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## Socioeconomic position and cancer stage at diagnosis in a fragmented Latin American health system

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Early cancer diagnosis is crucial to improving disease prognosis. Although several studies have investigated the relationship between socioeconomic position (SEP) and stage at diagnosis, there is limited evidence from contexts with highly fragmented health systems and pronounced socioeconomic inequalities. This study analyzed the association between SEP and stage of cancer diagnosis. Data were obtained from the EquityCancer-LA baseline study. The sample included patients aged 18 or older with a confirmed cancer diagnosis within the 12 months prior to participation. Cancer stage was determined by the oncology committees of participating healthcare centers and logistic regression models were used to assess the association between SEP and cancer stage at diagnosis. A total of 343 individuals participated in the study, 39.1% of whom were diagnosed at a late stage. Two SEP indicators were associated with this outcome. After adjusting for covariates, participants without formal income had higher odds of late-stage diagnosis ( $OR = 2.14$ ; 95% CI 1.02–4.53), and those who were non-head of household ( $OR = 1.83$ ; 95% CI 1.11–3.02). When adjusting for all SEP variables, only non-head of household condition remained significantly associated ( $OR = 1.77$ ; 95% CI 1.07–2.96). These results show that disadvantaged SEP was associated with higher odds of late-stage cancer diagnosis. The findings suggest the need for strategies that promote early diagnosis and address the socioeconomic inequities identified in this study.

**Keywords** Socioeconomic position, Stage at cancer diagnosis, Chile, Healthcare system

### Abbreviations

SEP	Socioeconomic position
OR	Odds ratio
TNM	Tumor, node, metastasis
FONASA	National Health Fund (Fondo Nacional de Salud by its acronym in spanish)
CASEN	Socioeconomic Characterization Survey (Encuesta de Caracterización Socioeconómica by its acronym in spanish)
USD	United States Dollar

### Background

Cancer represents a major global health challenge; in Chile, it has become the leading cause of mortality<sup>1</sup>. According to epidemiological forecasts from the Global Cancer Observatory, cancer mortality is expected to increase by 62% worldwide by 2040<sup>2</sup>, while in Chile, the increase could reach 96%<sup>3</sup>. To address this alarming situation, it is essential to detect cancer in early stages<sup>4</sup> (commonly defined as stages 0, I, and II according to the TNM classification). This is because, in contrast, people who are diagnosed in late stages (stage III or IV

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according to the TNM classification) have a lower probability of survival<sup>4</sup> and lower quality of life during the treatment phase<sup>5</sup>, which in turn generates higher costs for healthcare systems<sup>6</sup>. In Chile, the early stages of cancer diagnosis represent a significant challenge. On one hand, the proportion of people diagnosed at early stages is considerably lower compared to high-income countries. For example, in Chile, 69% of women with breast cancer are diagnosed at early stages<sup>7</sup>, whereas in the United Kingdom, this figure reaches 85%<sup>8</sup>.

The stage at which cancer is diagnosed depends on several factors. Some types of cancer, as is the case of lung or pancreatic cancer, present nonspecific symptomatology, which increases the probability of diagnosis in late stages<sup>9</sup>. On the other hand, patients with low awareness of cancer symptoms are more likely to present a late-stage of the pathology<sup>10</sup>. Likewise, the lack of oncology training of primary care physicians, difficulties in accessing exams, the lack of oncology specialists and the remoteness of health centers are factors related to late-stage cancer diagnosis<sup>11</sup>.

Patients with lower socioeconomic position (SEP) are more likely to be diagnosed with late-stage cancer<sup>12</sup>. SEP corresponds to the social and economic attributes that determine a person's position within society<sup>13</sup>. Its main indicators include household income, housing conditions, type of occupation, and educational level, among other factors<sup>13</sup>. Each of these indicators highlights a specific aspect of social stratification<sup>14</sup>. In cancer-related studies, the most used indicators are household income, educational level, and area poverty level<sup>15</sup>. Other social determinants of health have also been used, such as lack of health insurance, social isolation and poor public health infrastructure<sup>16</sup>.

