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Gender Inequalities in Coronary Heart Disease Treatment in Portugal

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Abstract

Cardiovascular disease develops at a later age for women and may have different symptoms than the classic textbook examples, which are often based on men's experiences. Women are also often underrepresented in medical trials for new drugs and devices. These and other factors lead to the under-recognition of heart disease among women and often less effective examinations, preventive action, and treatments ordered by doctors for the patients. This thesis uses administrative data on all discharges of patients admitted with coronary heart disease (CHD) from all National Health Service hospitals in Portugal, over the period from 2002 to 2015. It applies logistic regression models to document gender inequalities in treatment for CHD and explores three theories that may explain those inequalities. The results clearly show that a gender gap against women exists in treatment for CHD in Portugal. This is true for any type of in-hospital treatment and is especially pronounced for patients admitted through the emergency department. The gender gaps observed do not decrease until 2015. Moreover, women are more likely to die at the hospital than men, regardless of the treatment chosen for them.

Keywords: Gender Inequalities, Innovative Treatments, Cardiac Heart Disease

Introduction

The book Invisible Women: Exposing Data Bias In A World Designed For Men, written by Caroline Criado Perez, exposes how women are treated differently than men in many different regards. In healthcare, women have been repeatedly underrepresented in drug trials and as patient subjects in medical education and training. This leads for example to new drugs and medical devices not being well-tailored to women, or misinterpretations of women's symptoms by doctors.

Cardiovascular disease develops a few years later in women than in men and is considered to be the major cause of female deaths. For example in the United States, heart disease accounted for 300,000 female deaths in 2017, or about 1 in every 5 female deaths (Centers for Disease Control and Prevention, 2020). Doctors and patients often underestimate the risk of cardiovascular disease in women due to the misperception that women are naturally 'protected' against cardiovascular disease. The under-recognition of cardiovascular disease and differences in the clinical presentation of its symptoms in women leads to a lower representation of women in clinical trials as well as less preventive/aggressive treatment strategies (Maas & Appelman, 2010).

This thesis documents the gender inequalities in treatment for Coronary Heart Disease (CHD) in Portugal between the years 2002 and 2015, exploring three propositions regarding what might explain those inequalities against women: (1) more difficult detection, (2) perception of more difficult recovery from treatment, and (3) lower willingness to be treated.

This thesis is organized as follows: next, a Background section explains what is CHD and based on a literature review describes the theories that might explain gender differences in treatment. That is followed by the Data and Methods sections. The Results section then presents the results of the statistical analyses. The Discussion section reflects on results and compares them with prior literature. The final section draws some conclusions and recommendations.

Background

CHD is known to be the type of cardiovascular disease that is the leading cause of death in the world. CHD typically arises as a result of plaque build-up within the lining of coronary arteries. The presence of this substance in high levels in the arteries of the heart, also known as atherosclerosis, prevents these blood vessels from delivering oxygen-rich blood to the heart. Some of the most common risk factors of CHD include hypertension, high blood cholesterol, age, diabetes, obesity, genetics, inactivity, tobacco consumption, and an unhealthy diet (Cuffari & Benedette, 2020).

Recent studies have shown gender differences in CHD risk factors. The menopause transition is associated with a worsening CHD risk profile. Bodyweight often increases after menopause, which may lead to obesity or the development of type 2 diabetes. Women with diabetes are more likely to develop cardiovascular complications than men. The reason for this is multifactorial and related to a heavier risk factor burden, including inflammatory factors, smaller vessel size of the coronary arteries, and often less aggressive treatment of diabetes in women. Moreover, the systolic blood pressure rises more steeply with age for women than for men. Hypertension often starts in the menopausal transition period and can cause a variety of symptoms, such as chest pain, palpitations, headaches, and even hot flashes. These symptoms may be wrongfully attributed to the menopausal transition and lead to untreated high blood pressure. It is also possible to mistake these symptoms with symptoms of cardiac disease. Women with a history of hypertension in pregnancy are also at increased risk for hypertension and premature cardiovascular disease later in life. For these and other reasons, cardiovascular disease is the major cause of death in women and is still under-recognized and undertreated (Maas & Franke, 2009). A study on the impact of coronary diseases on women, their risk assessment, and unique sex-specific CHD characteristics shows that despite obesity prevalence being almost the same for men and women, it has a greater impact on the development of CHD in women. The consequences of this disease are also worse for women, with higher mortality rates, and the likelihood of having heart failure within 5 years of myocardial infarction. Contrary to the linear increase in CHD in men with age, for women after the age of 60, this increase has rather exponential growth. The presence of diabetes among women, the hormonal changes that occur over women's lives, and autoimmune diseases are more prevalent in women and they contribute to higher risk factors for women than they do for men (Ramachandran, Wu, He, Jiang & Wang, 2016).

