

Appendix 1. Classification of the urbanization level of residence

Urbanization level of residence

The classification of the urbanization level of residence adopted in this study was developed by the Department for the Economic Development and Cohesion of the Ministry of economic development of Italy; this classification is currently adopted for policy purposes and statistical reporting at national and regional level [36].

The municipality of residence were used to classify the urbanization level and the following categories were adopted:

- Urban areas
- Suburban areas
- Rural areas
- Isolated rural areas

Urban areas were defined as the municipalities that simultaneously offers:

- At least one high school for each of the specialization foreseen by Italian education system (lyceum; technical institute; professional institute)
- At least one hospital with a type 1 emergency department (*i.e.* Italian health care system define a type 1 emergency department a 24-hour service with full resuscitation facilities provided of short-stay and cardiac intensive care units, shock room, multi-specialty emergency services and dedicated diagnostic imaging and laboratory services)
- At least one railway station of middle-small size with high volume of passengers (“Silver category” accordingly to the Italian railway network classification)

According to tertiles of the distribution of time necessary to reach the nearest urban area, the remaining municipalities were classified in peri-urban, rural and isolated rural areas. For the present study the variable urbanization level of residence was dichotomized as follow: urban area - that includes urban and peri-urban areas - and rural area – that includes rural and very isolated rural areas.

Supplementary Tables

Table S1a. Crude odd ratios for delayed vaccination for HEXA-1 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		HEXA-1		
		Crude OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.32	1.20 - 1.45	<0.001
	VPTI GA: <32 weeks	5.19	4.00 - 6.73	<0.001
SGA status				
	≥10th percentile	Ref.		
	<10th percentile	1.15	1.06 - 1.25	0.001

Table S1b. Adjusted odd ratios for delayed vaccination for HEXA-1 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		HEXA-1		
		Adjusted OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.19	1.07 - 1.32	0.001

SGA status	VPTI GA: <32 weeks	4.63	3.50 - 6.14	<0.001
	≥10th percentile	Ref.		
	<10th percentile	1.12	1.03 - 1.22	0.01
Sex	Male	Ref.		
	Female	0.99	0.94 - 1.04	0.71
Pregnancy outcome	Singleton	Ref.		
	Multiple	1.31	1.13 - 1.50	<0.001
Conceived by ART¹	No	Ref.		
	Yes	0.86	0.75 - 0.99	0.04
Urbanization level of residence	Urban area	Ref.		
	Rural area	1.10	1.03 - 1.16	0.002
Birth hospital level	First level	Ref.		
	Second level	1.38	1.31 - 1.45	<0.001
Maternal nationality	Italian	Ref.		
	Foreign nationality	1.03	0.96 - 1.10	0.40
Maternal age at delivery	<25 years	Ref.		
	25-34 years	0.91	0.82 - 1.01	0.07
	>34 years	1.04	0.93 - 1.15	0.52
Maternal education level	High school diploma or higher	Ref.		
	Less than high-school diploma	0.94	0.88 - 1.00	0.04
Maternal employment status	Employed	Ref.		
	Unemployed	1.06	1.00 - 1.13	0.04
Sibling birth order	Having older sibling	Ref.		
	First born/only child	0.75	0.71 - 0.80	<0.001

¹ ART = assisted reproductive technologies.

Table S2a. Crude odd ratios for delayed vaccination for HEXA-3 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

	Crude OR	HEXA-3	
		95%CI	p
Gestational age at birth	FTI GA: ≥37 weeks	Ref.	
	MLPTI GA: 32-36 weeks	1.17	1.08 - 1.26
	VPTI GA: <32 weeks	1.80	1.44 - 2.22
SGA status	≥10th percentile	Ref.	
	<10th percentile	1	0.94 - 1.08

Table S2b. Adjusted odd ratios for delayed vaccination for HEXA-3 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

	Adjusted OR	HEXA-3	
		95%CI	p
Gestational age at birth	FTI GA: ≥37 weeks	Ref.	
	MLPTI GA: 32-36 weeks	1.20	1.09 - 1.31
	VPTI GA: <32 weeks	1.82	1.44 - 2.31

