

# Gestational age and hospital utilization: three-years follow-up of an area-based birth cohort

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## Abstract

**Objective.** To investigate differences by gestational age in emergency department visits and re-hospitalizations during the three years following childbirth discharge.

**Methods.** We performed a historical cohort study in Lazio Region, Italy, for infants born in 2007-2008 to resident mothers. Health administrative data were used. Analysis was performed by multinomial logistic regression.

**Results.** Of 90 545 infants, more than 50% had at least one emergency department visit, and 18.8% at least one re-hospitalization. After the exclusion of infants with congenital anomalies, relative risk ratios of re-hospitalization and, to a lesser extent, of emergency department visits increased by decreasing gestational age; the two events were also higher for mothers  $\leq 35$  years of age, with low education and of Italian nationality. Residency outside the metropolitan area was associated with an increased risk of re-hospitalization and a decreased risk of emergency department visits.

**Conclusion.** During the three years following childbirth discharge, re-hospitalizations and, to a lesser extent, emergency department use are inversely related to gestational age at birth; socio-demographic factors have an effect on the risk of infant use of hospital resources independent of gestational age.

## Key words

- child care
- gestational age
- preterm birth
- patient readmissions
- emergency service
- hospital

## INTRODUCTION

Conditions associated with prematurity may lead to an increased use of inpatient and outpatient hospital services during the early years of childhood [1-3]. Re-hospitalizations are particularly frequent during the first year of life [4]. The use and cost of hospital services were found to be inversely related to gestational age (GA), and occurred disproportionately during the first 12 months of life [5-7]. Some studies have also indicated that these elevated rates of hospital service utilization and costs among preterm infants persist through early and mid-childhood, and adolescence [8, 9]. Preterm birth therefore represents a great challenge for clinical and service decision-makers, and more broadly imposes a financial burden onto health systems and families.

Previous investigations about the long-term use of alternative categories of hospital services by children born across the GA spectrum and recruited from large

area-based cohorts are sparse [6-9]. In particular, use of hospital emergency department (ED) services beyond the neonatal period has been rarely estimated and analyzed separately from other hospital outpatient activities [10-12].

In this study we used information gathered from a large regional area-based cohort of infants born at 24-41 gestational weeks to describe the distribution by GA of ED visits and re-hospitalizations during the first three years after birth hospitalization discharge by time interval; to compare the risks of one and two or more ED visits and re-hospitalizations by GA; and to evaluate the extent to which maternal socio-demographic factors can affect the risk of infant ED use and re-hospitalization.

## METHODS

The study was carried out under the umbrella of the epidemiological and evaluation research activities of

the former Health Agency of Lazio, a public authority responsible for managing and analyzing the administrative hospital discharge records of Lazio Region, central Italy, up to 2013.

### Cohort identification

Data sources were: the regional Birth Certification Register, which includes information on GA at birth; and the regional Hospital Discharge Register and the regional ED Register, which report information on all hospital admissions and ED visits, respectively. The Regional Birth Certificate Register is implemented by the "Certificato di Assistenza al Parto (CedAP)" used at national level. The Hospital Discharge informative system is the administrative database which includes all hospital admissions within the Italian National Health Service.

In Italy, family pediatricians are responsible for primary pediatric care up to 6 years of age, while hospitals provide ED and other hospitalization services. The two systems can run symbiotically (such as for booking services), but in general they are organized independently. There are no standard rules regulating access to ED services; as a consequence, hospital admissions can occur following ED visits, depending on patients' health status and care needs, or on the basis of a booking plan.

The study population consisted of all infants born in hospitals in the Lazio Region to resident mothers between January 1<sup>st</sup> 2007 and December 31<sup>st</sup> 2008, with GA ranging between 24 and 41 completed weeks. The observation period covered the first three years following the birth hospitalization discharge. Both nursery and neonatal unit admissions, including inter-hospital transfers, were considered part of the birth hospitalization and were excluded from the analyses of readmissions. Pseudonymized deterministic linkage key was used to matching records of infants across and within our administrative database. Pseudonymized key was made up by combinations of four variables (birth date, sex, place of birth and tax code). For 12 408 (12%) out of the 103 178 eligible infants linkages between the registers failed because of incomplete or incorrect identifier patient codes. After the exclusion of a further 225 infants who died during the birth hospitalization, 90 545 children remained in the final cohort. The anonymous dataset incorporated the following maternal variables: age (categorized as  $\leq 35$  or  $> 35$  years); education level (primary or lower secondary, upper secondary, and tertiary education); nationality (Italian native or foreigner); and place of residence (metropolitan area, defined as residency in Rome municipality, or outside this area). The dataset also contained information about presence of congenital anomalies at birth.