Several studies have analyzed the relationship between SEP and stage of cancer diagnosis. Riba et al.<sup>17</sup> identified a positive association between higher SEP and early-stage breast cancer diagnosis in the U.S. population, a finding similar to those reported in studies conducted in the United Kingdom<sup>18</sup> and Australia<sup>19</sup>. Boscoe et al.<sup>20</sup> found a statistically significant association between high levels of area poverty and late-stage diagnosis in 14 of the 21 types of cancer studied in the United States. However, in the UK the effect of socioeconomic deprivation on late-stage diagnosis was observed in only four (melanoma, breast, prostate and endometrial) of the 10 most common cancers<sup>21</sup>.

Despite research advances, most of these studies have been conducted in high-income countries. In our region (Latin America), a few studies conducted in Brazil have found an association between SEP variables and late-stage cancer diagnosis<sup>22</sup>. In Chile this phenomenon has not been studied, and it is a challenge to address this knowledge gap. Although nearly 80% of the Chilean population is affiliated with the public healthcare system<sup>23</sup>, the widespread use of private healthcare services makes it difficult to ensure continuity of care within the public sector. This has led to Chile being considered a country with a highly fragmented healthcare system, a condition known to negatively impact population health and deepen disparities in access to care, particularly among socioeconomically vulnerable groups<sup>24</sup>. Considering the high levels of socioeconomic inequality in Chile (the average income of the richest 10% is 19 times higher than that of the poorest 10%)<sup>25</sup>, these findings suggest the need to examine whether SEP is associated with cancer stage at diagnosis. It is plausible that the association between SEP and stage at diagnosis could be even stronger than in higher-income countries with less fragmented public healthcare systems.

This study aims to analyze the association between SEP and stage of cancer diagnosis within two public healthcare networks in Chile. It contributes original and relevant evidence, addressing a research gap in Latin America. The findings could support policymakers and healthcare managers in developing or improving early cancer detection strategies for socioeconomically vulnerable populations, who are at greater risk of late-stage diagnosis. In the long term, such efforts may reduce mortality and improve healthcare system efficiency. As the cancer stage at diagnosis is a critical point in the cancer control continuum, our findings provide valuable insights within a highly fragmented healthcare system and are also relevant for countries with similar public-private healthcare service coexistence, such as Colombia<sup>26</sup> and Mexico<sup>27</sup>, which face comparable equity challenges in early cancer detection.

## Methods

### Design, study population and sample

We conducted a cross-sectional study using data obtained from the EquityCancer-LA Project in Chile<sup>28</sup>. The EquityCancer-LA project, “Improving equity in access to early diagnosis of cancer: implementation research in different healthcare systems of Latin America” is a multicenter study carried out in Colombia, Ecuador, and Chile. The study aims to evaluate the contextual effectiveness of the implementation, with a participatory approach, of a multi-component integrated care intervention in improving early diagnosis of cancer in public health service networks<sup>28</sup>. The EquityCancer-LA project follows a dual design. On one hand, it employs a controlled quasi-experimental design, assessing conditions before and after the intervention. On the other hand, it incorporates a case study design using mixed methods to analyze in depth the barriers to early cancer diagnosis for the most common cancers<sup>28</sup>.

In Chile, the study is conducted in two healthcare networks in the Metropolitan Region of Santiago (North and South health networks). Both networks share similar population characteristics in terms of the number of people cared for, as well as the demographic, social, and economic features of their populations<sup>29,30</sup>. For the purposes of this study, we used data from the baseline quantitative study of the EquityCancer-LA Project in Chile.

The study population consisted of individuals aged 18 or older with a primary diagnosis of breast, gastric, lung, colorectal, prostate, kidney, bladder, or testicular cancer, confirmed with staging up to 12 months before participation in the study. The sampling frame was obtained from the oncology registry databases of each health service, and the sample was randomly selected and proportionally stratified by cancer type. The first contact was made by the professionals of each healthcare network. Subsequently, the participants were contacted by the

research team of the EquityCancer-LA Project in Chile to coordinate the application of the survey. The survey was applied in the participants' homes or in the health centers.