SGA status				
	≥10th percentile	Ref.		
	<10th percentile	1.00	0.93 - 1.07	0.96
Sex				
	Male	Ref.		
	Female	0.94	0.90 - 0.98	0.006
Pregnancy outcome				
	Singleton	Ref.		
	Multiple	1.03	0.91 - 1.17	0.61
Conceived by ART¹				
	No	Ref.		
	Yes	0.90	0.80 - 1.01	0.08
Urbanization level of residence				
	Urban area	Ref.		
	Rural area	1.30	1.24 - 1.36	<0.001
Birth hospital level				
	First level	Ref.		
	Second level	1.23	1.18 - 1.29	<0.001
Maternal nationality				
	Italian	Ref.		
	Foreign nationality	1.01	0.96 - 1.07	0.60
Maternal age at delivery				
	<25 years	Ref.		
	25-34 years	0.93	0.85 - 1.01	0.11
	>34 years	0.90	0.82 - 0.99	0.04
Maternal education level				
	High school diploma or higher	Ref.		
	Less than high-school diploma	1.02	0.97 - 1.08	0.44
Maternal employment status				
	Employed	Ref.		
	Unemployed	1.03	0.98 - 1.09	0.21
Sibling birth order				
	Having older sibling	Ref.		
	First born/only child	0.68	0.65 - 0.71	<0.001

¹ ART = assisted reproductive technologies.

Table S3a. Crude odd ratios for delayed vaccination for MMR for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		MMR		
		Crude OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.03	0.95 - 1.11	0.001
	VPTI GA: <32 weeks	1.51	1.20 - 1.92	<0.001
SGA status				
	≥10th percentile	Ref.		
	<10th percentile	1.01	0.94 - 1.08	0.76

Table S3b. Adjusted odd ratios for delayed vaccination for MMR for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		MMR		
		Adjusted OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.04	0.95 - 1.14	0.36

SGA status	VPTI GA: <32 weeks	1.62	1.25 - 2.10	<0.001
	≥10th percentile	Ref.		
	<10th percentile	1.00	0.93 - 1.08	0.94
Sex	Male	Ref.		
	Female	0.95	0.91 - 0.99	0.01
Pregnancy outcome	Singleton	Ref.		
	Multiple	1.12	0.99 - 1.28	0.07
Conceived by ART¹	No	Ref.		
	Yes	0.83	0.74 - 0.92	<0.001
Urbanization level of residence	Urban area	Ref.		
	Rural area	0.91	0.87 - 0.96	<0.001
Birth hospital level	First level	Ref.		
	Second level	1.05	1.01 - 1.10	0.02
Maternal nationality	Italian	Ref.		
	Foreign nationality	0.82	0.78 - 0.87	<0.001
Maternal age at delivery	<25 years	Ref.		
	25-34 years	0.98	0.90 - 1.07	0.63
	>34 years	0.95	0.87 - 1.04	0.29
Maternal education level	High school diploma or higher	Ref.		
	Less than high-school diploma	1.12	1.06 - 1.18	<0.001
Maternal employment status	Employed	Ref.		
	Unemployed	1.00	0.95 - 1.05	0.97
Sibling birth order	Having older sibling	Ref.		
	First born/only child	0.82	0.78 - 0.85	<0.001

¹ ART = assisted reproductive technologies.

