Universitat Pompeu Fabra Barcelona

Faculty of Economics and Business

Academic year: 2020-2021

Final Year Project

Patient gender discrimination on cardiology: access and diagnosis. A discrete probability model for Catalonia.

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Abstract

In this project, we examine patient gender discrimination on both the probabilities of visiting the cardiologist and being diagnosed with a heart disease. Using micro data from the 2016 and 2017 Catalan Health Survey ($ESCA$), and two Probit estimations for the equations drawn for each case of study, we are able to reach the conclusion that there is gender discrimination both on access and diagnosis for patients with high prospects of suffering heart issues. Our findings suggest that women have lower probabilities of visiting the cardiologist and being diagnosed with a heart disease. Even after adding controls for risk factors, other significant socioeconomic variables, and using two different sub-samples, these results preserve their validity and significance intact.

Key words: gender, cardiology, cardiovascular diseases, diagnosis.

Contents

1 Introduction

According to the World Health Organization (WHO), cardiovascular diseases (CVD) are one of the leading causes of death around the world, with the only exception of Africa (Mendis, S., et al. 2011). This statement may sound strong, but not strange at all. However, if we said that CVD are the main cause of death among women, and that after an acute cardiovascular event their probability of making it through is lower than for men (Gao, Z., et al. 2019), that may be surprising.

Cardiovascular diseases have always been known as "male" diseases because of their higher incidence on men. Moreover, medical research has historically been conducted with male patients. There is no coincidence, then, that commonly known symptoms of myocardial infarction such as chest discomfort, pain in one or both arms, and breath difficulty, do not include other frequent signs manifested among women like cold sweats, nauseas, vomiting, unusual tiredness, among others (Erlinger, C., et al. 2020).

The situation described in the previous paragraph is an example of gender bias. Gender bias is defined as *inclination towards or prejudice against one gender* (Oxford dictionary, 2020). There is a large amount of literature on gender discrimination, sometimes interchangeable with gender bias; on heart diseases or pathology's diagnosis; outcomes after myocardial infarction; survival rates after heart interventions; mortality due to heart issues; etc. In fact, since the beginnings of the 21st century, as society has become more aware of gender discrimination, one can see how year after year more studies on this issue have flourished.

However, we have found no literature regarding whether there is gender bias in the access to specialized healthcare, visiting the cardiologist in this case. We believe that the lack of studies around this area may be due to a general scarcity of data; the impossibility to include those individuals who should have been diagnosed, but that never were, and who are of special interest for our research aims; and the differences in healthcare markets around the world. On the one hand, in the US, where most of the literature is from, they have a private system that does not require any screening for someone to go to the cardiologist. On the other hand, countries like Spain have a public universal health system, where in order to be examined by a cardiologist, one first needs to go to a general practitioner or be in an emergency room to then be transferred to the specialist (*Servei Català de la Salut*, 2017). In other words, you require a referral from a primary care professional. It is worth mentioning that, in Spain, there is also a private market that does not require any previous professional screening for an individual to visit a cardiologist, or any other kind of specialist.

On this wise, using the 2016 and 2017 cross sectional Health Survey from Catalonia (*Enquesta de Salut de Catalunya, ESCA*), a region in Northeast Spain, we want to contribute to the existing literature on discrimination by directing our focus to the cardiology specialty, trying to determine whether the probability of visiting a cardiologist, or being diagnosed with a heart condition, presents any form of gender discrimination.

To fulfil our study goals, we have come up with two Probit models from which we will try to estimate the true effect of gender, controlling for a subset of other variables, on both the probability of visiting a cardiologist and being diagnosed with a heart condition.

The remaining part of the study is organized as follows. In Section 2 we do a review of the existing literature on gender discrimination regarding heart issues. In Section 3 we present the data used for our study. In Section 4 we describe the empirical strategy implemented to obtain the results of our research, which are presented in Section 5. Then, in Section 6, we discuss our findings, and Section 7 concludes.

2 Review literature

For a long time, cardiovascular diseases (CVD) have been seen as "male" diseases, specially due to men's higher absolute risk and incidence compared to women (Gao, Z., et al. 2019). However, CVD are the leading cause of mortality for women, and were responsible for 35% of the total global deaths among women in 2019, which means that the relative risk for them of CVD morbidity and mortality is actually higher (Global Burden of Disease Collaborative Network, 2019).

According to The Lancet Commissions (Vogel, B., et al. 2021), one of the main reasons behind womens's higher relative risk of mortality due to a CVD is that they remain under-studied, under-recognised, under-diagnosed, and under-treated globally. Women have been under-represented in, or excluded from, cardiovascular clinical trials, which has reduced the ability to measure the safety and efficacy of therapies applied to them. This, has also decreased the potential for identifying sex-specific differences in important outcomes, and the development of gender-specific strategies that could lead to improved guideline recommendations for the prevention and management of cardiovascular diseases (Vogel, B., et al. 2021).

Möller-Leimkühler (2007) studies gender differences in cardiovascular diseases, and concludes that women with acute myocardial infarction (MI) tend to present atypical symptoms such as abdominal pain, dyspnoea, nausea, back and neck pain, indigestion, palpitations, and unexpected fatigue; rather than clearly defined chest pain, which is the typical male complaint and probably better recognized by physicians. Misconceptions about risks and symptoms, create a gender bias among general practitioners, since the screening for women is poorer than for men, and that may result in later and in a lower proportion arrival to the cardiologist.

In the same way, other studies conclude that following an acute myocardial infarction (MI), gender disparities for women include a significantly worse prognosis, higher reinfarction rate, heart failure, cardiogenic shock, and myocardial rupture; as well as higher in-hospital and later mortality rates (Alfonso, F., et al. 2006). In addition, a new VIRGO (Variation in Recovery: Role of Gender on Outcomes of Young Acute Myocardial Infarction Patients) analysis demonstrates that despite having a similar or greater risk factor burden, women are 11% less likely than men to have been told that they are at risk. (Leifheit-Limson,E.C., et al. 2015).