Ethics committee approval and patient informed consent were not required by national regulations for this observational study using anonymous administrative data for public health purposes, without treatment on human subjects. Data management was performed in respect of the current privacy laws in Italy.

### Statistical analysis

ED visits, with or without subsequent hospitalization, and re-hospitalization, with or without a previous

evaluation in the ED, were analyzed separately. Infants were divided in four GA categories: 24-31 weeks (very preterm infants, VPIs), 32-36 weeks (moderate and late preterm infants, MLPis), 37-38 weeks (early term infants, ETIs), and 39-41 weeks (full term infants, FTIs). Outcome measures included ED visits and hospital readmissions experienced by the cohort children during the three years after birth hospitalization discharge.

Multinomial logistic regression was used to compare differences in outcome risks among GA groups. FTIs were used as the reference category, and relative risk ratios (RRR) with 95% confidence intervals (CIs) were estimated for the other three GA categories. Children who used hospital services (either ED or inpatient services) only once and those who used the services more frequently were respectively compared with children who had no ED visits or re-hospitalization. All the available mothers' variables in the dataset were considered possible confounders and included in multivariable models; some interactions terms were also included and their effects tested by the Wald test. Congenital anomalies were found to be an effect modifier of the association between GA and ED/HD; affected infants were therefore excluded from the multinomial analysis. Because the distributions of GA and other variables for children with successful and unsuccessful record linkage showed some differences (Table 1), in the multinomial regression we weighted complete (*i.e.*, linked) cases by the inverse of their probability of being a linked birth in order to account for potential bias in the RRR estimations of hospital resource utilization [13].

Stata software, version 11, was used for statistical analyses [14].

### RESULTS

Out of the 90 545 live births included in the study cohort, 628 (0.7%) were VPIs, 6143 (6.8%) MLPis, 29 219 (32.2%) ETIs, and 54 555 (60.2%) FTIs. Overall, 56.0% of children had at least one and 36.0% two or more ED visits, and 18.8% had at least one and 5.0% two or more re-hospitalizations. At least one ED visit occurred in 55.5% of FTIs, 56.7% of ETIs, 58.0% of MLPis, and 58.9% of VPIs; at least one re-hospitalization occurred in 17.4% of FTIs, 19.9% of ETIs, 24.4% of MLPis, and 34.3% of VPIs.

The total numbers of ED visits and hospital re-admissions were 144 279 and 25 336, respectively (Table 2). The frequencies of the two events were higher in the first year, particularly for VPIs and MLPis, and decreased subsequently. More than one half of ED visits and re-hospitalizations occurred in FTIs, and more than 30% in ETIs, while the contribution to the total number of the two outcomes by VPIs was only 0.9% and 1.7%.

Overall, 13.6% of children were admitted to inpatient services following an ED visit, 12.4% in the same hospital and 1.2% in other hospitals. Frequencies declined at increasing GA: 24.0% for VPIs, 16.9% for MLPis, 14.2% for ETIs, and 12.7% for FTIs.

For re-hospitalization, 24.8% of VPIs were re-admitted during the first year, 9.8% during the second year, and 9.7% during the third year. The corresponding fig-

**Table 1**  
Distribution of newborn infants with successful and unsuccessful record linkage, according to gestational age, congenital anomalies at birth and maternal characteristics

