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THE IMPACT OF SOCIO-ECONOMIC DETERMINANTS ON THE VACCINATION RATES WITH ROTAVIRUS AND HUMAN PAPILOMA VIRUS VACCINE

VPLIV SOCIALNO-EKONOMSKIH DETERMINANT NA PRECEPLJENOST S CEPIVOM PROTI ROTAVIRUSNIM OKUŽBAM IN OKUŽBAM S ČLOVEŠKIM PAPILOMA VIRUSOM

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ABSTRACT

Background. Socio-economic inequalities may have an impact on the uptake of selfpaid vaccines. The aim of the study was to identify the effect of some socio economic determinants on vaccination rates with self-paid human papilloma virus (HPV) and rotavirus (RV) vaccines.

Methods. Vaccination coverage data, available in electronic database cepljenje.net (administered by the National Institute of Public Health), were collected at administrative unit level. The socio-economic determinants (the average gross pay in euros, the unemployment rate, the educational and households structure, the population density, the number of inhabitants, the number of children aged from 0 to 4, the number of women aged from 15 to 30) were extracted from Statistical Office of the Republic of Slovenia web page. The strength of the correlation between socioeconomic variables and self-paid HPV and RV vaccination rates was determined.

Results. Rotavirus vaccination rates show a slight negative correlation with the number of residents per administrative unit (ρ=-0.29, p=0.04), and no correlation with other socio-economic variables. Likewise, no correlation has been found between HPV vaccination rates and the selected socio-economic variables.

Conclusion. Ecological study did not reveal any correlations between socio economic variables and vaccination rates with RV and HPV self-paid vaccines on administrative unit level.

Keywords:
socio-economic determinants, vaccination rates, human papilloma virus, rotavirus

IZVLEČEK

***Izhodišče**. Socialno-ekonomske neenakosti lahko vplivajo na precepljenost s samoplačniškimi cepivi. Namen raziskave je bil ugotoviti vpliv povezanosti izbranih socialno-ekonomskih dejavnikov na stopnjo precepljenosti s samoplačniškima cepivoma proti humanemu papiloma virusu (HPV) in rotavirusu (RV).*

***Metode**. Podatke za analizo o precepljenosti na ravni upravne enote smo pridobili iz elektronske podatkovne baze cepljenje.net (skrbnik Nacionalni inštitut za javno zdravje). Socialno-ekonomski dejavniki (povprečna bruto plača v evrih, stopnja brezposelnosti, struktura izobrazbe prebivalstva, velikost gospodinjstva, gostota prebivalstva, število prebivalcev, število otrok, starih med 0 in 4 leta, število žensk, starih med 15 in 30 let) so bili na voljo na spletnih straneh Statističnega urada Republike Slovenije. Izračunali smo korelacijo med socialno-ekonomskimi spremenljivkami in deležem precepljenosti s samoplačniškimi cepivi proti HPV in RV.*

***Rezultati**. Precepljenost proti rotavirusu šibko negativno korelira s številom prebivalcev v upravni enoti (ρ=-0,29, p=0,04), medtem ko povezanosti z ostalimi spremenljivkami nismo ugotovili. Prav tako nismo ugotovili povezanosti med stopnjo precepljenosti proti HPV in katero koli izmed vključenih socialno ekonomskih spremenljivk.*

***Zaključek**. Z ekološko študijo za nobeno od izbranih socialno-ekonomskih spremenljivk nismo dokazali ustrezne moči povezave na ravni upravne enote.*

Ključne besede:
socialno ekonomske determinante, precepljenost, humani papiloma virus, rotavirus

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1 INTRODUCTION

Slovenia, as many developed countries, has a well-established vaccination program, which is the basis for the implementation of mandatory and optional vaccinations. High vaccination coverage for mandatory childhood vaccinations has been accomplished, and the burden of vaccine preventable communicable diseases has been effectively reduced (1–3). All vaccines from the mandatory program are paid by the insurance company and are, therefore, free of charge from the user's point of view, while vaccines from the optional program are entirely self-paid with one exception. The vaccination with human papilloma virus (HPV) vaccine has been added to childhood vaccination program in 2006, as optional for girls in the 6th grade and, if not accepted at that time, offered again in the 8th grade. Afterwards, and for boys/men of any age, HPV vaccine is available as self-paid vaccine (4–6). The vaccination coverage for six-graders is approximately 50%, which is nearly half of the coverage reached by mandatory vaccinations for diphtheria, tetanus, pertussis, Haemophilus influenza type b and polio for pre-school and school-aged children (3, 7).

