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Picturing Prevalence and Inequalities in Cancer Screening Attendance to Population-Based Programs in Portugal

Retrato da Prevalência e Desigualdades na Participação em Rastreios Oncológicos de Base Populacional em Portugal

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ABSTRACT

Introduction: Screening is effective in reducing cancer-related morbidity and mortality. The aim of this study was to analyze the level of, and income-related inequalities in, screening attendance, in Portugal for population-based screening programs.

Methods: Data from the Portuguese Health Interview Survey 2019 was used. Variables included in the analysis were self-reported: mammography, pap smear test, fecal occult blood test. Prevalence and concentration indices were computed at national/regional level. We analyzed: up-to-date screening (within recommended age/interval), under-screening (never or overdue screening), and over-screening (due to frequency higher than recommended or screening outside target group).

Results: Up-to-date screening rates were 81.1%, 72%, and 40%, for breast, cervical and colorectal cancer, respectively. Never-screening was 3.4%, 15.7%, and 39.9%, for breast, cervical, and colorectal cancer, respectively. Over-screening related with frequency was highest for cervical cancer; in breast cancer, over-screening was observed outside recommended age, affecting one third of younger women and one fourth of older women. In these cancers, over-screening was concentrated among women with higher income. Never-screening was concentrated among individuals with lower income for cervical cancer and higher income for colorectal cancer. Beyond the recommended age, 50% of individuals never underwent screening for colorectal cancer and 41% of women never underwent screening for cervical cancer.

Conclusion: Overall, screening attendance was high, and inequalities were low in the case of breast cancer screening. The priority for colorectal cancer should be to increase screening attendance.

Keywords: Early Detection of Cancer; Mass Screening; Neoplasms/diagnosis; Neoplasms/prevention and control; Portugal; Socioeconomic Factors

RESUMO

Introdução: Os rastreios reduzem a morbilidade e mortalidade associadas ao cancro. O objetivo deste estudo foi analisar os níveis de participação em rastreios oncológicos de base populacional em Portugal, e respetivas desigualdades.

Métodos: Os dados provêm do Inquérito Nacional de Saúde 2019. As variáveis utilizadas são: mamografia, citologia e a pesquisa de sangue oculto nas fezes. Calculámos prevalências e índices de concentração ao nível nacional e regional. Analisámos a participação 'devida' (idade/intervalo recomendados), 'insuficiente' (nunca ou em atraso), 'excessiva' (frequência superior à recomendada ou em idade não recomendada).

Resultados: A participação 'devida' atingiu 81,1%, 72% e 40%, enquanto a participação 'insuficiente-nunca' atingiu 3,4%, 15,7% e 39,9% para cancro da mama, cancro do colo do útero e cancro colorretal, respetivamente. A prevalência de participação 'excessiva' foi mais alta no cancro do colo do útero; relativamente ao cancro da mama, um terço das mulheres mais novas e um quarto das mulheres mais velhas fez mamografia. Este 'excesso' está concentrado nas mulheres com rendimento mais elevado. A participação 'insuficiente-nunca' está concentrada nos indivíduos com rendimentos mais baixos no cancro do colo do útero e nos rendimentos mais altos no colorretal. Acima da idade recomendada, 50% dos indivíduos nunca rastrearam para cancro colorretal e 41% das mulheres nunca o fizeram para cancro do colo do útero.

Conclusão: No rastreio do cancro da mama, no geral, a participação foi elevada e as desigualdades foram reduzidas. No cancro colorretal, a prioridade deve ser aumentar a participação no rastreio.

Palavras-chave: Deteção Precoce de Cancro; Factores Socioeconómicos; Neoplasias/diagnóstico; Neoplasias/prevenção e contolo; Portugal; Rastreio

INTRODUCTION

In Portugal, colorectal cancer (CRC) is the most frequent cancer (10 501 new cases in 2020) when considering both men and women combined. It is surpassed by prostate cancer in men, and breast cancer in women. In 2020, there were 7041 new cases of breast cancer and 1238 new cases of cervical cancer (fifth most frequent among women[1]). For CRC, the estimated age-standardized mortality rates (per 100 000) in Portugal in 2020 are 18.6 and 8.8 for men and women, respectively, which compare with 16.1 and 9.5 in Europe. Regarding breast and cervical cancers, in Portugal, the estimated age-standardized mortality rates (2020) are 12.7 and 3.2, respectively. These figures compare with 14.8 and 3.8 in Europe.[1]

Several studies have shown that screening people of average risk is effective in reducing cancer-related morbidity and mortality for CRC[2] as well as for breast and cervical cancers.[3,4] Since 2003, the Council of the European Union has recommended the implementation of population-based screening programs (individuals within target groups are systematically

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tested) for breast, cervical, and colorectal cancers.[5] In Portugal, there are population-based screening programs for only these three cancers, although the implementation of the programs has varied depending on cancer type and region. In mainland Portugal, the earliest programs that were implemented were breast and cervical cancer screening in the Center region (1990) and the latest programs, implemented in 2017, were CRC screening in Lisbon and the Algarve, as well as cervical cancer screening in Lisbon.[6,7] In Madeira, only in 2022 did CRC screening change from opportunistic (where participation in screening follows from recommendation made by healthcare professionals or the individuals' own choice) to a population-based program.[8] In the Azores, CRC screening was also the latest program implemented (2019), in two islands (S. Jorge and Graciosa).[9]

Screening guidelines were updated in 2017 by the Ministry of Health, with the main aim of homogenizing the criteria followed by health regions.[10] For CRC, the primary screening test is the fecal immunochemical test (FIT), every two years, for individuals aged 50 to 74 years old; colonoscopy should be performed in cases with a positive FIT. For breast cancer, the recommendation is for women aged 50 to 69 years old to undertake a mammography biannually. For cervical cancer, the target group is women aged 25 to 60 years old; the interval of screening is five years with the human papillomavirus (HPV) test.