Table S4a. Crude odd ratios for delayed vaccination for Var for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

	Crude OR	Var	
		95%CI	p
Gestational age at birth	FTI GA: ≥37 weeks	Ref.	
	MLPTI GA: 32-36 weeks	1.06	0.97 - 1.15
	VPTI GA: <32 weeks	1.69	1.32 - 2.18
SGA status	<10th percentile	Ref.	
	≥10th percentile	1	0.94 - 1.08

Table S4b. Adjusted odd ratios for delayed vaccination for Var for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

	Adjusted OR	Var	
		95%CI	p
Gestational age at birth	FTI GA: ≥37 weeks	Ref.	
	MLPTI GA: 32-36 weeks	1.07	0.97 - 1.17
	VPTI GA: <32 weeks	1.78	1.35 - 2.35

SGA status				
	≥10th percentile	Ref.		
	<10th percentile	1.00	0.93 - 1.08	0.99
Sex				
	Male	Ref.		
	Female	0.94	0.90 - 0.98	0.009
Pregnancy outcome				
	Singleton	Ref.		
	Multiple	1.13	0.99 - 1.29	0.07
Conceived by ART¹				
	No	Ref.		
	Yes	0.79	0.71 - 0.89	<0.001
Urbanization level of residence				
	Urban area	Ref.		
	Rural area	0.93	0.88 - 0.97	0.003
Birth hospital level				
	First level	Ref.		
	Second level	1.05	1.00 - 1.09	0.04
Maternal nationality				
	Italian	Ref.		
	Foreign nationality	0.79	0.74 - 0.83	<0.001
Maternal age at delivery				
	<25 years	Ref.		
	25-34 years	0.99	0.91 - 1.08	0.90
	>34 years	0.99	0.90 - 1.08	0.79
Maternal education level				
	High school diploma or higher	Ref.		
	Less than high-school diploma	1.09	1.04 - 1.15	0.001
Maternal employment status				
	Employed	Ref.		
	Unemployed	1.01	0.96 - 1.07	0.57
Sibling birth order				
	Having older sibling	Ref.		
	First born/only child	0.84	0.80 - 0.87	<0.001

¹ ART = assisted reproductive technologies.

Table S5a. Crude odd ratios for delayed vaccination for MenC for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		MenC		
		Crude OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.07	0.97 - 1.19	0.16
	VPTI GA: <32 weeks	1.66	1.30 - 2.12	<0.001
SGA status				
	≥10th percentile	Ref.		
	<10th percentile	1	0.92 - 1.10	0.89

Table S5b. Adjusted odd ratios for delayed vaccination for MenC for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		MenC		
		Adjusted OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.06	0.95 - 1.19	0.28
	VPTI GA: <32 weeks	1.89	1.45 - 2.46	<0.001

SGA status				
	≥10th percentile	Ref.		
	<10th percentile	0.99	0.90 - 1.08	0.78
Sex				
	Male	Ref.		
	Female	0.94	0.89 - 0.99	0.03
Pregnancy outcome				
	Singleton	Ref.		
	Multiple	1.26	1.08 - 1.47	0.003
Conceived by ART¹				
	No	Ref.		
	Yes	0.81	0.69 - 0.95	0.009
Urbanization level of residence				
	Urban area	Ref.		
	Rural area	0.99	0.93 - 1.05	0.69
Birth hospital level				
	First level	Ref.		
	Second level	0.85	0.80 - 0.90	<0.001
Maternal nationality				
	Italian	Ref.		
	Foreign nationality	0.93	0.86 - 0.99	0.03
Maternal age at delivery				
	<25 years	Ref.		
	25-34 years	0.90	0.81 - 1.00	0.04
	>34 years	0.91	0.81 - 1.02	0.10
Maternal education level				
	High school diploma or higher	Ref.		
	Less than high-school diploma	1.19	1.12 - 1.27	<0.001
Maternal employment status				
	Employed	Ref.		
	Unemployed	1.04	0.98 - 1.11	0.21
Sibling birth order				
	Having older sibling	Ref.		
	First born/only child	0.70	0.66 - 0.74	<0.001

¹ ART = assisted reproductive technologies.

