Socioeconomic inequalities of 3-year survival in formal employees with colorectal cancer between 2012 and 2019 in Colombia

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Abstract

Objective: This study aimed to assess socioeconomic inequalities in three-year survival among formal employees diagnosed with colorectal cancer in Colombia between 2012 and 2019, using legal monthly minimum wages (MMW) as a proxy for socioeconomic status.

Methods: A retrospective cohort study used administrative databases, including healthcare and mortality records. Formal employees newly diagnosed with colorectal cancer were identified through diagnostic and oncological procedure codes and followed for three years from diagnosis or until death. Patients were stratified into MMW quartiles, and Cox regression models were employed to estimate adjusted hazard ratios (HRs) for survival. Socioeconomic gradients were quantified using the Relative Index of Inequality (RII) and Slope Index of Inequality (SII).

Results: The cohort included 1,913 formal employees (mean age: 49.9 years), with 660 deaths (34.5%) recorded over the follow-up period. Patients in the lowest MMW quartile experienced the highest three-year mortality (39.5%) compared to those in the highest quartile (30.7%). After adjusting for confounders, individuals in the highest quartile had a 25% lower risk of death than those in the lowest quartile (aHR: 0.74; 95% CI: 0.59–0.92). The RII indicated a 50% higher risk of death in the lowest income group (RII: 1.50; 95% CI: 1.13–1.99), while the SII revealed an absolute difference of 0.16 deaths per 1,000 individuals (p=0.01).

Conclusion: Significant income-based disparities in colorectal cancer survival were observed among formal employees in Colombia despite the theoretically equitable healthcare system. These findings underscore the persistent influence of socioeconomic factors on health outcomes, even within populations assumed to have better access to care.

Key words:

Colorectal Neoplasms; Socioeconomic Factors; Healthcare Disparities; Survival Analysis; Colombia.

Introduction

Colorectal cancer is one of the leading causes of cancer-related morbidity and mortality worldwide. In 2020, it ranked as the second most deadly cancer and the third most commonly diagnosed, with an estimated 1.9 million new cases and 935,000 deaths annually [1]. Projections indicate that by 2040, the global burden could rise to 3.2 million new cases and 1.6 million deaths yearly [2]. In Colombia, colorectal cancer was the third leading cause of cancer incidence and mortality in 2021, primarily affecting individuals aged 50 and older, many of whom belong to the formal workforce [3].

In low- and middle-income countries (LMICs) like Colombia, formal employees are often regarded as a relatively advantaged group due to their regular income and access to employer-provided health benefits [4]. However, this perceived advantage does not entirely shield them from significant barriers to adequate healthcare access, particularly for complex conditions such as colorectal cancer. This disease requires timely and multidisciplinary care, which can be hindered by structural and socioeconomic factors, even among populations with formal employment and health coverage [5,6].

The Colombian health system, comprising contributory and subsidised schemes, covers over 97% of the population and aims to ensure equitable healthcare access regardless of affiliation [7]. Additionally, clinical practice guidelines have been developed to standardise diagnosing and managing diseases like colorectal cancer. Despite these measures, evidence from Colombia and other settings reveals persistent socioeconomic disparities in early detection, timely treatment, and survival outcomes, even within systems designed to promote equity [8-10].

Studying survival disparities among formal employees with colorectal cancer provides a unique perspective, as this group is critical to national productivity and is presumed to face fewer healthcare access barriers compared to informal workers or the unemployed. Nonetheless, fragmented care and delays in accessing specialised services remain significant challenges that may contribute to health outcomes inequity [11].

This study aims to assess socioeconomic inequalities in three-year survival among formal employees diagnosed with colorectal cancer in Colombia from 2012 to 2019, using monthly minimum wages (MMW) as a measure of socioeconomic status. By focusing on a population assumed to have relatively uniform access to healthcare, this analysis highlights the persistent influence of income disparities on health outcomes. It contributes to the broader understanding of social determinants of health.

