BMC Public Health

RESEARCH

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The impact of individual and contextual socioeconomic factors on colorectal cancer screening adherence in Turin, Italy: a multilevel analysis

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Abstract

Background Screening participation can be influenced by both individual socioeconomic position and contextual factors. In Italy, disparities exist regarding screening adherence, but it is important to understand the specific factors driving these disparities in specific locations according to different screening protocols. The aim of this study is to identify the impact of individual and contextual socio-economic factors on adherence to the organized colorectal cancer screening in the city of Turin, Italy.

Methods Retrospective observational study on the population of assisted residents in Turin, eligible for colorectal screening from January 2010– June 2019. Colorectal screening in Piedmont involved inviting 58-year-old individuals to undergo a flexible sigmoidoscopy (FS) or, in case of non-adherence, a faecal immunochemical test (FIT). The program also included another protocol based directly on FIT as the first test. Adherence to the two screening protocols according to demographic/socioeconomic characteristics and contextual factors was evaluated with multilevel Poisson models.

Results 90,227 eligible subjects (53% females) were analysed exploring adherence to FS/FIT. Lower likelihood of participation was found among males from High-Migratory-Pressure-Countries (HMPC), subjects with the lowest educational level, unemployed individuals, subjects living in rented houses, living alone/cohabiting and single parents. Among males, retirees and subjects living in more deprived areas participated more. 36,674 subjects (53% females) were analysed exploring adherence to the first FIT invitation. Adherence rate was higher among women (40% vs. 36%). Lower likelihood of participation was found among HMPC immigrants, males with the lowest educational level, people living in rented accommodation, living alone/cohabiting and single parents. Higher participation was found in retirees. In males, no differences were found between subjects living in more and less deprived areas, but a different likelihood of participation was observed across different areas of the city.

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Conclusions Socioeconomic and demographic characteristics influence access to organized colorectal screening in Turin. Immigrant status, low level of education, poor housing conditions and lack of social support, with some differences according to gender, emerged as the most significant barriers that should be tackled in order to increase screening participation and reduce inequalities. Contextual factors play a role only among male subjects.

Keywords Colorectal cancer, Organized screening, Socioeconomic position, Social inequalities, Contextual factors

Background

Colorectal cancer (CRC) is a challenging public health problem, accounting for 10% of all diagnosed cancer worldwide, with approximately 1.9 million new cases and 935,000 deaths reported in 2020. CRC is the third most diagnosed cancer and the second leading cause of cancer-related deaths globally. The incidence and mortality rates of CRC vary widely between countries, with the highest rates reported in developed countries [1, 2].

Several risk factors have been identified for the development of CRC, including age, family history of CRC, personal history of inflammatory bowel disease, genetic mutations and lifestyle factors such as smoking, alcohol consumption, physical inactivity, and diet [3]. Age is a significant risk factor, as CRC incidence increases rapidly after the age of 50 years [4], while the most important prognostic factor is the stage at diagnosis [3]. Hence, early diagnosis in average-risk persons through the detection and removal of precancerous polyps or early-stage invasive cancer is highly effective in reducing CRC mortality [5, 6]. In fact, the implementation of screening programmes, together with the improvement of medical and surgical therapies, have led to a significant decrease in CRC mortality over the last years [6, 7].

However, disparities in screening uptake exist worldwide and contribute to differences in CRC mortality rates across different socioeconomic and demographic groups, with individuals from disadvantaged backgrounds experiencing poorer survival rates, due to a lower adherence to organized screening [8, 9]. Understanding and addressing these disparities is a key public health issue.

Several recent studies have investigated the role of socioeconomic and demographic factors in CRC screening adherence in Europe. For example, astudy conducted in England as part of the national screening programme found that socioeconomic deprivation and belonging to the most diverse ethnic quintile of the population were strongly associated with lower screening uptake [10]. Similarly, a systematic review of studies conducted in several well-developed countries found that lower socioeconomic position (SEP) and level of education were consistently associated with lower screening participation [11].

In Italy, an organized population-based screening is active, involving a Faecal Immunochemical Test (FIT) performed every two years among individuals aged 50 to 69 years (extended to 74 in some Regions). Despite active invitation to all eligible subjects, social inequities in screening adherence persist. For example, Petrelli et al. found that high educational level, adequate economic conditions and being Italians are predisposing factors for accessing cervical and breast cancer screening [12]. Similar results were obtained by Damiani et al., which found that lower levels of education and occupational class are strongly associated with a reduced participation in both breast and cervical cancer screening, being also these disparities more accentuated in the Southern regions [13]. However, these studies did not consider CRC screening, so their results cannot be generalized to all organized screenings. Furthermore, these studies are based on data from cross-sectional surveys and not on official data from current dedicated informative systems.