Previous evidence suggests that population-based programs, as opposed to opportunistic ones lead to higher attendance rates[11] and lower levels of inequality.[12] According to the World Health Organization (WHO), both the average level of health and inequalities are important to assess the performance of healthcare systems.[13,14] Most studies on cancer screening have analyzed these dimensions for target groups (overlooking over-screening which occurs outside the target population), and have followed a conservative view assuming that what matters is to monitor up-to-date screening even if this means screening more frequently than recommended.[15-17] However, over-screening is not only a waste of resources but can also cause harm.[18] In addition, individuals for whom screening is overdue include both those whose last test was performed more than two or three years ago and those who were never screened. Most studies do not distinguish between them, but these are different situations.[19] Based on previous evidence, over-screening is more likely in opportunistic programs and among individuals of higher socioeconomic status.[20,21] Now that population-based screening programs are implemented in all Portuguese regions for CRC, breast, and cervical cancers, our aims were to analyze the level of, as well as income-related inequalities in screening attendance across Portuguese regions for these cancers, based on data from the Portuguese Health Interview Survey 2019 (PHIS 2019). We aimed to analyze not only up-to-date screening, but also non-target groups and different time frames, as these are important indicators of under-, and over-screening.

METHODS

Data

The data used in this study came from the PHIS 2019, collected between September 2019 and January 2020 (access to data was granted under the project registered in the Portuguese Office for National Statistics with the number 977). The database contains 14 617 individualized observations.[22] The samples used in this study included 8194, 8032, and 9940 observations for the analysis of breast, cervical, and colorectal cancer screening, respectively. Data by NUT 2 regions support the regional analysis. The NUT classification (nomenclature of territorial units for statistics) is a hierarchical system that divides the European Union (EU) territory. NUTS 2 corresponds to the second level of the hierarchy and refers to basic regions. Portugal is divided into seven NUT 2 regions: five in mainland Portugal (North, Center, Lisbon Metropolitan Area, Alentejo, Algarve) and two archipelagos (Madeira and Azores).

Variables

We used the variables from the PHIS 2019, corresponding to self-reported screening attendance for colorectal, breast, and cervical cancers, respectively. Individuals were asked about the last time they were screened. The options for CRC (presence of occult blood in feces) were: 'in the last 12 months', 'between one year and less than two years', 'between two years and less than three years', 'three years or more', and 'never'. We only considered individuals who never performed a colonoscopy. The reason for this procedure is that, according to the national guidelines,[10] colonoscopy is not the primary test, and our analysis is about screening of individuals with average risk for cancer. For breast and cervical cancer, the options for the last time women performed a mammography and cervical cytology (pap smear) were: 'in the last 12 months', 'between one year and less than two years', 'between two years and less than three years', 'between three years and less than five years', 'five years or more', and 'never'. Sex and age bands were used to define target and non-target groups. Net monthly equivalized income of the household (quintile), in PHIS, was used to rank individuals in the inequality analysis. Equivalized income is a measure of household income that considers the household's size and composition.[23]

Observations with missing values in these variables were dropped.

Statistical analysis

To analyze screening in target as well as in non-target groups and different time frames (to evaluate under-, and over-screening), we used the matrix proposed by Quintal and Antunes[24]: Fig. 1 identifies different situations, depending on the age interval of individuals and the last time they were screened for a given cancer.

As explained by the authors,[24] cells A+B reflect compliance with guidelines (up-to-date screening). Within this group, annual screening might happen in cell A, which consists of over-screening due to screening more frequently than recommended. Cell C represents cases where screening has been done before but is overdue. Cell D corresponds to never-screeners within the target group. Over-screening might occur not only due to excessive frequency but also due to screening of individuals younger, or older, than the recommended age (cells E and G, respectively). Cell F accounts for cases where screening rightfully never took place. Similarly, cases of individuals older than the recommended age, who did their last screening test outside the recommended interval (cell H) also conform to guidelines. Individuals who were never screened and are already beyond the recommended age (cell I) have lost their opportunity to benefit from screening.

For breast cancer and CRC screening, the target groups and recommended intervals were defined according to the criteria set up in 2017[10]: women aged 50 - 69 years/mammography biannually; individuals aged 50 - 74 years/FIT biannually. For cervical cancer screening, considering that the new guidelines were published in 2017 and the PHIS took place in 2019, the time in between was not enough to roll out every woman in the new program. Therefore, we assumed that the target group included women aged 25 - 64 years and the recommended interval is three years (except for the North, where since 2009 the criterion is HPV test/five years). In the analysis of women younger than the target group, in the case of breast cancer screening, the age band 45 - 49 years was dropped because, prior to 2017, these women were included in the eligible population for screening in several regions. This procedure ensures that our estimations of over-screening hold even in the light of previous criteria. In the analysis of individuals older than the target group, for all cancers, the age band adjacent to target was also dropped from the analysis – for example, a woman who just turned 71 years might have been screened in the last 12 months or in the last two years for breast cancer, but this is in accordance with the guidelines. Here, too, our estimates of over-screening were conservative.