There are at least three theories that could explain differences in treatment for CHD between women and men (Perelman et al., 2010). The first theory is that CHD is more difficult to be detected in women. Despite CHD being the leading cause of morbidity and mortality in women, it is often under-recognized as women perceive that the major killer is cancer and that CHD is a male disease (Woodward, 2019). Thus, detecting CHD in women can be more difficult due to several differences in CHD symptom presentation. According to Richards et al. (2000), symptoms of CHD are less frequently detected at early stages in women than in men, either due to patients' characteristics at presentation or to physicians' bias. It is also suggested that women may exhibit more diffuse or atypical symptoms than men and that this induces differences in primary care physician referral for non-invasive tests (Philpott et al., 2001). Richards et al. (2000) found out that men are more likely to present with chest pain than women and are more likely to receive a provisional general practitioner diagnosis of CHD. A study conducted in Australia found that women attending primary healthcare services were less likely than men to have risk factors measured and recorded, such that absolute cardiovascular disease risk could be assessed. For those with, or at high risk of, cardiovascular disease, the prescription of appropriate preventive medications was more frequent in older women, but less frequent in younger women, compared with their male counterparts (Hyun et al., 2017). In an experimental study, Arber et al. (2006) analyzed the behavior of primary care doctors and their diagnosis based on four patient characteristics presented to them on videotapes. Interestingly, in the experiment, the gender of patients had a significant influence on doctors' diagnostic and management decisions. Female patients received fewer questions, poorer examination and were also ordered fewer tests for CHD. Doctors' behavior in this study suggests that their actions may contribute to gender inequalities in health care. Another potential issue is the accuracy of diagnostic tests and outcomes following an intervention, as women have been repeatedly underrepresented in CHD clinical trials (Rollini et al., 2009).

The second theory considers the increased difficulty in recovery for women. This theory comes from the fact that women's coronary arteries are narrower than those of men and therefore, more difficulties could arise during and following surgery or other types of treatment. Alternatively, Redberg (2005) suggests that the discrepancies in treatment are not due to the patient's ability to recover but rather to the physician's perceptions about this ability. This may lead them to make judgments about their patients that in reality are not related to risk assessment. Traditional risk factors for CHD and complications after CHD treatment are the same for women and men; however, differences in prevalence and impact of those risk factors vary between the sexes. For example, women who have acute coronary syndrome or CHD are generally older and have more comorbidities, including higher prevalence of hypertension, dyslipidemia, diabetes, heart failure, and atrial fibrillation that independently decrease survival (Berger et al., 2006; Udell et al., 2017).