Adolescents not included in the free of charge HPV vaccination program, and young adults rarely decide to get vaccinated in Slovenia (7). Low vaccination coverage with optional HPV vaccine is in accordance with low uptake of other optional vaccines; e.g. Slovenia has one of the lowest vaccination rates against influenza among EU/EFTA countries with only 4%–5% of the population accepting influenza vaccine. The coverage rate for tick-borne encephalitis (TBE) vaccine is much lower compared to the neighbouring Austria, even though the risk of TBE, especially in the north-western parts of the country, is considerable (8). Only a fourth of all parents decide to vaccine their infants with self-paid rotavirus (RV) vaccine. The vaccination rates against RV therefore remain too low to effectively reduce the number of RV infections and hospitalizations (9).

Newer vaccines (i.e. HPV, RV, pneumococcal conjugated vaccine) are usually more expensive compared to those which are in use for many decades. According to previous studies, high cost represents an important barrier to vaccination (10). Apart from the cost, low vaccination rates can be associated with many different causes, but only a few studies address socio-economic inequality as a possible barrier for achieved higher vaccination rates. The correlation between a lower rate of chronic non-communicable diseases and high socio-economic status has been proven. Those with a higher education or a better economic status are, in general, more empowered to adopt health-promoting decisions (11–14). The socio-economic status affects the incidence and outcome of communicable diseases, like hepatitis C, sexually transmitted diseases and tuberculosis, even in developed countries (15, 16). The correlation between a lower socio-economic status and other infectious diseases has been less thoroughly studied. A lower socio-economic status can also have an unfavourable effect on the decision whether to vaccinate with vaccines, which are not a part of the national vaccination program and are, therefore, not financially supported by the state, which is particularly true for newer, often more expensive vaccines (17–19).

Currently, there were no studies in Slovenia aiming to explain causes for low vaccination rates with self-paid vaccines on an individual level. There are two published studies focusing on enabling and inhibiting factors for vaccination with seasonal and pandemic influenza vaccine (20, 21).

The aim of present ecological study was to analyse the correlation between the vaccination rates for self-paid HPV and RV vaccines and seven different socio-economic determinants at the administrative units (AU) level: average income, educational structure, unemployment rates, household size, population density, number of inhabitants and the number of children aged 0–4/the number of women aged 15–30.

2 METHODS

2.1 Data Sources

The number of individuals who were completely vaccinated with self-paid HPV or RV vaccine was obtained from the cepljenje.net electronic database. The database is designed to monitor the vaccination coverage in Slovenia. The administrator of the database is the National Institute of Public Health. Primary care physicians are required to report the number of vaccinations to the regional units of the National Institute for Public Health, which in turn report to the National Institute of Public Health (22). The database cepljenje.net does not contain any personal data. The data was available by individual vaccination providers aggregated by regional units of the National Institute for Public Health, therefore we had to integrate the data by AU for the years 2011, 2012 and 2013.

Socio-economic variables (the average gross pay in euros (EUR), the educational structure, the household structure with one, two, three, four, five or more than five members, the unemployment rate expressed in a percentage, the number of inhabitants, the number of children aged 0–4, the number of women aged 15–30, the population density or the number of inhabitants per square kilometre (inhabitants/km2)) were obtained from the web site of the Statistical Office of the Republic of Slovenia (SORS) for the years 2011, 2012 and 2013. The data was available only by municipalities, therefore we had to integrate the data by AU using SORS's code list of basic spatial units.

2.2 Statistical Analysis

The vaccination rates (per 1000) for RV were calculated out of the number of children who were given either two doses of Rotarix or three doses of RotaTeq fractioned by the number of children aged 0–4 who lived in the same AU.

Vaccination rates for HPV (per 1000) were calculated by fractioning the number of women who received three doses of the vaccine and the number of women in an AU aged 15–30.

The values of four socio-economic variables, e.g. the number of inhabitants, population density, unemployment rate, average gross pay and vaccination rates for RV and HPV, were summarized by using the average, standard deviation, median and range.

The educational structure and the size of the households were classified by AU. The data was entered into a graph and the distance chi-square (χ^2) was calculated. Educational structure was divided from the AU with the highest proportion of higher educated population to the AU with the lowest, so that the higher the value of χ^2 represented a lower educational structure. The structure of households was sorted from the AU with the lowest proportion of households with two or fewer members, so that the higher value of χ^2 represented more households with two or fewer members.

In the first step of the analysis, the correlations between socio-economic variables (the number of inhabitants, the number of children aged 0–4, the number of women aged 15–30, population density, unemployment rate, average gross pay and the educational structure expressed as a χ^2 distance) were analysed. Data for the structure of households by AU was available only for the year 2011, so it was analysed separately in relation to RV and HPV vaccination rates.

