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Association of individual and community-level socioeconomic status and education with medication use: a multilevel analysis in the PERSIAN cohort

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Abstract

Background Socioeconomic status (SES) and education influence medication use, but their effects at both individual and community levels remain poorly understood. This study investigates the association between medication count and polypharmacy with SES and education at both levels.

Methods We used data from the Prospective Epidemiological Research Studies in IrAN (PERSIAN), comprising 163,770 individuals aged 35–70 from 18 sites in Iran. Individual SES was evaluated using asset analysis, while community SES was determined based on the prevalence of low SES individuals in each site. Individual education level was dichotomized into having at least 5 years of schooling or not, while community education level was determined by the frequency of individuals with high education level in each site. Multi-level Poisson regressions, were conducted to explore the association between these variables and medication count in this cross-sectional study.

Results Approximately 45% of participants used at least one medication, with an average of 1.32 medications per person. Polypharmacy was observed in 8.85% of the population. Higher individual SES was associated with a slightly increased medication count (PR 1.05; 95% CI: 1.02–1.08) and a modest increase in polypharmacy risk (PR 1.08; 95% CI: 1.03–1.14). Residing in middle-SES communities was linked to lower medication use (PR 0.88; 95% CI: 0.85–0.91) but was not significantly associated with polypharmacy. Higher individual education was associated with reduced medication count (PR 0.92; 95% CI: 0.88–0.96) and a lower likelihood of polypharmacy (PR 0.85; 95% CI: 0.79–0.91). However, living in highly educated communities was associated with increased medication count (PR 1.70; 95% CI:

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1.62–1.78) and a higher risk of polypharmacy (PR 1.81; 95% CI: 1.16–2.81). The models were adjusted for age, gender, residence, ethnicity, marital status, body mass index, physical activity level, smoking status, opium use, hookah use, and alcohol consumption.

Conclusion Higher education was associated with lower medication use, whereas living in more educated communities was linked to higher usage. Although the association between individual SES and medication use was relatively weak, residing in middle-SES communities was associated with lower medication usage. These findings show the importance of addressing community-level factors in health research and policymaking.

Keywords Community-level factors, Health disparities, Medication use, Polypharmacy, PERSIAN, Multilevel analysis, Educational status, Socioeconomic status, Education

Background

The number of medications an individual takes is an important indicator of their health status [1]. While biological and behavioral elements including age, smoking and physical activity undoubtedly influence the number of medications an individual requires, socio-demographic factors such as education level and socioeconomic status (SES) are critical determinants that shape access to healthcare services, health literacy, and health-seeking behaviors independently correlate with the medication count [2, 3].

The link between SES and health has been extensively studied. Individuals with lower SES can be more prone to developing additional comorbidities, leading to an increased need for medications [4]. Furthermore, they encounter barriers in utilizing medications due to factors such as limited access to care, affordability issues, low health literacy, and prescribing biases [5]. Conversely, individuals with higher SES may face elevated risks of polypharmacy [6]. Besides individual-level SES, examining the influence of community-level socioeconomic characteristics on medication use is also critical for maintaining public health. Factors like access to healthcare, community resources, and social dynamics significantly influence the number of medications used [7, 8].

Education can help individuals acquire knowledge and beliefs that enable them to integrate healthy behaviors into their routine lifestyles [9]. However, the evidence of the relationship between medication usage and educational level is not entirely consistent. On one hand, certain studies have indicated that individuals with higher levels of education have a better understanding of their healthcare needs and are able to communicate more efficiently with medical professionals [10]. These studies suggest an association between education level and the overall health status of patients, with highly educated individuals receiving fewer inappropriate medications [11]. On the other hand, there is evidence suggesting that a higher education level may be linked to non-adherence to prescribed treatments or excessive use of medications [6, 12]. Higher education levels have been linked to greater autonomy in health decisions, which can sometimes result in non-adherence to prescribed treatments or even self-medication, increasing the risk of overuse [13].

In addition to individual-level education, the influence of community-level education on medication use is also crucial for public health. Studies have highlighted that higher community education levels can improve overall health literacy and reduce medication misuse by fostering better communication with healthcare professionals and increasing awareness of health needs [14]. Additionally, patient education interventions, such as educational videos, have been shown to improve medication-related health behaviors, highlighting the role of education in influencing healthcare decisions and medication use [15]. limited studies conducted in Iran also indicated benefitial effects of community-level education and training on medication-related health behaviors [16, 17].

Medication count serves as a key indicator of health status and reflects the complexity of an individual's health conditions and the healthcare service utilization [18]. Moreover, it provides valuable insights into broader healthcare issues, such as polypharmacy risks and access barriers [19]. Previous studies have either examined SES as a general construct without differentiating the specific role of education or have predominantly concentrated on individual-level factors, thereby overlooking the potential impact of community-level SES on medication use. This study seeks to fill existing gaps by analyzing both individual and community SES, with a particular emphasis on education, to offer a more comprehensive understanding of their influence on the number of medications consumed. Understanding these relationships is essential for developing targeted interventions to address disparities in medication use and promote equitable healthcare access and outcomes. In light of the mentioned points, we analyzed baseline data from the Prospective Epidemiologic Research IrAN (PERSIAN) cohort study to assess the association between medication use, specifically medication count, and community and individual SES and education level.

Methods

Study design and participants

This cross-sectional study utilized baseline data from the Prospective Epidemiological Research Studies in IrAN (PERSIAN), a cohort designed to investigate the burden and risk factors of non-communicable diseases in Iran. The cohort includes participants aged 35 to 70 years from 18 geographically distinct sites, selected to represent diverse ethnic, environmental, and socioeconomic backgrounds.