In Italy, CRC is the second most common cancer after breast cancer, with 50,500 new diagnoses estimated for 2023 [14]. In every Italian region the population-based organized screening is active, but there is evidence of social inequalities in CRC screening uptake. A recent study conducted in the region of Umbria showed that being born abroad and belonging to the most deprived quintile were associated with lower screening adherence [15]. However, as the Authors point out, in this study a SEP indicator was only available at the census tract level and no individual-level SEP indicator was added into the analysis. Using only area-level socioeconomic information, besides entailing a greater risk of ecological fallacy, excludes the possibility of a more in-depth assessment of inequalities, capable of disentangling a pure contextual effect from the compositional effect given by the sum of the individual characteristics of people living in the same area [16]. Further studies in different settings are needed to gain a better understanding of the real impact of individual socioeconomic factors on colorectal screening participation.

In addition, in agreement with the Whitehead's framework of social determinants of health [17], screening adherence can be influenced by broader contextual factors, as well as from neighbourhood or community factors, independently from the socioeconomic and demographic characteristics considered at an individual level. A recent study conducted in the US explored the relationship between colorectal screening adherence and neighbourhood variables, at the census tract level, linked to individual data [18]. The results of this study show that participants living in low SEP neighbourhoods had the

lowest odds of screening adherence, suggesting that the context in which people live could potentially exert an independent effect on adherence beyond the socioeconomic and demographic characteristics of the individuals. Similar results were obtained by another US study, which found that subjects living in the most deprived areas were almost half as likely to undergo recommended breast, cervical and colorectal cancer screenings, regardless of sex, age, race, comorbidities and neighbourhood rurality [19]. However, these studies were conducted in the US, where the public health service is significantly different from Italy, and an organized screening freely available for all eligible citizens does not exist.

To our knowledge, no previous studies were carried out in a big metropolitan Italian city in order to assess the impact of both individual and contextual variables on adherence to the organized CRC screening programme. In addition, despite the growing body of research on the social determinants of screening adherence, there is still much to learn about the factors driving these disparities in different geographical areas. By improving the understanding of the social determinants of CRC screening uptake, more effective interventions to increase screening participation and reduce disparities could be developed.

The aims of this paper are to explore the individual socioeconomic and demographic factors associated with CRC screening uptake in the city of Turin, Italy, and to examine the potential role of contextual factors using a multilevel approach, to assess whether living in specific areas of the city has an independent impact on screening adherence.

Methods

CRC screening program

In Turin (Piedmont, northern Italy), in the period considered in this study, from January 2010 to June 2019, the regional screening protocol included two different pathways.

The regional protocol had adopted sigmoidoscopy (FS), once in the lifetime as the primary screening strategy. Each regional Local Health Unit (LHU) identified the population eligible for colorectal cancer screening using the regional health registry lists, which contain information on resident and domiciled individuals. Subjects aged 58 years received an invitation to undergo a FS: in case of a positive result, a second level examination involving a complete colonoscopy was performed, while in case of a negative result the screening process terminated. Subjects who did not respond to the FS invitation were subsequently invited to undergo a Faecal Immunochemical Test (FIT), repeated every two years until the age of 69. In case of a positive FIT result, a complete colonoscopy was performed.

The regional screening programme also included a second protocol directly based on FIT. Subjects who did not receive the invitation to undergo FS (subjects older than 58 at the time of starting the program, or those who could not be invited at age 58 due to lack of endoscopy resources), were directly invited to undergo a FIT test, repeated every two years until the age of 69. In case of a positive result, a complete colonoscopy was performed.

Study population

Data regarding individuals invited to the two screening protocols were integrated with socioeconomic and demographics data from the Turin Longitudinal Study (TLS). TLS relies on the individual record-linkage between Turin historical municipal register, the population censuses (1971, 1981, 1991, 2001, 2011) and health data (mortality registries, hospital discharges and drug prescriptions) [20, 21]. Based on record-linkage procedures at individual level, over 90% of subjects invited to each screening pathway between 2010 and June 2019 were successfully matched with TLS data (94,660 out of 101,992 for the FS/FIT protocol; 40,934 out of 45,485 for the FIT protocol).

The study population consists of residents in Turin invited in one of the two screening pathways, between 1st January 2010 and 30th June 2019, and who took part in the 2001 or 2011 census (90,227 and 36,674 for the FS/FIT and FIT protocols respectively).

Outcome indicators

Adherence Rates (AR) were defined for each pathway of screening offered. In order to assess adherence to the screening protocol based on FS, a first indicator (FS/FIT) was constructed by dividing the total number of subjects who either underwent FS or the subsequent FIT by the total number of subjects invited to undergo FS in the first place, during the study period (2010–2019).

A second indicator was defined for the screening protocol based on FIT: adherence was assessed only to the first FIT invitation among all subjects directly invited to undergo FIT in the first place, during the same study period (2010–2019).

Socioeconomic position

Individual-level variables

To evaluate the presence of social inequalities affecting colorectal screening adherence, the characteristics that most directly represent the individual availability of resources, predictive of the main dimensions of disadvantage, were chosen among the self-reported information available in the 2001 and 2011 censuses:

- Educational skills, characterized by individuals' educational qualification, categorized into four

groups based on the highest level of education declared in the census (university degree or higher, high school diploma, middle school and vocational school diploma, primary school diploma or less).
- Family support, defined through a variable ("family composition") which compares couples with children, couples without children, single parents and subjects living alone or in cohabitation.
- Occupational status, assessed through the presence of a paid employment in comparison to several categories of individuals outside the labour market: retired, unemployed, housewives (only for females) and other inactive subjects.
- Material resources, represented by the variable "housing condition", which combines housing tenure and household crowding into four groups: owned and uncrowded houses; rented and uncrowded houses; owned and overcrowded houses; rented and overcrowded houses. Household crowding (uncrowded vs. overcrowded house) was assessed according to the size of the house in relation to the number of household members, according to the definition of Banca D'Italia: overcrowding is present if the size of the house is less than 30, 50, 65, 80, 110, and 125 square meters when the cohabiting members are, respectively, one, two, three, from four to six, seven, and eight or more [22].