A total of 643 patients were considered between August 2022 and December 2023. Of these, 1.2% did not respond to the call to participate (8 patients), 8.3% were deceased (54 patients), 8.9% were excluded because these patients entered the public health network only at the treatment phase (57 patients), 12.6% did not meet the inclusion criteria (81 patients), 14.5% declined to participate (93 patients) and 1.1% without information about cancer stage (7 patients). The final sample consisted of 343 patients.

### Data collection

The information was collected through a questionnaire specifically designed for the EquityCancer-LA study<sup>28,31</sup>. This questionnaire was developed to analyze patients' pathways during the cancer diagnostic process. It was designed within the conceptual framework of the EquityCancer-LA study, drawing on a review of the literature, relevant existing instruments, and findings from the qualitative component of the project<sup>31</sup>. Specifically, it was based on the Equity-LA questionnaire on access to care for patients with chronic diseases and Aarhus statement guidelines to ensure the systematic collection of data on essential time points and intervals during the cancer diagnostic pathway<sup>31</sup>. The instrument was adapted to the Chilean context, its content was rigorously validated by a panel of experts, and it was subsequently tested through cognitive interviews (pretest) and pilot test<sup>31</sup>. Data collection was conducted between August 2022 and December 2023 by previously trained interviewers. Other variables of interest, such as cancer stage and public health insurance category (FONASA), were obtained from oncology committee records and the FONASA database, respectively.

### Variables

#### *Dependent: stage of cancer diagnosis (early/late)*

We used the cancer stage to determine early-or late-stage, following the frameworks of previous studies<sup>22</sup>. Stage was determined by specialists in the oncology committee of each health center. Patients with stage I and II were classified as early-stage, while those with stage III and IV were considered late-stage cancer<sup>32</sup>.

#### *Independents: SEP*

We considered a set of SEP variables. According to Galobardes et al.<sup>14</sup>, using multiple SEP indicators allows for a better understanding of its effect on the phenomenon under study. This approach helps explain how social stratifiers relate to stage of cancer diagnosis. For this study, we used educational level, income per month and head of household status as SEP variables.

**Educational level:** According to Beebe-Dimmer et al.<sup>33</sup>, average educational attainment has increased across birth cohorts. For this reason, we classified educational level according to participants' birth cohorts, using the average educational attainment by age group reported in the Chilean National Socioeconomic Characterization Survey (CASEN, for its acronym in Spanish) as a reference<sup>34</sup>. Participants aged 18 to 44 who reported having completed secondary education or less, and those aged 45 or older with only primary education or less, were classified as having a low educational level. Participants with technical or university-level education were classified as having a high educational level.

**Income per month:** As a proxy for income, we used the FONASA classification system. FONASA affiliates are categorized into four groups according to formal income of the last 12 months, with Group A representing individuals without formal income and Group D those with the highest income levels<sup>35</sup>. For our study, income was converted from Chilean pesos to United States dollar (USD). We used the average exchange rate reported by the Chilean Internal Revenue Service between August 1, 2022, and December 31, 2023, which was 1 USD = 860 Chilean pesos<sup>36</sup>. Based on this, the following categories were defined: without formal income,  $\leq$  510 USD per month, and  $>$  510 USD per month.

**Head of household status:** We used head of household status as a contextual variable of social stratification. Participants who reported being the main economic provider were classified as head of household. This variable has been proposed by Conway et al.<sup>15</sup> as an individual-level indicator of SEP. We considered it relevant in our context, as it may reflect household dynamics (such as gender roles, decision-making power over household resources, etc.) that could be associated with the outcome variable.

