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Socio-economic determinants of the second-dose measles vaccination coverage in Poland

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Abstract

Introduction and Objective. Measles is one of the most contagious human viruses and serves as an early indicator of gaps in population immunity. Despite the introduction of measles vaccination 50 years ago, Poland remains one of nine endemic countries in the WHO European Region. The aim of the study is to assess the relationship between socio-economic factors and sufficient coverage (≥95%) with the second dose of vaccination against measles (MMR2) at the poviat level in Poland from 2014 – 2018.

Materials and Method. Data on MMR2 coverage was extracted from annual reports collected by sanitary-epidemiological stations in Poland. Socio-economic data was obtained from Statistics Poland. A multivariate logistic regression analysis, adjusted for population size and the number of physicians and nurses, was performed to identify predictors of sufficient MMR2 coverage.

Results. Three socio-economic variables were found to be significant independent predictors of sufficient MMR2 coverage across years: the number of households receiving community-based social assistance, families receiving child benefits, and the number of medical consultations in primary health care. Poviats with higher values for these variables had increased odds of achieving sufficient MMR2 coverage. In contrast, no significant association was observed between MMR2 coverage and the average monthly salary, employment rates, or the number of foster families.

Conclusions. MMR2 coverage at the poviat level in Poland is predictable using selected socio-economic variables. The findings suggest that benefitting from social assistance positively influences vaccination uptake. While individual-level data would provide greater insight, poviat-level data can still guide public health interventions to improve MMR2 coverage and reduce the risk of measles outbreaks.

Key words

measles, childhood immunization, vaccination coverage

INTRODUCTION

Socio-economic status is one of the key determinants of health [1]. The Constitution of the World Health Organization (WHO) acknowledges the importance of co-operation with other sectors, allowing for the improvement of social and economic conditions to achieve health gain [2]. One of the most successful tools in achieving health gain is immunization [3, 4]. The uptake of vaccines among children is subject to diverse factors that vary based on the particular vaccine and the distinct national context [5–10]. In Australia, the lowest vaccination rates in the highest socio-economic advantaged geographic areas demonstrated what is known as the 'privilege paradox' [6]. In the United Kingdom and Germany, for the MMR (measles, mumps, rubella) vaccines, evidence of an inverse relation (lower vaccine uptake among children from a higher socio-economic group) was found [7]. However, a longitudinal ecological study, also from the United Kingdom, showed the lowest MMR uptake among children from the most socio-economically deprived communities [8]. A relationship between adverse socio-economic factors and increased MMR vaccination coverage was also identified in Spain [9]. In the USA, MMR vaccine hesitancy has socio-cultural and geographical clustering elements [11]. In a Canadian city, significant disparities were found at the neighbourhood level, with areas of social and economic disadvantage having lower rates of total, complete, and up-to-date MMR uptake, compared to areas of greater social and economic wealth [12].

Given the critical role of vaccination in public health, it remains essential to systematically evaluate the country-specific determinants that most significantly impact childhood vaccination coverage.

Measles is one of the most contagious human viruses which is preventable through vaccination. According to the World

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Health Organization, because of its high transmissibility, measles acts as an early warning system, quickly exposing any immunity gaps in the population [13].

One of the strategic priorities outlined in the European Immunization Agenda 2030 includes achieving high and equitable coverage throughout the life course, and utilizing data to reduce the number of un- and under-vaccinated individuals in every country [14].