When available the most recent information was used, while 2001 information was used for subjects who did not take part in the 2011 census (about 3–4% of the study population).

Citizenship, available in the population register, was divided into two main groups: Italians (including a small subgroup of population with citizenship from Highly Developed Countries, HDC) and immigrants from High Migratory Pressure Countries (HMPC). Immigrants from HMPC were furtherly divided by macro-area of origin: Central and Eastern Europe, Northern and sub-Saharan Africa, Central and Southern America, Asia.

Area-level variables

The residential address at the moment of the screening invitation was geographically referenced into 94 statistical areas. The statistical areas are sub-municipal territorial units into which the city of Turin is divided (including approximately 10,000 inhabitants). For each one a deprivation index (DI) was estimated to represent the area-level socioeconomic context. The DI combines at an area level five dimensions of social and material deprivation (low education, unemployment, rented or free housing, overcrowding and single parent household) using information from the 2011 census [23].

Statistical analyses

Adherence Rate Ratios (ARRs), along with their 95% confidence intervals (95% CI), for each screening pathway by individual and area-level socioeconomic characteristics were analysed through a multilevel approach using random-effect Poisson regression models, considering the statistical areas as clusters.

Differences by statistical areas (estimated by the random intercept's variance) were assessed through the Likelihood Ratio Test (LRT) comparing the multilevel model with a Poisson model without clusters [24, 25]. At first, we used a multilevel model adjusted only for age and year of invitation (Model 1). Then, all individual level socioeconomic variables were added (Model 2) and area-level heterogeneity was assessed again. A non-multilevel Poisson model was employed if the LRT did not reveal additional variability across statistical areas. Conversely, if any residual heterogeneity was detected, it was furtherly explored to determine if it could be attributed to contextual factors by adding the area-level DI.

After these preliminary analyses, the differences by statistical area in both indicators dropped among females (LRT p-value = 1 and p-value = 0.316 for FS/FIT and FIT protocols, respectively; Supplementary Tables 1 and 2), leading to the adoption of a non-multilevel Poisson model. On the contrary, a residual area-level heterogeneity persisted among males (LRT p-value = 0.008 and p-value = 0.021; Supplementary Tables 1 and 2).

In a separate model, citizenship differences were exploded by comparing Italians with immigrants from HMPC detailed by macro-area of origin.

All analyses were stratified by gender and were carried out in STATA 17.

Results

Variables associated with adherence to FS/FIT

Table 1 reports the socioeconomic and demographic characteristics of the 90,227 eligible subjects (53% were females) analysed for the indicator exploring adherence to FS/FIT, and the results of the multivariable Poisson regression assessing the association between those characteristics and CRC screening adherence. The participation rate was 38% among men as among women.

Male subjects from HMPC showed a lower probability of adherence compared with Italians and HDC citizens (ARR 0.90, 95% IC 0.82–0.99). This result is mainly explained by the adherence pattern of immigrants from Northern and sub-Saharan Africa, who exhibited the lowest probability of adherence, among both females (ARR 0.63, 95% IC 0.50–0.80) and males (ARR 0.74, 95% IC 0.59–0.94). On the other side, women from Central and Southern America had a 26% higher likelihood of adhering to screening (ARR 1.26, 95% IC 1.08–1.47).

Table 1 Adherence to the screening program based on FS/FIT by socioeconomic/demographic characteristics and gender