The third and last theory is that women have a lower willingness to undergo CHD treatment. This idea could be potentially proven by a lower number of women admitted to hospitals, especially through planned admission. A potential explanation for the denial of treatment among women can be gender-related referral bias. As mentioned, women with CHD experience different or more vague symptoms than men resulting in less frequent referral for non-invasive testing (Berger et al., 2006). Multiple studies in the last decades have also shown that women, in general, have a lower awareness of possible treatments for their diseases, including CHD. One study has reviewed the literature on awareness, knowledge, and healthy lifestyle behaviors to CHD among women. Findings indicated that women under the age of 45 were more likely to cite breast cancer as the leading cause of death (LCOD) compared to older women who were more likely to name heart disease as the LCOD (Ramachandran, Wu, Kowitlawakul & Wang, 2016). Moreover, although women may be able to identify risk factors, they were less informed about their prevention and most women are often unsure of which foods to avoid or consume to prevent CHD. Additionally, though some women believed a lack of exercise as contributing to CHD, they believed ‘keeping one's mind busy and participating in family and social activities to be examples of staying active, as opposed to regular physical exercise (Lefler et al., 2013). Other studies have also revealed that certain risk factors were less known among women. Across several studies that identified individual risk factor knowledge levels, diabetes was the dominant risk factor that participants failed to recognize in association to CHD, followed by hyperlipidemia and hypertension (Arslanian-Engoren, 2007; Crouch & Wilson, 2011; Gholizadeh et al., 2009, McDonnell et al., 2013; Haidinger et al., 2012; McKenzie and Skelly, 2010). Overall, many studies from all geographies document deficient knowledge not only about cardiovascular disease risk factors, but also about the true risk of developing the disease, about the symptoms, and about the available treatments (Lange et al., 2009; Gholizadeh, Salamonson, Worrall-Carter, DiGiacomo & Davidson, 2009). What's more, the knowledge gap is related to socioeconomic factors like income, education, employment, as well as age (Haidinger et al., 2012; Ramachandran, Wu, He, Jiang & Wang, 2016).

In Portugal, Perelman et al. (2010) found that gender differences in high technology diagnosis procedures and treatments for CHD are favoring male patients. The gender gaps remained stable over the 2002-2006 period that the authors analyzed. They found that the gender differences appear to be worse for women before detection of acute myocardial infarction (AMI) and when admitted to the hospital through the emergency unit. This suggests that gender differences are higher among patients diagnosed with CHD before any acute episode. Women are more likely to die during their hospital stay, in particular after treatment. The present thesis updates the study of Perelman et al. (2010) until 2015 and considers more recent treatments that appeared in the healthcare market since then.

Data

This study uses administrative data on discharges of all 434,870 patients who were admitted with CHD from all National Health Service (NHS) hospitals in Portugal over the period from 2002 to 2015. The study relies on information available in the dataset on patients' gender and age, grouped into 18 – 54, 55 – 64, 65 – 79, and 80 – 100 years old age groups. In addition to this, using comorbidity information coded by physicians based on patients' symptoms and diagnoses, we construct the Charlson Comorbidity Index (CCI). The CCI captures the level of comorbidities in increasing severity; it is widely accepted as a predictor of patient prognosis and healthcare expenditure (Charlson et al., 2014). The study considers also two additional variables: AMI, which identifies patients who were admitted with acute myocardial infarction (1) or not (0), and URG, which specifies whether the patient was admitted to the hospital through planned admission (0) or the emergency department (1).

The dependent variables capture whether patients received each of five innovative treatments for CHD. These treatments constitute an update to the treatments considered by the older Portuguese study by Perelman et al. (2010).

The first treatment variable (**EP/CB**) identifies whether the patient received embolic protection and coronary brachytherapy. Embolic protection devices (EPDs) prevent or restrict plaque debris from entering the distal bed and therefore have the potential to reduce adverse clinical events (Bangalore, & Bhatt, 2014), while brachytherapy is a coronary procedure that consists of radiation, that stuns or kills some of the cells causing restenosis (Cleveland Clinic 2021). The next one (**BMS**) captures whether the patient received a bare-metal stent that acts as self-expanding scaffolding and is used extensively in cardiology to maintain coronary artery patency (Mayo Clinic 2021). A drug-eluting stent, which is coded under the variable **DMS**, is the most common type of stent used to treat a blockage of the heart arteries. Many people with heart problems have been successfully treated with drug-eluting stents, preventing the need for more invasive procedures, such as coronary artery bypass (Mayo Clinic 2021). The fourth dependent variable stands for coronary artery bypass graft (**CABG**) surgery, which is a procedure used to treat coronary artery disease (Johns Hopkins Medicine 2021), and percutaneous ventricular support devices that maintain partial or total circulatory support in case of severe ventricular failure (Windecker, 2007). The last dependent variable (**THRMB**) indicates a procedure called thrombolysis which is used to break up abnormal blood clots that restrict blood flow in veins and arteries (Johns Hopkins Medicine 2021).