Methods

Data source and study population

This retrospective cohort study analysed administrative databases to examine the entire population of formal employees in Colombia who were newly diagnosed and treated for colorectal cancer between January 1, 2012, and December 31, 2019. The cohort was constructed using the Base for the Study of Capitation Unit Sufficiency (UPC) to identify patients meeting criteria established by an electronic algorithm based on diagnostic and oncological procedure codes. Since ICD-10 codes in the UPC database may indicate confirmed or suspected diagnoses, electronic algorithms are essential to identify individuals with specific conditions accurately. Colorectal cancer cases were defined as patients with at least three diagnostic codes recorded in different months and at least one oncological procedure code (e.g., chemotherapy, radiotherapy, or surgery). This algorithm has been validated and used in previous studies [14,16,17]. The list of ICD-10 and CUPS codes used in the algorithm is available in the S1 File. The final study sample included all adults who met the colorectal cancer diagnosis algorithm criteria during the study period and were actively employed at the time of diagnosis. Cohort entry was defined as the date of the first recorded ICD-10 code, with follow-up extending for three years or until death, whichever occurred first. Data was accessed on August 10, 2024. This study was approved by the Faculty of Medicine Ethics Committee at the Universidad Nacional de Colombia (Approval Number: 019-179).

This study utilised four primary administrative databases, anonymised and linked using unique identifiers by the Ministry of Health (MoH). The UPC includes comprehensive records of healthcare service utilisation for individuals within the health system, capturing information on the type of services provided, associated ICD-10 codes, costs, service dates, municipalities, and healthcare providers. This database supports risk-adjusted capitated payment calculations and is populated by the largest insurers within the contributory scheme, covering approximately 19 million individuals (88% of this scheme's population nationwide). It is highly standardised and reports minimal underreporting of health service utilisation [12]. The Unique Enrollees Database (BDUA) is the government registry for tracking demographic and enrolment information of all health system beneficiaries across contributory, subsidised, and other schemes. It provides data on enrolment status, age, sex, insurer, and affiliation scheme [18]. The Death Registry (RUAF) compiles mortality data from death certificates, including location, date, cause of death, and sociodemographic characteristics (e.g., sex, age, marital status, education level, occupation, and ethnicity). International assessments have confirmed the reliability of RUAF data, with 91% of deaths registered through death certificates as of 2016 [13,19]. Finally, the Wages Database (PILA), managed by the MoH, contains detailed records on payroll contributions to health, pensions, and social security and precise information on formal employee wages. This database

enables analysis of employment trends and wage distribution. While self-employed individuals self-report income, formal employee wage data is aggregated and reported by employers, ensuring higher data quality for this group [20]. These datasets, widely used in national studies [14,16,21–24], were provided to the Clinical Research Institute of the Universidad Nacional de Colombia for this research.

Study variables

This study examined socioeconomic inequalities in 3-year survival among colorectal cancer patients. The primary exposure variable was the patient's socioeconomic position, measured as the formal wage earned during cohort entry, as recorded in the PILA database. This variable was expressed in units of legal monthly minimum wages (MMW) and further stratified into quartiles to facilitate analysis. The primary outcome variable was 3-year survival time, defined as the period from the cohort entry date to the date of death or the end of the 3-year follow-up period, whichever occurred first. The date of death was obtained from death certificates in the RUAF database.

We included sociodemographic and clinical variables measured during colorectal cancer diagnosis to control for potential confounders. Sociodemographic variables included age, sex, insurer, and geographic region (Colombia is divided into 32 departments). Clinical variables included the Charlson Comorbidity Index (CCI), validated for use in Colombia by Oliveros et al. [24], derived from ICD-10 codes. The CCI considered the presence of the following conditions: acute myocardial infarction, congestive heart failure, peripheral vascular disease, stroke, dementia, chronic pulmonary disease, connective tissue disease, peptic ulcer disease, liver disease, diabetes, complications of diabetes, cancer, metastatic cancer, paraplegia, renal disease, severe liver disease, and HIV. Based on the oncological services used during diagnosis and treatment, we classified the cancer stage as local, locally advanced, or advanced.

Statistical analysis

We performed descriptive statistics on the sociodemographic characteristics of formal employees with colorectal cancer. Continuous variables with normal distributions were summarised using means and standard deviations, while continuous variables with non-normal distributions were summarised using medians and interquartile ranges. Categorical variables were summarised using absolute and relative frequencies. The descriptive analysis was stratified according to quartiles of wages. We described the three-year mortality proportion by quartiles of wages with 95% confidence intervals. Using semiparametric Cox regression models, we estimated unadjusted and adjusted hazard ratios (HRs) and 95% CIs for three-year survival. Variables used for model adjustment included sex, age, year, insurer, geographic region, CCI, cancer stage, and year of diagnosis. Statistical and graphical tests were performed to evaluate the assumption of proportionality.