	Females				Males			
	Invited	**AR**	**ARR***	**95% CI**	**Invited**	**AR**	**ARR****	**95% CI**
Total	47,727	38%			42,500	38%		
Citizenship								
Italian and HDC	45,302	39%	1.00		40,819	38%	1.00	
HMPC	2425	33%	1.00	0.94–1.06	1681	28%	0.90	0.82–0.99
Central and Eastern Europe	1598	34%	1.03	0.96–1.10	936	31%	0.94	0.83–1.06
Northern and sub-Saharan Africa	256	20%	0.63	0.50–0.80	349	21%	0.74	0.59–0.94
Central and Southern America	298	41%	1.26	1.08–1.47	159	32%	1.03	0.78–1.36
Asia	281	30%	0.86	0.71–1.03	244	27%	0.85	0.66–1.08
Educational qualification								
Degree or higher	8033	40%	1.00		7798	40%	1.00	
High school diploma	12,254	39%	0.99	0.96–1.03	12,971	42%	1.05	1.01–1.10
Middle school diploma	21,221	39%	1.03	0.99–1.06	17,687	37%	0.93	0.89–0.97
Primary school diploma or lower	6219	33%	0.90	0.86–0.95	4044	25%	0.67	0.62–0.72
Occupational status								
Employed	29,074	40%	1.00		32,075	39%	1.00	
Unemployed	1919	32%	0.87	0.81–0.93	2199	26%	0.79	0.73–0.86
Housewives	10,311	36%	0.90	0.88–0.93				
Retired	3983	41%	1.02	0.98–1.07	4559	43%	1.17	1.11–1.23
Others inactive	2440	32%	0.85	0.80–0.91	3667	28%	0.83	0.78–0.89
Housing condition								
Owned and uncrowded houses	27,479	41%	1.00		23,085	42%	1.00	
Owned and overcrowded houses	5949	40%	0.96	0.93–1.00	6140	41%	0.97	0.92–1.01
Rented and uncrowded houses	10,172	32%	0.82	0.79–0.84	8942	30%	0.79	0.75–0.82
Rented and overcrowded houses	3815	31%	0.78	0.74–0.82	3861	30%	0.78	0.73–0.83
Family composition								
Couples with children	19,366	41%	1.00		21,773	42%	1.00	
Couples without children	11,124	40%	1.00	0.97–1.03	7964	38%	0.93	0.89–0.97
Single parents	6951	35%	0.88	0.85–0.91	2626	30%	0.74	0.68–0.79
Alone / cohabiting	10,168	34%	0.86	0.83–0.89	9987	30%	0.77	0.73–0.80
Deprivation index								
I quintile (low)	10,064	39%			8616	38%	1.00	
II	9771	38%			8435	40%	1.07	1.01–1.14
III	9301	39%			8110	39%	1.07	1.01–1.14
IV	9372	39%			8323	38%	1.09	1.03–1.16
V quintile (high)	9219	37%			9016	36%	1.07	1.01–1.14
Variance (random intercept)							0.002	0.0007–0.0054
LRT (*p*-value)							0.006	

HDC = immigrants from Highly Developed Countries

HMPC = immigrants from High Migratory Pressure Countries

LRT = Likelihood Ratio Test comparing multilevel vs. non-multilevel Poisson models

*Poisson regression model adjusted for age and year of invitation

**Multilevel Poisson regression model (statistical areas as clusters) adjusted for age and year of invitation

Both males and females who achieved the lowest educational level were less likely to participate in the screening program, compared to higher educated subjects (ARR 0.90, 95% IC 0.86–0.95 and ARR 0.67, 95% IC 0.62–0.72 respectively).

Housewives (ARR 0.90, 95% CI: 0.88–0.93) and unemployed individuals of both genders (females ARR 0.87, 95% CI: 0.81–0.93 and males ARR 0.79, 95% CI: 0.73–0.86), as well as subjects in other inactive positions, had lower probability of adherence compared to employed counterparts, while retired males had a higher probability of adherence (ARR 1.17, 95% IC 1.11–1.23).

Both males and females living in worse housing conditions, particularly subjects living in rented and overcrowded houses, had lower adherence to the screening program compared to subjects in better housing conditions.

Regarding family composition, compared to subjects living in couple with children, lower likelihood of participation was found among subjects living alone or cohabiting (ARR 0.86, 95% IC 0.83–0.89 in females and ARR 0.77, 95% IC 0.73–0.80 in males), and among single parents (females ARR 0.88, 95% IC 0.85–0.91 and males ARR 0.74, 95% IC 0.68–0.79).

After the inclusion of the area DI in the model and accounting for individual socioeconomic characteristics, men living in the least deprived area showed a lower probability of adherence compared to subjects living in all the other areas. Some residual variability among areas still persisted, also after adjusting for area DI (LRT p-value = 0.006). Figure 1 shows the amount by which each area-specific AR coefficient departs from the adjusted mean (represented by the red line); the plot thus highlights areas showing a significantly higher or lower likelihood of adherence.

Variables associated with adherence to the first FIT invitation

Table 2 reports the baseline socioeconomic and demographic characteristics of the 36,674 subjects (53% were females) analysed for the second indicator, exploring the participation to the first FIT invitation and the results of the multivariable Poisson regression.

The AR was significantly higher among women (40%) than in men (36%) (Chi-square test p-value < 0.001).

Individuals from HMPC showed a lower adherence, both in females (ARR 0.85, 95% IC 0.75–0.97) and males (ARR 0.82, 95% IC 0.68–0.99). Again, immigrants from Northern and sub-Saharan Africa showed the lowest likelihood of adherence, in both genders (ARR 0.53, 95% IC 0.37–0.78 among females and ARR 0.34, 95% IC 0.19–0.60 among males).

Regarding educational qualification, compared to subjects with a degree or higher qualification, males with primary school diploma or less were less likely to participate (ARR 0.85, 95% IC 0.77–0.94).

Retired females and males had respectively almost 27% and 42% higher adherence compared to their employed counterparts.

People living in rented accommodations participated less, independently of household crowding, among both females and males. Regarding family composition, females in couples without children had higher participation (ARR 1.06, 95% IC 1.00-1.13) than couples with children, while a lower participation was observed among both females and males living alone or cohabiting and single parents.