The prevalence of attendance to screening was assessed both at the regional and national levels.

Sample weights (the inverse of the probability of selection of each unit) provided in the database have been used. National averages were calculated from the individualized observations in the dataset.

In the assessment of over-screening, within each target group, due to a frequency higher than recommended, we considered that if the proportion of women/individuals performing a mammography/FIT in the last 12 months comprised more than 50% of women/individuals screening in the last two years, then there was over-screening. This procedure assumes that screening was evenly distributed over the two years of the recommended interval. The same procedure was followed in other studies[18,24] and it is also in accordance with the methodology followed by the Directorate-General of Health, in Portugal, to determine the annual eligible population for screening.[6] In the case of cervical cancer screening, because the recommended interval is three years, if the percentage of women screened in last 12 months is more than 33% of women screening in the recommended period, then there is over-screening. In the case of the North, the proportion which defines over-screening is 20% (five-year interval).

To quantify inequalities in screening attendance, we resorted to the computation of concentration indices (CI). This methodology has been used to assess inequalities and inequities in the use of healthcare services, including doctor visits and hospitalizations[25-28] as well as cancer screening attendance.[24,29] In our case, concentration indices measure relative inequality in screening attendance over the distribution of income, thus being a tool to measure income-related inequality in the use of healthcare. The index is bounded between -1 and 1, meaning (extreme) disproportionate concentration of screening attendance among the poorer and the richer, respectively.[30] When there is no income-related inequality in screening attendance, the CI is zero. Hence, when testing the statistical significance of the CI, if the null hypothesis (CI = 0) cannot be rejected, then one cannot rule out an equal distribution of screening attendance. In contrast, if the null hypothesis is rejected, then we can conclude that there is inequality in screening attendance. In this work, the CI was computed using the *conindex* command from Stata 15.1[31] and the statistical significance of the CI is assessed at the 5% level. Further details about the computation and statistical significance of the CI are provided in Appendix 1 (Appendix 1: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/19443/15154).

Since we used anonymized secondary data, it was not necessary to request ethics committee approval.

RESULTS

Table 1 displays, for the cases of breast, cervical, and colorectal cancers, the levels of screening attendance (or absence of screening, where it applies) for all the situations identified in Fig.1, for all regions and nationwide as well.

Screening attendance in target group

Starting with breast cancer, for the target group, 81.1% of women were screened within the recommended interval (this value is not directly observable in Table 1; it results from the sum of the percentage of women being screened in last 12 months with the percentage of women being screened between one and two years). There was some variation across regions, with the North reaching 85.5%, while in Algarve this figure is the lowest (70.9%). The scenario was not so favorable for cervical cancer, with 72% of women in the target group being screened within the recommended interval. The North emerged with the highest percentage (86.7%) and Azores with the lowest (53.9%). As for CRC, only 40% of men and women underwent screening within the recommended period. Again, the North showed the highest figure (51.9%), and the lowest value occurred in the Center (26.2%). At the country level, under-screening was not so different across cancers, even though, there were some discrepancies within regions. However, extreme under-screening varied across cancers: in breast cancer, at the country level, only 3.4% of women in target group never performed a mammography, while this figure rose to 15.7% of women who never did an HPV/Pap Smear test, reaching 48.6% in the case of individuals who never did a FIT. Unlike in the case of breast cancer, for cervical and especially for colorectal cancer screening, for those individuals who were not screened within the recommended interval, the problem is above all not having been screened at all. In the Azores, basically one third of women in the target group had never been screened for cervical cancer (Madeira and Alentejo were close). In three regions (Center, Alentejo and Azores), 60% or more individuals of the target group (excluding those who already had a colonoscopy) never underwent screening for CRC.

In the case of cervical cancer screening, because the target group included women within a wide age band (25 - 64 years), we checked whether never screeners, in Portugal, were the youngest women. That is, we computed the prevalence rate of never screeners by age bands and found that the prevalence rates do not noticeably differ across groups [as can be seen in Appendix 2 (Appendix 2: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/19443/15155)].

Based on Fig. 2, in the case of breast cancer, more than half of the women being screened within the recommended interval had screened in the last 12 months, in the whole country. In terms of regions, the North, Lisbon and the Algarve were slightly above the national average. Concerning cervical cancer screening, 49% of women being screened within the recommended interval had done so in the last 12 months. In the North, if screening was evenly distributed over the five years of the recommended interval, the expected proportion of women being screened in the last 12 months would be 20%. Figure 2 shows that the actual percentage more than doubles this level. Lisbon, Madeira, and the Algarve also stand out with a proportion of women screening in the last 12 months more than 1.5 times the value corresponding to an even distribution of screening. Regarding CRC, results should be read with caution as, by 2019, geographic coverage of the program had reached 100% only in the Azores and in Lisbon.[7]