We estimated the Relative Index of Inequality (RII) and the Slope Index of Inequality (SII) to quantify the socioeconomic gradient in absolute and relative terms. As these indices can only be estimated for socioeconomic characteristics with at least three categories, they were identified for the quartile of MMW at the month of first diagnosis of colorectal cancer. Following the recommendations of Moreno-Betancur et al., we used Poisson regression models to estimate the RII as the incidence rate ratio between the individual with the best socioeconomic position and the one with the worst. After conducting the Poisson regression, the SII was calculated from the absolute difference in the predicted mortality rates per 1,000 adults for the two groups. All indices were adjusted with the variables previously mentioned in the survival models. All analyses were conducted using Stata v.18 MP (Universidad Nacional de Colombia license). This article followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines to ensure transparency and thoroughness in reporting the findings. Additionally, an artificial intelligence language model, specifically OpenAI's GPT-4, assisted with style corrections and enhanced the text's clarity and coherence during the writing process.

Results

Between January 1, 2012, and December 31, 2019, 1,950 formal employees were diagnosed with colorectal cancer. After excluding 37 records (1.89%) due to incomplete data on variables such as age and sex, the final cohort consisted of 1,913 individuals who were followed for three years or until death, whichever occurred first. The flowchart in Figure 1 provides additional details on the selection process. Among the final cohort, 1,164 individuals (60.85%) were male, and the mean age at diagnosis was 49.88 years (SD: 10.58). The majority of patients (1,231; 64.35%) were diagnosed with locally advanced colorectal cancer, and 76.48% had a CCI of 2 at the time of diagnosis. Most cases were concentrated in Bogotá (623 cases; 32.57%) and the Central region (558 cases; 29.17%).

Fig 1. STROBE flow chart. UPC: Base for the Study of Capitation Unit Sufficiency Database; PILA: Wages Database

Table 1 presents detailed sociodemographic and clinical characteristics of the cohort. The distribution of monthly minimum wages (MMW) was stratified into quartiles, with the 25th, 50th, and 75th percentiles corresponding to 1.00, 1.31, and 2.34, respectively. MMW values ranged from 1.00 to 24.81. Median MMWs varied significantly across regions, with the Orinoquía y Amazonías region reporting the highest median MMW (5.63) and the Atlántica region the lowest (1.24).

Table 1. Baseline characteristics

	Total sample	MMW quartiles			
		Q1	Q2	Q3	Q4
	N=1,913	N=489	N=465	N=483	N=476
Age, mean (sd)	49.88 (10.58)	51.74 (10.95)	48.58 (11.20)	48.25 (10.08)	50.89 (9.62)
Categorised age, n (%)					
Under 40 years old	359 (18.77%)	73 (14.93%)	105 (22.58%)	107 (22.15%)	74 (15.55%)
40 to 60 years old	1,260 (65.87%)	315 (64.42%)	294 (63.23%)	327 (67.70%)	324 (68.07%)
Over 60 years old	294 (15.37%)	101 (20.65%)	66 (14.19%)	49 (10.14%)	78 (16.39%)
Male, n (%)	1,164 (60.85%)	298 (60.94%)	280 (60.22%)	283 (58.59%)	303 (63.66%)
Stage[a], n (%)					
Early	152 (7.95%)	34 (6.95%)	42 (9.03%)	39 (8.07%)	37 (7.77%)
Locally advanced	1,231 (64.35%)	316 (64.62%)	292 (62.80%)	316 (65.42%)	307 (64.50%)
Metastatic	530 (27.71%)	139 (28.43%)	131 (28.17%)	128 (26.50%)	132 (27.73%)