Participants were recruited through a population-based census, followed by door-to-door invitations by trained personnel to ensure high participation rates. In smaller cities and rural areas, all eligible individuals were invited, while in larger cities, recruitment targeted districts with diverse socioeconomic backgrounds. Data collection occurred at cohort centers, where participants provided informed consent, biological samples, anthropometric measurements, and detailed questionnaire-based information on demographics, medical history, and lifestyle factors.

To ensure data quality, a centralized smart data server minimized entry errors, while local and central QA/QC teams conducted real-time monitoring, periodic audits, and interviewer evaluations. Random participant re-evaluations and external expert inspections further validated data integrity. Additional methodological details are available in a previous report [20].

Variables and measurements

The PERSIAN cohort study recorded demographics (age, gender, ethnicity), physical activity, SES, medical history, and medication history using questionnaires. Anthropometrics (height, weight, waist and hip circumference) were recorded by trained nurses during baseline examination.

Medication counts

All participants in the PERSIAN cohort study were asked to bring all of their medications to the interview session, and the medications that were used routinely in the past three months were identified and recorded. The recorded medications were classified using the Anatomic Therapeutic Classification (ATC), developed by the World Health Organization (WHO) [21]. In our study, the sex hormones and modulators of the genital system (ATC code G03) were omitted from medications because they have a gender-specific pattern of utilization. The primary outcome variable used in this study was medication count, which was defined as the number of medications each person consumes; we also replicated some of our analysis for polypharmacy, which was considered to be the use of five or more medications concurrently [22].

Education level and socioeconomic status

We identified four primary independent variables for our study: individual-level education level, community-level education level, individual-level SES, and community-level SES. Individual education level is represented as a binary variable. High education is defined as completing more than five years of schooling, while education below the fifth grade in primary school is categorized as low individual education level. This classification aligns with previous research indicating that five years of formal education serves as a threshold for fundamental literacy and numeracy skills, which are critical determinants of health literacy, healthcare access, and medication adherence [2, 9]. Additionally, in the Iranian education system, completing five years corresponds to the end of primary schooling, marking an important transition in cognitive and functional skills that influence health behaviors. Community-Level Education was defined as the proportion of individuals within a cohort site who had completed more than five years of schooling. The 18 cohort sites were classified into tertiles based on this proportion. Each individual within a site was categorized as belonging to a low, middle, or high education-level community, depending on their site's classification.

To determine individual socioeconomic status (SES), a score was created using multiple correspondence analysis (MCA). This score was derived from variables such as access to a freezer, washing machine, dishwasher, computer, internet, motorcycle, and car (categorized as no access, access to a car valued under 500 million Rials, or access to a car valued over 500 million Rials, with 1 US dollar approximately equivalent to 25,940 Rials in 2014). Additional variables included access to a vacuum cleaner, type of color TV (no TV/regular vs. Plasma), ownership of a mobile phone, PC or laptop, and the frequency of international trips (none, pilgrimage only, or both pilgrimage and non-pilgrimage trips). This comprehensive MCA approach provided an SES score for each participant across all cohort centers. Subsequently, study participants were grouped into four quartiles based on these scores.

Community SES was determined as follows: Firstly, the relative frequency of participants within the 20th percentile of SES scores for the entire study was calculated for each site. Secondly, the 18 sites were ranked based on this relative frequency, resulting in three groups, each containing six sites. Finally, individuals who lived in the first six sites were labeled as having low community-level SES, the second six sites as middle community-level SES, and the third as high community-level SES.

While both community-level education and community-level SES relate to social and economic conditions within a site, they capture distinct aspects of socioeconomic disparities. Community education reflects the

overall educational attainment of the population, which may influence collective health knowledge and social norms. In contrast, community SES captures the material resources available within the community, including wealth and living conditions, which can affect healthcare infrastructure and access to healthcare services. Our preliminary analyses showed that community education and SES were not strongly correlated, suggesting that while related, they represent complementary dimensions of socioeconomic conditions.

Other independent variables

Self-reported participants' daily activities were collected using the IPAQ questionnaire. Then, each activity's metabolic equivalent rates (METs) were extracted, and total daily activity METs were calculated. The participants were divided into three categories based on total daily METs. Body mass index (BMI) was calculated and classified according to recommendations of WHO [23].

Participants were also asked about their health-related habits. They were asked about their smoking habits with the question, "Have you smoked at least 100 cigarettes during your lifetime?". Hookah use was defined as the regular consumption of hookah at any point throughout the participants' lives. Alcohol use was defined as drinking approximately 200 ml of beer or 45 ml of liquor once per week for at least six months. Opium use was defined as the once-per-week consumption of opium for at least six months. Participants were also asked about having received diagnoses of several chronic diseases through a structured questionnaire.

Statistical analysis

An overview of the study sample's features and the relevant variables was provided using descriptive statistics. Mean with standard deviation (mean ± SD) or 95% confidence interval (95% CI) were used to summarize continuous variables, and frequencies and percentages were used to describe categorical variables.

The random intercept two-level Poisson regression was employed to account for the hierarchical structure of the data, where individuals are nested within distinct cohort sites, each characterized by unique socioeconomic and infrastructural factors [24]. The random intercept two-level Poisson regression was employed to account for the hierarchical structure of the data, where individuals are nested within distinct cohort sites, each with unique socioeconomic and infrastructural characteristics [24]. The cohort site serves as the second-level variable, while the primary-level variables include four SES and education indicators at both individual and community levels, as well as age, gender, residence (urban vs. rural), ethnicity, marital status, BMI, physical activity level, smoking status, opium use, hookah use, and alcohol consumption. These variables were selected to construct a model primarily based on modifiable covariates.

Poisson regressions were also used to determine the contribution of morbidities to medication counts. In reporting the analysis of all regressions, the prevalence ratios (PRs), derived by exponentiating the Poisson regression coefficients, and their 95% confidence interval (95% CI) were reported.