Even though 50 years have passed since the introduction of measles vaccinations in Poland and the incidence of measles cases per 100,000 population has decreased from 588 to 0.12 [15, 16], Poland is still among 9 of the 53 Member States from the WHO European Region considered to be endemic for measles by the Regional Verification Commission (RVC) in 2023. The RVC expressed concerns that the decrease in routine immunization coverage with both MMR doses at the national and sub-national level presented an additional risk of outbreaks. Poland was urged to ensure high routine immunization coverage (of at least 95%) with both doses of MMR. The RVC also called for continued efforts to ensure high coverage in groups with suboptimal immunization. One of the general recommendations was to gather the latest immunization coverage data at both: national and subnations levels [17]. Coverage of 95% or greater of two doses of measles-containing vaccine is needed to create herd immunity in order to protect communities and achieve and maintain measles elimination [18]. Locating areas where the vaccination coverage is lower than needed is crucial. Identifying these areas may be possible through examining the correlation between the vaccination coverage and socio-economic variables, as their impact leads to the differentiation of health status between social groups, and also territorially between areas of the country with different levels of economic development. Finding a territorial unit with accessible vaccination coverage and socio-economic data is essential for facilitating evidence-based interventions by local government authorities and sanitary-epidemiological institutions within the respective areas.

The aim of this study is to assess the relationship between socio-economic factors and sufficient coverage (≥95%) with the second dose of vaccination against measles, mumps, rubella (MMR2) at the poviat[1] level in Poland from 2014 – 2018.

MATERIALS AND METHOD

Data collection. Data on mandatory vaccination uptake in Poland was registered in paper form by the medical entity where the vaccination was performed. According to the Statistical Research Programme on Public Statistics, entities performing medical activities providing outpatient and inpatient health services participating in vaccination, provided annually individual data in paper form to the poviat sanitary-epidemiological stations. This data was later aggregated and sent to the voivodeship sanitary-epidemiological stations (VSES). VSES further aggregated the data from its territory and sent it to the National Institute of Public Health – National Institute of Hygiene – National Research Institute [19].

Data to calculate the MMR2 coverage in this study was extracted from annual reports on mandatory vaccinations from 2014–2018 collected from sanitary-epidemiological stations in Poland with granularity at the poviat level. The coverage rate for each calendar year was calculated as the proportion of the vaccinated children in a birth cohort targeted for immunization. The numerator represented the number of children who received the second dose of vaccination against measles, mumps, rubella (MMR2) during the observed calendar year. In the study period, the MMR2 was administered to children aged 10. This study does not extend to the period following the change in the immunization schedule which, beginning in 2019, shifted MMR2 administration to children aged six [21]. The aggregated format of received data prevented any identification of a patient receiving the vaccination.

The following socio-economic variables of interest were extracted from Statistics Poland public database at the poviat level: population, number of nurses per 10,000 population, number of physicians per 10,000 population, average monthly gross salary (PLN), number of people working, number of foster families per 10,000 population, number of children aged 3–5 in pre-school education institutions, number of beneficiaries of environmental social assistance, number of households that have benefitted from community-based social assistance benefits for 10,000 population, number of families receiving child benefit per 10,000 population, number of medical consultations in primary health care per 10,000 population.

Statistical analysis of the results was performed with the SAS programme version 9.4. A multi-variate logistic regression adjusted for population, the number of medical doctors and nurses, was computed to identify determinants of sufficient MMR2 vaccination coverage at the poviat level.

RESULTS

Table 1 contains descriptive statistics of the socio-economic variables included in the study.

The number of voivodeships and the number of poviats with sufficient MMR2 coverage decreased over time. The percentage of poviats without sufficient MMR2 coverage, across the years in the voivodeships, was the highest in the Subcarpathian, Silesian and Mazovian voivodeships. In the Subcarpathian Voivodeship, the MMR2 coverage was not sufficient in more than 50% of the poviats in each of the years studied. Nationally, MMR2 coverage shows an unequal uptake across poviats, with almost 67 percentage point difference in MMR2 coverage between poviats with the lowest and highest vaccination coverage.

From 2014 – 2018, the percentage of counties with sufficient MMR2 coverage decreased by 14.5%. For all socio-economic parameters, a unit was selected (see: footer of Tab. 2), which was used to estimate the odds of the sufficient MMR2 coverage at poviat level. It is expressed using the odds ratio additionally adjusted for the number of healthcare workers (physicians, nurses) and population. The units were selected so that the odds ratios had similar values.