I consider a sixth dependent variable which is inpatient mortality, i.e. whether the patient died while at the hospital. Lastly, the study uses the information on the year of admission, to evaluate how the availability of the treatments changed over time and investigate the evolution of gender inequalities in treatment.

Methods

This study uses logistic regression to understand the relationship between gender and the likelihood of receiving each of five innovative treatments for CHD or dying at the hospital. First, I estimate five separate logistic regression models, for each treatment, controlling for comorbidities (CCI), age group, as well as the year of admission. Records on EP/CB and DES start in 2006, as previously the corresponding treatments were not available. Therefore, previous years are removed from the regressions for these two treatments.

Then, I rerun all five models, dividing the sample into patients admitted with and without AMI. This analysis indirectly tests the first theory, i.e., we observe whether gender differences are larger prior to the detection of acute disease.

Additionally, the models were rerun by dividing the patients into the ones admitted through emergency and planned departments. This analysis provides some insight into women's willingness to be treated (third theory). A greater gender gap for emergency admissions may reflect a greater reluctance to undergo diagnosis or treatment procedures, while the patient can still decide.

To present how gender inequalities in treatment evolved over time, all the models were also rerun year by year.

Lastly, the analysis of inpatient mortality explores women's more difficult recovery after equal treatment (second theory).

Results

Summary statistics

The general comparison of use variables for women and men in the dataset is presented in Table 1. From the descriptive statistics, we can see that first of all, there are more than two times more men admitted to hospitals for CHD than women. Moreover, the average age of female patients is at least 6 years older than male ones. The average value of CCI is higher for women, indicating generally more complicated cases. The percentage of patients admitted with AMI or through emergency admission is higher for women than it is for men. Additionally, we observe a smaller percentage of women receiving every treatment than men. The inpatient mortality rate is also slightly higher for women than it is for men, with a higher standard deviation.

Table 1. Summary statistics by gender

	Men					**Women**				
	#		%			#		%		
Patients	293673		0.68			141197		0.32		
	#	mean	std	min	max	#	mean	std	min	max
Age		65.0417	11.8966	19	100		71.3153	11.7315	18	100
AMI	113693	0.3871	0.4871	0	1	60510	0.4286	0.4949	0	1
URG	160538	0.5467	0.4978	0	1	88018	0.6234	0.4845	0	1
Death	11525	0.0392	0.1942	0	1	10086	0.0714	0.2575	0	1
CCI		0.9535	1.3029	0	16		1.0825	1.4248	0	18
EP/CB	62950	0.2144	0.2144	0	1	21526	0.1525	0.3595	0	1
BMS	47972	0.1634	0.3697	0	1	16210	0.1148	0.3188	0	1
DES	44851	0.1527	0.3597	0	1	14936	0.1058	0.3076	0	1
CABG	21895	0.0746	0.627	0	1	5735	0.0406	0.1974	0	1
THRMB	8146	0.0277	0.1642	0	1	2530	0.0179	0.1327	0	1

All differences in means/proportions by gender are statistically significant at the 1% significance level.

Main results

Over the entire 2002 -2015 period, women have a significantly lower likelihood of undergoing any of the five innovative treatments (odds ratios significantly below one in the first line in Table 2). For example, for CABG, women are only about half as likely as men to receive the treatment. For DES, women are 0.76 times as likely as men to receive the treatment. Regarding the control variables, in general, and as expected, the likelihood of receiving treatment decreases with severity of comorbidities (CCI) and with age, as these make treatments riskier. The exceptions are THRMB, where the likelihood of receiving the treatment increases with CCI, and CABG, where the likelihood of receiving the treatment is higher in the 55-64 and 64-79 age groups than in the <55 age group. An indication for THRMB appears when other treatments cannot be carried out. It is not usually a recommended treatment but a higher CCI is likely to cause that it is the only remaining option. Also, women generally develop CHD at a later age than men do, and therefore the disease is diagnosed later as well. At that point in time, women often already have multivessel heart disease, which is a direct indication to carry out CABG over other types of treatments.