Statistical analysis was conducted using Stata version 11.2 (Stata Corporation, College Station, TX). Statistical significance was defined as $\alpha = 0.05$, or when the 95% confidence interval (CI) for prevalence ratios did not include the value of 1. Graphs were created using Stata and R software (version 4.2.1; R Core Team, 2022).

Sensitivity analysis

We conducted a sensitivity analysis by modifying the original multilevel Poisson regression model in two ways. First, we included the deprivation index of each cohort site as an additional covariate at the individual level to account for healthcare accessibility. The deprivation index primarily reflects the availability of infrastructure and healthcare resources in a given location. Cohort sites were categorized into four groups based on this index to examine whether variations in infrastructure influence the association between socioeconomic status (SES), education, and medication use. Second, we adjusted for all self-reported comorbidities, incorporating them into the second level of the original model. This adjustment aimed to determine whether the associations between SES, education, and medication use persist after accounting for the presence of diagnosed health conditions. By removing the direct influence of these comorbidities, we assessed how SES and education independently contribute to medication usage beyond the effect of disease contraction and diagnosis.

Results

The research sample comprised 163,770 individuals, with an average age of 49.4 (± 9.4), who were nested within 18 sites. Among all participants, 55.2% ($n = 90,397$) were female, 64.4% ($n = 105,394$) had completed at least five years of education, and 70.8% were urban residents (Supplementary Table S1). Within these 18 sites, there was a wide variation in education status, with the percentage of high-educated individuals ranging from 38 to 87%, as well as a wide variation in SES, with the percentage of low SES individuals ranging from 3 to 48%.

Nearly 45% (95% CI: 45.25-45.73%) of the population, which equals 74,504 individuals, used at least one form of medication. The mean number of medications used per person was found to be 1.32 (95% CI: 1.31–1.32). Additionally, 8.85% (95% CI: 8.72-8.99%) of the population exhibited polypharmacy. This amount was 11.09%

(95% CI: 10.89-11.30%) among females, while for males, it stood at 6.09% (95% CI: 5.92-6.27%). Furthermore, 22.75% (95% CI: 21.95-23.56%) of elderly (≥65 years old) individuals experienced polypharmacy (Table 1).

In Fig. 1, we present the average medication count across different levels of education and SES. The barplots of average medication count closely resemble those depicting the frequency of medication users and the mean medication count after excluding non-users (see Supplementary Figure S1 and S2). Surprisingly, higher levels of community education were associated with increased medication use, while higher levels of individual education were correlated with reduced medication usage.

Figure 2 provides data on the prevalence of use of different medications classes and indicates that the prevalence of medication classes varies across different sociodemographic variables. This figure illustrates that participants with a low individual education level or a high community education level are using more medications from nearly every prevalent class of medications.

Higher individual SES (low middle class: adjusted PR 1.05; 95% Cl: 1.02–1.08), residing in middle-level SES communities (adjusted PR 0.88; 95% Cl: 0.85–0.91), having at least five classes of education (adjusted PR 0.92; 95% Cl: 0.88–0.96), and living in a high education community (adjusted PR 1.70; 95% Cl: 1.62–1.78) were all associated with the number of medications an individual took. Furthermore, in the model assessing polypharmacy (use of ≥5 medications), individuals with higher education levels were less likely to experience polypharmacy (adjusted PR 0.85; 95% CI: 0.79–0.91), whereas those in high-education communities were at a greater risk (adjusted PR 1.81; 95% CI: 1.16–2.81). These contrasting effects suggest that while higher individual education may contribute to better health management and lower unnecessary medication consumption, community-level educational characteristics may promote increased healthcare access and medication utilization (Table 2). the complete results of univariate and multivariable analysis are brought in supplementary table S2.

To assess the impact of various morbidities on the number of medications consumed, we employed Poisson regression, as detailed in Fig. 3. For example, diabetic patients receive twice as many medications as nondiabetics, indicating that, those with diabetes are prescribed 100% more medications than those without diabetes, after accounting for age, gender, and other comorbidities. Due to the pronounced effect of education level on medication counts, we examined the contribution of morbidities at different levels of community and individual education (Fig. 3).

The results of the sensitivity analysis, detailed in Supplementary Table S3, indicate that adjusting for the deprivation index had a negligible effect on the prevalence ratios of individual SES, individual education, and community education, with the primary associations observed in the original model remaining consistent. However, it altered the U-shaped relationship between community SES and medication use, showing that living in a community with higher SES was associated with lower medication use. While controlling for comorbidities attenuated the associations of community SES and individual education with medication use, the association with community education remained significant.

Discussion

The amount of medication consumed is an important indicator of a person's health. For example, among over 600 variables related to health, the number of medications taken ranked among the top ten predictors of ten-year risk of cardiovascular disease [25]. Health is not the only factor that predicts the number of medications consumed; various behavioral and socio-demographic variables also affect medications consumption [26]. Knowing the relationship between these variables and the number of medications used by a person can give us a more accurate understanding of the effect of these health determinants.

In this study, we investigated medication consumption by examining more than 160 thousand individuals in 18 different sites, with a focus on obtaining a better understanding of the influence of education level and SES on medication use. Following adjustments for other variables, individual-level SES showed little association with medication count, whereas residents of communities with moderate SES levels tended to use fewer medications compared to those in low or high SES communities. We also found a complex relationship between education levels and medication usage, with higher individual education level correlating with lower medication use, whereas higher community-level education was associated with higher medication use across various prevalent medication classes. Furthermore, across nearly all health conditions, higher individual education was linked to a greater number of medications per diagnosis, whereas higher community education correlated with a lower medication count.

Medication use and polypharmacy decreased in higher individual-level SES categories, although this relationship is nearly eliminated in the adjusted model. Our findings are consistent with the findings of the meta-analysis of Iqbal et al., where no significant relationship between income and SES categories with polypharmacy was found [3].