Screening attendance outside the target group

Looking at Table 1 we see that for breast cancer, on average, one third of younger women had already performed a mammography (only in the Azores this proportion was relatively low – 13.8%). For cervical cancer the proportion of younger women who received screening is not particularly high, but it surpasses 20% in Alentejo and Madeira. CRC shows the lowest figures for screening among younger groups, in all regions. Among older women, on average, almost one fourth underwent breast cancer screening. In Lisbon, this proportion was the highest, corresponding to one third of women. For cervical cancer, the figures are the lowest in the older group, while, for CRC, the results are a bit surprising. Among individuals younger than 50 years, the vast majority never performed a fecal occult blood test, which conforms to the guidelines (in no region this value falls below 80%). But, on average, 21% of individuals above the target group was screened in the last two years, when the equivalent proportion in the target group is 40%. Over-screening in the older group was particularly high in Madeira, followed by Lisbon.

The last case to be analyzed in Table 1 concerns individuals beyond the recommended age for screening, who never underwent screening in their lives. At the country level, this figure was the lowest for breast cancer (13.4%); however, there were marked differences between regions. For instance, in the Algarve, about one third of older women never performed a mammography. There was a clear difference in the results, with Lisbon (by far the region with the best result with only 7.2% of 'never' users), North and Center in more favorable positions compared to the remaining regions. Two fifths of women

and almost 60% of individuals above the target age never underwent screening for cervical cancer and CRC, respectively. The highest values, for both cancers, were observed in Alentejo. The North was the region with fewer 'never' users in both cases.

Income-related inequalities in screening attendance

Figure 3 combines information on prevalence (vertical axis) with information on income-related inequality (horizontal axis) in screening attendance in the target group, within the recommended interval, for all three cancers analyzed in this study. Note that Fig. 3 shows the situation of up-to-date screening (corresponding to the joint analysis of screening in last 12 months -'Due/Possible over-screening' - and screening between one year and the upper-limit of recommended interval – 'Due-screening').

Breast cancer screening was, in general, characterized by high levels of attendance and no inequalities across income groups. The concentration index (CI) for Portugal was not significant and was virtually null (0.006). Zooming into the regions, except for the Center and Algarve, the remaining CIs are positive, suggesting a disproportionate concentration of screening among women with higher income. Nonetheless, we only observed a statistically significant CI in the Azores (0.047), meaning that in most regions we cannot rule out an equal distribution of screening. The picture was different for cervical cancer screening. Not only the level of attendance was lower compared to breast cancer, but virtually all CIs were positive and significant for four regions as well as for the whole country. At the country level the CI was 0.028 (statistically significant at the level of 1%), indicating the concentration of screening among women with a higher socioeconomic status. Inequalities were more pronounced in the Azores (CI = 0.076), Madeira (CI = 0.059) and Lisbon (CI = 0.052), and to a lesser extent in the North (0.027). In the other regions, the null hypothesis of equality of screening across income groups cannot be rejected. The scenario changes again when we look at CRC screening. The level of attendance was lower when compared to the previous cancers, and CIs were all negative, pointing to the concentration of screening among individuals with a lower socioeconomic status. The coefficients were statistically significant in Alentejo and Madeira, and therefore, in these cases, we are confident that screening was concentrated in men and women with lower income. Table 2 provides information for CIs for all cases identified in Fig. 1.

Overall, there were no income-related inequalities in screening attendance as most coefficients were not statistically significant. Some exceptions apply; namely, the concentration of screening for cervical cancer in the last 12 months among women with a higher socioeconomic status in Portugal as well as in the Azores, Lisbon and North. Extreme under-screening, for cervical cancer, was concentrated among women with a lower socioeconomic status in the North, Azores, Madeira, and nationwide. CRC shows the opposite signals: concentration of screening in last 12 months among individuals with a lower socioeconomic status, while extreme under-screening was concentrated among individuals with a higher socioeconomic status. However, considering the regions, the coefficient was significant only for Madeira. Restricting the analysis of CRC screening to those individuals from the target group who never performed a FIT (3001 observations), we found that two-thirds of these individuals had not performed a colonoscopy either. We also checked differences between men and women, but very few were statistically significant [as shown in Appendix 3 (Appendix 3: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/19443/15156)].

Some inequalities emerged in screening among younger groups – always concentrated in individuals with a higher socioeconomic status for all cancers. Lastly, for the case of cervical cancer, 'never' screeners in the older group (women who are not eligible for screening anymore) were concentrated among women with a lower socioeconomic status.

DISCUSSION

This study aimed to analyze the level of, and income-related inequalities in, cancer screening attendance in all population-based programs implemented in Portugal. Overall, the findings suggest that screening attendance is the highest for breast cancer, followed by cervical cancer, and CRC. The prevalence of CRC screening attendance is quite below the prevalence of screening attendance for the other two cancers (in the whole country, screening attendance in target group within recommended interval for CRC was about half the equivalent value for breast cancer). This might be explained by the fact that CRC was the last program to be implemented in all regions. Still, the North was one of the last regions to implement it (in 2016) and still is the best performing region. In fact, this situation of more favorable results in the North (with the worst being in Alentejo and in the Azores) is a general pattern across programs, already identified in studies based on data from previous rounds of the PHIS.[32-36] On the other hand, screening attendance seems to have improved over time. For CRC, both extreme-, and under-, screening decreased 10 percentage points between 2014 and 2019.[32] Extreme under-screening for breast cancer was about the same in 2019 as in 2014, but it was already low in 2014 (3.8%).[34] The proportion