The interpretation of the odds ratios associated with the year dummies must be done carefully because it reflects the availability of treatments on top of any other trends. For example, the (very) large odds ratios for EP/CB and DES are mostly due to the treatments only becoming available later in the year 2006, which implies few treatments performed in 2006 (the reference year in these two models).

Table 2: Logistic regression results for all patients (odds ratio with 95% confidence intervals)

	EP/CB (95% CI)	**BMS** (95% CI)	**DES** (95% CI)	**CABG** (95% CI)	**THRMB** (95% CI)
female	0.7273 (0.7138, 0.7412)	0.7199 (0.7058, 0.7344)	0.7645 (0.7485, 0.7809)	0.5755 (0.5583, 0.5933)	0.7228 (0.6900, 0.7573)
cci	0.9497 (0.9438, 0.9556)	0.9588 (0.9518, 0.9659)	0.9124 (0.9057, 0.9192)	0.949 (0.9391, 0.9590)	1.2396 (1.2252, 1.2542)
55 – 64 yo	0.7812 (0.7616, 0.8012)	0.811 (0.7908, 0.8317)	0.8275 (0.8056, 0.8501)	1.3976 (1.3448, 1.4524)	0.6358 (0.6024, 0.6710)
65 – 79 yo	0.6251 (0.6108, 0.6398)	0.686 (0.6703, 0.7020)	0.6373 (0.6216, 0.6534)	1.3457 (1.2984, 1.3947)	0.5077 (0.4834, 0.5332)
80+ yo	0.4222 (0.4093, 0.4356)	0.4822 (0.4665, 0.4984)	0.3455 (0.3330, 0.3584)	0.4247 (0.3992, 0.4517)	0.2768 (0.2555, 0.2998)

year 2003	-	1.5462 (1.4784, 1.6172)	-	0.9231 (0.8659, 0.9842)	1.2748 (1.1795, 1.3778)
year 2004	-	1.8737 (1.7932, 1.9578)	-	0.9282 (0.8707, 0.9896)	1.0934 (1.009, 1.1849)
year 2005	-	2.2859 (2.1890, 2.3872)	-	0.9988 (0.9373, 1.0643)	0.8859 (0.8136, 0.9645)
year 2006	-	2.1132 (2.0234, 2.207)	-	1.0528 (0.9892, 1.1206)	0.8308 (0.7625, 0.9052)
year 2007	118.5851 (75.4884 186.2861)	1.2854 (1.2298, 1.3436)	3.7078 (3.4401, 3.9963)	0.8218 (0.772, 0.8748)	0.6547 (0.6001, 0.7142)
year 2008	368.9399 (235.1062, 578.9583)	1.1209 (1.0717, 1.1724)	4.6722 (4.3409, 5.0287)	0.779 (0.7315, 0.8295)	0.5137 (0.4685, 0.5633)
year 2009	529.4393 (337.412, 830.7528)	0.9795 (0.9348, 1.0263)	6.2191 (5.7823, 6.6889)	0.8219 (0.7713, 0.8758)	0.4346 (0.3937, 0.4798)
year 2010	727.0354 (463.3712, 1140.728)	0.9333 (0.8901, 0.9787)	7.3311 (6.8189, 7.8817)	0.7798 (0.7309, 0.8319)	0.3924 (0.3542, 0.4346)
year 2011	829.0995 (528.4256, 1300.857)	1.1191 (1.0684, 1.1721)	7.4159 (6.8969, 7.9739)	0.8208 (0.7695, 0.8754)	0.3439 (0.3088, 0.383)
year 2012	840.5854 (535.7419, 1318.889)	0.9622 (0.9174, 1.0092)	8.844 (8.2286, 9.5054)	0.8256 (0.7739, 0.8809)	0.3152 (0.2822, 0.3521)
year 2013	948.3611 (604.4522, 1487.94)	0.6913 (0.6572, 0.7272)	11.2791 (10.5018, 12.114)	0.8346 (0.7827, 0.8898)	0.2354 (0.2085, 0.2658)
year 2014	920.5185 (586.7032, 1444.264)	0.4586 (0.4336, 0.4851)	12.7479 (11.8719, 13.6885)	0.8268 (0.7753, 0.8817)	0.1915 (0.168, 0.2184)
year 2015	956.0955 (609.3823, 1500.074)	0.2976 (0.2792, 0.3173)	14.7831 (13.7706, 15.8701)	0.7563 (0.7083, 0.8076)	0.1354 (0.1164, 0.1575)