The effect of community-level SES on the number of medications had a U-shaped curve, which means that the lowest medication consumption was seen in individuals

Table 1 Characteristics of study participants and the prevalence of polypharmacy and number of medications in each subgroup

	Subjects	Medication use	Medication count	Polypharmacy
Characteristics	**N (%)**	**N (%)**	**Mean (95%CI)**	**N (%)**
Gender				
Male	73,373 (44.8)	27,426 (37.4)	1.00 (1.0–1.0)	4472 (6.1)
Female	90,397 (55.2)	47,078 (52.1)	1.58 (1.6–1.6)	10,026 (11.1)
Age				
< 50 y	87,555 (53.5)	30,276 (34.6)	0.79 (0.8–0.8)	3119 (3.6)
50–64	65,684 (40.1)	37,012 (56.3)	1.82 (1.8–1.8)	8983 (13.7)
≥ 65	10,531 (6.4)	7216 (68.5)	2.61 (2.6–2.7)	2396 (22.8)
Residence				
Urban	115,916 (70.8)	54,891 (47.4)	1.41 (1.4–1.4)	11,200 (9.7)
Rural	47,854 (29.2)	19,613 (41)	1.11 (1.1–1.1)	3298 (6.9)
Ethnicity				
Other	73,655 (45.0)	33,058 (44.9)	1.27 (1.3–1.3)	6019 (8.2)
Azari	41,019 (25.0)	15,263 (37.2)	1.03 (1.0–1.0)	2670 (6.5)
Fars	49,095 (30.0)	26,182 (53.3)	1.64 (1.6–1.7)	5809 (11.8)
Marital Status				
Single	3438 (2.1)	1077 (31.3)	0.71 (0.7–0.8)	107 (3.1)
Married	149,122 (91.1)	66,561 (44.6)	1.27 (1.3–1.3)	12,454 (8.4)
Widowed	9321 (5.7)	6049 (64.9)	2.34 (2.3–2.4)	1796 (19.3)
Divorced	1811 (1.1)	775 (42.8)	1.19 (1.1–1.3)	134 (7.4)
Other	78 (0.0)	42 (53.8)	1.78 (1.2–2.4)	7 (9.0)
BMI				
Underweight	2974 (1.8)	1088 (36.6)	0.80 (0.7–0.8)	107 (3.6)
Normal	42,193 (25.8)	16,316 (38.7)	1.01 (1.0–1.0)	2533 (6.0)
Overweight	66,428 (40.6)	30,302 (45.6)	1.3 (1.3–1.3)	5596 (8.4)
Obese	52,175 (31.9)	26,798 (51.4)	1.63 (1.6–1.6)	6262 (12)
Physical activity				
Low	54,366 (33.4)	28,075 (51.6)	1.67 (1.6–1.7)	6849 (12.6)
Moderate	54,303 (33.3)	25,823 (47.6)	1.35 (1.3–1.4)	4775 (8.8)
High	54,319 (33.3)	20,420 (37.6)	0.96 (0.9-1.0)	2857 (5.3)
Smoking				
non-smoker	127,490 (78.2)	59,500 (46.7)	1.37 (1.4–1.4)	11,744 (9.2)
Smoker	35,479 (21.8)	14,970 (42.2)	1.17 (1.1–1.2)	2747 (7.7)
Opium use				
No	147,667 (90.2)	66,683 (45.2)	1.31 (1.3–1.3)	12,941 (8.8)
Yes	16,103 (9.8)	7821 (48.6)	1.38 (1.4–1.4)	1557 (9.7)
Hookah use				
No	151,010 (92.2)	68,636 (45.5)	1.31 (1.3–1.3)	13,248 (8.8)
Yes	12,760 (7.8)	5868 (46)	1.37 (1.3–1.4)	1250 (9.8)
Alcohol use				
No	152,515 (93.6)	70,412 (46.2)	1.35 (1.3–1.4)	13,890 (9.1)
Yes	10,449 (6.4)	4057 (38.8)	0.98 (0.9-1.0)	601 (5.8)
Individual SES				
Low	42,668 (26.2)	19,822 (46.5)	1.42 (1.4–1.4)	4361 (10.2)
Low-middle	41,671 (25.6)	19,036 (45.7)	1.37 (1.4–1.4)	4042 (9.7)
Middle-high	42,230 (25.9)	19,400 (45.9)	1.29 (1.3–1.3)	3545 (8.4)
High	36,494 (22.4)	16,098 (44.1)	1.18 (1.2–1.2)	2539 (7.0)
Community Level SES				
Low	55,323 (33.8)	25,753 (46.6)	1.35 (1.3–1.4)	5144 (9.3)
Middle	54,650 (33.4)	22,614 (41.4)	1.14 (1.1–1.2)	3840 (7.0)
High	53,797 (32.8)	26,137 (48.6)	1.46 (1.4–1.5)	5514 (10.2)
Individual Education Level				
Low	58,139 (35.6)	29,576 (50.9)	1.65 (1.6–1.7)	7247 (12.5)

Table 1 (continued)

	Subjects	Medication use	Medication count	Polypharmacy
Characteristics	**N (%)**	**N (%)**	**Mean (95%CI)**	**N (%)**
High	105,394 (64.4)	44,899 (42.6)	1.14 (1.1–1.2)	7250 (6.9)
Community Education Level				
Low	50,008 (30.5)	19,768 (39.5)	1.05 (1.0-1.1)	3253 (6.5)
Middle	63,790 (39)	27,132 (42.5)	1.24 (1.2–1.3)	5324 (8.3)
High	49,972 (30.5)	27,604 (55.2)	1.69 (1.7–1.7)	5921 (11.8)