#### *Covariates*

The following covariates were considered as potential confounders regarding previous studies: gender (male or female), age<sup>37</sup>, family size (1, 2, and 3 or more persons)<sup>37</sup>, comorbidities (none and yes (1 or more))<sup>37</sup>, and type of cancer (breast, colorectal, gastric, prostate, lung, kidney/bladder, and testicle)<sup>21</sup>.

### Statistical analysis

A descriptive analysis of the variables under study was conducted. For categorical variables, frequencies and proportions were reported, while for continuous variables, the median and interquartile range were provided. The distribution of continuous variables was assessed using the Shapiro-Wilk test. The relationship between independent and dependent variables was analyzed through a bivariate analysis. For categorical variables, chi-square test was used, and for continuous variables, the Mann-Whitney U test or Kruskal-Wallis test were applied.

Additionally, we assessed the potential multicollinearity of the independent variables using variance inflation factor (VIF) threshold of 10 and a tolerance of 0.1. To estimate the association of SEP and stage of cancer diagnosis, we used both crude and adjusted logistic regression models. The odds ratios (OR) for late-stage cancer diagnosis were reported with a 95% confidence interval for the crude model (with each SEP variables unadjusted by covariates), Model 1 (with each SEP variables adjusted for gender and age), Model 2 (with each SEP variables adjusted for all covariates), and Model 3 (all SEP variables adjusted for all covariates). Confounders were selected

by previous evidence. In addition, we evaluated interaction with covariables (gender, age and type of cancer). The Hosmer-Lemeshow test was used to assess the goodness of fit. All statistical analyses were two-sided, and a  $p$ -value  $< 0.05$  was considered statistically significant. Statistical analyses were performed using Stata SE 18 software (StataCorp, CollegeStation, TX).

### Ethical aspects

This study adhered to the ethical principles established in the Declaration of Helsinki and the Council for International Organizations of Medical Sciences (CIOMS). The Ethics Committees of the Metropolitan North Health Service (No. 062-2021) and the Metropolitan South Health Service (No. 39-16052022) approved the study protocol. The study was conducted in accordance with the guidelines and regulations of national legislation.

All participants were provided with information regarding the study's objectives, the voluntary nature of participation, the risks and benefits of the research, and their rights, including anonymity, confidentiality, data protection, and the right to decline participation. This information was communicated through the informed consent process. Participation was confirmed by signing the informed consent document.