Despite the models among males exhibited additional variability attributable to the statistical area of residence, no differences were found according to area deprivation. The multilevel analysis showed residual area-level variability (LRT p-value = 0.043), with a few zones showing a significantly higher or lower likelihood of adherence (Fig. 2).

Discussion

The results of this study shed light on the socio-demographic inequalities in CRC screening uptake in the city of Turin, Italy, underlining several key factors that influence participation, such as citizenship, education, household and familiar conditions, occupational status and area of residence.

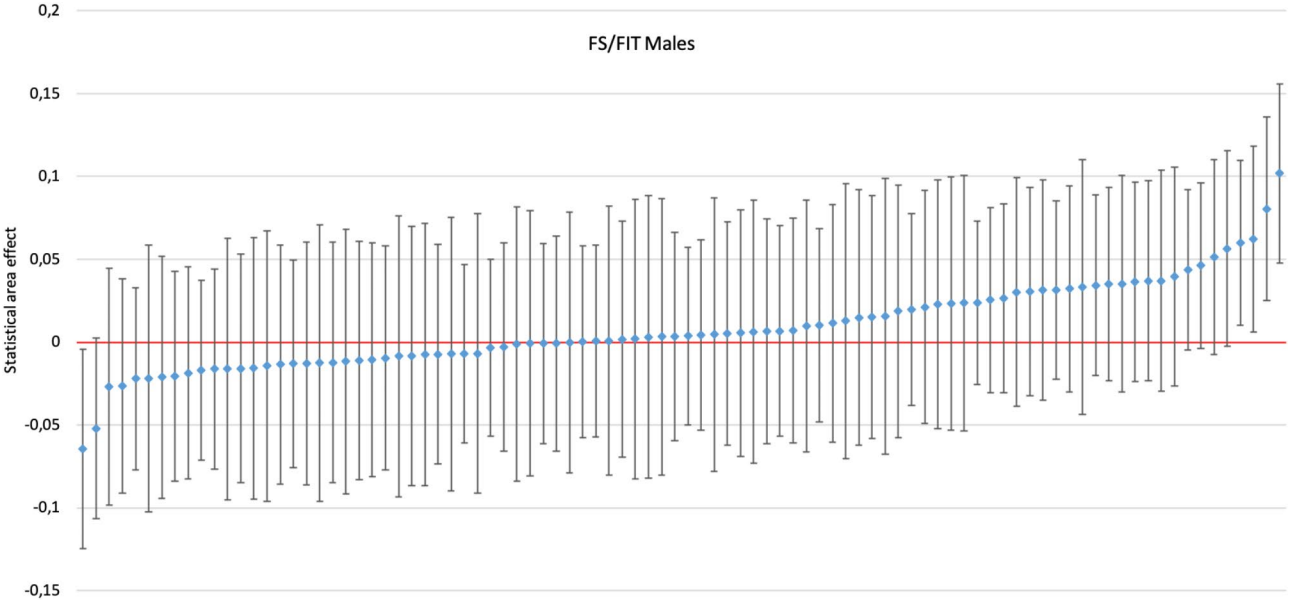

Fig. 1 Deviation of area-specific coefficient from the mean AR, adjusted for individual and area-level socioeconomic characteristics (FS/FIT)

Table 2 Adherence to the screening program based on FIT by socioeconomic/demographic characteristics and gender

	Females				Males			
	Invited	**AR**	**ARR***	**95% CI**	**Invited**	**AR**	**ARR****	**95% CI**
Total	19,333	40%			17,341	36%		
Citizenship								
Italian and HDC	18,390	41%	1.00		16,774	37%	1.00	
HMPC	943	28%	0.85	0.75–0.97	567	22%	0.82	0.68–0.99
Central and Eastern Europe	554	31%	0.93	0.80–1.09	267	22%	1.01	0.80–1.28
Northern and sub-Saharan Africa	172	16%	0.53	0.37–0.78	145	7%	0.34	0.19–0.60
Central and Southern America	124	33%	1.05	0.77–1.43	60	20%	1.00	0.61–1.64
Asia	93	24%	0.66	0.44–1.01	95	19%	0.84	0.55–1.29
Educational qualification								
Degree or higher	2659	40%	1.00		2980	34%	1.00	
High school diploma	3972	40%	1.02	0.94–1.10	4657	38%	1.08	0.99–1.16
Middle school diploma	8054	42%	1.06	0.99–1.13	6721	38%	1.06	0.98–1.15
Primary school diploma or lower	4648	39%	0.99	0.91–1.07	2983	31%	0.85	0.77–0.94
Occupational status								
Employed	6331	37%	1.00		8320	31%	1.00	
Unemployed	441	32%	0.95	0.80–1.13	635	24%	0.89	0.76–1.06
Housewives	4078	37%	0.99	0.93–1.07				
Retired	7533	47%	1.27	1.18–1.35	6848	45%	1.42	1.33–1.52
Others inactive	950	33%	0.97	0.86–1.09	1538	26%	0.98	0.88–1.10
Housing condition								
Owned and uncrowded houses	11,854	44%	1.00		9989	41%	1.00	
Owned and overcrowded houses	2081	41%	0.98	0.91–1.06	2101	38%	0.94	0.87–1.02
Rented and uncrowded houses	3812	34%	0.84	0.79–0.89	3616	28%	0.78	0.73–0.84
Rented and overcrowded houses	1348	28%	0.72	0.65–0.80	1398	25%	0.73	0.65–0.82
Family composition								
Couples with children	6020	40%	1.00		7141	37%	1.00	
Couples without children	6262	45%	1.06	1.00–1.13	5119	43%	1.05	0.99–1.11
Single parents	2222	35%	0.89	0.82–0.96	917	26%	0.71	0.62–0.81
Alone / cohabiting	4668	37%	0.90	0.84–0.96	4061	29%	0.82	0.76–0.88
Deprivation index								
I quintile (low)	4203	40%			3705	36%	1.00	
II	3852	40%			3326	37%	1.02	0.93–1.12
III	3656	43%			3261	38%	1.05	0.96–1.16
IV	3933	41%			3533	37%	1.04	0.95–1.14
V quintile (high)	3689	37%			3516	33%	0.98	0.89–1.08
Variance (random intercept)							0.004	0.001–0.016
LRT (*p*-value) test vs. Poisson Model							0.043	