Regarding the use of medical services, The National Health Interview Survey (US, 2009) states that 25% of men had no medical office visits registered in the last 12 months compared to 12% of women (Pleis, J.R., et al. 2010). Therefore, women have been visiting the primary care services in the US more frequently than men. In the case of Catalonia (Brugulat, P., et al. 2000), we can observe the same trend, as 24,4% of women visited any type of clinician during the previous two weeks, while only 18,9% of men did so during the same period; independently of the time of the year the survey was conducted, the social class or the age. Moreover, Fernandez et al. (1999) are also able to make a claim in this same direction.

With respect to the relevance of y-care on people's health, Macinko et al. (2007) found that an increase in primary care physician supply was associated with improved health outcomes, including all-cause, cancer, heart disease, stroke, infant mortality, low birth weight, life expectancy, and self-reported health. Consequently, one could believe that women should be better diagnosed than men. However, due to the potential gender bias present in the healthcare system, we can not affirm that, even if they visit more frequently health professionals.

In Spain, and more specifically in Catalonia, in order to access specialized care services in the public health system (as it could be the cardiologist), it is essential to be referred beforehand by a general practitioner, or from an emergency room (*Servei Català de la Salut*, 2017). Therefore, it is not enough to only tackle gender bias at the specialized clinicians level, but it should also be addressed at the less specific layers of the Healthcare system, since the first screening, done by the general practitioner, is a key determinant for granting access to the particular professional.

The main risk factors associated with CVD have traditionally been assumed to be the same for men and women, although important quantitative differences in physiological and pathological aspects have been observed (Möller-Leimkühler, A. M. 2007). According to Legato (1997), women have smaller artery dimensions, distinct electrical properties, and different plaque composition and development, which could influence consequent CVD dissimilarities among genders.

In this regard, the risk factor with the greatest divergence between men and women is diabetes, as it results in a 3 to 7 fold increased CVD risk in women compared with a 2 to 3 fold elevated risk for men (Eastwood, J.A., et al. 2005). Another important risk factor is hypertension, which is a major CVD predictor for both sexes, but is more prevalent in women than in men after the age of 65 (Vaccarino, V., et al. 1999).

Hypercholesterolemia plays a central role in the development of CVD in men and women (Polk, D.M., et al. 2005); as well as smoking, which among females younger than 50 years old, is one of the leading causes of CVD. Although the prevalence of smokers is still slightly higher in men than in women, the decline in tobacco consumption among the latter is less evident than for men. In fact, rather than a decrease, a rise may be observed within younger women. This could explain the increased incidence rates of CVD among them (Morbidity and Mortality Weekly Report. 2002).

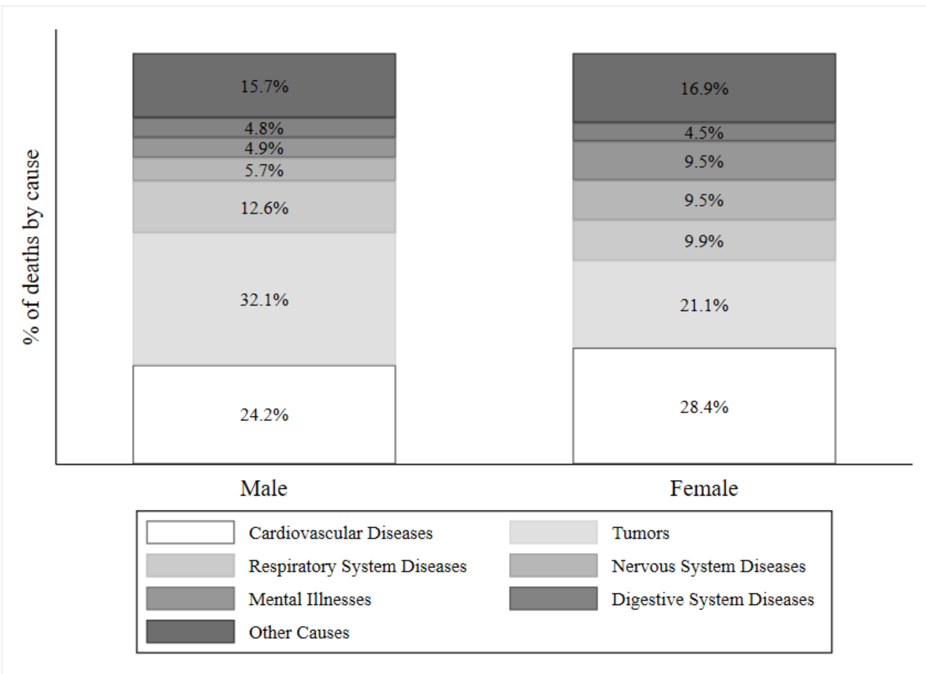
Moreover, obesity and particularly central obesity, more prevalent in men up to the age of 45 years old and in women over this same age, increases CVD risk specially among females. Furthermore, it is associated with diabetes, hypertension, and dyslipidaemia, as well as other lifestyle-related risk factors such as physical inactivity and a poor diet (Kenchaiah, S., et al. 2004). On the other hand, there are other studies (Bairez Merz, C.N., et al. 2015) in which general obesity is not found as an independent risk factor and does not improve CVD propensity amidst men and women. To evidence this potentially surprising point, CVD mortality has continued to fall despite a robust obesity epidemic in which 74% of men and 64% of women are overweight or obese, and obesity reduction trials have failed to reduce CVD incidence (Bairey Merz, C.N., et al. 2015).

Finally, another important point to consider is that CVD risk factors are highly prevalent among adults from low social classes in Spain. However, little is known on how these factors are distributed among the immigrant population, which is usually characterized as a socioeconomic disadvantaged cohort. The evidence from Rodriguez-Alvarez et al. (2020) shows that there are significant differences between natives and immigrants in the probabilities of suffering from at least three CVD risk factors.

3 Data

Firstly, we wanted to get a general sense of the distribution of the various causes of mortality for both men and women, to then observe whether CVD in particular are the leading sources of mortality among women in Catalonia. To do that, we have used data from the *Generalitat de Catalunya*'s Health Department.

Figure 1: Relative mortality in Catalonia by cause, 2017.