CCI, median (p25 - p75)	2.00 (2.00-2.00)	2.00 (2.00-2.00)	2.00 (2.00-2.00)	2.00 (2.00-2.00)	2.00 (2.00-3.00)
Categorised CCI, n (%)					
2	1,463 (76.48%)	368 (75.26%)	362 (77.85%)	383 (79.30%)	350 (73.53%)
2-3	298 (15.58%)	79 (16.16%)	73 (15.70%)	67 (13.87%)	79 (16.60%)
≥5	152 (7.95%)	42 (8.59%)	30 (6.45%)	33 (6.83%)	47 (9.87%)
Region[b], n (%)					
Atlántica	155 (8.10%)	39 (7.98%)	39 (8.39%)	40 (8.28%)	37 (7.77%)
Bogotá DC	623 (32.57%)	133 (27.20%)	151 (32.47%)	167 (34.58%)	172 (36.13%)
Central	558 (29.17%)	164 (33.54%)	135 (29.03%)	127 (26.29%)	132 (27.73%)
Oriental	294 (15.37%)	66 (13.50%)	81 (17.42%)	70 (14.49%)	77 (16.18%)
Pacífica	273 (14.27%)	86 (17.59%)	56 (12.04%)	76 (15.73%)	55 (11.55%)
Other departments	10 (0.52%)	1 (0.20%)	3 (0.65%)	3 (0.62%)	3 (0.63%)

Data are means (SD). [a]Stage categories were defined by initial treatment: early (only surgery or surgery-radiotherapy), locally advanced (surgerychemotherapy or chemotherapy-surgery-radiotherapy), and advanced (radiotherapy-chemotherapy, only radiotherapy, or only chemotherapy). [b]Region

Abbreviations: MMW: Monthly Minimum Wages; SD: standard deviation; p25: percentil 25; p75: percentil 75; CCI: Categorized Charlson Index.

A total of 660 deaths were observed during the follow-up period, corresponding to a three-year mortality proportion of 34.50%. The regions with the highest mortality rates were Atlántica (41.14%) and Pacífica (39.93%), exceeding the overall cohort mortality proportion. Mortality proportions stratified by MMW quartiles revealed significant differences. Patients in the lowest MMW quartile had the highest three-year mortality (39.47%; 95% CI: 35.22–43.88), while those in the highest quartile had the lowest (30.67%; 95% CI: 26.15–35.72). Figure 2 illustrates the three-year mortality rates across MMW quartiles, showing a transparent socioeconomic gradient.

Fig 2. Three-year mortality proportion of formal employees with colorectal cancer per quartile of MMW. MMW: Monthly Minimum Wages

The risk of death within three years of a colorectal cancer diagnosis significantly increased with lower MMW, as shown in both crude and adjusted hazard ratios. After adjusting for age, sex, cancer stage, CCI, region, insurer, and year of diagnosis, formal employees in the highest MMW quartile had a 25% lower risk of death compared to those in the lowest quartile (adjusted HR: 0.74; 95% CI: 0.59–0.92). Table 2 summarises the unadjusted and adjusted HRs for each MMW quartile. At the same time, Figure

3 displays survival curves from the multivariate models, highlighting a dose-response relationship: lower MMWs were associated with reduced survival.

Fig 3. Overall three-year survival of formal employees with colorectal cancer per quartile of MMW. MMW: Monthly Minimum Wages.

Table 2. Unadjusted and Adjusted HR of overall survival of formal employees with colorectal cancer per quartile of MMW

	Unadjusted HR of overall survival			Adjusted HR of overall survival[a]		
MMW quartiles						
	HR	95% CI	p	HR	95% CI	p
Q1	ref	ref	ref	Ref	Ref	Ref
Q2	0,87	0.71 - 1.08	0,20	0,89	0.72 - 1.11	0,32
Q3	0,80	0.65 - 0.99	0,04	0,80	0.64 - 0.99	0,04
Q4	0,74	0.60 - 0.92	0,01	0,74	0.59 - 0.92	0,01

[a]The HR was adjusted for Sex, Stage of Cancer at the moment of diagnosis, Region, CCI, insurer, and year of diagnosis.

Abbreviations: MMW: Monthly Minimum Wages; HR: Hazard Ratio; 95% CI, 95% confidence interval; p: p-value, Q: Quartiles.

The calculated RII and SII further supported these findings, showing significant differences by MMW even after adjustment for key covariates (Table 3).

