions of the intersectional approach to our research is the fact that, although men have a higher frequency of CVRFs, women on the most oppressed axes of inequality have a higher frequency of the 3 CVRFs than men. The interaction of women with the older age group increases the risk of having three CVRFs [31]. If we add other vulnerability factors to this association, such as belonging to the African region and living in urban areas, older women are more likely to have the three CVRFs than men of the same age. Therefore, it seems that the cumulative effect of vulnerability has a more negative effect in women than in men. Other studies support these findings. Sujane et al. suggest that women from vulnerable populations, defined as socially or economically disadvantaged, low-income, non-white and older, are at greater risk of CVD than men [34]. Additional vulnerabilities, which may exist in combination, increase women's risk of these diseases due to gender-based social, financial and health inequalities [44]. This finding points the utility of intersectional analyses to identify groups of risk in cardiovascular health.

Strengths and limitations

Most studies on CVRFs focus on the different etiological factors and their impact on health outcomes, leaving intersectionality and its effects unexplored [45]. The main strength of this study is the use of an intersectional approach to improve our understanding of immigrant cardiovascular health using the RWD. This approach, which generates axes of oppression and privilege, allows the different intersections of identities to be explored. In addition, this study has been conducted using the CARhES cohort, a population cohort based on RWD, which will ensure the external validity of the results.

This study has also some limitations. First of all, since our RWD cohort includes individuals with existing CVRFs, we compare the extent of risk factor burden rather than their mere presence, which may explain discrepancies with studies using CVRF occurrence as the outcome. Immigrants from Asia, North America and Oceania could not be included due to the small number of subjects in our population. This is a cross-sectional observational study, so it is not possible to establish associations between variables and outcomes [46]. Another limitation is related to the type of information available in the cohort. For example, we use sex in order to explore gender. Although it is not equivalent, this is the only available information. We were also forced to use the country of origin instead of other ethnicity variables as this was the only information available in our datasets. It would be appropriate to include other variables, such as skin color, ethnicity and area, to provide a more holistic view of CVRFs behavior across different groups of origin, but this is limited to the information availability. Nonetheless, these variables have been used in similar studies [11, 47]. We limited the number of interaction terms to two due to loss of statistical significance and challenges in model interpretability. Finally, in order to account for the time of residence we used the length of stay in the Aragonese health system, which may be different from the length of stay in the country. This fact could have limited the results obtained.

Conclusions

The highest burden of CVRFs was observed in immigrants from European countries. The frequency of three CVRFs increases with age and are more common in men, living in urban areas and among people with low income. When considering an intersectional perspective, we observe that the strata with the highest burden of CVRFs were those of Latin American and Caribbean men and African women, older, living in urban areas. Despite men had more CVRFs on average, intersectional analysis revealed that women facing multiple axes of social disadvantage had a greater risk than men of having three CVRFs.

Understanding the role of socioeconomic determinants is crucial to address cardiovascular risk, as social conditions shape health behaviors and access to care. The intersectional approach using RWD helps to identify vulnerable groups facing multiple disadvantages from a populational perspective, enabling more targeted and equitable interventions to reduce inequalities and improve health outcomes.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
Y. C.: Conceptualization, Methodology, Formal Analysis, Writing – original draft, Writing – review & editing. A.G: Conceptualization, Methodology, review & editing; S.M: Conceptualization, Funding acquisition, review & editing; MJ.R: Funding acquisition, Supervision, review & editing; J.C.: Methodology, Data curation, Formal Analysis, review & editing; I.A-P: Conceptualization, Methodology, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. All authors read and approved the final version of the manuscript.

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Data availability
The datasets analysed during the current study are not publicly available as they comprise administrative data from the Aragonese Health Service. Data will be available under request by email to Isabel Aguilar [iaguilar@unizar.es] (mailto: iaguilar@unizar.es).

Declarations

Ethics approval and consent to participate
This study used pseudonymized data from the CARhES cohort and was approved by the Aragon Clinical Research Ethics Committee (CEICA) of the Aragón Government. Identification code: PI21/148. Informed consent was waived by the CEICA due to its retrospective, non-interventional design. This study was conducted in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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