	Linked (%) N. = 90 770 <sup>a</sup>	Unlinked (%) N. = 12 408
<b>Gestational age (weeks)</b>		
24-31	0.9	1.6
32-36	6.8	7.9
37-38	32.2	26.0
39-41	60.1	64.5
<b>Congenital anomalies at birth</b>		
No	94.8	93.7
Yes	5.2	6.3
<b>Maternal age</b>		
≤35	48.8	63.3
>35	51.2	36.7
<b>Mother's education</b>		
Primary/Lower secondary	33.9	58.9
Upper secondary	48.0	34.3
Tertiary	17.9	6.6
Missing	0.2	0.2
<b>Mother's place of birth</b>		
Native	84.2	50.7
Foreigners	15.8	49.3
<b>Mother's area of residence</b>		
Metropolitan area	52.2	51.0
Other area	47.8	49.0

<sup>a</sup>Including 225 infants who died during the birth hospitalization.

ures for MLPs were 16.0%, 8.4%, and 5.3%, for ETIs 15.7%, 8.9%, and 5.4%, and for FTIs 12.6%, 7.5%, and 4.9%, respectively (data not shown in the Tables).

Approximately 44% more ED visits per day occurred during week-ends than during week-days (mean values 101 and 70 visits per day, respectively); this relative difference was similar within each GA category (Figure 1).

Table 3 shows the results of the multinomial logistic regression analyses for children without congenital anomalies. GA was a strong predictor of hospital service use, especially for hospital readmissions. The RRR of both sets of hospital service encounters were significantly higher for ETIs, MLPs and VPIs than for FTIs, except for having one ED visit in all groups of GA and two or more ED visits in the group of VPIs. When estimating the risk of hospital re-admission, an inverse relationship with GA was observed. In particular, in VPIs the risk of one re-admission was double, and that of multiple re-admissions 4.36 times higher than for FTIs. All the selected confounders showed an association with the outcomes, more consistently for re-hospitalizations than for ED visits. The likelihood of using hospital services was lower for infants born to older mothers. A decreased use of ED and, conversely, an increased risk of re-hospitalization were found for infants whose mothers lived outside the metropolitan area. An interaction was found between education and place of birth of the mothers: the RRR of 2 or more events for both ED visits and re-hospitalizations decreased with increasing education level, but the relationship was more pronounced for foreign compared to native mothers. No consistent relationship with maternal education was found for children of native mothers when those having one ED visit were compared with those having no visit.

**Table 2**  
Number of emergency department (ED) visits and hospital admissions observed per year after birth hospitalization for each GA group, and their % contribution to the total number of events per year and per GA group

Gestational age (weeks)	Year when events were observed						Total events N.
	1 <sup>st</sup> (0-11 months)		2 <sup>nd</sup> (12-23 months)		3 <sup>rd</sup> (24-36 months)		
	N.	%	N.	%	N.	%	
<b>ED visits</b>							
24-31	539	42.2	408	31.9	330	25.8	1277
32-36	4292	39.2	3831	35.0	2820	25.8	10943
37-38	17996	38.0	17068	36.0	12354	26.1	47418
39-41	30622	36.2	31214	36.9	22805	26.9	84641
Total	53449	37.0	52521	36.4	38309	26.6	144279
<b>Hospital admissions</b>							
24-31	258	60.7	84	19.8	83	19.5	425
32-36	1367	56.0	655	26.8	418	17.1	2440
37-38	4591	52.4	2599	29.7	1572	17.9	8762
39-41	6887	50.2	4120	30.1	2702	19.7	13709
Total	13103	51.7	7458	29.4	4775	18.8	25336