Poviats with higher number of following variables: children in preschool education institutions (abbr. *preschool children*),

[1] poviat – local self-government community (all residents) and the relevant territory, i.e. a unit of basic territorial division covering an area from several to a dozen or so communes (gminas) or the entire area of a city with poviat rights (i.e. a commune with the status of a city that has been granted poviat rights) [20].

Table 1. Quantitative characteristics (median, interquartile range, range) of the socio-economic variables of interest by years (units explained in the footer)

		Calendar Year						
		2014	2015	2016	2017	2018	Trends[#]	P[§]
Population[a] (thous.)	med(IQR) range	79 (56–123) 21–1,735	79 (56–123) 21–1,744	79 (55–123) 20–1,754	79 (55–124) 20–1,765	79 (55–125) 20–1,778	–	.80
Nurses[b]	med(IQR) range	46 (33–59) 6–169	45 (33–60) 6–153	45 (33–60) 5–153	47 (35–63) 4–162	48 (35–65) 7–171	+	.058
Physicians[c]	med(IQR) range	31 (24–42) 10–139	32 (24–41) 7–142	31 (25–43) 8–150	33 (25–44) 3–162	33 (25–44) 5–167	+	.021
Salary[d]	med(IQR) range	3,350 (3,155–3,832) 2,544–14,128	3,453 (3,250–3,919) 2,569–14,698	3,575 (3,387–4,062) 2,659–15,153	3,781 (3,582–4,321) 2,960–15,912	4,062 (3,815–4,581) 3,183–17,155	+	.0001
Workers[e]	med(IQR) range	2,639 (2,245–3,039) 1,595–5,054	2,668 (2,268–3,056) 1,603–5,307	2,709 (2,333–3,131) 1,664–5,395	2,762 (2,372–3,157) 1,645–5,416	2,792 (2,407–3,211) 1,669–5,476	+	.0001
Foster fam[f]	med(IQR) range	10 (8–13) 3–23	10 (8–12) 3–23	10 (7–13) 2–22	10 (7–12) 2–23	9 (7–12) 2–24	–	.063
Preschool children[g]	med(IQR) range	761 (690–851) 514–3,423	808 (739–888) 548–3,614	771 (692–860) 533–3,417	808 (734–886) 577–3,584	834 (761–908) 602–3,651	+	.0001
Beneficiaries[H]	med(IQR) range	999 (729–1,295) 287–2,967	914 (657–1,216) 275–2,739	835 (585–1,109) 269–2,559	729 (519–983) 236–2,367	657 (461–896) 203–2,165	–	.0001
Households[i]	med(IQR) range	336 (257–404) 134–855	319 (247–389) 121–796	298 (233–369) 118–769	276 (219–346) 112–736	256 (201–319) 102–682	–	.0001
Benefit fam[j]	med(IQR) range	364 (269–432) 67–625	336 (246–405) 64–627	364 (270–430) 72–657	363 (269–426) 75–608	354 (272–409) 84–565	+	.96
Advice[k] (thous.)	med(IQR) range	42 (39–45) 28–56	44 (40–47) 29–65	44 (41–47) 27–58	45 (41–48) 29–59	46 (42–49) 31–58	+	.0001

[#] direction of correlation with calendar year (sign of correlation coefficient)
[§] refers to significance of correlations
[a] population in poviats
[b] number of nurses per 10,000 population
[c] number of physicians per 10,000 population
[d] average monthly gross salary (PLN)
[e] number of people working in poviats
[f] number of foster families per 10,000 population
[g] number of children aged 3-5 in preschool education institutions
[h] number of beneficiaries of environmental social assistance
[i] number of households that have benefited from community-based social assistance benefits per 10,000 population
[j] number of families receiving child benefit per 10,000 population
[k] number of medical consultations in primary health care per 10,000 population