Source: *Own elaboration with Generalitat de Catalunya's Health Department data.*

From Figure 1, we can observe how there are differences in the relative weight of the various sources of mortality among men and women. Paying special attention to CVD results, we see that these are the leading cause of death for women, and that they also have a higher relative importance than for men. We can affirm, then, that in Catalonia women have a higher relative risk of dying due to cardiovascular diseases than men, as mentioned in Section 2 (Global Burden of Disease Collaborative Network, 2019).

As this is purely descriptive data, to answer whether there exists a gender bias in the

Catalan Healthcare System with regard to cardiological issues, we have used the micro data from the 2016 and 2017 Catalan Health Interview Survey (*Enquesta de Salut de Catalunya, ESCA*), which is a cross sectional survey that interviews 5,000 people every year since 2010 in this region.

This questionnaire gathers information from non-institutionalized individuals of all ages living in Catalonia, regarding self-reported information on health status, morbidity, healthy habits, use of healthcare services, socioeconomic conditions, among many other variables.

The 9,648 individuals that make up the total sample were randomly chosen to achieve population, geographical and temporal representativeness. However, because of the characteristics of our study, this sample is reduced considerably.

As cardiovascular diseases are uncommon among the younger age cohorts, we dropped individuals under 40 years old. Not omitting them would have led to an underestimation of the true relationship between visiting the cardiologist or being diagnosed with a cardiovascular disease, and the biological sex. This process leaves our study sample with 5,122 individuals. Table 1 shows the descriptive statistics for this set of individuals.

From this table we can observe the mean and the standard deviation for the 24 variables used in our below-explained empirical method. These statistics are shown both for women and men.

Table 1: Summary Statistics

	Female		Male	
	Mean	**SD**	**Mean**	**SD**
Visited the Cardiologist last 12 months	0.089	0.285	0.121	0.327
Diagnosed with a Heart Pathology	0.084	0.278	0.122	0.328
Age	61.430	14.780	59.788	14.271
Alt Pirineu i Aran	0.073	0.261	0.076	0.266
Barcelona Ciutat	0.203	0.402	0.179	0.383
Barcelona-Àrea Metropolitana Nord	0.159	0.365	0.160	0.367
Barcelona-Àrea Metropolitana Sud	0.153	0.360	0.158	0.364
Camp de Tarragona	0.080	0.272	0.087	0.282
Catalunya Central	0.079	0.270	0.080	0.271
Girona	0.148	0.355	0.151	0.359
Lleida	0.053	0.224	0.053	0.224
Terres de l'Ebre	0.052	0.222	0.056	0.229

Suffer from HBP	0.359	0.480	0.379	0.485
Suffer from CHO	0.299	0.458	0.308	0.462
Suffer from DIA	0.118	0.322	0.142	0.349
Suffer from VSC	0.254	0.436	0.094	0.292
Medication for HBP	0.298	0.457	0.321	0.467
Medication for CHO	0.198	0.399	0.219	0.413
Medication for DIA	0.088	0.284	0.122	0.328
Medication for OHD	0.085	0.279	0.118	0.323
Visit General Practitioner last 12 months	0.845	0.362	0.796	0.403
Emergency Room visits last 12 months	0.554	1.538	0.477	1.248
Underweight	0.017	0.128	0.004	0.063
Normal or Healthy Weight	0.430	0.495	0.289	0.453
Overweight	0.330	0.470	0.475	0.499
Obese	0.195	0.397	0.218	0.413
NS/NC	0.028	0.166	0.014	0.116
Daily smoker	0.167	0.373	0.236	0.425
Occasional smoker	0.011	0.102	0.016	0.125
Former smoker	0.143	0.350	0.313	0.464
Non-smoker	0.616	0.487	0.387	0.487
NP	0.064	0.245	0.048	0.214
Non-drinker	0.384	0.486	0.212	0.409
Low-risk drinker	0.539	0.499	0.695	0.461
High-risk drinker	0.013	0.114	0.045	0.208
NP	0.064	0.245	0.048	0.214
Low Phy Act	0.158	0.365	0.138	0.345
Medium Phy Act	0.425	0.494	0.394	0.489
High Phy Act	0.103	0.304	0.194	0.396
NP	0.064	0.245	0.048	0.214
NP (Over 70 yo)	0.250	0.433	0.225	0.418
Primary Education or lower	0.286	0.452	0.296	0.456
Secondary Education	0.431	0.495	0.445	0.497
Tertiary Education	0.271	0.445	0.256	0.436
Other Possibility	0.000	0.019	0.000	0.000

NC	0.011	0.104	0.003	0.057
Foreigner	0.090	0.286	0.097	0.296
Very difficult to Make Ends Meet	0.043	0.202	0.040	0.197
Difficult to Make Ends Meet	0.109	0.312	0.089	0.285
Relatively difficult to Make Ends Meet	0.235	0.424	0.223	0.416
Relatively easy to Make Ends Meet	0.396	0.489	0.414	0.493
Easy to Make Ends Meet	0.196	0.397	0.205	0.404
Very easy to Make Ends Meet	0.015	0.124	0.024	0.153
NS/NC	0.006	0.080	0.006	0.075
Private Insurance	0.266	0.442	0.250	0.433
Weekly hours of Care Work	5.333	3.473	2.874	2.483
Observations	2646		2476	

Notes: HBP=High-Blood Pressure. CHO=Cholesterol. DIA=Diabetes. OHD=Other heart disease. VSC=Variscose veins.