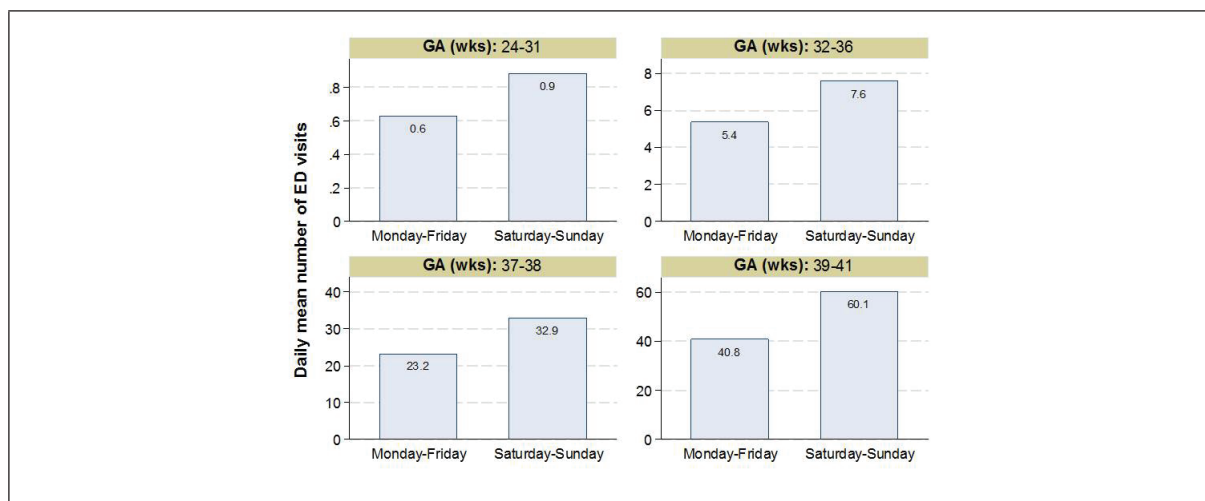
GA; gestational age.

**Table 3**

Relative distribution (%) of infants without congenital anomalies (N. = 85 849) according to the number of emergency department (ED) visits and re-hospitalizations in the three years after birth hospitalization, and results of multinomial logistic regression models

Characteristics	Events			1 vs 0 events			≥ 2 vs 0 events		
	0 %	1 %	≥ 2 %	RRR <sup>a</sup>	95% CI <sup>b</sup>	CI <sup>b</sup>	RRR <sup>a</sup>	95% CI <sup>b</sup>	CI <sup>b</sup>
<b>ED visits</b>									
<b>All infants</b>	44.0	20.0	36.0						
<b>Gestational age (wks)</b>									
24-31	43.8	16.1	40.1	0.85	0.64	1.12	1.18	0.95	1.45
32-36	41.8	20.0	38.2	1.06	0.98	1.14	1.18	1.11	1.26
37-38	43.5	20.2	36.3	1.02	0.98	1.06	1.08	1.04	1.12
39-41	44.5	20.1	35.4	1			1		
<b>Maternal age (years)</b>									
≤35	42.1	18.9	39.0	1			1		
>35	45.8	21.2	33.0	0.96	0.92	1.00	0.73	0.70	0.75
<b>Mother's area of residence</b>									
Metropolitan area	41.1	20.7	38.2	1			1		
Other area	47.3	19.4	33.3	0.79	0.76	0.82	0.69	0.67	0.71
<b>Mother's education x mother's place of birth</b>									
<i>Native</i>									
Primary/Lower secondary	41.6	19.5	39.0	1			1		
Upper secondary	41.6	20.7	37.7	1.05	1.00	1.10	0.96	0.92	0.99
Tertiary	46.2	22.7	31.1	1.00	0.95	1.06	0.71	0.67	0.74
Missing	79.3	10.4	10.3	0.27	0.15	0.47	0.13	0.08	0.23
<i>Foreigners</i>									
Primary/Lower secondary	52.7	16.3	31.0	0.63	0.58	0.68	0.56	0.52	0.59
Upper secondary	50.3	17.0	32.7	0.69	0.64	0.75	0.62	0.58	0.67
Tertiary	52.5	19.6	27.9	0.75	0.66	0.86	0.52	0.46	0.58
Missing	75.0	5.0	20.0	0.14	0.02	1.04	0.26	0.08	0.79
Wald test for interaction				P = 0.2200			P = 0.0000		
<b>Hospital admissions</b>									
<b>All infants</b>	81.8	13.6	4.6						
<b>Gestational age (wks)</b>									
24-31	67.0	19.8	13.2	2.00	1.57	2.55	4.36	3.26	5.84
32-36	76.5	16.7	6.8	1.45	1.34	1.57	1.91	1.70	2.14
37-38	80.7	14.3	5.0	1.16	1.11	1.21	1.33	1.24	1.43
39-41	83.1	12.9	4.0	1			1		
<b>Maternal age (years)</b>									
≤35	80.3	14.5	5.2	1			1		
>35	83.2	12.8	4.0	0.85	0.81	0.88	0.75	0.70	0.80
<b>Mother's area of residence</b>									
Metropolitan area	83.5	12.8	3.7	1			1		
Other area	80.0	14.5	5.5	1.12	1.08	1.17	1.41	1.32	1.51
<b>Mother's education x mother's place of birth</b>									
<i>Native</i>									
Primary/Lower secondary	79.5	15.0	5.5	1			1		
Upper secondary	81.1	14.2	4.7	0.94	0.89	0.98	0.86	0.80	0.93
Tertiary	84.7	12.1	3.2	0.81	0.76	0.86	0.63	0.57	0.71
Missing	94.1	5.2	0.7	0.31	0.14	0.66	0.13	0.02	0.95
<i>Foreigners</i>									
Primary/Lower secondary	84.4	11.5	4.1	0.71	0.65	0.77	0.69	0.60	0.79
Upper secondary	84.0	11.9	4.1	0.75	0.69	0.83	0.71	0.61	0.83
Tertiary	86.5	10.7	2.8	0.68	0.58	0.80	0.53	0.39	0.71
Missing	95.0	5.0	0.0	0.27	0.04	2.08	-	-	-
Wald test for interaction				0.1065			0.0000		