Table 2. Odds of achieving sufficient MMR2 vaccination coverage across the years depending on socio-economic variables (all ORs were adjusted for population size and the number of physicians and nurses)

Year		2014		2015		2016		2017		2018	
	Units	OR	P	OR	P	OR	P	OR	P	OR	P
Salary	a	0.95	.65	1.05	.67	1.13	.26	0.99	.92	1.01	.901
Workers	b	1.03	.26	1.00	.86	0.99	.83	1.01	.63	1.03	.26
Foster fam	c	0.98	.63	1.04	.37	1.03	.39	0.99	.78	1.00	.97
Preschool children	d	1.11	.025	1.09	.027	1.13	.01	1.04	.313	1.11	.008
Beneficiaries	e	1.10	.001	1.10	.001	1.13	.001	1.10	.002	1.15	.001
Households	f	1.05	.005	1.07	.001	1.06	.001	1.06	.003	1.07	.001
Benefit fam	g	1.06	.001	1.04	.029	1.04	.014	1.04	.009	1.04	.02
Advice	h	3.52	.0001	3.18	.001	1.66	.07	1.57	.109	1.98	.011

[a] average monthly gross salary (PLN)
[b] number of people working in poviats per 100 people
[c] number of foster families per 10,000 population
[d] number of children in preschool education institutions aged 3-5 per 1,000 population
[e] number of beneficiaries of environmental social assistance per 1,000 population
[f] number of households that have benefited from community-based social assistance benefits per 1,000 population
[g] number of families receiving child benefit per 1,000 population
[h] number of medical consultations in primary health care per person

beneficiaries of environmental social assistance (abbr. *beneficiaries*), households that benefited from community-based social assistance benefits (abbr. *households*), families receiving child benefit (abbr. *benefit fam*), medical advice provided in primary healthcare (abbr. *advice*) were more likely to achieve sufficient MMR2 coverage. No significant association was noted between the average monthly gross salary (abbr. *salary*), number of people working in poviats (abbr. *workers*), nor the number of foster families (abbr. *foster fam*) and sufficient vaccination coverage in any of the years studied.

Odds ratios of ≥95% MMR2 vaccination coverage in poviats for the number of *preschool children, beneficiaries, households, benefit fam, advise* were within the ranges: 1.04–1.13, 1.10–1.15, 1.05–1.07, 1.04–1.06, 1.57–3.52, respectively (Tab. 2).

In 2018, the odds to achieve sufficient MMR2 coverage adjusted for the number of healthcare workers (physicians, nurses) and population increased by 98% with each *advice*, by 15% with each *beneficiary*, by 7% with each *household*, by 4% with each family receiving child benefit. In 2014, the set of independent predictors consisted of two: *advice, benefit*

Table A1. Correlations between the variables of interest in 2014

	Workers[e]	Foster fam[f]	Preschool children[g]	Beneficiaries[h]	Households[i]	Benefit fam[j]	Advice[k]
Population[a]	0.17	-0.04	0.58	-0.11	-0.44	-0.47	-0.08
	.002	.46	.001	.052	.001	.001	.14
Nurses[b]	0.24	0.00	0.35	0.12	-0.07	-0.23	0.05
	.001	.96	.001	.028	.23	.001	.35
Physicians[c]	0.17	0.14	0.52	-0.09	-0.29	-0.45	0.14
	.002	.010	.001	.09	.001	.001	.012
Salary[d]	0.18	0.14	0.61	0.02	-0.30	-0.57	-0.05
	.001	.014	.001	.79	.001	.001	.37
Workers[e]	1.00	-0.49	0.27	-0.04	-0.31	0.05	-0.06
		.001	.001	.53	.001	.35	.29
Foster fam[f]		1.00	0.05	0.03	0.21	-0.37	0.24
			.40	.61	.001	.001	.001
Preschool children[g]			1.00	-0.20	-0.55	-0.63	0.04
				.001	.001	.001	.51
Beneficiaries[h]				1.00	0.75	0.51	0.12
					.001	.001	.034
Households[i]					1.00	0.55	0.21
						.001	.001
Benefit fam[j]						1.00	-0.02
							.67
Advice[k]							1.00