Table 3. Relative and Slope Index of inequality (RII & SII) in overall mortality of patients with colorectal cancer belonging to the contributory regime in Colombia by MMW

	Index	**95% CI**	**p-value**
RII			
Overall mortality	1.50	1.13 – 1.99	0.01
SII			

Overall mortality (per 1.000 adults)	0.16	0.05 – 0.27	0.01

241 Relative and Slope Index of inequality were calculated by controlling by sex, age, stage of diagnosis,
242 Charlson Comorbidity Index, geographic region, insurer and year.
243 Abbreviations: RRI: Relative Index of inequality; SII: Slope Index of inequality.
244

Discussion

This population-based study focused on formal employees diagnosed with colorectal cancer in a low- and middle-income country (LMIC), specifically Colombia. Over seven years, patients were followed for three years to assess survival outcomes. To our knowledge, this is the first study in an LMIC targeting a theoretically advantaged population due to their formal employment status and the associated health benefits. Our findings reveal significant disparities in three-year survival rates based on income, even within this ostensibly protected group. Despite being part of a health system designed to ensure equitable access to healthcare services, our results underscore that income remains a critical determinant of survival, challenging the assumption of universal access and highlighting persistent inequalities in health outcomes.

These findings align with research conducted in both high-income countries and LMICs, where substantial disparities in cancer survival related to socioeconomic status have been documented, even in systems striving for equitable healthcare access [25]. Numerous studies have demonstrated the impact of income inequalities on colorectal cancer survival, consistently reporting lower survival rates among individuals with lower incomes [26–30]. Disparities have also been identified across other dimensions, including geographic location, residential socioeconomic status, education level, race, and health insurance coverage [9,31–34]. Our findings are further supported by studies evaluating income-based inequalities using indicators such as the SII and the RII, which consistently show significant differences in outcomes based on these factors [35,36]. This study contributes to this growing body of evidence by highlighting that income plays a crucial role in survival outcomes, even within a relatively advantaged group, such as formal employees, who theoretically face fewer healthcare access barriers.

It is important to note that income disparities often intersect with other forms of inequality, such as differences in education, working conditions, geographic barriers, and the quality of healthcare services. For example, lower-income individuals may reside in areas with limited access to specialised healthcare or face longer wait times for advanced treatments, even in systems that aim to provide equitable healthcare access. These interconnected factors likely contribute to the observed disparities in survival outcomes, even in settings where primary healthcare access is ostensibly uniform. Beyond access to specialised care, other structural barriers—such as the quality and continuity of care, navigation through the healthcare system, and the availability of multidisciplinary teams—may also significantly influence survival outcomes.

This study has several strengths. The reliability of the data is a crucial advantage, as it includes comprehensive information on income and formal employee status, with wage data mandatorily reported by employers to the PILA database under national regulations. Furthermore, the RUAF death registry provides extensive coverage, documenting over 90% of deaths nationwide, making it a robust resource for investigating healthcare inequalities. These databases, including the UPC and BDUA, have been widely used in previous studies, further supporting their validity as valuable tools for research. However, some limitations should be considered. Patient identification relied on algorithms using procedural and ICD-10 codes, which, while necessary for administrative databases, could lead to misclassification. Additionally, although administrative databases provide reliable data on healthcare utilisation, they lack detailed clinical variables that could offer a more nuanced understanding of cancer characteristics. To mitigate this limitation, we staged the disease based on procedure codes related to cancer treatment, supported by clinical expertise.

Finally, this study focuses on a relatively privileged population in terms of health status and income. The income-related disparities identified here may be even more pronounced in other population groups, such as informal employees or the unemployed. Moreover, survival differences could be exacerbated in countries with greater overall inequality. Thus, while our findings are significant, they may underestimate the true extent of socioeconomic disparities in cancer outcomes across broader or more disadvantaged populations. Further studies are needed to explore the impact of social inequalities on health outcomes in populations with poorer socioeconomic conditions and more significant barriers to adequate healthcare access.