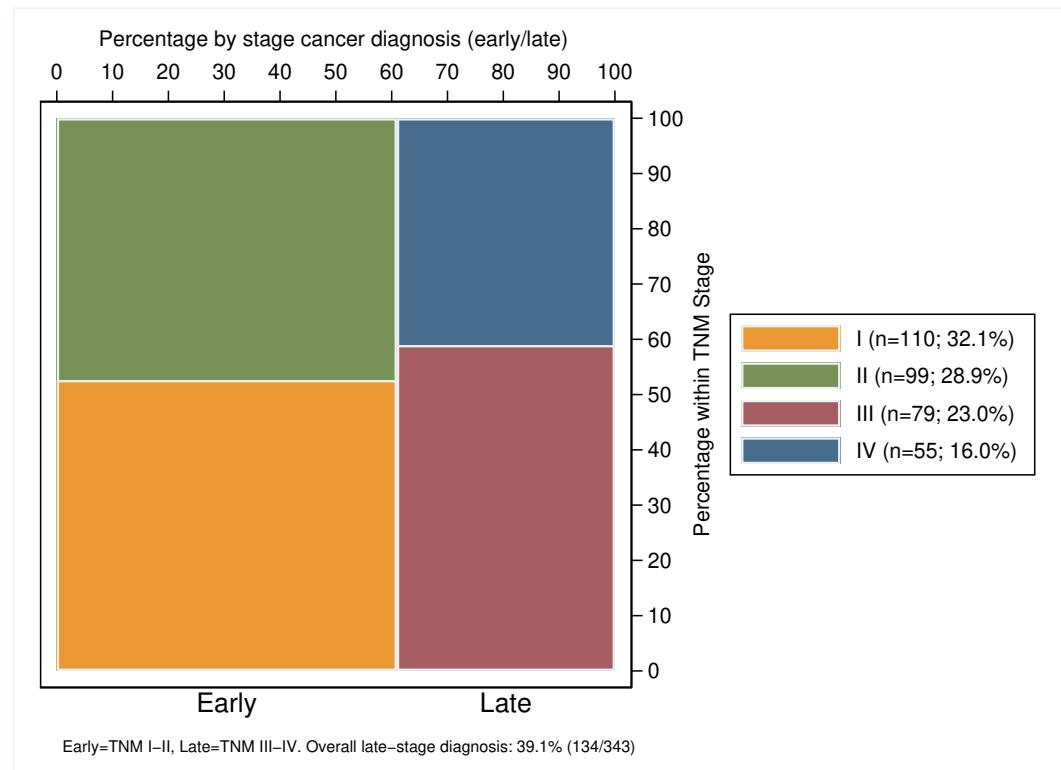
### Results

343 participants were included in the study. Median age was 63 years (IQR = 54–71). Of the participants, 59.2% were women, 88.6% lived with at least one other person. 59.2% of the participants reported not having a chronic disease, while 37.9% were diagnosed with breast cancer (Table 1). In relation to SEP, 50.1% of the participants had low educational level, 13.1% had no formal income per month, and 65.6% were head of household (Table 1). No multicollinearity was detected among the SEP variables (Supplementary Table S1). Figure 1 shows the proportions according to I, II, III, and IV stage of TNM system. 39.1% of the participants presented late-stage of cancer diagnosis (Fig. 1).

Table 2 shows the description of the participants and the bivariate analysis between the independents and dependent variables. Statistically significant differences were found between early-and late-stage groups in age, type of cancer, income per month and head of household status. The bivariate analysis between covariates and

Variables	n	%
Age (years)	Median = 63	IQR = 54–71
Gender		
Female	203	59.2
Male	140	40.8
Family size (number of persons)		
1 (lives alone)	39	11.4
2	106	30.9
3 or more	198	57.7
Comorbidities		
None	203	59.2
Yes	140	40.8
Type of cancer		
Breast	130	37.9
Colorectal	86	25.1
Prostate	58	16.9
Lung	23	6.7
Kidney/Bladder	21	6.1
Gastric	18	5.2
Testicle	7	2.1
Education level		
Low	172	50.1
Medium	65	19.0
High	106	30.9
Income per month		
Without formal income	45	13.1
≤ 510 USD	193	56.3
> 510 USD	105	30.6
Head of household status		
Yes	225	65.6
No	118	34.4

**Table 1.** Characteristics of study participants ( $n = 343$ ). IQR = Interquartile range USD = United States dollar



**Fig. 1.** Distribution of cancer participants by early-stage (TNM = I-II) and late-stage (TNM = III-IV) ( $n = 343$ ).

SEP variables is shown in Supplementary Table S2. Statistically significant differences were observed between age and all SEP variables, while for gender and family size only for the head of household variable.

Table 3 presents the association between SEP variables and stage of cancer diagnosis (early/late). Both the crude model and Model 1 (adjusted for gender and age) independently showed that having no formal income per month and non-head of household were associated with a late-stage of cancer diagnosis. Model 2 (adjusted for all covariates and including each SEP indicator separately) revealed that individuals without formal income had 2.14 times higher odds of late-stage of cancer diagnosis compared to those with formal income greater than 510 USD (95%CI = 1.02–4.53). Similarly, non-head of households had higher odds of late-stage of cancer diagnosis compared to those who were head of household (OR = 1.83; 95%CI = 1.11–3.02). Although low educational level was associated with late-stage in the crude model, Model 1, and Model 2, this association was not statistically significant. Finally, Model 3 (adjusted for all SEP variables and all covariates) showed a similar pattern of associations as in the previous models; however, head of household was only variable with statistical significance. Non-heads of households had 1.77 times higher odds of late-stage diagnosis compared to heads of household (95%CI = 1.07–2.96). No interactions were detected with gender, age (as a categorical variable), or cancer type. Model 3 indicated a good fit ( $p$ -value = 0.379).