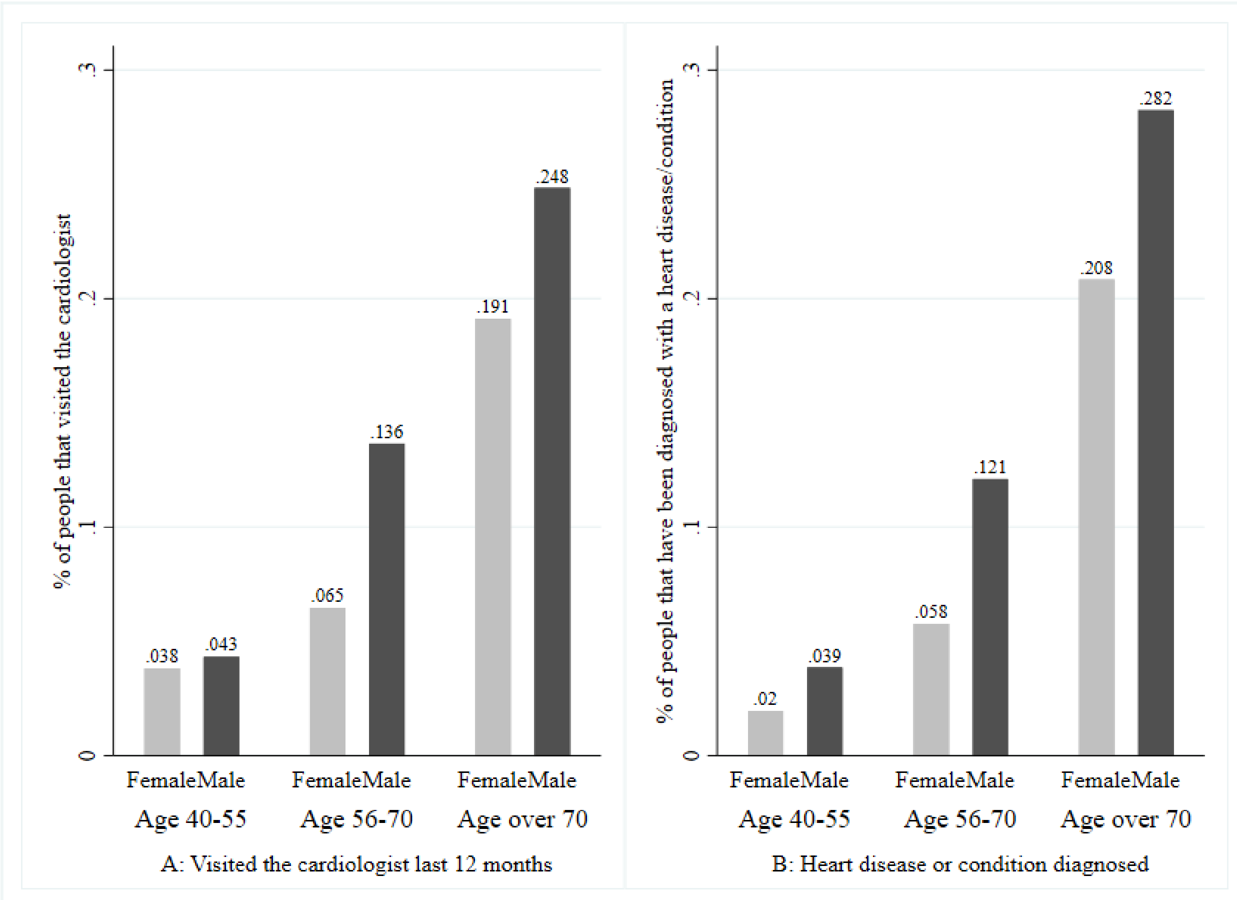
Source: *Own elaboration with 2016 and 2017 Catalan Health Interview Survey data.*

We can see how the proportion of people who had visited the cardiologist in the previous year is higher for men than for women. This is also the case when looking whether they had been diagnosed with a heart condition. Figure 2 shows how each dependent variable from both of our models, presented in Section 4, is distributed differently among the various age cohorts. Both variables present the same trend, with lower values for the younger groups to start increasing with the age of the individuals. Moreover, for every age span it is both the case that more males have visited the cardiologist and have been diagnosed an issue with regard to their hearts than their female counterparts.

To capture the effects of suffering from a heart disease risk factor, as this could increase the probability of visiting the cardiologist or being diagnosed with a heart condition, we include variables that tell whether people are taking medication for High Blood Pressure, Cholesterol, Diabetes, Other Heart Diseases, or if they are not. We decided to use drug intake rather than self-reportedly diagnosed variables, as we believed that they would control better for the fact that someone was really experiencing these conditions or was preventing them with such medication. Figure 3 shows that medication intake increases with age for each condition included, and it can also be seen that in most cases a higher proportion of men take a certain type of medicine. However, women are not that far behind and in some cases are quite similar to men or even register a higher percentage.

For the remaining of the control variables, we can say that men tend to have a higher