[a] population in poviats
[b] number of nurses per 10,000 population
[c] number of medical doctors per 10,000 population
[d] average monthly gross salary (PLN)
[e] number of people working in poviats
[f] number of foster families per 10,000 population
[g] number of children aged 3-5 in preschool education institutions
[h] number of beneficiaries of environmental social assistance
[i] number of households that have benefited from community-based social assistance benefits per 10,000 population
[j] number of families receiving child benefit per 10,000 population
[k] number of medical consultations in primary health care per 10,000 population

Table A2. Correlations between the variables of interest in 2015

	Workers[e]	Foster fam[f]	Preschool children[g]	Beneficiaries[h]	Households[i]	Benefit fam[j]	Advice[k]
Population[a]	0.16	-0.03	0.61	-0.11	-0.44	-0.45	-0.08
	.003	.55	.001	.053	.001	.001	.14
Nurses[b]	0.20	-0.01	0.35	0.12	-0.07	-0.24	0.00
	.001	.82	.001	.037	.18	.001	.98
Physicians[c]	0.17	0.09	0.53	-0.09	-0.30	-0.44	0.11
	.002	.09	.001	.10	.001	.001	.053
Salary[d]	0.16	0.15	0.65	-0.03	-0.33	-0.59	-0.05
	.005	.006	.001	.62	.001	.001	.40
Workers[e]	1.00	-0.48	0.28	-0.02	-0.29	0.08	-0.07
		.001	.001	.71	.001	.17	.23
Foster fam[f]		1.00	0.05	0.01	0.19	-0.37	0.26
			.42	.81	.001	.001	.001
Preschool children[g]			1.00	-0.24	-0.59	-0.63	0.02
				.001	.001	.001	.69
Beneficiaries[h]				1.00	0.76	0.53	0.06
					.001	.001	.27
Households[i]					1.00	0.55	0.17
						.001	.002
Benefit fam[j]						1.00	-0.06
							.32
Advice[k]							1.00

[a] population in poviats
[b] number of nurses per 10,000 population
[c] number of medical doctors per 10,000 population
[d] average monthly gross salary (PLN)
[e] number of people working in poviats
[f] number of foster families per 10,000 population
[g] number of children aged 3-5 in preschool education institutions
[h] number of beneficiaries of environmental social assistance
[i] number of households that have benefited from community-based social assistance benefits per 10,000 population
[j] number of families receiving child benefit per 10,000 population
[k] number of medical consultations in primary health care per 10,000 population

Table A3. Correlations between the variables of interest in 2016

	Workers[e]	Foster fam[f]	Preschool children[g]	Beneficiaries[h]	Households[i]	Benefit fam[j]	Advice[k]
Population[a]	0.17	-0.04	0.61	-0.11	-0.44	-0.45	-0.11
	.003	.49	.001	.041	.001	.001	.051
Nurses[b]	0.20	-0.01	0.35	0.17	-0.02	-0.22	0.01
	.001	.80	.001	.002	.67	.001	.89
Physicians[c]	0.15	0.12	0.50	-0.04	-0.25	-0.42	0.11
	.008	.032	.001	.44	.001	.001	.060
Salary[d]	0.14	0.15	0.65	-0.03	-0.34	-0.61	-0.04
	.011	.007	.001	.59	.001	.001	.43
Workers[e]	1.00	-0.49	0.30	-0.03	-0.28	0.10	-0.07
		.001	.001	.57	.001	.08	.20
Foster fam[f]		1.00	0.01	0.03	0.20	-0.40	0.25
			.84	.65	.001	.001	.001
Preschool children[g]			1.00	-0.23	-0.59	-0.60	-0.01
				.001	.001	.001	.91
Beneficiaries[h]				1.00	0.76	0.50	0.06
					.001	.001	.33
Households[i]					1.00	0.51	0.17
						.001	.002
Benefit fam[j]						1.00	-0.07
							.201
Advice[k]							1.00