HDC = immigrants from Highly Developed Countries

HMPC = immigrants from High Migratory Pressure Countries

LRT = Likelihood Ratio Test comparing multilevel vs. non-multilevel Poisson models

*Poisson regression model adjusted for age and year of invitation

**Multilevel Poisson regression model (statistical areas as clusters) adjusted for age and year of invitation

For the FS/FIT protocol a global adherence rate of 38% was found, in both genders. For the FIT protocol, a higher participation rate was observed in females (40% for females and 36% for males). A higher participation among women than among men has been reported from most FIT based programs, likely as a consequence of women being more aware of screenings due to their practice of breast and cervical cancer screenings. A protocol offering the option to undergo a different test might favour a reduction of the gender gap: men showed a higher participation to FS and a lower participation to the FIT screening as compared to women [26].

Citizenship seems to be a characteristic strongly associated with screening participation: immigrants from HMPC showed lower adherence to the FIT programme in both genders, in accordance with several previous studies carried out in different settings [27–29]. Our results are also consistent with the findings of an Italian

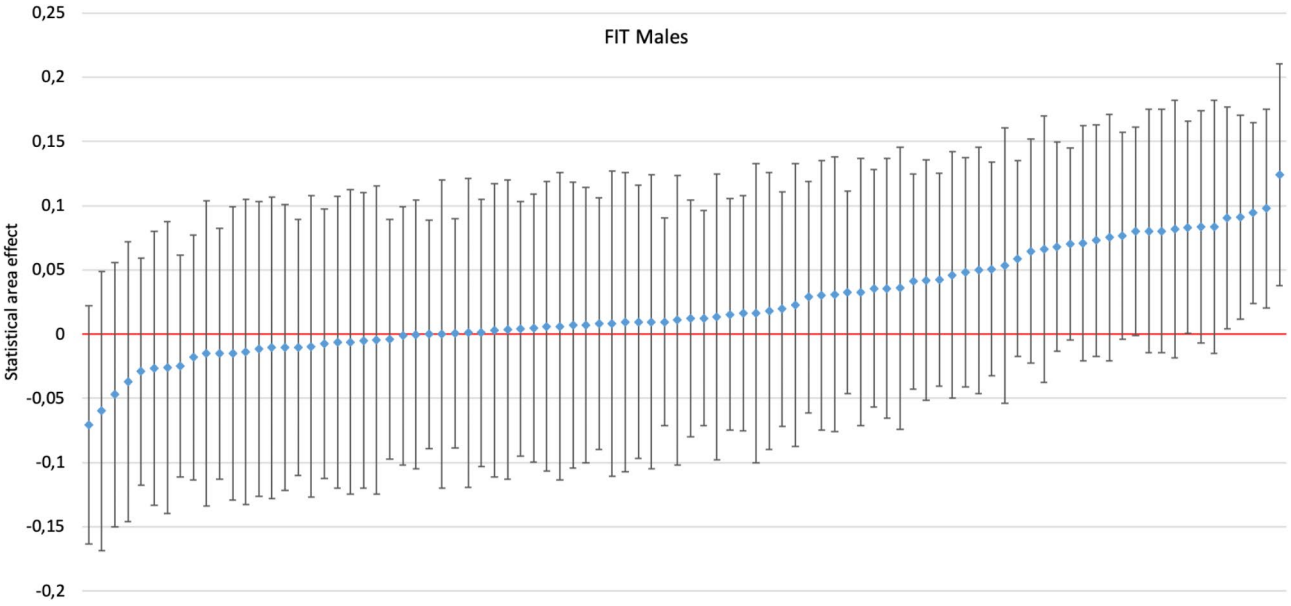

Fig. 2 Deviation of area-specific coefficient from the mean AR, adjusted for individual and area-level socioeconomic characteristics (FIT)

survey conducted by the National Centre for Screening Monitoring in 2013, which analysed data from 85 Italian screening programmes finding that being an immigrant was a significant barrier to colorectal screening participation [30]. Cultural differences and linguistic barriers are the most likely explanations for these results and should be adequately understood and tackled in order to reduce health inequalities in this population subgroup. For example, a recent Danish qualitative study among ethnic minority women found that informative letters written in native language, visual communication and tailored interaction with a healthcare provider could be successful tools to improve screening knowledge and participation [31]. Interestingly, regarding the FS/FIT protocol, a lower adherence was observed only in male immigrants, suggesting the potential existence of a resistance towards more invasive medical procedures which could be more rooted in males rather than females for cultural and religious reasons. Furthermore, when immigrant status was analysed more in detail, very low adherence rates for both indicators were observed among immigrants from Northern and sub-Saharan Africa, which appears to be the most refractory/hesitant community regarding access to CRC screening.