Table S6a. Crude odd ratios for delayed vaccination for PCV-1 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		PCV-1		
		Crude OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.36	1.24 - 1.49	<0.001
	VPTI GA: <32 weeks	5.62	4.34 - 7.29	<0.001
SGA status				
	≥10th percentile	Ref.		
	<10th percentile	0.29	1.08 - 1.27	<0.001

Table S6b. Adjusted odd ratios for delayed vaccination for PCV-1 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

		PCV-1		
		Adjusted OR	95%CI	p
Gestational age at birth				
	FTI GA: ≥37 weeks	Ref.		
	MLPTI GA: 32-36 weeks	1.21	1.09 - 1.35	<0.001

SGA status	VPTI GA: <32 weeks	4.95	3.74 - 6.55	<0.001
	≥10th percentile	Ref.		
	<10th percentile	1.13	1.04 - 1.24	0.003
Sex	Male	Ref.		
	Female	0.98	0.93 - 1.04	0.55
Pregnancy outcome	Singleton	Ref.		
	Multiple	1.33	1.16 - 1.54	<0.001
Conceived by ART¹	No	Ref.		
	Yes	0.90	0.78 - 1.03	0.14
Urbanization level of residence	Urban area	Ref.		
	Rural area	1.11	1.04 - 1.17	0.001
Birth hospital level	First level	Ref.		
	Second level	1.43	1.36 - 1.51	<0.001
Maternal nationality	Italian	Ref.		
	Foreign nationality	1.06	0.99 - 1.13	0.08
Maternal age at delivery	<25 years	Ref.		
	25-34 years	0.92	0.83 - 1.02	0.12
	>34 years	1.04	0.93 - 1.16	0.48
Maternal education level	High school diploma or higher	Ref.		
	Less than high-school diploma	0.95	0.89 - 1.01	0.10
Maternal employment status	Employed	Ref.		
	Unemployed	1.07	0.99 - 1.12	0.07
Sibling birth order	Having older sibling	Ref.		
	First born/only child	0.76	0.72 - 0.80	<0.001

¹ ART = assisted reproductive technologies.

Table S7a. Crude odd ratios for delayed vaccination for PCV-3 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

	Crude OR	PCV-3	
		95%CI	p
Gestational age at birth	FTI GA: ≥37 weeks	Ref.	
	MLPTI GA: 32-36 weeks	1.13	1.04 - 1.22
	VPTI GA: <32 weeks	1.39	1.11 - 1.73
SGA status	≥10th percentile	Ref.	
	<10th percentile	1	0.93 - 1.07

Table S7b. Adjusted odd ratios for delayed vaccination for PCV-3 for prematurity classes (very preterm infants – VPTI; moderate and late preterm infants – MLPTI; full-term infants – FTI) and SGA status.

	Adjusted OR	PCV-3	
		95%CI	p
Gestational age at birth	FTI GA: ≥37 weeks	Ref.	
	MLPTI GA: 32-36 weeks	1.15	1.05 - 1.26

	VPTI GA: <32 weeks	1.35	1.06 - 1.72	0.01
SGA status				
	≥10th percentile	Ref.		
	<10th percentile	0.98	0.91 - 1.06	0.69
Sex				
	Male	Ref.		
	Female	0.93	0.89 - 0.97	0.002
Pregnancy outcome				
	Singleton	Ref.		
	Multiple	1.05	0.92 - 1.19	0.45
Conceived by ART¹				
	No	Ref.		
	Yes	1.01	0.90 - 1.13	0.85
Urbanization level of residence				
	Urban area	Ref.		
	Rural area	1.36	1.29 - 1.43	<0.001
Birth hospital level				
	First level	Ref.		
	Second level	1.22	1.17 - 1.28	<0.001
Maternal nationality				
	Italian	Ref.		
	Foreign nationality	0.92	0.87 - 0.98	0.006
Maternal age at delivery				
	<25 years	Ref.		
	25-34 years	0.94	0.86 - 1.02	0.16
	>34 years	0.91	0.83 - 0.10	0.05
Maternal education level				
	High school diploma or higher	Ref.		
	Less than high-school diploma	1.04	0.99 - 1.10	0.11
Maternal employment status				
	Employed	Ref.		
	Unemployed	0.99	0.94 - 1.04	0.79
Sibling birth order				
	Having older sibling	Ref.		
	First born/only child	0.72	0.69 - 0.76	<0.001

¹ ART = assisted reproductive technologies.