Abbreviations: BMI, body mass index; SES, socioeconomic status

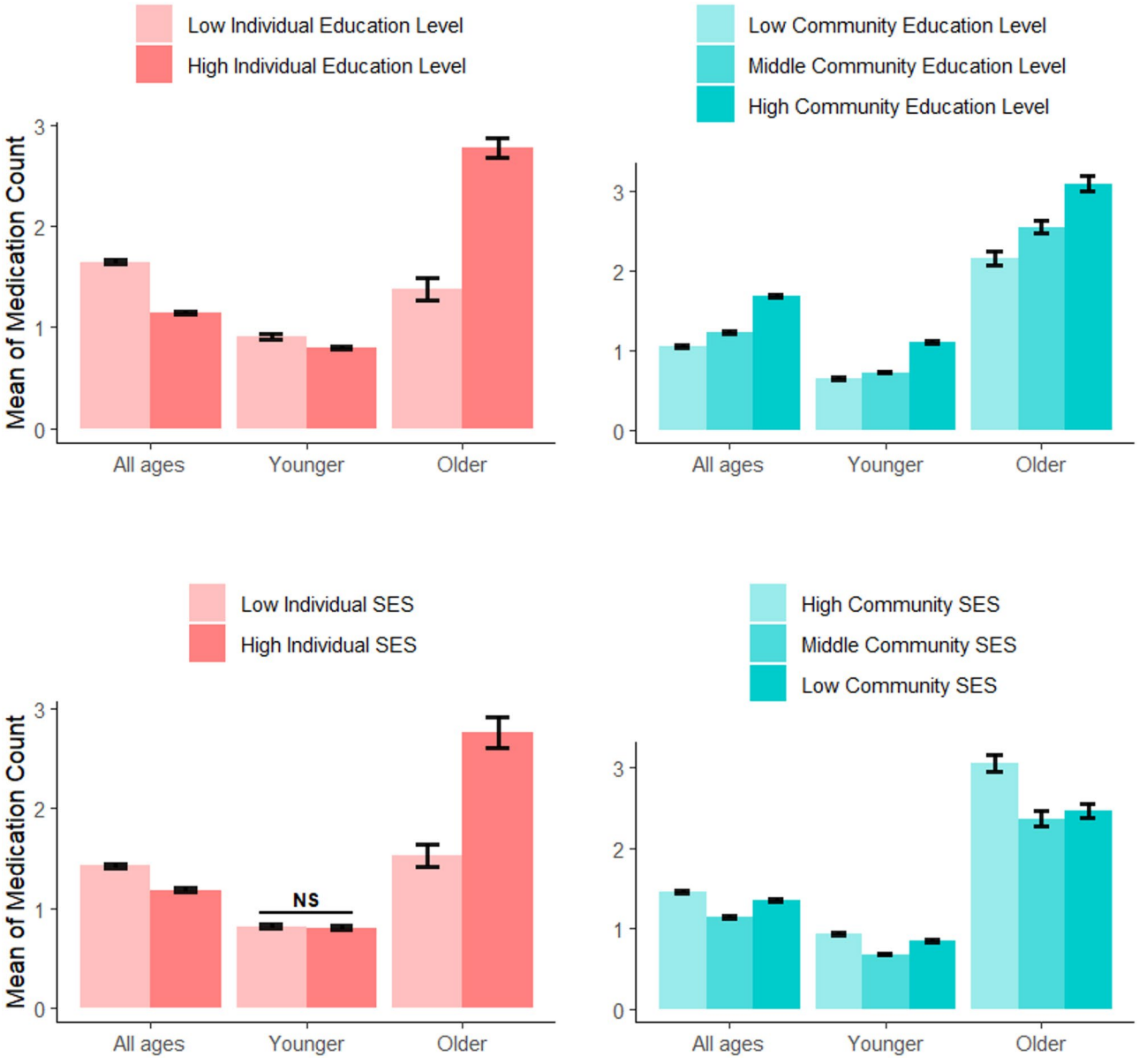

Fig. 1 The number of medications used by older (above 65 years old) and younger (less than 50 years old) participants with different individual and community socioeconomic status (SES) and education level. This graph illustrates the mean number of medications taken and their 95% confidence intervals. All differences between grouped bar plots are statistically significant, except for those marked with "NS"

ATC	Drug Class
C09	Agents Acting On Renin-Angiotensin System
C10	Lipid Modifying Agents
C07	Beta Blocking Agents
B01	Antithrombotic Agents
A10	Drugs Used In Diabetes
A02	Drugs For Acid Related Disorders
H03	Thyroid Therapy
N05	Psycholeptics
N06	Psychoanaleptics
M01	Anti-inflammatory And Anti-rheumatic
C08	Calcium Channel Blockers
A11	Vitamins
N02	Analgesics
C03	Diuretics