Regarding the association between educational level and participation, in people invited to FS/FIT a consistent trend emerged across both genders, showing that individuals with the lowest educational levels had lower participation rates. Also, among people directly invited to FIT, male subjects with the lowest educational level had the lowest probability of participation. These results are in line with literature data, which suggests that having a higher educational level facilitates the use of FS and FIT screening [27, 29, 32]. This could reflect the potential existence of barriers due to limited health literacy and challenges in navigating the healthcare system, especially when more complex and invasive exams such as FS are involved. However, educational attainment was not associated with participation in the FIT programme among female subjects. Hence, while education plays a role in both genders, the impact seems to be more heterogeneous. A better understanding of the interplay between educational qualification, gender, health literacy and screening attendance is therefore necessary to adequately contrast these discrepancies.

Individuals residing in rented accommodations (uncrowded or overcrowded) exhibited the lowest probability of participation, irrespective of gender and screening protocol. The lack of ownership of the house represents a lesser availability of material resources, including the ability to provide for private transportation. These factors could hinder screening participation, especially in areas with a higher concentration of households living in poor housing conditions, where reaching screening centres via public transport is more difficult.

Furthermore, differences emerged regarding household composition. Compared to subjects living in couples, the ones living alone or cohabiting showed lower adherence to both screening protocols, consistently with literature data showing that subjects living in couples have the highest probability of attendance to CRC screening [29, 33]. These results highlight the potential positive influence of a supportive partner on health-care decision-making. Also, single parents showed a lower adherence to both screening protocols, probably due to a heightened

sense of responsibility for caregiving roles that could potentially divert attention from one's health needs.

Employment status emerged as a significant determinant of screening adherence. Specifically, compared to employed individuals, unemployed ones exhibited lower adherence in both genders, but only considering adherence to FS/FIT. This finding suggests that unemployed individuals might have competing priorities that impede their ability to attend complex and potentially time-consuming preventive healthcare measures.

On the other hand, retired people displayed a higher probability of adherence to the FIT protocol in both genders and to FS/FIT among males. This could be attributed to greater availability of time and flexibility among this category, together with a higher awareness of the importance of preventive measures favoured by the past working experience and social relationships.

Considering the deprivation index, independently from the individual socioeconomic position, a lower probability of screening participation was found in the least deprived quintile compared to the other quintiles only among men and only for the adherence to FS/FIT, while we did not observe a different likelihood of participation across the deprivation index quintiles for the adherence to FIT. The lower participation of the male population residing in the richest neighbourhoods may be partially explained by the frequency of opportunistic screening carried out in private facilities and not captured by the regional screening databases. In particular, this phenomenon, although of limited extent, might have a greater impact for FS, whose high costs if carried out privately would be affordable only for a small portion of the population. Mixed results were found in the literature in studies addressing the role of contextual deprivation on colorectal screening participation. In line with our results, in a Korean study, participation rates increased with a composite deprivation index score, adjusting also for health insurance premium (an indicator of individual income level) and individual disability [34]. As the Authors point out, this could be a consequence of interventions and political support targeting deprived areas. On the contrary, several studies found lower participation in more deprived areas [9, 35]. For example, a French study found a 25% difference in participation between the least deprived and the most deprived areas [36]. It should be considered that in most studies the area level deprivation index is used as a replacement for unavailable individual level socioeconomic indicators. Hence, the association between area deprivation and colorectal screening adherence is still controversial, and further research is needed.

Even after the adjustment for individual level socioeconomic variables and the index of deprivation, further heterogeneity among statistical areas of residence was observed, with specific areas exhibiting higher or lower probabilities of participation among males. This result suggests the existence of a partial geographical variance in screening adherence not completely explained either by individual or by area-level socioeconomic factors, and potentially more related to organizational features within the screening programme. Indeed, an Italian study conducted in the region of Lazio found that the major determinant of non-compliance to CRC screening was lack of time, in fact subjects living close to the screening provider were more likely to participate [37]. So, it is conceivable that the geographical disparity that emerged in our study is, at least partially, due to an uneven distribution of screening providers across different neighbourhoods in the period under study. These findings highlight the importance of localized interventions that consider neighbourhood characteristics and tailor strategies accordingly. However, this geographical variance was observed only among male subjects. It is conceivable that women, having a more consolidated habit of participating in the organized screening with a regular schedule, such as breast cancer screening, are less affected by logistic difficulties. Further research is needed to better understand the specific contextual factors driving these disparities.