Subgroup analyses

With the exception of EP/CB, the gender gaps in treatment do not differ between patients admitted with or without AMI, as the confidence intervals overlap (Table 3). For EP/CB, the gender gap is higher among patients with AMI (lower odds ratios); the difference is statistically significant but not very large in practical terms.

Regarding the type of admission, the gender gaps in EP/CB, BMS, and DES are higher among patients admitted through the emergency department (i.e., significantly lower odds ratios). For CABG, the opposite is true. For THRMB, the gender gap is not statistically different between patients with emergency or planned admission. This could be potentially explained by the fact that women who are admitted to the hospital by appointment are mostly getting treatments for their existing heart problems with the main goal of preventing acute events (EP/CB, BMS, or DES). However, when they are admitted through the emergency units, they are probably in an acute situation and may have to get CABG surgery.

The likelihood of getting any of the five treatments remains much lower for women than it is for men across the entire period considered. Comparing 2015 with the first year that the treatment is available does not provide any evidence of decreasing gender gaps as the confidence intervals overlap.

Table 3: Logistic regression results by subgroups (odds ratios with 95% confidence interval)

	EP/CB (95% CI)	**BMS** (95% CI)	**DES** (95% CI)	**CABG** (95% CI)	**THRMB** (95% CI)
All Cases	0.7273 (0.7138, 0.7412)	0.7199 (0.7058, 0.7344)	0.7645 (0.7485, 0.7809)	0.5755 (0.5583, 0.5933)	0.7228 (0.6900, 0.7573)
Type of diagnosis					
Patients without AMI (0)	0.7395 (0.7209, 0.7585)	0.7252 (0.7054, 0.7456)	0.772 (0.7509, 0.7938)	0.5721 (0.5538, 0.591)	0.7709 (0.6748, 0.8806)
Patients with AMI (1)	0.6912 (0.6711, 0.7119)	0.708 (0.6876, 0.7289)	0.7525 (0.7278, 0.7781)	0.644 (0.5884, 0.7049)	0.7273 (0.6911, 0.7654)
Type of admission					
Planned Admission (0)	0.7664 (0.7461, 0.7872)	0.7914 (0.7663, 0.8174)	0.8015 (0.7783, 0.8253)	0.5971 (0.5762, 0.6187)	0.7394 (0.5996, 0.9119)
Emergency admission (1)	0.706 (0.6873, 0.7252)	0.6953 (0.6779, 0.7132)	0.7476 (0.7249, 0.7711)	0.6754 (0.6339, 0.7197)	0.6878 (0.6554, 0.7217)
Year of admission					
2002	-	0.6968 (0.6424, 0.7559)	-	0.5972 (0.5359, 0.6656)	0.6592 (0.5719, 0.7599)
2003	-	0.7146 (0.6669, 0.7657)	-	0.5991 (0.5361, 0.6695)	0.7672 (0.6793, 0.8665)
2004	-	0.6865 (0.6432, 0.7328)	-	0.615 (0.5500, 0.6876)	0.7854 (0.6894, 0.8948)
2005	-	0.7084 (0.6655, 0.7541)	-	0.6075 (0.5443, 0.6781)	0.7447 (0.6417, 0.8642)
2006	0.9620 (0.3405, 2.7178)	0.7396 (0.6944, 0.7877)	0.8253 (0.7059, 0.9650)	0.6056 (0.544, 0.6741)	0.7354 (0.6313, 0.8568)
2007	0.7999 (0.7269, 0.8801)	0.7251 (0.6782, 0.7751)	0.7921 (0.7305, 0.8589)	0.6406 (0.5756, 0.7129)	0.7588 (0.6487, 0.8876)