The variables including the number of inhabitants, the number of children aged 0–4 and the number of women aged 15–30, were expressed in a logarithmic (log10) scale, because of their range. The correlation between all the explanatory variables was demonstrated by scatter graphs and by Spearman's correlation coefficient rho (ρ) for the pairs of variables. The Spearman's ρ considers a strong correlation in the range -1.0 to -0.7 or 0.7 to 1.0, a weak correlation -0.7 to -0.3 or 0.3 to 0.7, and no correlation in the range -0.3 to 0 or 0 to 0.3 (23).

The vaccination rates for RV and HPV were presented with scatter graphs with each of the explanatory variables. On each graph, the data was combined for all three years; the values for each year are color-coded (2011- black, 2012 - dark grey, 2013 - light grey). The aim was to study the correlation in the diagrams by shape (linear or nonlinear), size (correlation coefficient) and direction (positive or negative). The correlation size was demonstrated by Spearman's ρ and the p-value. The shown p-values are only approximate; they are corrected for multiple groups, but not for their dependence. The vaccination rates on each diagram are shown on a logarithmic scale; the values themselves are not in logarithm, only the scale is adjusted accordingly.

3 RESULTS

3.1 Vaccination Rates by Administrative Units

The vaccination data were not reported by all 58 AU during the whole study period. Therefore, RV vaccination data from 42, 37 and 29 AU were analysed for the years 2011, 2012 and 2013, respectively. The RV vaccination coverage range varied widely (from the highest number of vaccinated in AU Radlje ob Dravi 178.7/1000 in 2012, to the lowest in AU Žalec 0.4/ 1000 in the same year).

HPV vaccination data was available from 44, 37 and 30 AU in the years 2011, 2012 and 2013, respectively. Seven AU (Dravograd, Grosuplje, Izola, Metlika, Ribnica, Slovenske Konjice, Trebnje and Tržič) did not submit any data on HPV vaccination in the 3-year period. Similar as for RV vaccination rates, the numbers of vaccinated against HPV significantly varied between AU; from the highest in 2011 in AU Ilirska Bistrica (257.4/1000) to the lowest in 2012 in AU Pesnica (0.6/1000). A constantly high vaccination rate was observed only in AU Ravne na Koroškem (in 2011 130.3/1000, in 2012 122.5/1000 and in 2013 131.2/1000).

3.2 Socio-economic Features of Administrative Units

The average, standard deviation, median and range for the unemployment rate, average gross pay, population density and number of inhabitants in 2011–2013, are presented in Table 1. In the observed period, the number of inhabitants had remained almost unchanged. The average gross wage and unemployment rates have both shown a slight upward trend.

Table 1. Average ± standard deviation, median and range for population, population density, unemployment rates and average gross pay for the years 2011, 2012 and 2013.

Year	2011	2012	2013
Population (per 1000)			
Average ± standard deviation	35.3 ± 47.5	35.4 ± 47.7	35.5 ± 48.1
Median	21.0	21.0	21.1
Range	8.4–347.1	8.4–348.6	8.4–352.3
Population density (population/km^2)			
Average ± standard deviation	118.8 ± 106.8	119.0 ± 107.0	119.0 ± 107.5
Median	83.2	83.7	83.3
Range	20.2–554.1	20.2–557.1	20.1–557.8
Unemployment rates (%)			
Average ± standard deviation	14.5 ± 4.7	14.7 ± 4.7	16.3 ± 4.5
Median	13.6	13.9	15.1
Range	7.1–29.9	5.7–29.4	6.9–28.9
Average gross pay (euro)			
Average ± standard deviation	1344 ± 117	1377 ± 118	1378 ± 121
Median	1328	1358	1351
Range	1171–1745	1200–1765	1202–1813

The educational structure did not change significantly in the three year period. A slight rise (2%) of highly educated individuals has been observed. The largest proportion of highly educated resided in AU Ljubljana (26%–28%), followed by AU Vrhnika, Piran, Maribor, Domžale and Kranj (average 22%), and the lowest in AU Ormož and Lenart (11% on average). The difference in the educational structure between the Western and Eastern Slovenia is noticeable; AU in the west have generally a higher educational level than those located in the east.

Data on household size was available only for the year 2011. The largest proportion of smaller households was observed in AU Maribor and Piran (66% of households with two or fewer members), followed by AU Celje and Trbovlje (64%). The largest proportion of bigger households was observed in AU Škofja Loka (10% of households with 5 members and 8% of households with six or more members).