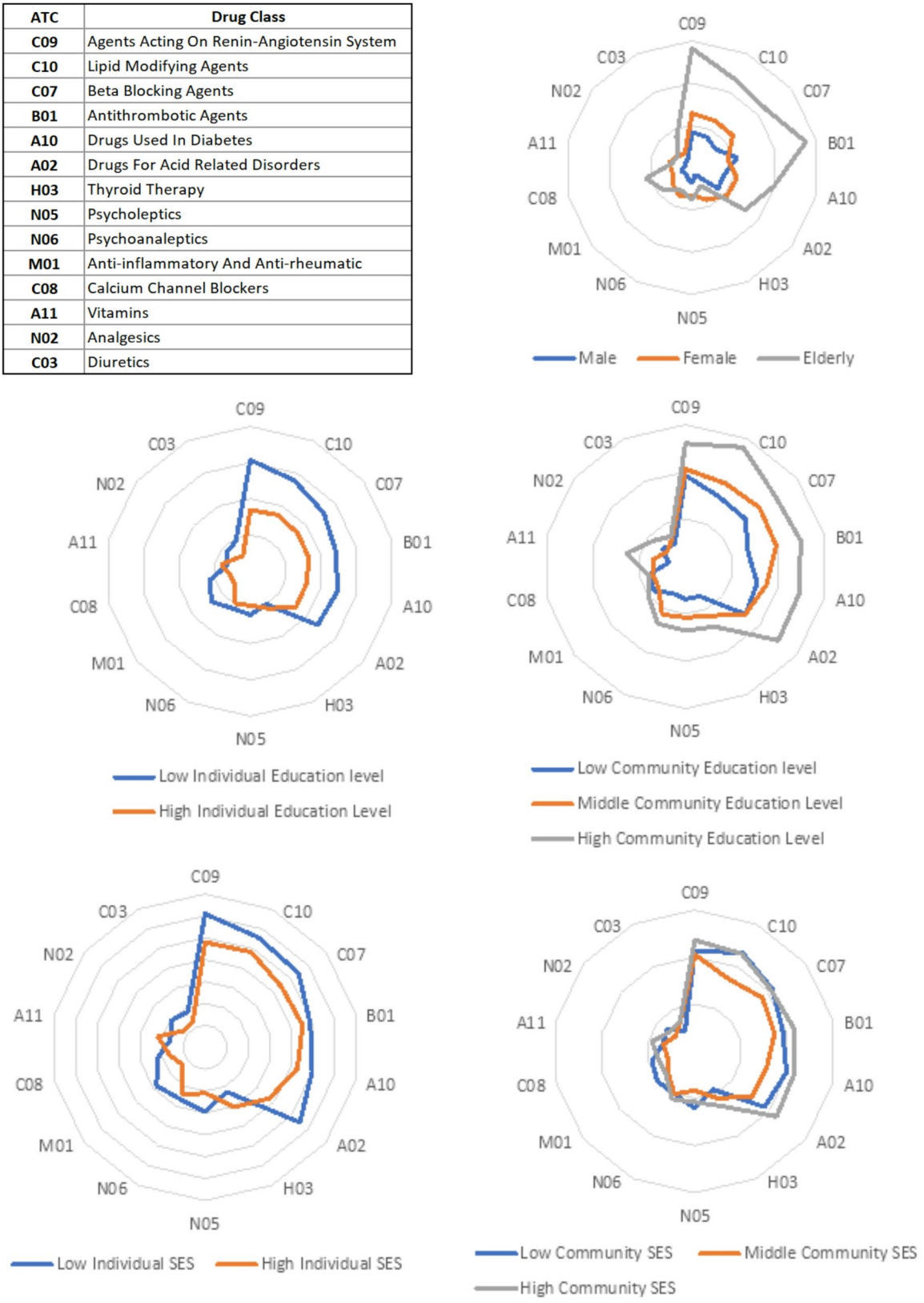

Fig. 2 Consumption of the most frequently used medication classes among different demographics, education levels and socioeconomic (SES) levels. The graphs present the ATC second code, while the corresponding list provides the medication classes' names

Table 2 Adjusted count ratios (PRs). Models were applied to analyze 162,425 observations, with reported ratios of medication counts along with their corresponding 95% confidence intervals and P-values for our four primary independent variables. Adjustment was conducted for age, gender, residence, ethnicity, marital status, body mass index, physical activity level, being smoker, opium use, Hookah use, and alcohol consumption

	Model for medication count		Model for Polypharmacy	
Characteristics	**Adjusted count ratios (95%CI)**	**P-value**	**Adjusted count ratios (95%CI)**	**P-value**
Individual SES				
Low	Ref		Ref	
Low-middle	1.05 (1.02–1.08)	< 0.001	1.08 (1.03–1.14)	0.003
Middle-high	1.04 (1.01–1.08)	0.026	1.02 (0.95–1.09)	0.617
High	1.05 (1.01–1.1)	0.027	0.97 (0.88–1.08)	0.614
Community Level SES				
Low	Ref		Ref	
Middle	0.88 (0.85–0.91)	< 0.001	0.9 (0.59–1.38)	0.634
High	1.04 (0.99–1.11)	0.003	1.02 (0.66–1.58)	0.918
Individual Level Education				
Low	Ref		Ref	
High	0.92 (0.88–0.96)	< 0.001	0.85 (0.79–0.91)	< 0.001
Community Level Education				
Low	Ref		Ref	
Middle	1.14 (1.08–1.21)	< 0.001	1.27 (0.84–1.91)	0.265
High	1.70 (1.62–1.78)	< 0.001	1.81 (1.16–2.81)	0.008

Abbreviations: SES, socioeconomic status; CI, Confidence Interval

from communities with middle SES, and the number of medications consumed by a person in these communities is about 10% less than in other communities. One possible explanation is that middle SES communities achieve a balance between healthcare accessibility and cautious medication use. In low SES communities, individuals often face barriers to healthcare, including financial constraints, limited access to specialists, and lower health literacy, which may result in underuse of essential medications or delayed treatment until conditions worsen, requiring more intensive pharmacological interventions [7, 27]. In contrast, high SES communities tend to have greater healthcare access and health awareness, leading to higher healthcare utilization and potential overprescription of medications—a phenomenon observed in studies from high-income countries [3, 28]. Our findings align with research indicating that excessive medication use is more prevalent in high SES communities, where individuals are more likely to undergo routine health screenings and have access to specialist care that encourages early pharmaceutical intervention [28, 29]. Conversely, middle SES communities may exhibit more cautious medication behaviors, balancing access with a more judicious approach to medication consumption. Our sensitivity analysis, which included the deprivation index—primarily reflecting infrastructure and healthcare accessibility—supported this explanation. After adjusting for the deprivation index, the U-shaped association changed, indicating that living in a higher SES community is associated with lower medication use. Future research should investigate whether health literacy, healthcare-seeking behaviors, and physician prescribing patterns differ significantly across SES levels and contribute to this trend.