of older women who never underwent screening for breast cancer also decreased from 20% in 2014, to 13.4% in 2019. Extreme under-screening for cervical cancer was slightly above the value found in the past (15.7% in 2019 *vs* 13.2% in 2014).[36] Over-screening for breast cancer in younger women was still an issue. In 2014, 50% of women between 30 and 44 years had undergone screening.[34] In this study, the percentage was lower (33%), even though we considered all women aged 15 to 44 years old (over-screening would likely be higher if we restricted the analysis to women closer to the target group). In the case of cervical cancer, the problem with over-screening seems to be, above all, a matter of screening more frequently than recommended. Although there is an organized screening program for this cancer, opportunistic screening, under which over-screening is more likely,[20] might still exist. Based on the data used in this study, it is not possible to know if women screened within or outside organized programs or if they screened in the public or the private sector. De Prez *et al*[18] found that reimbursement initiatives can alter over-screening. In Portugal, reimbursement schemes do not penalize repeated tests. Soon, over-screening for cervical cancer might increase as doctors and patients might take some time to adjust to the new guidelines which recommend longer intervals between tests.[10] This phenomenon has been reported in the US.[37]

Regarding the inequality analysis, previous evidence for Portugal is scarce. Compared with 2014, inequality in target group/recommended interval (whole country) was the same for breast cancer, that is, the CI was basically null (and not significant) in both years, while it seems to have worsened for cervical cancer, given that the concentration of screening among women with a higher socioeconomic status has increased (CI = 0.038 in 2019 *vs* CI = 0.028 in 2014).[24] For cervical cancer, 'never' screening within the target group was concentrated among women with a lower socioeconomic status, even though it seems to have slightly improved (CI = -0.101 in 2019 *vs* CI = -0.148 in 2014).[24] The situation seems quite worrisome in Madeira and Azores where large and negative CIs were combined with high prevalence of 'never' screeners. As previously noted, the absence of screening is not concentrated in any particular age band, similarly affecting women within the target group, from younger to older ages. Women who lost the opportunity to undergo screening for cervical cancer were also concentrated among groups with a lower socioeconomic status. In the Algarve and Center, a negative (and significant) CI combined with high prevalence, which is a worrying finding. Although there are organized programs, it seems that the access is still affected by income, at least to some extent. In the Algarve, for example, a low adherence to cervical cancer screening by doctors and patients in primary care services has been reported. Doctors themselves do not feel comfortable or capable of performing the tests.[38] This means that in practice, there are still many constraints. Results for CRC were somewhat puzzling because, while screening in target group/recommended interval seemed to be equal across income groups, extreme under-screening was concentrated among individuals with a higher socioeconomic status. Are individuals with a higher socioeconomic status not undergoing screening as they should or are they bypassing FIT and using colonoscopy as their primary test? Based on our results (when we restricted the analysis to those individuals who never did a FIT), it does not seem to be a matter of substitution between FIT and colonoscopy. Based on the findings from the comparison between men and women, it does not seem to be a sex-specific issue either.

In the future, more attention should be paid to over-screening to ensure that individuals are making informed choices. Regarding cervical cancer screening, two extreme situations seem to coexist. For the target group, the findings suggests that some women are undergoing screening annually while other women, of lower income, are not receiving screening at all. In the case of CRC, screening attendance was clearly lower than for breast and cervical cancers, probably reflecting the fact the CRC screening program was the last to be implemented. Somewhat unexpectedly, the evidence suggests that extreme under-screening is concentrated among individuals with a higher income. Once the program becomes completely implemented, these issues should be further investigated.

Limitations

Our results are based on self-reported data, meaning that there might be an overestimation of attendance[39] or inequalities,[40] but this is the usual procedure due to difficulties in accessing administrative data.[41] While we focused on levels of attendance, it is essential to ensure that services are of high quality and that there is an adequate follow-up.[42] Still, a study that looked at the North reported high standards in terms of the tests performed and detection rate.[43] As acknowledged in previous studies,[32,34,36] the analysis for regions relied on data for NUTS 2, which do not entirely correspond to the health regions responsible for implementing screening programs.

CONCLUSION

This study aimed to diagnose the levels of attendance and the respective inequalities in cancer screening for breast, cervical, and colorectal cancers in Portugal. Situations vary depending on the program and region, but overall, the

attendance was high, and the inequalities were low in the case of breast cancer screening. For cervical and colorectal cancers, challenges still lie ahead and there is the need to involve both healthcare professionals and patients if screening guidelines are to be effectively implemented.

AUTHOR CONTRIBUTIONS

CQ: Study design, literature review, analysis of results, writing of the manuscript.

MA: Study design, database preparation, empirical analysis, analysis of results, writing of the manuscript.

PROTECTION OF HUMANS AND ANIMALS

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the Helsinki Declaration of the World Medical Association updated in 2013.