## Discussion

Our study analyzed the association between SEP and stage of cancer diagnosis. We found that lower income per month and non-head of household were significantly associated with a late-stage of cancer diagnosis. Although a lower level of education showed a similar trend, this association was not statistically significant.

Firstly, in our study, the prevalence of late-stage cancer diagnosis was 39.1%, which is similar to findings from other studies conducted in Latin America and the Caribbean. For example, de Lemos et al.<sup>38</sup> reported that the proportion of late-stage breast cancer diagnoses (stages III and IV) in South America was 37.7%. This similarity may be explained by the comparable socioeconomic conditions across populations in the region. South America is characterized by pronounced socioeconomic inequalities and limited healthcare availability, which contribute to a higher proportion of late-stage cancer diagnoses compared to regions with better living conditions and healthcare systems<sup>39</sup>.

Regarding SEP variables, we found a significant association of two indicators with late-stage of cancer diagnosis. Individuals with lower income per month had higher odds of late-stage diagnosis compared to those with higher income. This finding is consistent with previous studies employing different methodologies and data levels. For example, Clegg et al.<sup>40</sup> reported that lower annual family income was associated with distant-stage breast and prostate cancer in the United States, while Ruan et al.<sup>41</sup> found an association between lower neighborhood-level income and late-stage diagnosis across all cancer sites in Alberta, Canada.

As a possible interpretation of this finding, we may hypothesize that individuals with lower income have fewer material resources and face greater difficulties in accessing services. In this context, our study may provide

Variables	Stage of cancer diagnosis (n,%)		p-value <sup>a</sup>
	Early (TNM I-II) (n=209, 60.9%)	Late (TNM III-IV) (n=134, 39.1%)	
Age (Median, IQR)	62 (53–70)	66 (58–73)	<b>0.014*</b>
Gender			
Female	131 (62.7)	72 (53.7)	0.100
Male	78 (37.3)	62 (46.3)	
Family size			0.525
1 (lives alone)	27 (12.9)	12 (9.0)	
2	64 (30.6)	42 (31.3)	
3 or more	118 (56.5)	80 (59.7)	
Comorbidities			0.769
None	125 (59.8)	78 (58.2)	
Yes	84 (40.2)	56 (41.8)	
Type of cancer			<b>0.004*</b>
Breast	91 (43.6)	39 (29.1)	
Colorectal	40 (19.1)	46 (34.3)	
Lung	9 (4.3)	14 (10.5)	
Prostate	37 (17.7)	21 (15.7)	
Gastric	12 (5.7)	6 (4.5)	
Kidney/Bladder	14 (6.7)	7 (5.2)	
Testicle	6 (2.9)	1 (0.7)	
Education level			0.165
Low	97 (46.4)	75 (56.0)	
Medium	45 (21.5)	20 (14.9)	
High	67 (32.1)	39 (29.1)	
Income per month			<b>0.020*</b>
Without formal income	19 (9.1)	26 (19.4)	
≤ 510 USD	125 (59.8)	68 (50.8)	
>510 USD	65 (31.1)	40 (29.8)	
Head of household status			<b>0.021*</b>
Yes	147 (70.3)	78 (58.2)	
No	62 (29.7)	56 (41.8)	

**Table 2.** Description of variables according to stage of cancer diagnosis (early/late) (n=343).

IQR=Interquartile range; USD=United States dollar. Significant values are in bold. \*Statistically significant differences. <sup>a</sup> Chi-square test for categorical variables or Mann-Whitney U test for continuous variable.

evidence of the cumulative effect of income throughout the cancer control continuum in Chile. Several studies have shown that people with low income are more exposed to cancer-related etiological factors and face greater barriers to accessing early detection strategies<sup>42</sup>, which may help explain why this group has a higher chance of receiving a late-stage cancer diagnosis.