[a] population in poviats
[b] number of nurses per 10,000 population
[c] number of medical doctors per 10,000 population
[d] average monthly gross salary (PLN)
[e] number of people working in poviats
[f] number of foster families per 10,000 population
[g] number of children aged 3-5 in preschool education institutions
[h] number of beneficiaries of environmental social assistance
[i] number of households that have benefited from community-based social assistance benefits per 10,000 population
[j] number of families receiving child benefit per 10,000 population
[k] number of medical consultations in primary health care per 10,000 population

Table A4. Correlations between the variables of interest in 2017

	Workers[e]	Foster fam[f]	Preschool children[g]	Beneficiaries[h]	Households[i]	Benefit fam[j]	Advice[k]
Population[a]	0.17	-0.03	0.64	-0.13	-0.46	-0.44	-0.08
	.002	.54	.001	.016	.001	.001	.16
Nurses[b]	0.21	-0.01	0.34	0.14	-0.06	-0.23	0.02
	.001	.79	.001	.014	.28	.001	.70
Physicians[c]	0.18	0.09	0.49	-0.07	-0.27	-0.40	0.10
	.001	.10	.001	.19	.001	.001	.06
Salary[d]	0.17	0.16	0.65	-0.05	-0.36	-0.60	-0.02
	.003	.005	.001	.34	.001	.001	.74
Workers[e]	1.00	-0.46	0.30	-0.05	-0.29	0.10	-0.04
		.001	.001	.35	.001	.08	.47
Foster fam[f]		1.00	0.01	0.02	0.18	-0.42	0.27
			.91	.68	.001	.001	.001
Preschool children[g]			1.00	-0.23	-0.60	-0.58	0.00
				.001	.001	.001	.99
Beneficiaries[h]				1.00	0.76	0.48	0.08
					.001	.001	.17
Households[i]					1.00	0.48	0.17
						.001	.002
Benefit fam[j]						1.00	-0.08
							.14
Advice[k]							1.00

[a] population in poviats
[b] number of nurses per 10,000 population
[c] number of medical doctors per 10,000 population
[d] average monthly gross salary (PLN)
[e] number of people working in poviats
[f] number of foster families per 10,000 population
[g] number of children aged 3-5 in preschool education institutions
[h] number of beneficiaries of environmental social assistance
[i] number of households that have benefited from community-based social assistance benefits per 10,000 population
[j] number of families receiving child benefit per 10,000 population
[k] number of medical consultations in primary health care per 10,000 population

Table A5. Correlations between the variables of interest in 2018

	Workers[e]	Foster fam[f]	Preschool children[g]	Beneficiaries[h]	Households[i]	Benefit fam[j]	Advice[k]
Population[a]	0.18	-0.03	0.66	-0.14	-0.46	-0.42	-0.04
	.002	.55	.001	.016	.001	.001	.46
Nurses[b]	0.25	-0.05	0.34	0.13	-0.07	-0.22	0.05
	.001	.37	.001	.025	.24	.001	.36
Physicians[c]	0.23	0.06	0.50	-0.12	-0.32	-0.40	0.14
	.001	.30	.001	.033	.001	.001	.010
Salary[d]	0.17	0.17	0.66	-0.06	-0.37	-0.60	0.00
	.002	.003	.001	.26	.001	.001	.94
Workers[e]	1.00	-0.43	0.29	-0.05	-0.27	0.06	0.00
		.001	.001	.42	.001	.25	.96
Foster fam[f]		1.00	0.01	0.02	0.17	-0.39	0.23
			.88	.69	.002	.001	.001
Preschool children[g]			1.00	-0.22	-0.59	-0.57	0.01
				.001	.001	.001	.88
Beneficiaries[h]				1.00	0.76	0.47	0.04
					0.001	0.001	0.48
Households[i]					1.00	0.46	0.14
						.001	.012
Benefit fam[j]						1.00	-0.10
							.07
Advice[k]							1.00