DATA CONFIDENTIALITY

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

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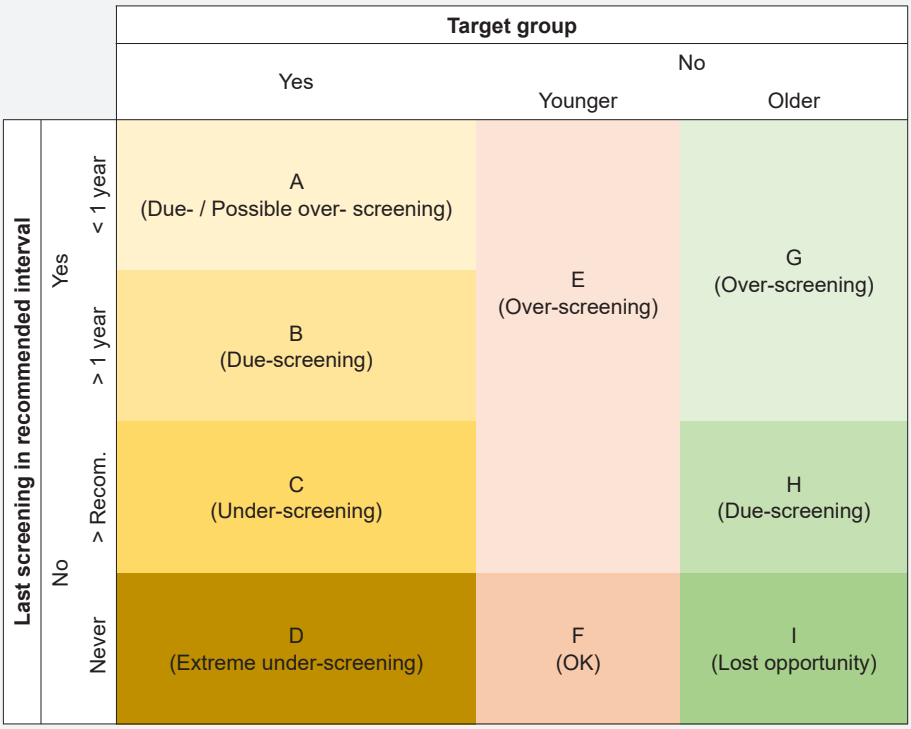

Figure 1 – Matrix proposed by Quintal and Antunes to analyse due-, under-, and over-screening. Reprinted with permission.[24]

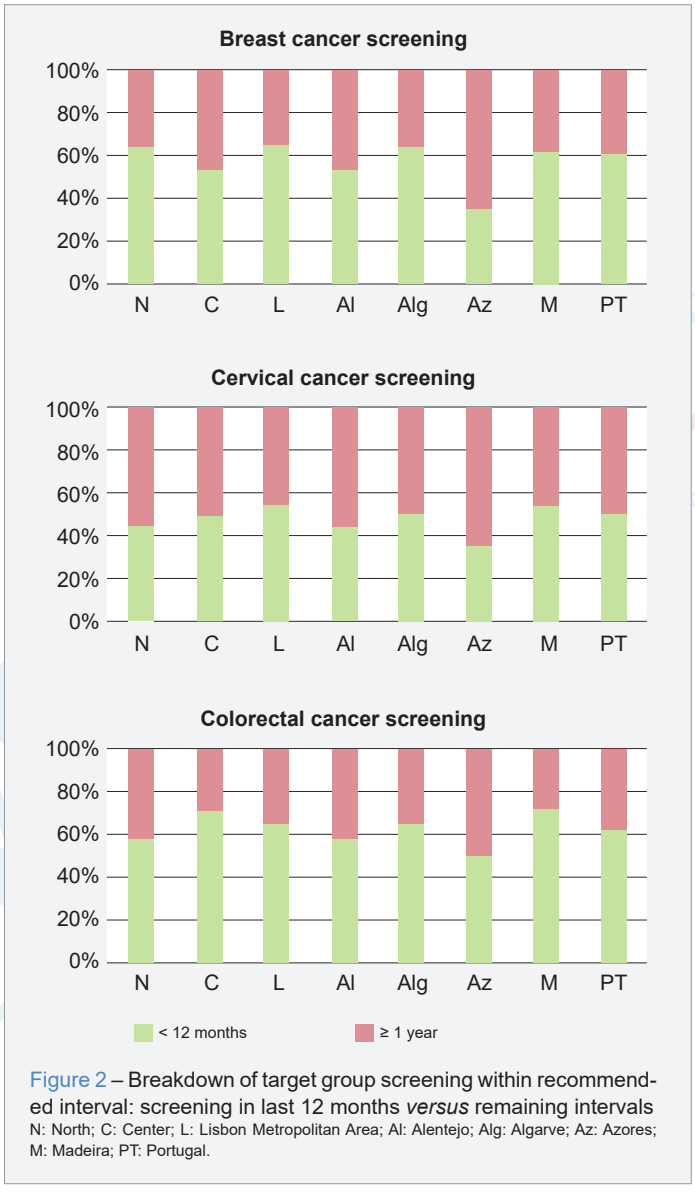

Figure 2 – Breakdown of target group screening within recommended interval: screening in last 12 months *versus* remaining intervals
N: North; C: Center; L: Lisbon Metropolitan Area; Al: Alentejo; Alg: Algarve; Az: Azores; M: Madeira; PT: Portugal.