3.3 The Correlation between Explanatory Variables

The scatter graphs between explanatory variables and Spearman's ρ have shown the following characteristics:

1. The correlation between pairs is mostly nonlinear (this also applies for the pair population/population density (ρ=0.51), because the number of inhabitants is in a logarithm scale). The only exception seems to be the correlation between the educational level and the average gross pay (ρ=-0.68).
2. High correlations between the number of inhabitants and the number of women aged from 15 to 30 (ρ=0.99), as well as the number of inhabitants and the number of children aged from 0 to 4 (ρ=0.97) stand out; therefore, the analysis requires only one of the two variables to be sufficient. This correlation was expected.
3. The unemployment rate weakly correlates with other variables; the exception is a weak correlation with a low educational structure (ρ=0.55).
4. The educational structure weakly correlates with other explanatory variables.

3.4 The Correlation between RV Vaccination Rates and Socio-economic Variables

An overview of the number of children aged between 0 and 4, and RV vaccination rates in the observed three years is presented in Table 2. The RV vaccination rates vary widely among individual AU and have shown a decline in the observed three year period (from 22.4 per 1000 children in 2011 to 15.0 per 1000 children in 2013).

Table 2. Average ± standard deviation, median and range for the number of children aged 0-4 and RV vaccination rates.

Year	2011 (n*=42)	2012 (n=37)	2013 (n=29)
The number of children aged 0-4 years (per 1000)			
Average ± standard deviation	2.1 ± 3.0	2.3 ± 3.2	2.5 ± 3.7
Median	1.1	1.3	1.3
Range	0.4–19.1	0.5–19.6	0.4–20.1
Vaccination rates; the number of vaccinated per 1000 children aged 0-4			
Average ± standard deviation	22.4 ± 30.9	19.4 ± 35.1	15.0 ± 27.1
Median	7.7	5.2	2.1
Range	1.1–146.1	0.4–178.7	0.6–102.2

Note 1: *n – the number of AU reporting the data

Scatter graphs for the pairs of variables (RV vaccination rates and socio-economic variables) are presented in Figures 1 to 5. Four out of five scatter graphs have shown no correlations between RV vaccination rates and socio-economic variables (unemployment rate ρ=-0.02 (Figure 2), population density ρ=-0.16 (Figure 3), average gross pay ρ=-0.06 (Figure 4) and educational structure ρ=0.12 (Figure 5)).

The only exception is the number of inhabitants (Figure 1), which has shown a weak negative correlation with RV vaccination rates (ρ=-0.29, p=0.04). Administrative units with a higher number of inhabitants have generally lower vaccination rates than those that are less populated. The two variables linearly correlate in a logarithmic scale. The regression analysis (from the following equation: log10 (RV vaccination rates) = -0.6 log10 (population in thousands) + 3.5) shows that 1,000 more inhabitants in an AU means an approximately 6.5% smaller proportion in RV vaccination rates (exponential decline).

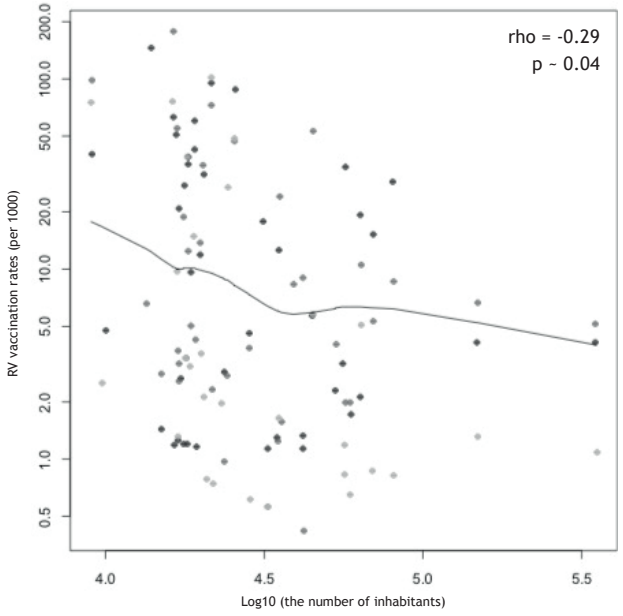

Figure 1. Scatter graph between RV vaccination rates and population.

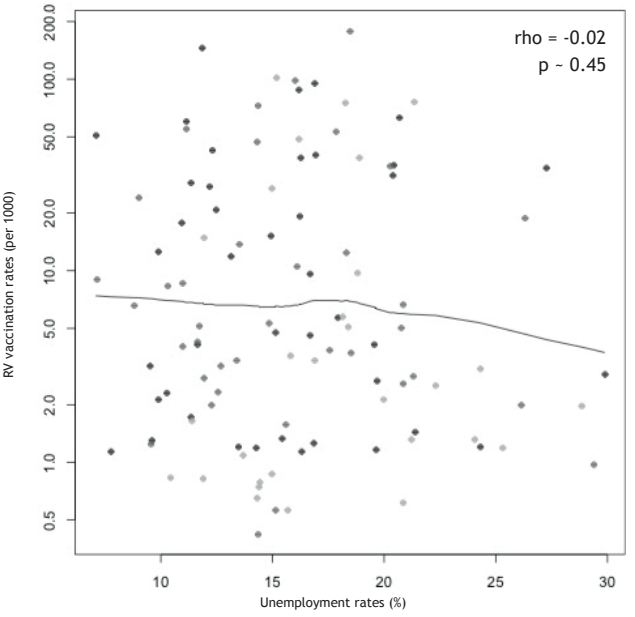

Figure 2. Scatter graph between RV vaccination rates and unemployment rates.