Figure 2: Dependent variables by age and sex

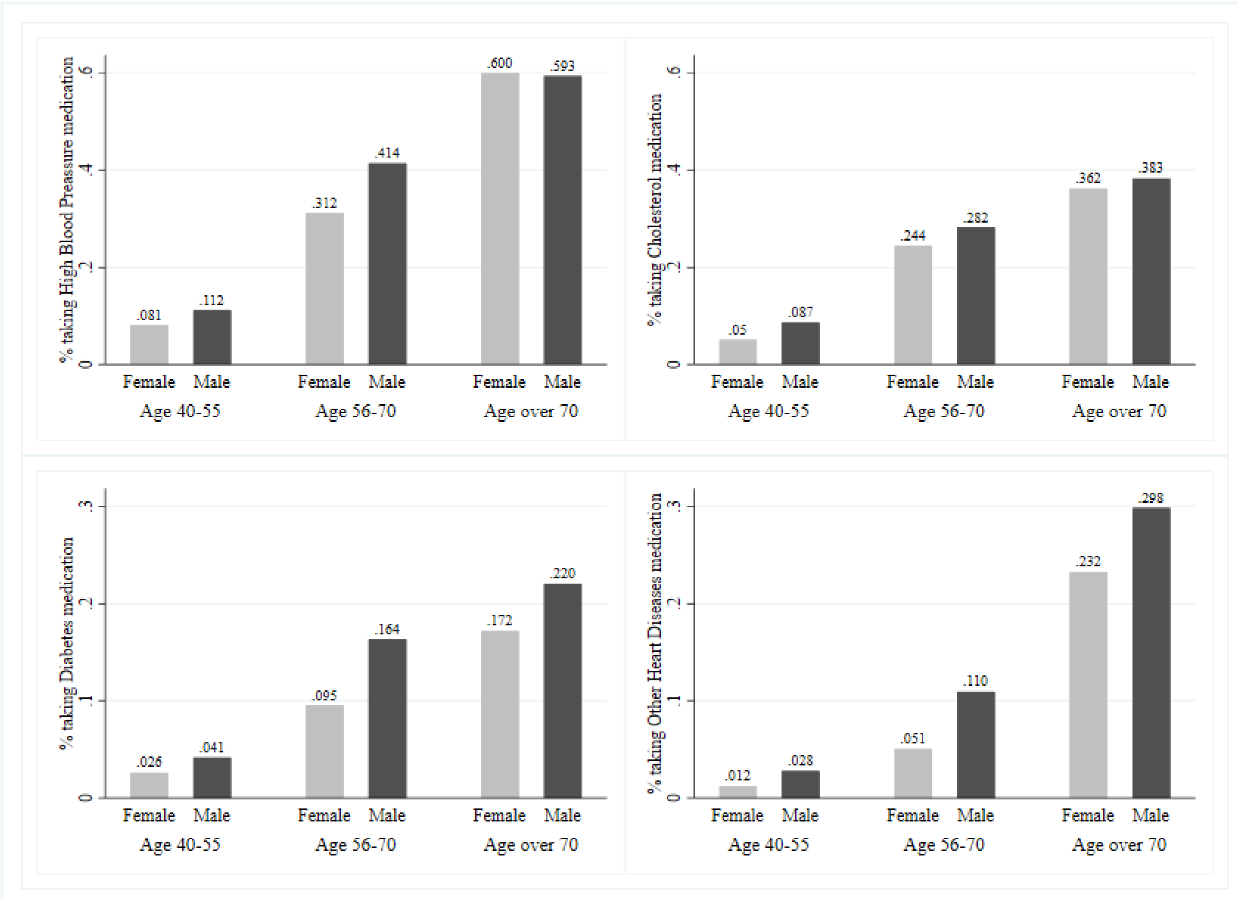


Source: *Own elaboration with 2016 and 2017 Catalan Health Interview Survey data.*

Body Mass Index (BMI) and smoke more, whereas women are slightly more educated (a higher proportion of women have tertiary education) and they double the average of men in care work responsibilities (care work as household tasks). We see hardly any differences in the variable for make ends meet difficulty, which was included to control for household income as such feature was not available in the data set; the variable whether the individual is a foreigner or has Spanish nationality, and if the interviewee has private insurance or not.

To contrast even more our two questions of interest, we drew two alternative sub-samples. For the first one, we only included the individuals that were taking medication for at least one of these conditions: High Blood Pressure, Cholesterol, Diabetes, or Other Heart Diseases. In the second one, we followed a similar structure and only considered individuals who were suffering from High Blood Pressure, Cholesterol, Diabetes, or Varicose Veins. We decided to use these self-reportedly diagnosed variables as opposed to drug intake to avoid the plausible

Figure 3: Percentage of people taking medication by Age and Sex

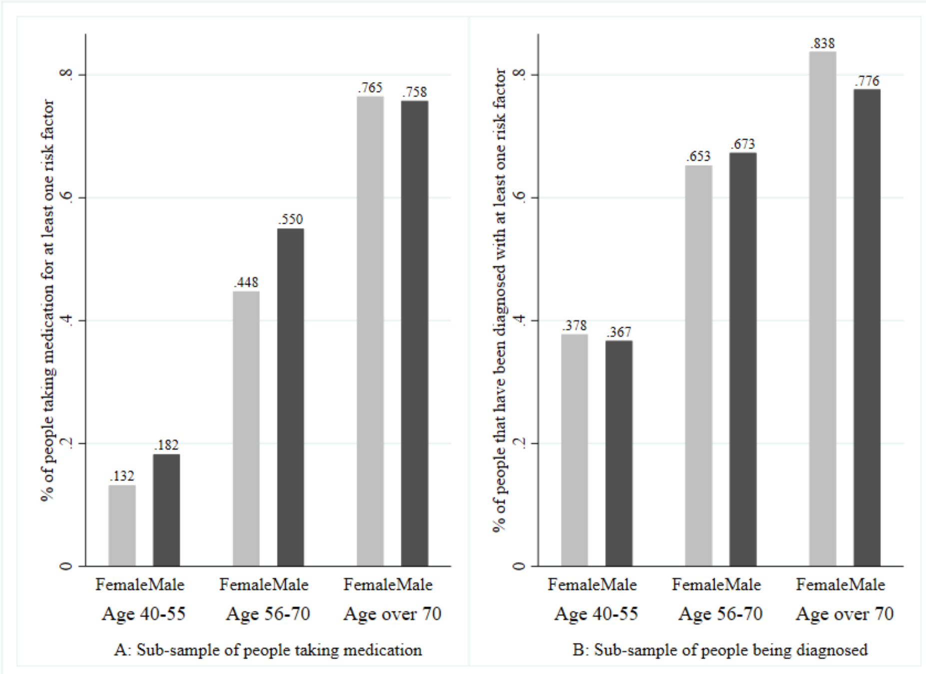


Source: *Own elaboration with 2016 and 2017 Catalan Health Interview Survey data.*

existence of a Double-Causality Bias between being diagnosed with a Myocardial Infarction or Other Heart Diseases and drug intake for risk factors regarding heart issues.

In conclusion, we created two different sub-samples with 2,153 individuals that take medicines for Heart Diseases' risk factors, and 2,955 people who are self-reportedly diagnosed with a risk pathology for further heart issues. Each was used in a third specification for each Probit model designed, to try to further disentangle the discriminating component regarding cardiologist visits and diagnosis, as both sub-samples included individuals who were especially prone to suffering heart conditions as they were either taking medication or already suffering from risk factors for serious heart issues. Figure 4 displays how are individuals distributed among sex and age in the previous mentioned sub-samples.