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421

422 **Supporting information**

423 S1 File. List of ICD-10 and CUPS codes is used in the electronic algorithm for colorectal cancer.

424 S1 Table. Coefficients of survival regression.

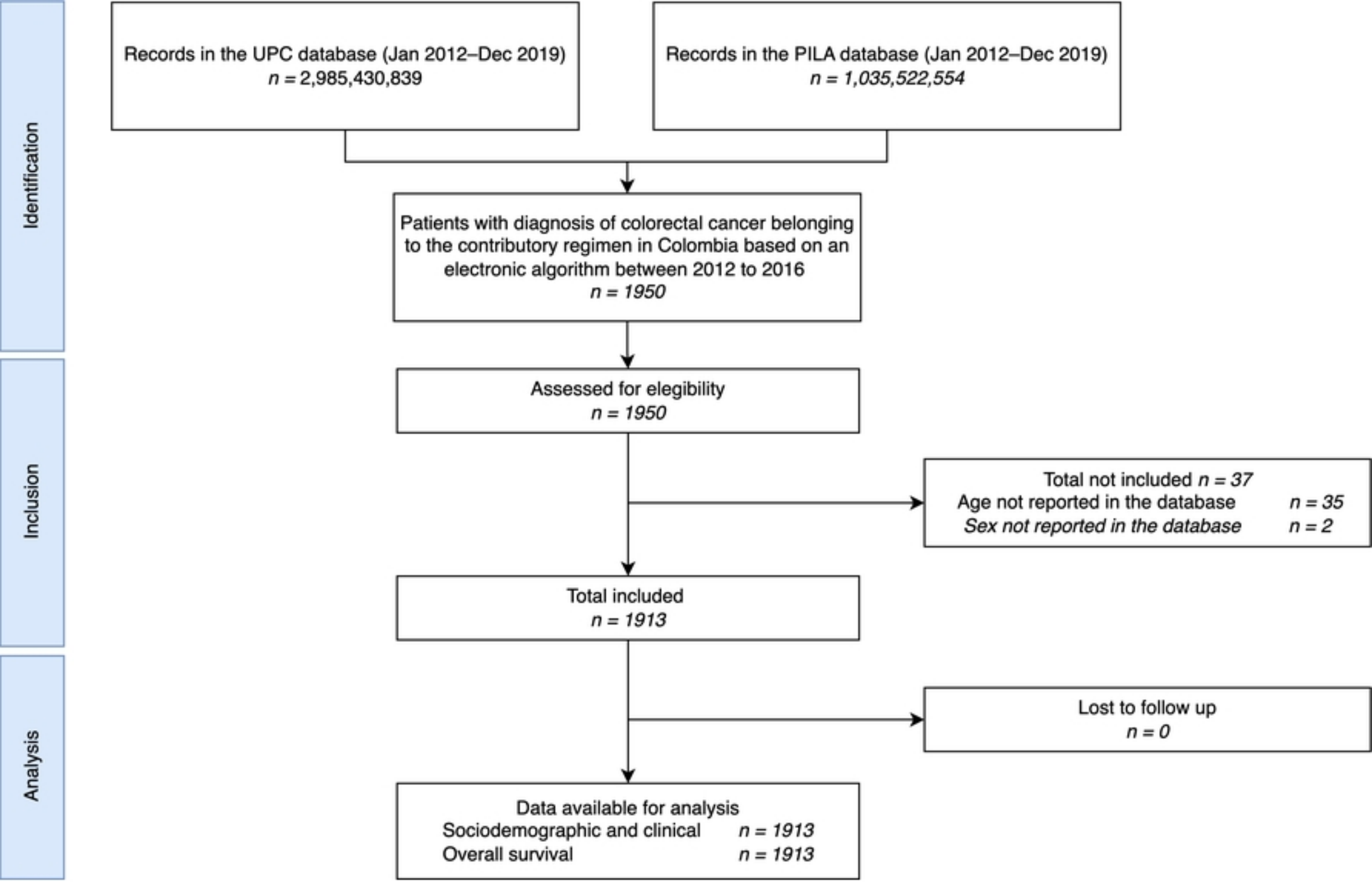
Identification
Inclusion
Analysis
Records in the UPC database (Jan 2012–Dec 2019)
n = 2,985,430,839
Records in the PILA database (Jan 2012–Dec 2019)
n = 1,035,522,554
Patients with diagnosis of colorectal cancer belonging to the contributory regimen in Colombia based on an electronic algorithm between 2012 to 2016
n = 1950
Assessed for elegibility
n = 1950
Total not included n = 37
Age not reported in the database n = 35
Sex not reported in the database n = 2
Total included
n = 1913
Lost to follow up
n = 0
Data available for analysis
Sociodemographic and clinical n = 1913
Overall survival n = 1913

Fig1


Proportion of mortality by quartil of MMW in formal workers with CCR
0.45
0.40
0.35
0.30
0.25
Proportion of mortality
0.39
0.35
0.33
0.31
Q1
Q2
Q3
Q4
MMW
Proportion
95% CI