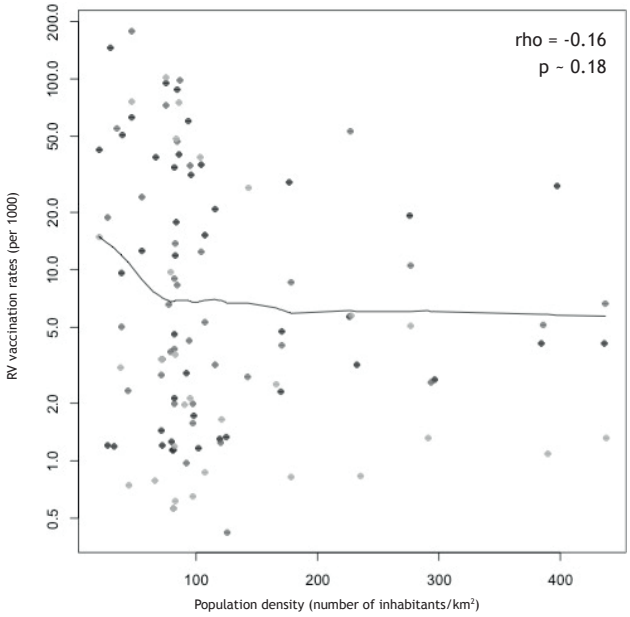

Figure 3. Scatter graph between RV vaccination rates and population density.

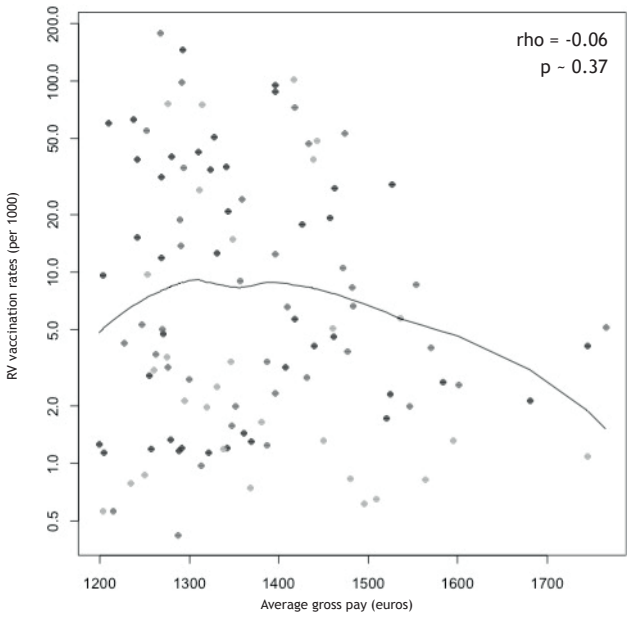

Figure 4. Scatter graph between RV vaccination rates and average gross pay.

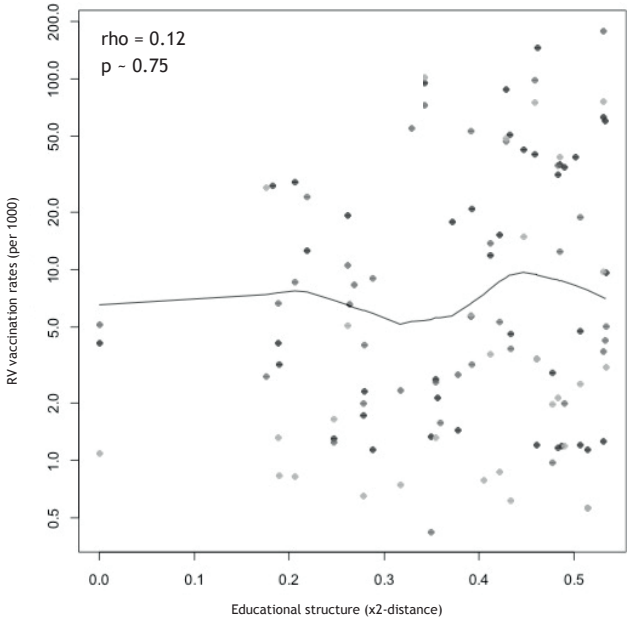

Figure 5. Scatter graph between RV vaccination rates and educational structure.