Figure 4: Distribution of sub-sample individuals



Source: *Own elaboration with 2016 and 2017 Catalan Health Interview Survey data.*

4 Empirical strategy

With regard to the first hypothesis of discrimination that we want to evaluate, we need to capture the true effect of gender on the probability of visiting the cardiologist. To estimate this potential causal relationship, we have designed equation (1), which will be estimated through a Probit method, and that reads:

$$\begin{aligned} VCAR_i = \alpha + \beta_1 * FEMALE_i + \beta_2 * AGE_i + \beta_3 * HR_i + \beta_4 * GPV_i + \beta_5 \\ * EMRV_i + \beta_6 * BMI_i + \mu_k * X_{ki} + \gamma * HA_i + \delta * SE_i + \rho_t + \varepsilon_i \end{aligned} \tag{1}$$

where, $VCAR_i$ is a dummy variable indicating whether an individual had been visited by a cardiologist in the previous 12 months; $Female_i$ is another dummy variable taking value 1 if the individual is a female; AGE_i stands for the age of the interviewees separated by 3 spans; HR_i represents a categorical variable determining from which of the 9 Health Regions in Catalonia the individual is from; GPV_i picks up whether the individual had attended the general practitioner during the previous 12 months; $EMRV_i$ shows the number of times the individual had visited an emergency room during the previous year; BMI_i is the body mass index separated by the four standardized BMI categories; X_{ki} is a vector of K explanatory variables indicating whether the individual was taking drugs related to X heart diseases or risk factors; HA_i is another vector of variables controlling for the following healthy habits: drinking, smoking, and physical activity; and SE_i corresponds to a final vector of variables that control for socioeconomic characteristics including make ends meet difficulty, nationality, education, among others. Finally, ρ_t are year fixed effects.

When running the Probit model in the equation, standard errors will be clustered at the Healthcare Management Area (*Àrea de Gestió Assistencial*) level to control for the variance between these 43 administrative divisions Catalonia has in order to do operative planning, coordination and analysis of the principal flows between primary attention centres and hospitals.

To determine the true effect of biological sex and the various control variables included, on the probability of being diagnosed with a Myocardial Infarction (MI) or any Other Heart Disease (OHD), we will estimate the following equation, also using a Probit model:

$$\begin{aligned} DIAGNOSED_i = \alpha + \beta_1 * FEMALE_i + \beta_2 * AGE_i + \beta_3 * HR_i + \beta_4 * VCAR_i + \beta_5 * GPV_i \\ + \beta_6 * EMRV_i + \beta_7 * BMI_i + \mu_k * Z_{ki} + \gamma * HA_i + \delta * SE_i + \rho_t + \varepsilon_i \end{aligned} \tag{2}$$

Although having a very similar structure, equation (2) is based on a dummy dependent variable which takes the value of 1 for those individuals who had been diagnosed with a Myocardial Infarction and/or any Other Heart Disease during their life. Moreover, a vector of explanatory variables Z_{ki} is included, which replaces X_{ki} from equation (1), and that consists of a group of K self-reportedly diagnosed dummy variables indicating whether individuals were suffering from Z heart risk factors. Finally, the variable $VCAR_i$ is also included to control for whether people visited the cardiologist, as this could be directly related with a higher chance of ending up being diagnosed with a heart condition.

For each of the two Probit models constructed, three different specifications are run, adding further control variables and using the specific sample of individuals prone to suffer from serious heart conditions, as described in the previous section. With this three-layer strategy, we intend to refine the true causal effect of gender discrimination on both the probabilities of visiting a cardiologist and being diagnosed with a heart condition.

5 Results

Before starting with the estimation of equations (1) and (2), we first wanted to run a simple regression to determine whether the explanatory covariates included in the two main models, and which we thought they would have the most relevant effects on the corresponding dependent variables, were actually significant for having a Myocardial Infarction in our sample. Table 2 shows the results from this "significance test" of the later-included controls.

Table 2: Effects of the potential explanatory variables on having a Myocardial Infarction

VARIABLES	(1) Probit
High Blood Pressure	0.179**
	(0.0842)
Cholesterol	0.275***
	(0.0701)
Diabetes	0.405***
	(0.0839)
Overweight	-0.0287
	(0.0745)
Tobacco Consumption	0.278***
	(0.0836)
Observations	4,703

*Notes: This Table provides the Probit estimates for the effect of these variables on having a Myocardial Infarction. Using the sample of individuals over 40 years old and controlling for individual's age, Catalan Health Regions, visits to the general practitioner and to the emergency room, alcohol consumption, physical activity, education, making ends meet, hours of care work and nationality. Year fixed effects are also included. Standard errors clustered at the Healthcare Management Area level are in parentheses. Significant levels: *** p<0.01, ** p<0.05, * p<0.1.*

Source: *Own elaboration with 2016 and 2017 Catalan Health Interview Survey data.*

In this Probit estimation, we added dummy variables for individuals having the following risk factors: High Blood Pressure, Cholesterol, Diabetes, Overweight or smoking. We can see how the first three variables mentioned and tobacco consumption are significant for every level of confidence, so we are now sure about including them as controls in our two main equations that intend to determine gender discrimination in cardiology.

Regarding being overweight, we find no significance in this first regression. However, we believe that by controlling for more categories within the BMI (underweight, normal weight, etc.) we may find statistical significance for this potential risk factor. So, we will break down this variable and include its categories in our estimations.

Once tested for the independent variables' relevance, we move forward to the presentation of the study results. Table 3 displays estimates from a Probit model applied to equation (1) in three different ways. The main coefficients of interest for our study are the ones from the variable *Female*, as they describe how the probability of visiting the cardiologist changes if the individual is a woman.

Table 3: Effect of biological sex and control variables on the probability of visiting the cardiologist

VARIABLES	(1) Probit	(2) Probit	(3) Probit
Female	-0.128**	-0.189***	-0.367***
	(0.0586)	(0.0699)	(0.0755)
Age 56-70	0.185**	0.236***	0.238**
	(0.0831)	(0.0859)	(0.0948)
Age over 70	0.332***	0.465***	0.514***
	(0.0863)	(0.150)	(0.158)
Medication for HBP	0.0881	0.0811	
	(0.0679)	(0.0716)	
Medication for CHO	0.189***	0.189***	
	(0.0573)	(0.0550)	
Medication for OHD	1.565***	1.588***	
	(0.0806)	(0.0813)	
Medication for DIA	0.149**	0.164**	
	(0.0694)	(0.0723)	
Visited General Practitioner last 12 months	0.427***	0.466***	0.695***
	(0.113)	(0.115)	(0.187)
Emergency Room visits last 12 months	0.0595***	0.0584***	0.102***
	(0.0163)	(0.0182)	(0.0242)
Private Insurance		0.282***	0.316***
		(0.0670)	(0.0918)
Observations	5,118	5,107	2,147
Healthy habits	**NO**	**YES**	**YES**
SE controls	**NO**	**YES**	**YES**