[a] population in poviats
[b] number of nurses per 10,000 population
[c] number of medical doctors per 10,000 population
[d] average monthly gross salary (PLN)
[e] number of people working in poviats
[f] number of foster families per 10,000 population
[k] number of medical consultations in primary health care per 10,000 population
[g] number of children aged 3-5 in preschool education institutions
[h] number of beneficiaries of environmental social assistance
[i] number of households that have benefited from community-based social assistance benefits per 10,000 population
[j] number of families receiving child benefit per 10,000 population

fam, in 2015, of two: *advice, households*, in 2016, of one: *households*, in 2017, of two: *households*, *benefit fam*, and in 2018, of two: *advice, households*.

Supplementary tables A1-A5 present the correlations between the socio-economic variables. The number of physicians, medical consultations provided in primary health care, children in pre-school education institutions, average monthly gross salary and people working in poviats were positively correlated with calendar year. Across the time the number of medical doctors, medical consultations provided in primary health care, children in pre-school education institutions, average monthly gross salary and people working in poviats have increased. However, the negative correlation with calendar time was observed between number of households that have benefited from community-based social assistance benefits, number of foster families and the number of beneficiaries of environmental social assistance.

Supplementary table B presents the odds ratios of parameters that were concerned significant independent predictors of ≥95% MMR2 vaccination coverage of all variables considered.

Neither the number of foster families in poviat, nor *workers*, nor *salary* are variables that independently determine MMR2 vaccination status. In contrast, across the years, *advice,*

Table B. Calendar year-dependent final models of the sufficient MMR2 vaccination coverage (≥95%) consisting of significant predictors selected from all variables considered

Calendar year	2014			2015			2016			2017			2018		
	OR[§]	95%CI	P	OR[§]	95%CI	P	OR[§]	95%CI	P	OR[§]	95%CI	P	OR[§]	95%CI	P
Salary[a]															
Workers[b]															
Foster Fam[c]															
Preschool children[d]															
Beneficiaries[e]															
Households[f]				1.05	1.02–1.09	.006	1.06	1.02–1.1	.001	1.04	1.00–1.08	.035	1.06	1.02–1.10	.002
Benefit Fam[g]	1.06	1.03–1.09	.001							1.04	1.00–1.07	.027			
Advice[h]	3.03	1.54–5.97	.001	2.76	1.46–5.24	.002							1.73	1.01–2.95	.046

[§] refers to significance of correlations
[a] average monthly gross salary (PLN)
[b] number of people working in poviats per 100 people
[c] number of foster families per 10,000 population
[d] number of children i aged 3-5 in preschool education institutions per 1,000 population
[e] number of beneficiaries of environmental social assistance per 1,000 population
[f] number of households that have benefited from community-based social assistance benefits per 1,000 population
[g] number of families receiving child benefit per 1,000 population
[h] number of medical consultations in primary health care per person

households, beneficiaries, number of families receiving child benefit, *preschool children* reveal as independent variables determining MMR2 coverage. These variables are independent of the poviat size, the number of physicians and the number of nurses in the poviat. The independent predictors of sufficient MMR2 coverage that repeat in more than 1 year are: *households, advice, benefit fam*.

DISCUSSION

Main findings and result analysis. Despite the provision of vaccines being funded for all children by the National Immunization Programme, the current study shows evidence that an association between socio-economic variables and vaccination coverage exists in Poland.