3.5 The Correlations between HPV Vaccination Rates and Socio-economic Variables

An overview of the number of women between 15 and 30 years and HPV vaccination rates in the observed three year period, are presented in Table 3. HPV vaccination rates vary widely between administrative units and have shown a decline in the observed three years (from 36.4 per 1000 women in 2011, to 16.5 per 1000 women in 2013).

Table 3. Average ± standard deviation, median and range for the number of children aged 0-4 and RV vaccination rates.

Year	2011 (n*=44)	2012 (n=37)	2013 (n=30)
Women aged 15-30 years (per 1000)			
Average ± standard deviation	3.5 ± 5.1	3.7 ± 5.4	3.9 ± 6.1
Median	1.9	2.0	1.9
Range	0.9–33.6	1.2–32.9	0.8–33.4
Vaccination rates: the number of vaccinated per 1000 women aged 15-30 years			
Average ± standard deviation	36.4 ± 59.1	21.2 ± 27.9	16.5 ± 30.3
Median	8.5	7.3	4.1
Range	1.0–257.4	0.6–122.5	1.7–131.2

Note 2: same as for Table 2.

Figures from 6 to 10 present scatter graphs for the pairs of variables (HPV vaccination rates and socio-economic explanatory variables). All five scatter graphs show no correlation between any of the presented variable pairs (population ρ=-0.13 (Figure 6), unemployment rate ρ=-0.05 (Figure 7), population density ρ=-0.07 (Figure 8), average gross pay ρ=-0.01 (Figure 9) and educational structure ρ=0.13 (Figure 10)).

The data on the household structure was available only for the year 2011 and hence analysed separately. No correlation between household structure and RV or HPV vaccination rates has been found.

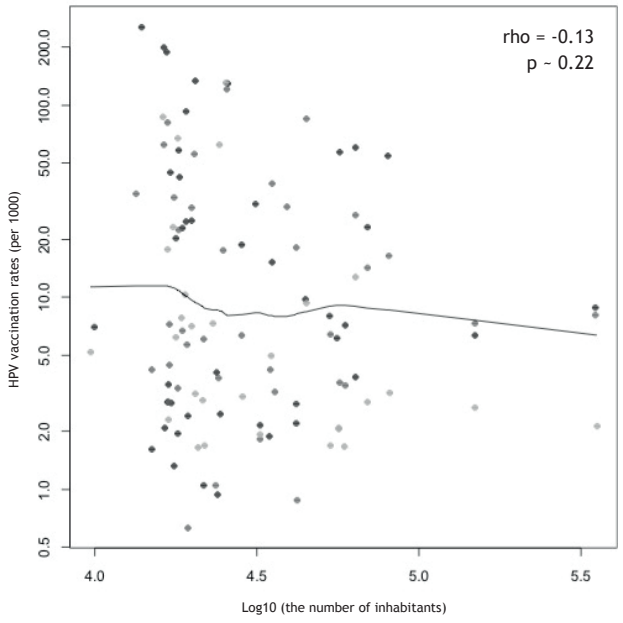

Figure 6. Scatter graph between HPV vaccination rates and population.

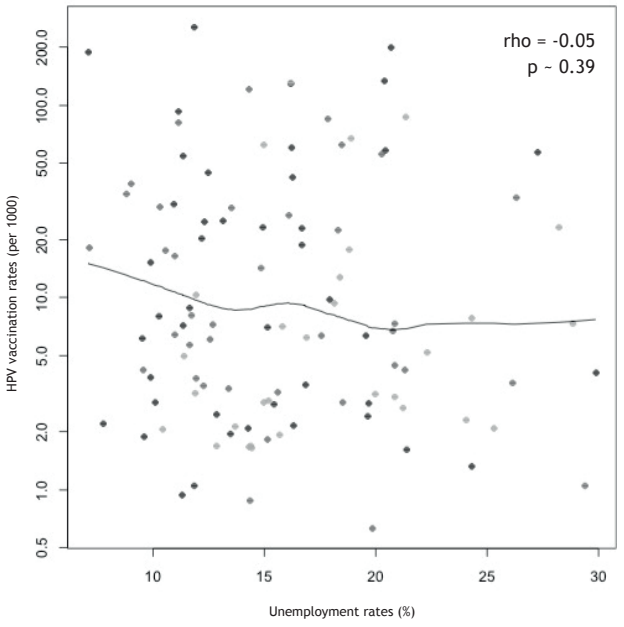

Figure 7. Scatter graph between HPV vaccination rates and unemployment rates.