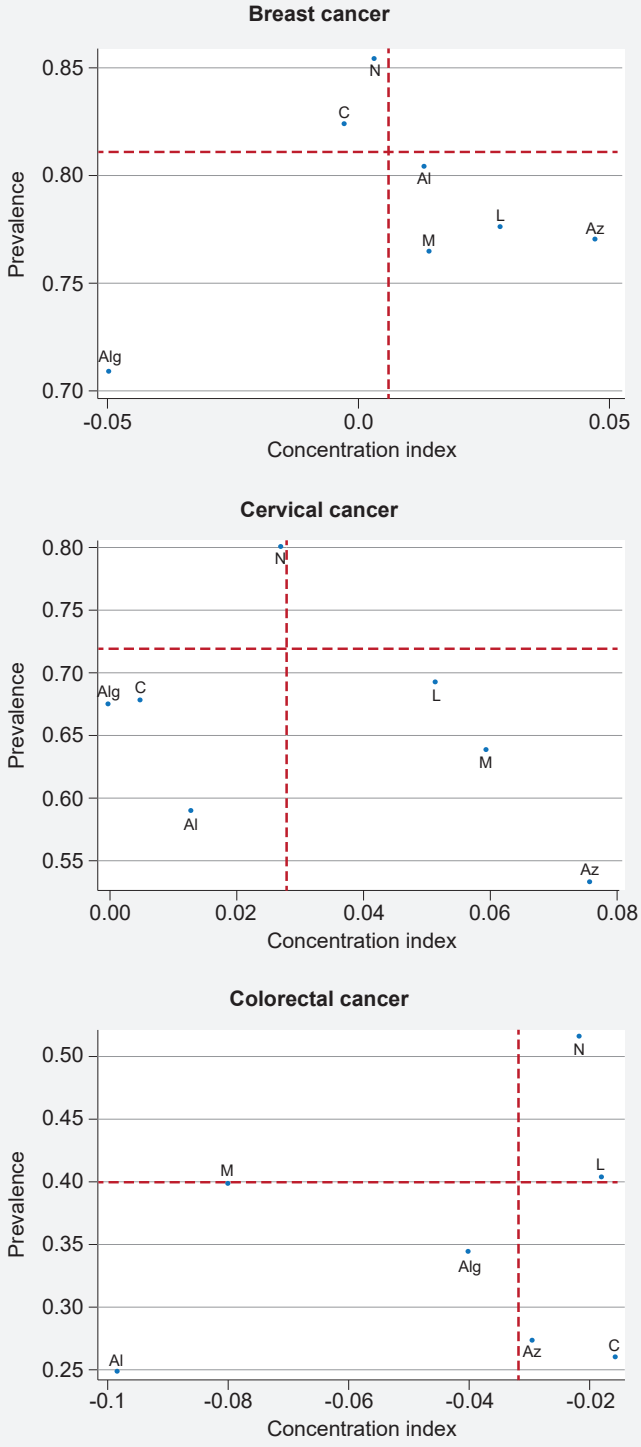

Figure 3 – Prevalence and income-related inequality in screening in target group, within recommended interval

N: North; C: Center; L: Lisbon Metropolitan Area; Al: Alentejo; Alg: Algarve; Az: Azores; M: Madeira.

Table 1 – Prevalence of due-, under-, and over screening in target and non-target groups for breast, cervical and colorectal cancers

			Target group										
			Yes			No							
						Younger				Older			
			BC	CC	CRC		BC	CC	CRC		BC	CC	CRC
Last screening in recommended interval	Yes	< 1 year	N:	54.5	37.5	30.6	N:	34.8	20.3	13.5	N:	20.4	13.5	21.5
			C:	44.1	32.7	18.8								
			L:	50.4	37.3	26.7					C:	18.9	8.2	12.6
			Al:	42.6	25.5	14.7	C:	29.3	15.7	9.9				
			Alg:	45.6	33.5	22.8					L:	32.9	19.8	27.7
			Az:	27.3	18.7	14.1								
			M:	47.4	34.4	29.3	L:	35.5	17.8	12.6	Al:	18.8	8.5	9.2
			PT:	49.7	35.4	25.3								
		> 1 year	N:	31.0	49.2	21.3								
			C:	38.3	35.3	7.4					Alg:	9.4	10.7	20.1
			L:	27.3	32.1	14.0	Al:	25.8	23.2	12.4				
			Al:	37.8	33.5	10.3					Az:	17.7	12.4	10.1
			Alg:	25.3	34.1	11.8								
			Az:	49.8	34.7	13.3	Alg:	31.5	15.6	11.6	M:	11.4	14.5	31.3
			M:	29.1	29.5	10.8					PT:	23.6	15.4	20.7
			PT:	31.4	36.6	14.7								
	No	> Recommended	N:	13.0	4.3	14.3					N:	65.5	31.2	24.4
			C:	14.2	11.8	8.9	Az:	13.8	13.0	10.7	C:	65.2	37.8	7.2
			L:	17.7	13.1	10.9					L:	59.9	44.0	30.4
			Al:	16.9	14.0	11.4					Al:	66.4	25.0	7.4
			Alg:	20.5	19.3	8.3	M:	28.2	22.8	16.1	Alg:	57.8	32.7	11.1
			Az:	17.2	13.9	9.1					Az:	62.0	25.2	11.9
			M:	18.8	9.1	9.5	PT:	33.0	18.5	12.5	M:	62.0	35.4	11.3
			PT:	15.5	12.3	11.4					PT:	63.0	44.1	20.4
		Never	N:	1.6	9.0	33.8	N:	65.2	79.7	86.5	N:	14.1	29.6	54.1
			C:	3.3	20.3	64.9	C:	70.7	84.3	90.1	C:	15.9	54.0	80.2
			L:	4.6	17.6	48.5	L:	64.3	82.2	87.4	L:	7.2	36.1	41.9
			Al:	2.7	27.0	63.6	Al:	74.2	76.8	87.6	Al:	20.8	66.4	83.3
			Alg:	8.5	13.1	57.2	Alg:	68.5	84.4	88.4	Alg:	32.7	56.6	68.8
			Az:	5.7	32.7	63.4	Az:	86.1	87.0	89.3	Az:	20.3	62.4	78.0
			M:	4.7	27.0	50.4	M:	71.8	77.2	83.9	M:	26.7	50.1	57.5
			PT:	3.4	15.7	48.6	PT:	66.9	81.5	87.5	PT:	13.4	40.6	58.9