Fig2

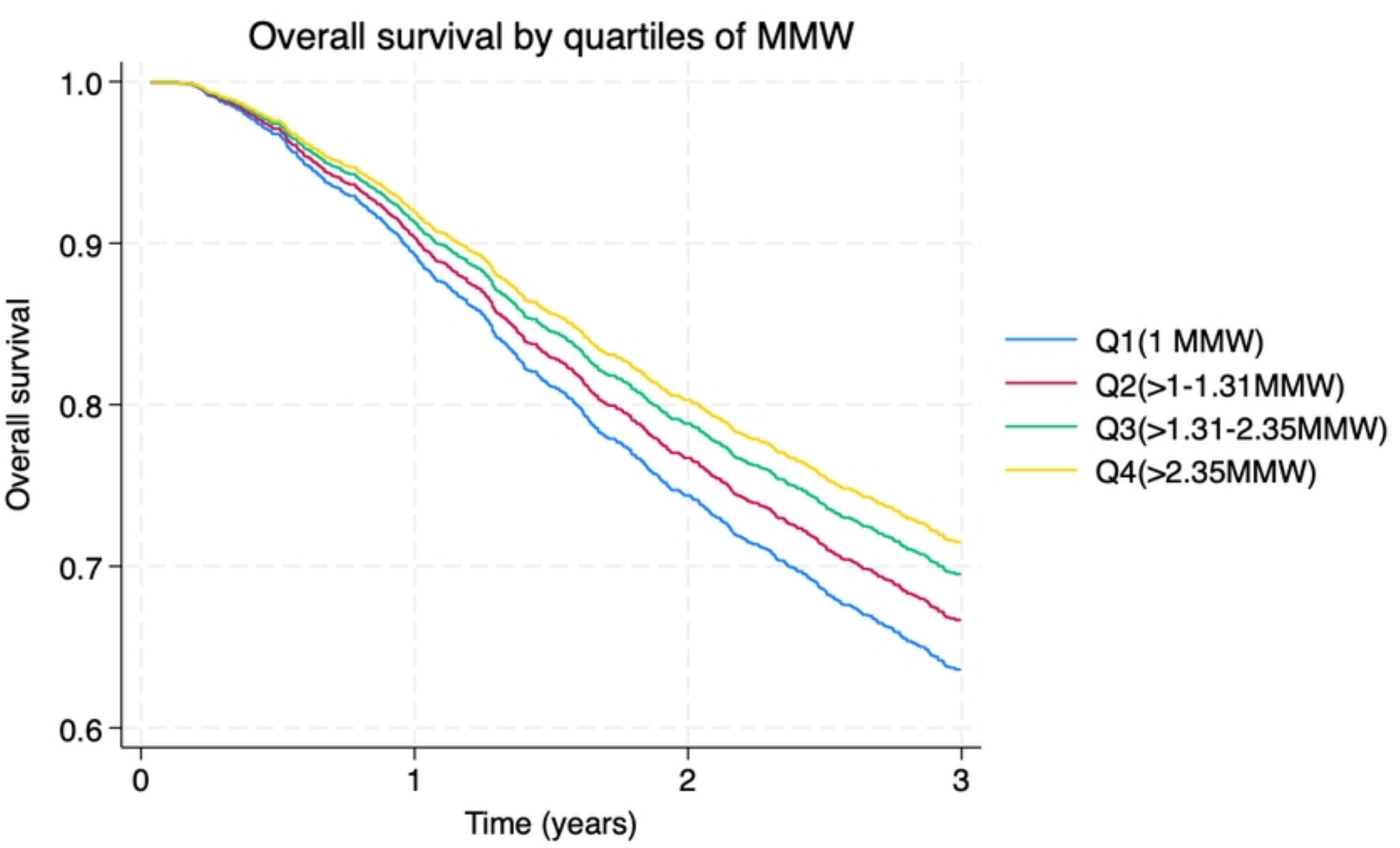
Overall survival by quartiles of MMW
Overall survival
1.0
0.9
0.8
0.7
0.6
0
1
2
3
Time (years)
Q1(1 MMW)
Q2(>1-1.31MMW)
Q3(>1.31-2.35MMW)
Q4(>2.35MMW)

Fig3