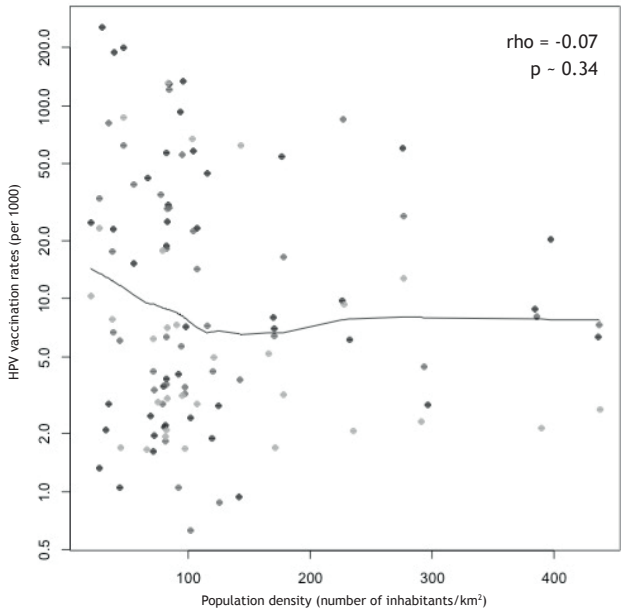

Figure 8. Scatter graph between HPV vaccination rates and population density.

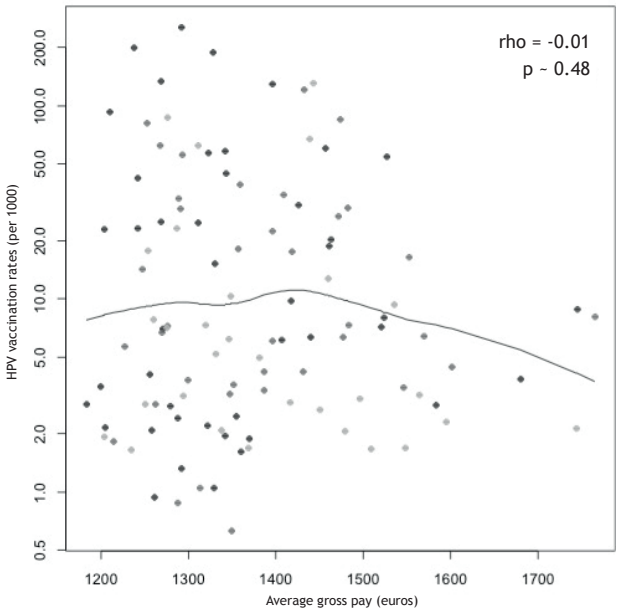

Figure 9. Scatter graph between HPV vaccination rates and average gross pay.

4 DISSCUSION

The aim of the ecological study was to determine whether there was a relationship between selected socio-economic determinants and HPV or RV vaccination rates at the AU level in Slovenia. We made a hypothesis that unfavourable socio-economic factors should show a certain impact on the vaccination rates for self-paid HPV and RV vaccines. The difference of economic indicators (income inequality and unemployment rates) and consequent inequalities in health that exists between eastern and western parts of Slovenia could similarly mirror in different vaccination coverage for self-paid vaccines (24).

The proposed hypothesis has not been confirmed, as we found no correlations between the level of immunization with HPV or RV vaccine in target groups and any of the included socio-economic variables. The only exception was weak negative correlation between RV vaccination rates and the number of inhabitants in an AU (ρ=-0.29, p=0.04). The administrative units with a larger population have, on average, lower vaccination rates than those with fewer inhabitants. The decline is exponential; 1000 more inhabitants in an AU according to this model correspond to a decline in vaccination rates for approximately 6.5%. The model explains only a small part of the variation in vaccination rates, which indirectly implies that other factors have a considerable effect.

For both self-paid vaccines, the vaccinations rates have declined in the observed three years' period. We assume that the drop in vaccination coverage has multiple causes, one of them being distrust in the safety and efficiency of vaccines in general.

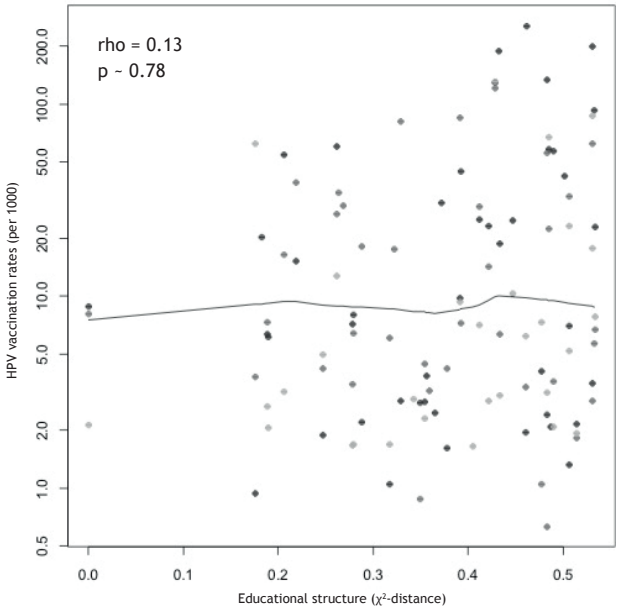

Figure 10. Scatter graph between HPV vaccination rates and educational structure.