2008	0.7232 (0.6796, 0.7696)	0.7098 (0.6623, 0.7607)	0.8032 (0.7467, 0.8639)	0.5,447 (0.4864, 0.6099)	0.6445 (0.5384, 0.7714)
2009	0.7662 (0.7236, 0.8113)	0.7499 (0.6962, 0.8078)	0.7934 (0.7413, 0.8491)	0.622 (0.5565, 0.6950)	0.7331 (0.6045, 0.8890)
2010	0.7044 (0.6671, 0.7437)	0.7108 (0.6579, 0.768)	0.7625 (0.7138, 0.8146)	0.5984 (0.5328, 0.67210	0.6342 (0.5138, 0.7829)
2011	0.7231 (0.6856, 0.7626)	0.737 (0.6854, 0.7925)	0.7449 (0.697, 0.7961)	0.5049 (0.4476, 0.5696)	0.5926 0.4713, 0.7451)
2012	0.7182 (0.6806, 0.7579)	0.7318 (0.6771, 0.7909)	0.7831 (0.7349, 0.8345)	0.5227 (0.4633, 0.5898)	0.7845 (0.6267, 0.9821)
2013	0.7534 (0.7153, 0.7936)	0.8137 (0.7468, 0.8866)	0.7621 (0.7186, 0.8082)	0.5185 (0.4601, 0.5842)	0.9303 (0.7271, 1.1902)
2014	0.7377 (0.7003, 0.7772)	0.7171 (0.6461, 0.7959)	0.79 (0.7465, 0.8360)	0.5382 (0.4783, 0.6057)	0.5832 (0.4301, 0.7910)
2015	0.6784 (0.6440, 0.7146)	0.7514 (0.6623, 0.8525)	0.6897 (0.6526, 0.7288)	0.5313 (0.4695, 0.6012)	0.6447 (0.4590, 0.9056)

Only the odds ratios for the variable female are shown. All models control for comorbidities, age, and year.

In-hospital mortality

According to the model for in-hospital mortality among all patients, as expected, women are much more likely to die than men, with the 95% confidence interval strictly above one (Table 4). Moreover, the odds ratios when considering only the patients receiving each treatment are significantly above one, with the highest for THRMB where almost 2 women die for every man who dies after getting the procedure. This observation is in line with the theory that doctors perceive women to have more difficult recovery from treatment (theory 2).

Table 4: Logistic regression results for inpatient mortality (odds ratios with 95% confidence intervals)

	5%	95%	Odds Ratio
all admissions	1.191	1.2637	1.2268
by treatment			
EP/CB	1.2398	1.5321	1.3782
BMS	1.2161	1.5347	1.3662
DES	1.2709	1.75	1.4913
CABG	1.1312	1.576	1.3352
THRMB	1.5223	2.0973	1.7868

Only the odds ratios for the variable female are shown. All models control for comorbidities, age, and year.

Discussion

This study documents significant gender differences in the likelihood of receiving five innovative treatments for CHD in Portugal that favor men. Such gender gaps do not seem to fade over the 2002 - 2015 period.

Concerning the first theory that could explain such gender differences — CHD being more difficult to detect in women, which could lead doctors to start diagnosis and preventive treatments with a delay— results show that women are about equally disadvantaged whether they are admitted with or without AMI. So, there is no evidence that inequalities are larger prior to the detection of acute disease.

More than 62% of all female patients in the dataset get to the hospital through emergency rather than planned admission. For EP/CB, BMS, and DES, results indicate a larger disadvantage among women admitted through the emergency department. The opposite is true for CABG. This suggests potentially greater reluctance to be diagnosed and treated when the patient's decision still plays a role (theory 3).