BC: breast cancer; CC: cervical cancer; CCR: colorectal cancer.
N: North; C: Center; L: Lisbon Metropolitan Area; Al: Alentejo; Alg: Algarve; Az: Azores; M: Madeira; PT: Portugal.
All values are in percentage; For each column/region, the total sum is 100%.
Cell colour key on Fig. 1.

Table 2 – Concentration indices for due-, under-, and over screening in target and non-target groups for breast, cervical and colorectal cancers

Last screening in recommended interval			Target group: Yes			Target group: No – Younger			Target group: No – Older		
			BC	CC	CRC	BC	CC	CRC	BC	CC	CRC
Yes	< 1 year	N:	0.057	**0.069**	-0.018	0.005	0.107	0.081	0.168	0.137	-0.072
		C:	0.015	0.003	-0.044						
		L:	0.020	**0.071**	-0.039				0.067	0.067	-0.042
		Al:	-0.004	0.030	-0.012	0.070	**0.332**	0.064			
		Alg:	**-0.088**	0.039	-0.031				0.108	**0.141**	0.112
		Az:	0.030	**0.155**	0.038						
		M:	0.036	0.053	**-0.112**	**0.158**	-0.015	0.094	0.070	0.086	0.011
		PT:	0.030	**0.058**	-0.034						
	> 1 year	N:	**-0.091**	-0.006	-0.028						
		C:	-0.024	0.006	0.056				0.079	0.126	0.231
		L:	0.043	0.029	0.022	0.097	0.216	0.089			
		Al:	0.032	0.000	**-0.221**				0.152	0.006	-0.077
		Alg:	0.019	-0.039	-0.059						
		Az:	0.056	0.033	-0.101	-0.009	-0.131	0.107	0.209	**0.137**	-0.220
		M:	-0.022	0.067	0.007						
		PT:	-0.032	-0.001	-0.028				**0.132**	**0.218**	0.057
No	> Recommended	N:	-0.049	-0.038	0.042				-0.033	-0.041	0.030
		C:	0.030	**0.141**	-0.025	**0.198**	0.129	0.084	-0.039	**0.091**	0.157
		L:	-0.077	**-0.147**	-0.060				-0.054	-0.048	-0.066
		Al:	-0.045	-0.036	0.062				-0.010	0.014	0.189
		Alg:	**0.211**	-0.020	0.019	0.046	0.158	**0.261**	-0.009	**0.205**	0.058
		Az:	**-0.210**	-0.040	0.047				-0.031	0.021	0.128
		M:	-0.076	0.003	-0.036	**0.088**	0.106	**0.092**	-0.058	0.068	0.257
		PT:	-0.026	-0.033	-0.007				**-0.041**	-0.006	-0.005
	Never	N:	0.235	**-0.236**	0.015	-0.003	-0.027	-0.013	-0.087	**-0.159**	0.042
		C:	-0.057	-0.098	0.010	-0.029	**-0.062**	-0.007	0.080	**-0.074**	-0.008
		L:	-0.176	-0.094	0.029	**-0.088**	0.003	-0.014	-0.047	-0.019	-0.026
		Al:	-0.106	-0.009	0.028	-0.034	-0.065	-0.013	-0.011	-0.016	-0.018
		Alg:	-0.095	0.030	0.022	0.004	0.024	-0.014	0.039	**-0.142**	-0.077
		Az:	0.000	**-0.107**	0.006	**-0.032**	-0.019	-0.010	-0.039	-0.036	-0.009
		M:	0.074	**-0.142**	**0.070**	-0.018	-0.047	**-0.050**	0.045	-0.050	0.070
		PT:	-0.026	-0.101	**0.028**	**-0.043**	-0.024	**-0.013**	-0.036	**-0.076**	-0.018

BC: breast cancer; CC: cervical cancer; CRC: colorectal cancer.
N: North; C: Center; L: Lisbon Metropolitan Area; Al: Alentejo; Alg: Algarve; Az: Azores; M: Madeira; PT: Portugal.
Coefficients in bold are statistically significant at the level of 1% or 5%.
Negative (positive) coefficients indicate disproportionate concentration among poorer (richer) individuals. In the absence of statistical significance, the null hypothesis of equal distribution cannot be rejected.
Cell colour key on Fig. 1.