Additionally, we observed an association between non-head of household and late-stage cancer diagnosis. Similar findings have been reported in other studies but based on the income of the head of household<sup>43</sup>. The observed association between head of household status and stage at diagnosis may be understood from several perspectives. First, people who are heads of household are more likely to have formal employment<sup>44</sup>. In Chile, the workplace plays an important role in providing access to preventive strategies (e.g., occupational health screenings) and health information (e.g., awareness campaigns)<sup>45</sup>. Therefore, individuals non-head of household may have reduced exposure to cancer prevention and early detection strategies due to lower participation in the labor market.

From a gender perspective, we observed that a high proportion of non-heads of household were women. It is widely recognized that women often take on caregiving responsibilities and unpaid domestic labor<sup>46</sup>, frequently prioritizing the care of family members over their own health<sup>47</sup>. This may result in lower awareness of preventive measures or early signs and symptoms of cancer. Furthermore, persons non-head of household may experience economic dependency on those who are. This situation could create power dynamics and decision-making patterns regarding the use of family resources, potentially hindering timely access to healthcare services.

Regarding educational level, we observed an association between lower educational level and late-stage cancer diagnosis. However, this association was not statistically significant. Our findings differ from previous studies. De Almeida et al.<sup>48</sup> found that educational level is an important predictor of late-stage cancer diagnosis in Sao Paulo-Brazil. In light of our results, we believe that future studies, with greater statistical power, may identify statistically significant associations between educational level and stage of cancer diagnosis (early vs late).

Variables	Crude model	Model 1 <sup>b</sup>	Model 2 <sup>c</sup>	Model 3 <sup>d</sup>
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Education level				
Medium/High	Ref	Ref	Ref	Ref
Low	1.46 (0.95–2.27)	1.36 (0.86–2.14)	1.42 (0.89–2.28)	1.52 (0.94–2.46)
Income per month				
>510 USD	Ref	Ref	Ref	Ref
Without formal income	<b>2.22 (1.09–4.52)*</b>	<b>2.32 (1.13–4.77)*</b>	<b>2.14 (1.02–4.53)*</b>	1.93 (0.90–4.14)
≤510 USD	0.88 (0.54–1.45)	0.82 (0.49–1.37)	0.81 (0.48–1.37)	0.76 (0.44–1.30)
Head of household status				
Yes	Ref	Ref	Ref	Ref
No	<b>1.70 (1.08–2.68)*</b>	<b>1.99 (1.24–3.22)*</b>	<b>1.83 (1.11–3.02)*</b>	<b>1.77 (1.07–2.96)*</b>

**Table 3.** Logistic regression models of late-stage of cancer diagnosis in two healthcare networks in Chile ( $n = 343$ )<sup>a</sup>. OR = Odds ratio; CI = Confidence interval; USD = United States Dollar. Significant values are in bold.

<sup>a</sup> The odds ratios for late-stage cancer diagnosis were reported. <sup>b</sup> With each SEP variables adjusted for gender and age. <sup>c</sup> With each SEP variables adjusted for all covariates (age, gender, family size, comorbidities and type of cancer). <sup>d</sup> With all SEP variables adjusted for all covariates (age, gender, family size, comorbidities and type of cancer). \* $p$ -value < 0.05.

Finally, we highlight the association of two SEP indicators, with a stronger effect observed for the head of household status. These findings warrant further studies that explore these indicators in greater depth using diverse methodological approaches. Such research efforts would contribute to a more comprehensive understanding of the social and economic inequities identified in this study.

### Strength and limitations

Our study has several strengths. The data collected are of high quality, given the rigorous survey application process and the use of official databases. In this context, the exposures and outcome variables were obtained directly from primary official databases of the Health Services included in the study, which helped minimize potential information bias.

Another strength of this study was the use of multiple SEP indicators. This approach provides new insights into three distinct SEP measures in relation to the phenomenon under study, within the context of a highly fragmented healthcare system. An additional strength was the contextual treatment of the educational level variable. To address potential cohort effects on educational attainment, we followed the approach proposed by Beebe-Dimmer et al.<sup>33</sup>.