Strengths and limitations

This study allows the analysis of screening adherence on the entire invited population resident in Turin as it is based on population registers. Moreover, through linkage with censuses, it allows the inclusion of individual level socio-economic information.

However, some limitations have to be acknowledged. Firstly, the FS/FIT indicator of participation was constructed in order to consider the particularity of the screening protocol that existed in Piedmont during the study period, reducing the generalizability of our results and making comparison with other studies more complex. In addition, this study is based on subjects from an urban area, and the results may not be generalizable to different contexts.

Secondly, we studied only the determinants of participation in the first screening invitation for FIT-based protocols. However, repeated participation is also a highly relevant outcome. Participation in the first screening round represents a strong predictor of participation in subsequent rounds. We didn't analyse factors associated with repeated participation because our setting wasn't ideal for this analysis. In the FS/FIT protocol, subjects opting for FIT represent a selected group—they initially refused the invitation but later showed a preference for FIT. Moreover, subjects invited directly to the FIT screening protocol represent a closed cohort older than 58, no longer eligible for the FS/FIT screening protocol

at the start of the regional program. Further research on the determinants of participation is a priority for future studies.

Thirdly, the presence of comorbidity and familiar history of CRC, which tend to be associated with higher screening adherence [33, 38], were not considered in our analysis, as the information was not routinely collected within the programme.

Finally, socio-economic characteristics were only collected at the 2001 and 2011 census, but may have changed over time (especially housing and household composition); others, such as educational qualifications, tend to be more stable over time, particularly in the age group studied.

Conclusions

In conclusion, this study provides comprehensive insights into the socio-demographic inequalities in CRC screening uptake in the city of Turin, Italy. In general, the most significant barriers to screening adherence in our sample were immigrant status, low level of education, poor housing conditions and lack of social support. However, the results were heterogeneous according to gender and screening protocol, hence further research is needed to understand more precisely how socio-demographic and contextual factors interact and influence screening adherence.

Nevertheless, the findings of this study underline the need for complex interventions that address diverse barriers.

Improving communication is a key factor. This can be achieved through targeted communication campaigns and simplifying the informational materials. It is crucial to actively involve general practitioners (GPs), who can play an active role in promoting the screening program.

It is also essential to further implement the organizational aspects of screening, such as implementing the distribution of kits for the FIT test through the pharmacies, in order to reduce the area-level disparities in screening adherence.

Finally, partnering with volunteer organizations can be a useful strategy to make colorectal screening more accessible to immigrants. These organizations serve as gathering places for many immigrants and are an ideal context for their involvement in prevention programmes through the distribution of informational materials translated into multiple languages and the presence of cultural mediators.

By targeting these factors and implementing contextually appropriate strategies, healthcare authorities and policymakers can work towards an equitable access to CRC screening and a consequent reduction of health inequalities.

Abbreviations

AR	Adherence Rate
ARR	Adherence Rate Ratio
CRC	Colorectal Cancer
DI	Deprivation Index
FIT	Faecal Immunochemical Test
FS	Flexible Sigmoidoscopy
GP	General Practitioners
HDC	Highly Developed Countries
HMPC	High Migratory Pressure Countries
LRT	Likelihood Ratio Test
SEP	Socioeconomic Position
TLS	Turin Longitudinal Study

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22396-x.

Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

Conceptualization: CS, NZ, GF. Data Curation: GF, ES, CS, MC. Formal analysis: ES, GF, SR. Methodology: GF, NZ, ES, CS. Supervision: GF, NZ, CS, TS. Writing–original draft: SR, ES. Writing– review & editing: SR, ES, GF, CS, NZ, TS, MC. All authors have reviewed and approved the final manuscript.

Funding

Not applicable.

Data availability

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Ethical approval and consent to participate

TLS is a specific project within the Italian National Statistical Program (NSP), coordinated by the National Statistical System (Sistan). Sistan is a network of public and private entities that provide official statistical information to national and international bodies. The NSP is approved annually by law through the Italian Parliament. Since 2003, the NSP has introduced a specific form, PIE-00001 ("Monitoring of socio-economic differences in mortality and morbidity through longitudinal studies"), including the Turin Longitudinal Study (TLS). PIE-00001 states who are the TLS holder (the ASL TO3 Epidemiology Unit) and the partners (owners of each single source of data), and describes the record-linkage and statistical procedures. The owners of each data source used in this study are: the **City of Turin** for the historical municipal register, the **Italian National Institute of Statistics (ISTAT)** for the population censuses, and the University hospital Città della Salute e della Scienza for screening data. To ensure compliance with **EU General Data Protection Regulation (GDPR) 2016/679**, the Italian Data Protection Authority reviews the NSP in advance. It also adheres to the **Deontological Rules for Statistical and Scientific Research** (introduced by Legislative Decree No. 101 of August 10, 2018, Art. 20-ter, Paragraph 4), ensuring that personal data processing follows national regulations for statistical and scientific purposes. Confidentiality is safeguarded by removing personally identifiable information from individual records and assigning internal IDs to enable secure linkage across multiple data sources. The aggregated datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

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Received: 20 December 2023 / Accepted: 19 March 2025
Published online: 01 April 2025

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