<sup>a</sup>Relative risk ratios. <sup>b</sup>95% confidence interval. Inverse probability weighting method used [13].



**Figure 1** Daily mean number of emergency department (ED) visits during week-days and week-ends, by gestational age (GA).

## DISCUSSION

In this study, we used record linkage procedures among different health administrative databases in order to explore the relationship between GA at birth and hospital service use during the three years following discharge after birth hospitalization in a large area-based cohort of infants. In particular, we compared the use of ED visits and re-hospitalizations among infants born at 24-31, 32-36, 37-38, and 39-41 GA weeks. To our knowledge, this is the first study investigating simultaneously the use of ED and re-hospitalizations in an area-based cohort of children during the early years of life, without selection of specific clinical groups.

After adjustment for socio-demographic characteristics of mothers and excluding infants with congenital anomalies, we found that the risk of re-hospitalizations and, to a lesser extent, ED use decreased at increasing GA at birth, with the highest value for VPIs, and lowest for FTIs. The differences in risk among GA groups were largest in children who experienced two or more hospital events.

With respect to ED visits, few published studies focus on children born across the GA spectrum; furthermore, they are limited to the neonatal period [11, 15], the first 30 days after birth hospitalization discharge [12], or the first year of life [16]. In addition, some studies have not disentangled ED visits from other hospital outpatient activities [2, 3]. In the present study, we found that more than one half of children had at least one ED visit, and more than one-third 2 or more visits. The frequencies were higher in preterm than in term infants, but the differences by GA group were small. For this reason and because ETIs and FTIs contributed 92.5% of the whole cohort, the largest component of ED resources were used by these groups. Although no direct comparison with other studies and settings is possible, the recourse to ED services, especially, but not exclusively, for ETIs and FTIs, appears very high when considering that the Italian National Health Service provides universal primary pediatric care up to 6 years of age through family pediatricians. In adjunct, our observation that the mean number of daily ED visits during week-ends is

44% higher than during week-days is most likely due to the fact that pediatricians usually are not at work during week-ends. In these circumstances, therefore, parents may opt to take their children to EDs even if they are not very sick. These findings indicate that the organization and the appropriateness of ambulatory care should be improved in order to reduce hospital resource use among both high risk and low risk infants.

In previous studies, re-hospitalization rates for infants born at <32 weeks GA or with birth weight <1500 g ranged between 28% and 49% during the first year of life [1, 3, 17, 18], between 13% and 28% during the second year [1, 3, 18], and were still as high as 21% during the third year [3]. In MLPs, the re-hospitalization rates during the first year were found to be around 15%, a rate still higher than for term infants [19, 20]. In a population-based study in the UK, 6.6% of VPIs were re-admitted to inpatient hospital services more than twice during the first 9 months, in comparison to 0.6% of FTIs [7]; between 9 months and 5 years of age the re-hospitalization rates were 13.6% and 2.8%, respectively, in the two groups of children; intermediate values were found for children of the other GA classes. Such differences in hospital re-admission between preterm and term infants decline with advancing age, but have also been found to extend into adolescence and adulthood [9, 21].