This study has several limitations. First, its cross-sectional design does not allow causal inference between SEP and stage at cancer diagnosis. Accordingly, our findings should be interpreted as associations measured at diagnosis, rather than as evidence of causal effects over time. Second, TNM stages were collapsed into a binary variable (I–II vs III–IV), which may mask heterogeneity within stages and limit the granularity of the results. A potential limitation of this study was the exclusion of patients who accessed the public health networks only at the treatment phase, and whose entire cancer diagnostic process was therefore conducted in private healthcare services. However, given that individuals who use private healthcare generally have greater socioeconomic resources (higher SEP), we hypothesize that including this group would likely have resulted in an even stronger association, thereby reinforcing our findings.

One potential limitation of our study is the use of certain SEP variables that may be susceptible to reverse causality. Specifically, Galobardes et al.<sup>14</sup> have reported this potential issue with the income variable, noting that poor health can lead to reduced income. However, we used FONASA affiliation as a proxy for income, which reflects earnings over the previous 12 months. This approach substantially reduced the likelihood of reverse causality in our analysis.

Another limitation was the lack of data on informal income at both the individual and household levels. Future studies could consider assessing total household income—including both formal and informal sources—as well as income fluctuations over time. This approach may provide a more comprehensive understanding of the phenomenon under study. Moreover, this study did not include other social stratification variables such as ethnicity or type of occupation. Future research should incorporate these indicators to explore potential associations with the stage of cancer diagnosis. Likewise, it would be relevant to study the relationship between SEP and outcomes of previous points to diagnosis in the cancer control continuum (etiology, prevention and detection), which would provide information on the potential cumulative effects at the stage of cancer diagnosis.

Although data on diagnostic intervals were available, it was not included in this analysis because our primary objective was to examine socioeconomic differences in stage at diagnosis. Similarly, screening participation was not considered as a variable because our sample included several cancer types, some of which lack organized screening programs (e.g., gastric or prostate cancer), which would have introduced heterogeneity and reduced comparability across cancers. Future research could examine diagnostic intervals and screening participation as complementary outcomes or mediators to further elucidate pathways leading to late-stage diagnosis.

Finally, we reported odds ratios in this study. Given the high prevalence of late-stage diagnosis in our sample (39.1%), the interpretation of the odds ratios may overestimate the strength of associations and should therefore be interpreted with caution.

## Conclusions

In conclusion, our study found an association between SEP variables and stage at cancer diagnosis. Although the Chilean public health system guarantees free care for its population, substantial social and economic inequities persist in the stage of cancer diagnosis. Individuals facing greater socioeconomic vulnerability have higher odds of late-stage cancer diagnosis compared to those with greater socioeconomic privilege. These findings are relevant for policymakers and health system managers, as they highlight the need for more targeted and equitable early detection strategies. In light of recent advances in cancer control in Chile, these results may inform future reflections and updates to the National Cancer Plan.

Finally, future research should investigate the relationship between different social stratifiers and stage at cancer diagnosis using longitudinal designs in the Chilean context. Such studies would help identify potential explanatory pathways and provide a more comprehensive understanding of socioeconomic inequities in cancer stage at diagnosis.

## Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to confidentiality policies but are available from the corresponding author on reasonable request.

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## Author contributions

C.GN, P.E, I.AB, and M.L.G. conceptualized and designed the study. P.E. and I.AB. acquired the data and organized the database. C.GN and M.L.G. analyzed the data and wrote the original draft. All authors reviewed the draft and made substantial contributions to the work. All authors reviewed and accepted the final version of the manuscript.

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## Declarations

### Competing interests

The authors declare no competing interests.

### Ethical approval and consent to participate

The study was approved by the Ethics Committees of the Metropolitan North Health Service (No. 062-12021)

and the Metropolitan South Health Service (No. 39-16052022).

### Additional information

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