*Notes: This Table provides the Probit estimates for the effect of these variables on the probability of having visited the cardiologist. Columns (1) and (2) use the sample of individuals over 40 years old, and column (3) uses the sample of individuals over 40 years old that take medication for risk factors of heart diseases. Year fixed effects included. Besides from the control variables shown in the table, we have also controlled for the Catalan Health Regions, Body Mass Index, tobacco consumption, alcohol consumption, physical activity, education, making ends meet, hours of care work and nationality. Standard errors clustered at the Healthcare Management Area level are in parentheses. Significant levels: *** p<0.01, ** p<0.05, * p<0.1.*

Source: *Own elaboration with 2016 and 2017 Catalan Health Interview Survey data.*

We can see how these coefficients are significant for the three regressions, which means that there exist gender differences on the probability of visiting the cardiologist. As the coefficients are negative, we can affirm that women have a lower probability of visiting the cardiologist compared to that from men.

In addition, when including healthy habits and socioeconomic controls in the regression (column 2), the probability of females visiting a cardiologist is even lower than in the first model. Eventually, by using the sub-sample of individuals taking medication for risk factors (column 3), all the coefficients are larger in absolute terms than those from the previous two specifications. Therefore, we can conclude that, for women, the probability of visiting the cardiologist is diminished and, among the population with risk factors, it is even lower.

From Table 3, it can also be seen how older people have a greater chance of visiting the cardiologist, as well as people who take medication for cholesterol (CHO), other heart diseases (OHD) and/or diabetes (DIA). Although high blood pressure (HBD) is also considered to be a risk factor for heart conditions, we found that taking medication for it (a highly plausible proxy for suffering it) yields no significant change in the probability of attending a cardiologist.

Visiting a general practitioner or an additional check at an emergency room in the last 12 months, also increases the probability of ending up visiting a cardiologist. Since a referral from a primary care professional is needed to attend to such specialist in the Catalan Public Healthcare System, this finding was expected. Related to this, people who have a private insurance policy, are more likely to visit a cardiologist, potentially because they can access specialized healthcare in the private market with no need for the previous screening from a general practitioner.

Table 4 displays the estimates from a Probit model applied to equation (2). In this case, once again, we are especially interested in the coefficients of the variable *Female*, which will provide us with the intuition whether there really exists gender discrimination or not.

We can observe some differences between the coefficients of the variables in the first two columns, where the main distinction between these two specifications is the inclusion of healthy habits and socioeconomic controls. However, the larger changes are in the third column, where we use the sub-sample of people suffering from at least one risk factor.

The probability of being diagnosed with a Myocardial Infarction (MI) or Other Heart Diseases (OHD) is, once again, lower for women than for men. That can be seen in each of the three columns of the table, but in the third one, the effect of being a woman decreases even more the likelihood of being diagnosed. This suggests that women suffering from at least one of the risk factors are even less likely to be diagnosed than men that are under the same risky conditions.

Table 4: Effect of biological sex and control variables on the probability of being diagnosed with a Myocardial Infarction or another Heart Disease

VARIABLES	(1) Probit	(2) Probit	(3) Probit
Female	-0.261***	-0.288***	-0.315***
	(0.0571)	(0.0682)	(0.0697)
Age 56-70	0.265***	0.244***	0.480***
	(0.0935)	(0.0913)	(0.107)
Age over 70	0.737***	0.650***	0.830***
	(0.0840)	(0.156)	(0.178)
Suffer from HBP	0.296***	0.296***	
	(0.0579)	(0.0594)	
Suffer from CHO	0.145**	0.156**	
	(0.0735)	(0.0731)	
Suffer from DIA	0.147**	0.119*	
	(0.0701)	(0.0716)	
Suffer from VSC	0.146*	0.136*	
	(0.0770)	(0.0796)	
Visited the Cardiologist last 12 months	1.700***	1.713***	1.670***
	(0.0557)	(0.0632)	(0.0792)
Visited General Practitioner last 12 months	0.546***	0.511***	0.520***
	(0.144)	(0.146)	(0.175)
Emergency Room Visits last 12 months	0.0545***	0.0394***	0.0415**
	(0.0137)	(0.0150)	(0.0183)
Private Insurance		-0.116	-0.0251
		(0.0709)	(0.0849)
Observations	5,112	5,101	2,947
Healthy habits	**NO**	**YES**	**YES**
SE controls	**NO**	**YES**	**YES**

*Notes: This Table provides the Probit estimates for the effect of these variables on the probability of being diagnosed a Myocardial Infarction or another Heart Disease. Columns (1) and (2) use the sample of individuals over 40 years old, and column (3) uses the sample of individuals over 40 years old that suffer from high blood pressure and/or cholesterol and/or diabetes and/or varicose veins. Year fixed effects included. Besides from the control variables shown in the table, we have also controlled for the Catalan Health Regions, Body Mass Index, tobacco consumption, alcohol consumption, physical activity, education, making ends meet, hours of care work and nationality. Standard errors clustered at the Healthcare Management Area level are in parentheses. Significant levels: *** p<0.01, ** p<0.05, * p<0.1.*

Source: *Own elaboration with 2016 and 2017 Catalan Health Interview Survey data.*

Age has a positive effect on the prospect of being diagnosed with a MI or OHD, with a substantially higher probability for population over 70 years old in the sub-sample of individuals suffering from any of the risk elements previously stated.

Regarding these risk factors, when used as explanatory variables in columns 1 and 2, we can see how suffering from HBP is the predictor that most increases the probability of being diagnosed. Paradoxically, taking medicine for it has no significant effect on the likelihood of visiting the cardiologist, but it seems that once you visit him/her, it is the risk factor with the highest and most significant effect on the chances of being found a heart disease.

Suffering from cholesterol, diabetes, and/or varicose veins (VSC) also has a positive effect on the probability of being diagnosed, although their impact is not statistically significant for all the levels of significance.