In the present study, a clear increase in risk of re-hospitalization with decreasing GA was found in the three years following birth hospitalization discharge. Overall, slightly less than one fifth of children were re-hospitalized; the proportions were one fourth for MLPs, and more than one third for VPIs. One out of 20 children had  $\geq 2$  re-hospitalizations; this frequency increased to 1 out of 7 for VPIs. The increased risk of re-hospitalizations in preterm children can be in relation with their high risk of poor general health, and of respiratory, neuro-developmental and sense organs sequelae [22]. In adjunct, like other studies in different settings and health care organizations [7, 9], we found that also ETIs were at higher risk of re-hospitalization than FTIs, in particular for respiratory or gastrointestinal disor-

ders. Several studies have demonstrated that ETIs are at higher risk of poorer health than FTIs. These babies are still, to a large extent, physiologically immature, and they are at risk of adverse effects including poor weight gain, longstanding illnesses, and asthma or wheeze. All these observations, including ours, reinforce the vision that maturation is a continuum along the whole span of gestation [7, 23, 24]. Because ETIs are often born by planned births through induction of labor or pre-labor elective cesarean section, from a public health perspective, it is strongly advised that delivery before 39 completed weeks of gestation should be avoided in the absence of clear maternal or fetal indications [25, 26].

All the maternal variables investigated were associated with the risk of ED visit and re-hospitalization. In particular, children born to foreign mothers had a lower risk of both outcomes than those born to Italian mothers, having taken level of education into account. Immigrants and their children may face individual, socio-cultural, economic, administrative, and political barriers when using health services, or demonstrate better-than-expected health status (a finding termed "the immigrant paradox") [27-30]. The use of health resources by immigrants should ideally take into account the different ethnic mix, their country of origin, their length of stay in the host country, the context and the organization in which the services run, and the reasons for emergency visits and hospitalizations [31-33]. All these factors, however, were not investigated by our study.

Another notable result is that residency outside the metropolitan area was associated with a decreased risk of use of ED services and an increased risk of re-hospitalization. In Lazio, hospitals that offer 24 hour on-call pediatric consultation are mostly located in the metropolitan area, which may result in families living in this area being more prone to use ED resources [34]. In addition, physician support toward re-hospitalization, where there is substantial uncertainty about the need for it, could be frequent if the infant resides farther from hospital services [35].

The main purpose of our study was to analyze the burden of hospital services' utilization during the three years following childbirth hospitalization, for separate GA categories. Approximately 12% of eligible newborns did not have an adequate personal identifier patient code that permitted linkage with other registry data. To account for potentially under-estimation of hospital resource utilization due to unlinked newborns and the resulting possible bias in the RRR estimations, an inverse probability weighting method was used, in

which for each infant included into the model we defined a weight equal to the inverse probability of being a linked birth [13]. As a result, each newborn with characteristics similar to unlinked ones were up-weighted in the model to represent their original contribution to the overall cohort. However, also assuming a residual bias, missing identifier patient code information was more likely in preterm infants, suggesting that we may, if anything, have under-estimated the differences in hospital resource utilization between the comparison GA groups. Our results should therefore be considered conservative.

The main strength of the study is the large study population and the use of an area-based cohort of infants, thus minimizing selection biases caused by centre-based approaches. Another point of strength regards the feasibility of the method employed, that seems to be practicable when using administrative data of healthcare resource utilization. Additionally, and unlike most previous studies, recruitment was performed irrespective of GA, infant characteristics, maternal and perinatal risk factors, or newborns' clinical conditions, which minimized biases associated with studies exploring the relationships between GA and outcomes in selected populations.

## CONCLUSION

This study demonstrates that ED use and re-hospitalization are significant concerns across the GA spectrum in early childhood. During the three years following birth hospitalization discharge, re-hospitalizations and, to a lesser extent, ED use are inversely related to GA at birth. From a public health perspective, our findings emphasize the need to improve the organization and the appropriateness of primary pediatric care system and to avoid a birth before 39 weeks of gestation in absence of maternal or fetal indications.

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## Conflict of interest statement

There are no potential conflicts of interest or any financial or personal relationships between the authors and other people or organizations that could inappropriately bias conduct and findings of this study.

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