As the individual education level increased, the number of medciations consumed decreased and individuals with higher education used all prevalent medication classes less except for vitamins. This finding is consistent with the findings of a study of 600,000 people in Sweden, which showed that the prevalence of polypharmacy decreased with higher education levels [2]. Education can have a positive impact on health in several ways, including increased health literacy, improved access to healthcare services, stress reduction, enhanced decision-making and information-gathering abilities, employment with fewer occupational hazards, access to better neighborhoods and peers, and the promotion of healthier behaviors [27, 30, 31].

Our findings also showed that age modifies the effect of individual educational levels on medication use (Fig. 1). While higher individual education was associated with lower medication use among younger individuals, the opposite trend was observed among older adults, where higher education correlated with increased medication consumption. A possible explanation for these patterns is that younger individuals with higher education may have better health literacy, adopt healthier behaviors, and engage in preventive healthcare, reducing their need for medications. In contrast, older adults with higher education may have better access to healthcare, be more aware of their health conditions, and adhere more strictly to prescribed treatments, leading to increased medication

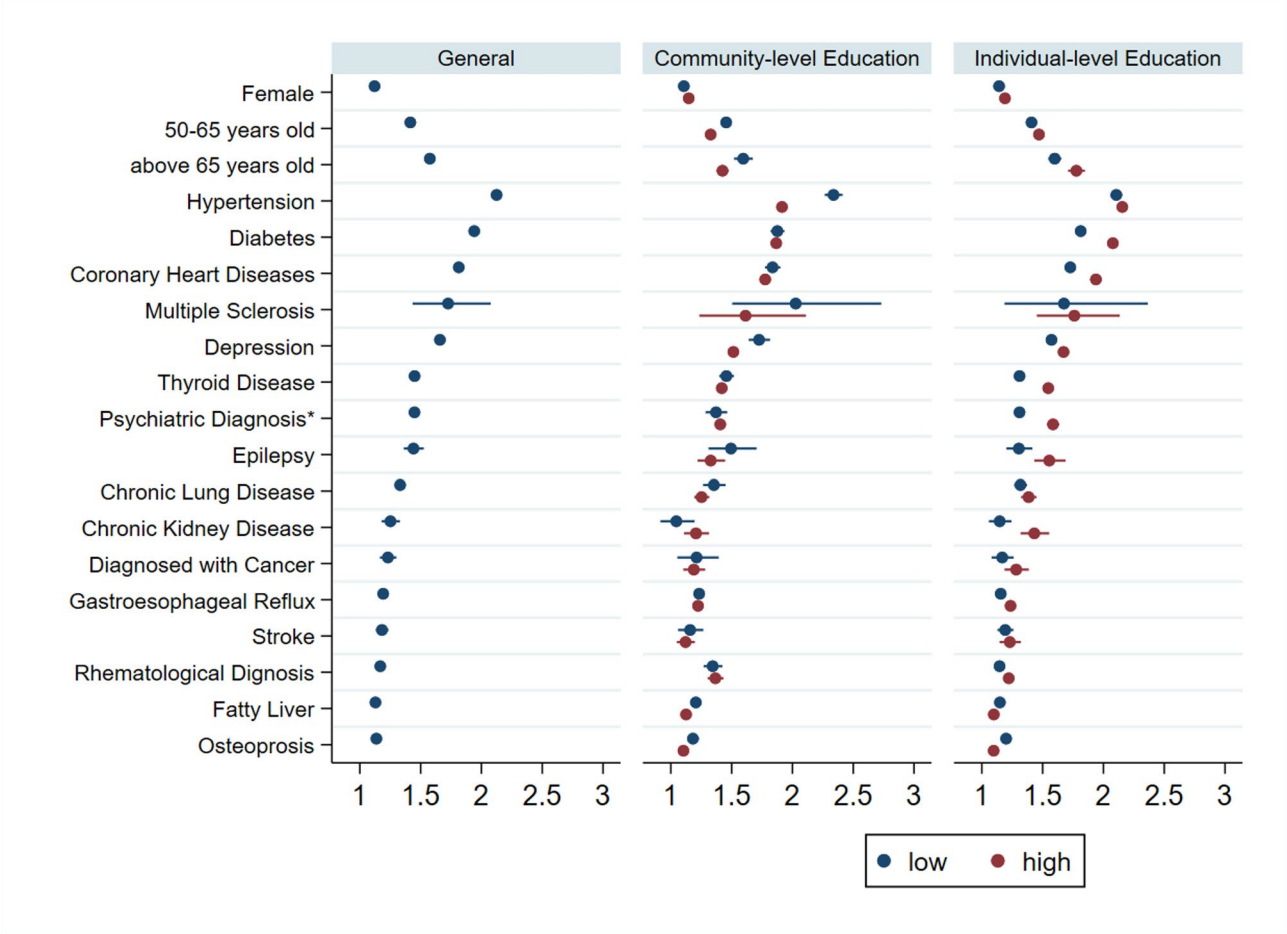

Fig. 3 Contribution of morbidities to the number of medications used. This graph presents the ratio of Medication counts for each established diagnosed morbidity at the time of the interview, along with its 95% confidence interval for all participants (general) and at different levels of community and individual education. *Psychiatric diagnoses other than depression

use. These findings highlight the need for age-specific health interventions. For younger populations, promoting preventive care and lifestyle modifications may further reduce unnecessary medication use. For older adults, ensuring appropriate medication management and adherence education is crucial. Future studies should investigate the role of healthcare-seeking behavior, physician prescribing patterns, and medication adherence in different age groups to better understand the mechanisms underlying these associations.