Univariate analyses involving socio-economic variables revealed five variables: *preschool children, beneficiaries, households, benefit fam, advice,* as those significantly associated with greater chances of sufficient MMR2 vaccination coverage. However, not all of them turned out to be independently associated with sufficient MMR2 vaccination coverage, which was revealed in multivariate analyses.

Only three of the variables (of the five above) turned out to be independent: *households, benefit fam and advice*. In poviats with greater number of *households, benefit fam* and *advice*, the chance of sufficient vaccination coverage was higher. The current study, however, did not answer the question whether this phenomenon would also be observed at the individual level, nor whether it would be possible to discover a better correlation of socio-economic variables with sufficient vaccination coverage by examining smaller or bigger units than a poviat.

The variables of interest can hardly be considered modifiable. The number of beneficiaries of environmental social assistance, number of households that have benefited from community-based social assistance benefits, and number of families receiving child benefit, are indicators, because they reflect the needs in these areas of life, but they can also be factors when they reflect the efficiency of activities in this area by the relevant services. The variables of interest are the resultant of these indicators and factors.

The current study proves that by examining the administrative unit at the poviat level in terms of sufficient MMR2 coverage, shows the relationship between these socio-economic variables and people's willingness to vaccinate their children with MMR2. It is possible that the two variables that revealed their relationship with the risk of sufficient MMR2 coverage in univariate analyses (*pre-school* and *beneficiaries*), were also directly related to the end point. The correlations found for these two variables with three independent variables supported this assumption (Tab. A in the Annex). Perhaps their independent relationship with the risk of sufficient MMR2 coverage would be revealed in multifactorial models at a lower or higher administrative level. At the moment, the relationship between *preschool children* and *beneficiaries* with sufficient vaccination coverage was observed only indirectly. Their absence in the model may be related to the study being conducted at the poviat level.

The chosen granularity at poviat level reflects very well the influence of the environment on individuals.

Limitations of the study. The most important limitation is that this is an ecological study. Socio-economic data is collected from the census and represents the average of the characteristics for the population in a given poviat, which can conceal the differences that exist between communities within each poviat. Although generalizations would still apply for data averaged at the poviat level, it is the smallest area for which most health status and use of health services information is available, and was the unit used in this study. Individual level data about socio-economic characteristics was not available in the vaccination register. Sanitary-epidemiological stations shared vaccination coverage data in various formats, including handwritten hard copies, scanned images, and digital records. To standardize the dataset for subsequent analysis, one of the authors manually digitized the information, ensuring consistency and compatibility across formats.

Future research. The sole education-related variable examined in this study was the number of children aged 3–5 enrolled in preschool education institutions. In future research, additional educational factors should be taken into consideration, as prior research has demonstrated that children whose mothers attained secondary or higher education exhibit significantly greater odds of completing the full childhood vaccination schedule, compared to those whose mothers had no formal education [22]. These findings underscore the substantial influence of educational attainment on vaccination coverage.

A complete implementation of the Electronic Vaccination Card will allow gathering data at the individual level, which would serve future analysis on vaccine uptake in Poland. Thus, while it is important that these findings are confirmed by individual level data on vaccination coverage, population level data can provide useful insight, particularly where individual level data is not available.

CONCLUSIONS

In Poland, MMR2 coverage at the poviat level is predictable when using selected socio-economic variables There are variables that allow prediction whether there is an increase or decrease in vaccination coverage. Based on that, it may be hypothesized that benefitting from social assistance results in an increased odds of achieving sufficient MMR2 coverage at the poviat level, which is predictable, regardless of the size of the poviat, and the number of physicians and nurses in the area. Even though the trend of decreasing MMR2 coverage is visible, the majority of poviats are characterized by sufficient MMR2 coverage. Tailoring immunization intervention at the poviat level enables local authorities to address specific barriers and allocate resources more efficiently. This localized approach is essential to reduce immunity gaps and prevent outbreaks in high-risk communities.

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