In Europe, the main obstacles for achieving higher immunization against RV are the belief in the low burden of the disease, unfavourable cost analysis and doubts about the safety of the vaccine (25). However, immunization against RV is still high in some countries. A Belgian study from 2012, found out that important determinants of low vaccination rates are a household size (lower vaccination rates in larger families) and an

unemployed mother, mostly because the vaccine is partially self-paid. Nevertheless, Belgium has reached high (90%) vaccination coverage against RV (26). In our study, no correlations have been found with regards to the average household size or unemployment rates and the number of vaccinated with the RV vaccine at the AU level. The unemployment rate in relatively young adults, i.e. the part of the population with the highest percentage of infants, might show a correlation to RV vaccination rate.

The price of vaccination has the major impact in economically disadvantaged environments if the vaccine has to be self-paid. Therefore, the finding of Mortensen that the price itself represents a major obstacle for HPV vaccination of young women between 16 and 26 years of age, who have to pay fully by themselves, is not surprising (27). A Polish study has shown that a high cost of RV vaccine was proven to be an important barrier to vaccinate. The researchers concluded that better immunization could be achieved with financial support for young low income families. Furthermore, parents' decision whether to vaccinate or not was based on the advice or initiative of the medical staff; the concern about unwanted side-effects was shown to be unimportant (28).

In our study, lower vaccination rates in AU did not correlate with lower average income per resident. The average income difference between AU might be too small to have an impact on the level of vaccination rates in Slovenia. A study with a different design (i.e. income and unemployment data collected on an individual level) might find a link between higher income per family member and better vaccination rates. Furthermore, we found no relationship between the proportions of higher educated in an AU and the immunization rate. It would be interesting to know what kind of correlation exists (if any) on an individual level with regards to parental education and vaccination coverage with RV vaccine. Since among the opponents of vaccination are often individuals with a high level of education, the correlation could even be negative.

Individual studies have also shown that poor immunization coverage is influenced by geographical inequalities; lower vaccination rates were found in rural areas (29).

We assume that socio-economic determinants are only one of the many determinants that play an important role in the decision-making process. Perception of severity, concerns about the influence on health, the fear of alleged and real side-effects, the perceived low efficacy of the vaccine, beliefs that vaccination is not required, scarce knowledge about the vaccine, the ability of health workers to professionally and appropriately present the vaccine and its benefits, and the fear that HPV vaccine will have negative effects on the image of sexuality and cervical cancer screening among minors, were found to influence the acceptance (7, 30-32).

Declining HPV vaccination rates in the three-year period in younger women may reflect the trend of disadvantageous economic conditions or the negative impact of the media and online campaign against the vaccine. An example of a negative campaign is available on the website of the association "We are change" (http://wearechange.si/vodilna-raziskovalka-hpv-cepiva-prizna-da-nekoristna-verjetno-nevarna/). The data presented on the above-mentioned webpage is not confirmed by scientific studies, but is probably read by many and its views are accepted without any critical thought. Given the relatively weak campaign for HPV vaccination from the public health side, the non-scientific data prevails when deciding for or against vaccination. A study is warranted to gain the knowledge about the impact of those pieces of information on information seekers, as no such study has been performed in Slovenia yet.

The main limitations of our study were the incompleteness of the data (the data from some AU missing) and the type of study selected (ecological study). Even though this type of a study was the most appropriate for the initial investigation of our hypothesis, it is important to acknowledge that the relationships observed for groups do not necessarily hold for individuals, that aggregating data loses information and therefore the diversity and deviations between individuals are poorly detected. A better insight would be gained by studying socio-economic determinants on the individual level in correlation with RV or HPV vaccine acceptance or declination (24).

5 CONCLUSSION

Ecological study did not reveal any correlations between socio-economic variables and vaccination rates with the two self-paid vaccines. Therefore, we can only assume that other factors (beliefs, attitudes, scarce knowledge) play an important role in the decision-making process to get vaccinated with RV and HPV vaccine.

These findings represent the starting point for a methodologically different research, aiming to identify the key factors that impede, support and enable vaccine acceptance. A multifaceted understanding of determinants is needed to support the development of effective policies for self-paid vaccinations in Slovenia.

CONFLICTS OF INTEREST

The authors declared that they have no financial, professional or personal conflicting interests related to this article.

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