Unlike individual education, higher community-level education correlated with greater medication use across all age groups. This may be driven by enhanced healthcare infrastructure, increased awareness of medical services, and social norms that promote seeking formal healthcare interventions [8]. Our findings are in contrast to those of the multilevel survey in West Virginia [32]. They observed that living in a county with a higher education level reduces polypharmacy. A part of this difference may be related to the difference in resource consumption in developing versus developed societies, that is, the excessive resource utilization in high-income countries and the underuse of resources in low-income countries [28, 33]. Therefore, a rise in education levels in a country like Iran may be associated with an increase in drug consumption, and in a society like America, it may be related to a decrease in drug consumption.

The distinction between individual and community-level education becomes more apparent through an analysis of the impact of morbidities on medication counts. For nearly all health conditions, having a higher level of individual education increased the number of medications used for each diagnosis, while a higher level of community education decreased this count. For instance, individuals residing in communities with high education levels tend to use fewer medications for hypertension and depression, possibly because these illnesses are detected at earlier stages due to improved access to care, requiring fewer medications for management. On the other hand, patients with a higher individual education level used more medications. One plausible explanation

could be better adherence and compliance among these individuals.

Interestingly, community education—but not community SES or individual education—remains significantly associated with medication use even after adjusting for all comorbidities. This suggests that higher community education levels may have a stronger influence on health behaviors and healthcare access beyond merely improving individual health. It may also encourage greater medication adherence or increased use of preventive medications. Further research is needed to explore these mechanisms in more detail.

Our findings have important implications for public health policies, particularly in developing countries. By revealing the contrasting effects of individual and community education levels on medication use, this study addresses a significant gap in the literature. Previous studies have primarily focused on individual-level factors, often overlooking the broader community context. Our results suggest that community-level factors exerts a distinct influence on medication use patterns, which could inform the design of more comprehensive public health interventions. Future policies should leverage these insights to implement multilevel strategies that simultaneously target individual behaviors and community health infrastructures. Interventions aimed at promoting health literacy and rational medication use should not only focus on individuals but also address community-level factors. Community-based educational programs could enhance collective health knowledge and empower communities to make informed health decisions. Moreover, policies should consider the unique social and economic contexts of developing countries, where both underuse and overuse of medications may coexist.

Despite its valuable insights, this study has several limitations. Its cross-sectional design prevents causal inferences, and self-reported data may introduce recall bias. SES was assessed solely through asset ownership, omitting factors like occupation and income. Additionally, we did not evaluate healthcare utilization or personal health beliefs, which could influence medication use. The PERSIAN cohort's age limit (≤ 70 years) may have reduced potential confounding but also underestimated polypharmacy among the elderly. Findings may not fully generalize to high-income countries with universal healthcare or lower-income settings with limited access, where SES and education may influence medication use differently. Future studies should incorporate broader SES indicators and explore healthcare utilization, access, and social factors as potential mediators.

Conclusion

Sociodemographic factors significantly influence the number of medictaions consumed by individuals. Among these factors, education level exhibits a more pronounced effect compared to SES. More educated individuals tend to use fewer medications, whereas those residing in more educated societies tend to use more medication. This difference in medication utilization is not limited to specific medication categories, emphasizing the significant influence of education level on shaping patterns of medication use. Further studies are warranted to identify the mediators influencing the relationship between education level and medication use. These studies should explore various factors such as health status, improved access to healthcare, and compliance to better understand the dynamics between education and medication utilization.

Abbreviations

SES	Socioeconomic Status
PERSIAN	Prospective Epidemiological Research Studies in Iran
METs	Metabolic Equivalent Rates
BMI	Body Mass Index
ATC	Anatomical Therapeutic Classification
PR	Prevalence Ratio
CI	Confidence Interval
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1

Author contributions

The study conception and data analysis were performed by Mohammadreza Akbari and Hossein Molavi Vardanjani. Material preparation and data collection were carried out by Reza Malekzadeh, Hossein Poustchi, Farhad Pourfarzi, Afshin Gharekhani, Azim Nejatizadeh, Farhad Moradpour, Elahe Piraie, Bahareh Fakhraei, Farahnaz Joukar, Nader Saki, Ali Reza Safarpour, Mehdi Moradinazar, Abbas Rezaianzadeh, Mohsen Tafaghodi, Ali Esmaeili-nadimi, Alireza Moslem, Moluk Hadi Alijanvand, Mahmood Moosazadeh, Amir Houshang Mehrparvar, Zahra Mohammadi, and Alireza Ansari-Moghaddam. The final manuscript was written and revised by Mohammadreza Akbari, Erfan Taherifard, Seyed Reza Abdipour Mehrian, Zahra Rahimian, Bita Mesgarpour, Ehsan Taherifard, and SaharNaz Ghahremani, with contributions from all authors, who reviewed and commented on earlier versions. All authors read and approved the final manuscript.

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Data availability

The dataset used in this article is from a national cohort study. Due to national data protection regulations, the dataset cannot be publicly accessed. However, it may be made available from the Iran Cohort Consortium (https://irancohorts.ir/collaborations/join-projects/) upon reasonable request and with permission from the Iran National Committee for Ethics in Biomedical Research.

Declarations

Ethics approval and consent to participate
The design of the PERSIAN cohort study was approved by the ethics committees of the Tehran University of Medical Sciences, the Digestive Diseases Research Institute (IR.TUMS.DDRI.REC.1396.1). While each cohort center received ethical approval from local universities, for the purpose of this study and pooling all PERSIAN data, the ethics committee of Shiraz University of Medical Sciences approved the study (IR.SUMS.REC.1402.594). Informed consent was obtained from all participants prior to their enrollment in the PERSIAN cohort study, and all study procedures were conducted in accordance with the Declaration of Helsinki.

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

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