Since cardiologists are the ones diagnosing people suffering a MI or OHD, visiting them should increase the probability of being diagnosed with a CVD, and that is exactly what we see in Table 4. However, due to the Catalan Healthcare System screening process, both attending a general practitioner and having stayed in an emergency room, have been used as controls. From their respective coefficients it can be learned a positive effect on the probability of being diagnosed, especially in the case of visiting the general practitioner, which has a much more relevant impact.

Having a private insurance policy has been proved to be a determining factor to explain the probability of visiting the cardiologist. However, it has no effect on the likelihood of being diagnosed with heart diseases. This means that people with private insurance are likely to have an easier access to the cardiologist, which could increase the probability of being diagnosed. Nevertheless, having private insurance *per se*, does not seem to rise the prospect of being found a heart disease.

6 Discussion

The estimations from our models show that women have a lower probability than men to visit the cardiologist and of being diagnosed with a heart condition. By controlling for the presence of risk factors, use of primary care services, healthy habits and socioeconomic characteristics of the individuals, we are confident to state that the coefficients of interest (those from the variable *Female*) are plausibly close to precisely pick up the causal impact of biological sex on both probabilities. We can affirm, then, that there is gender discrimination in the two approaches, and that consequently, men and women are being treated differently in the context of cardiological illnesses, just because of their sex.

There are some coefficients estimated for other variables in our models that, even though they are not of primary interest for us, we believe they are worth mentioning. First, the different Body Mass Index categories have not shown any significant effects in any of our models. Although the BMI is commonly related to heart complications, as we have stated before, it may not be an independent risk factor.

Tobacco consumption is also considered to be a risk factor for suffering a MI or any Other Heart Disease. However, we see in the results how the estimated coefficients from our models are not significant. It must be said, though, that studies assessing the effect of tobacco in health, tend to design the sample in order to have a group of smokers and a control group of non-smokers. The survey used for our study is not framed in this way, and that could explain our insignificant findings.

In this same regard, neither coefficient related to alcohol consumption is relevant, and only going from no physical activity to doing a medium or high level, actually reduces the probabilities of both visiting the cardiologist and being diagnosed with a heart disease.

In the area of socioeconomic control variables, only achieving secondary education is associated with an increased chance of attending the cardiologist, while make ends meet factors show a significant inverse relationship between economic difficulties and both dependant variables. These results may seem surprising if we assume that those for whom it is easier to face their expenses at the end of each month, are more likely to be private insurance holders. Nevertheless, while potentially having an easier access to the cardiologist (as explained in Section 5), heart pathologies and risk factors may be more extended among the poorer strata of society.

While the majority of the control variables included to estimate equations (1) and (2) yield no significant effects, these variables were introduced to help us capture the true effect of biological sex on both the probability of visiting the cardiologist and being diagnosed with a heart issue. So, this lack of significance does not represent a major source of concern for us.

As gender inequalities are one of the main concerns in today's society, policymakers should consider taking action to close the existing gaps in many different areas between men and women. In the case of our study, we believe it is crucial to start by raising awareness on the gender bias present in the healthcare sector, and more precisely, in cardiology.

From a short-term perspective, launching informational campaigns for the population, so that they are conscious about the differences in causes, symptoms, and treatment of CVD among genders, would be an interesting first step. Moreover, at the level of healthcare professionals, not only cardiologists but also general practitioners, it would be advisable to organize compulsory training sessions in order to give them better-adapted diagnosis and treatment tools to overcome this gender bias, and provide an improved service for women.

Then, to fight this issue from its source, in a long-term perspective, investing in research on how CVD are presented among women, what are their specific risk factors, how to better treat them in terms of prevention, healing, follow up, etc. would be a sensible course of action. In addition, more gender-equal research studies should be presented and taught at medical schools, so that doctors of the future will be better prepared to diagnose and treat women in heart-related issues.

7 Conclusions

Determining gender discrimination is a difficult and tricky task, not only in health or healthcare related issues, but in many other areas. There are lots of factors that enter the equation, most of them related to gender specific characteristics and, in a more important way, social stereotypes that have been constructed throughout human history and are still present to these days.

With this study, we sought to control for as many elements as possible, as simple correlations are often regarded as strong causal relationships in a highly misleading way. After analysing and making use of the data available, we believe that we have obtained estimates which confirm that there is gender discrimination in the access to cardiology specialists and the diagnosis of heart conditions. By considering gender differences in doctor turnout, that could likely have its source in the strongly rooted social norms that still place women at a different level in both the working and family context; and also in the grounds of medical diagnosis, with yet gender-unadapted standards; we have studied gender discrimination in cardiological issues from these two interesting perspectives, to reach the conclusion that highly similar individuals present significantly different outcomes solely because of their gender. These results we believe that could be of high value to society in general and policymakers in particular, as they confirm recurrent trends in gender discrimination and, as stated in Section 6, should incentivise governments around the World to put resources on the provision of better healthcare services for women, both in the short-term and in the long-term.

However, we do believe that we have faced limitations in our study. For example, having access to health-related micro data is quite challenging. Although we could make use of the Catalan Health Interview Survey (*ESCA*), because of how the questions in the questionnaire are set, we had to re-adapt some of the variables provided or make use of less-conventional variables to control for important factors. The use of the *Make ends meet* element is a clear example of this, as we wanted to control for income but it is not asked to the interviewees.

Moreover, when designing our model, we wanted to use registered physicians data to control for the sex of the healthcare professionals, as there is literature that states it is highly significant for patient outcomes (Greenwood, B. N. et al., 2018). However, we were not able to get this information. We claim, though, that future work on our study goal should strongly consider the gender-concordance between healthcare professionals and patients. It could be interesting to see whether men and women physicians are more or less likely to diagnose with a heart disease similarly affected individuals that only differ in their gender, and to try to observe if gender-concordance with their patients plays any significant role.

Finally, we also believe that, in 10 years' time, a study similar to this could be conducted again in order to see how the findings from our research have evolved over time. Will gender discrimination still be present in cardiology? Will actions have been taken to close some of the existing gaps? Only time will tell.

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