Patients at risk of CHD can be identified, and primary care physicians and nurses are capable to enhance the awareness of the prevalence of CHD. They can guide education about primary and secondary preventive measures to empower such women to make healthy lifestyle changes to stop the disease progression, in turn helping to reduce health disparities in women. There is still a lot of research required among less investigated populations to scrutinize the awareness and knowledge related to CHD in order to determine the barriers as well as assistance for the personalization of CHD risk and getting the broad adoption of preventive action. Such research would improve the identification and subsequent management of CHD risk factors and help tackle the number one killer of women globally (Ramachandran, Wu, Kowitlawakul & Wang, 2016).

Cabral & Dillender (2021) document a significant gender gap where women are less likely to be assessed as disabled and receive cash benefits than their male counterparts with the same observable characteristics. Interestingly, their analysis indicates that being assessed by a female doctor increases the chance of being deemed eligible for disability pensions and cash benefits for patients, while with little impact on male patients. They suggest that policies for increasing the proportion of doctors who are female and increasing gender homophily in patient-doctor matches could increase the incidence of female physicians evaluating women patients and decrease the current gender gap in medical healthcare.

The second theory suggests that women may experience more difficulties when recovering from treatment, leading doctors to postpone any type of treatment until it is extremely necessary. Such discrepancy in the “timing” of treatments for women and men could be reflected in an increased rate of mortality following treatment for women. Results in this study show that indeed, women are much more likely to die following admission for CHD and treatment for CHD than men.

Because of the older age, at which CHD develops among women, it is also possible that they are admitted with additional co-existing diseases like hypertension, high blood cholesterol, diabetes, or obesity, which may explain the higher mortality. These factors also may explain why detection can be more difficult in such situations (theory 1) as well as why symptoms that occur because of CHD may be more easily ignored by patients, who may be unaware of them or assign them to other coexisting health problems (related with theory 3). Although the regression models control for age and comorbidities, it is possible that the available controls are not fully exhaustive to account for all the relevant confounding factors.

Overall, this study confirms the gender differences in medical treatment presented in numerous studies before. Results are mostly in line with those of Perelman et al. (2010), despite the different procedures considered. These gender inequalities, according to the studies cited above, are likely to arise also due to subconsciously incorrect decision of doctors concerning the examination as well as the treatment order. This explanation was not originally considered in this analysis due to the missing data but it is a significant subject necessary to be explored further.

The main limitation of this study is lacking information on clinical and patient characteristics (e.g., primary care records, health behaviors, socioeconomic background). It complicates or even makes it impossible to find causal effects or to separate the various underlying mechanisms for observed gender differences. Thus, despite administrative data allowing to make analysis on a larger sample, qualitative interviews or clinical cases could be a valuable input. Another difficulty appears as it is not possible to see how the patient was treated before the admission (e.g. in primary care) or what happens afterward (e.g. post-discharge mortality).

Restrictive gender norms affect everybody. Gender inequalities are a bad determinant of human health because they lead to excess mortality and morbidity on a large scale worldwide. Multiple studies have presented that gender equality in science, medicine, and global health has the potential to lead to substantial health, social, and economic gains. Diversified workplaces improve productivity, innovation, decision making, and even employee retention or overall satisfaction. Thus, a gender-diverse medical workforce should also translate into improved patient outcomes (Shannon et al., 2019). A study investigating mortality of female patients with AMI found higher mortality in women treated by male doctors than in those treated by female doctors (Greenwood, Carnahan & Huang, 2018). There is also emerging evidence of beneficial differences in the way female doctors practice, leading to lower patient morbidity and mortality (Wallis et al., 2017). Another study on Canadian patients with female primary care physicians had presented more consistently received recommended health screening and had fewer emergency department visits than those treated by male primary care physicians (Ali, Subhi, Ringsted & Konge, 2015).

This study documents substantial gender inequalities against women in treatment for CHD, a disease with one of the largest morbidity and mortality burdens globally. It is not controversial to say that a big change should be done with and within societies to decrease the gender gap in the health industry and healthcare access. Gender Equality is one of the 17 sustainable development goals and it has to be enforced as gender inequalities lead not only to worsening economic or business outcomes but above all lead to life-threatening situations.

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