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Cost effects of preterm birth: a comparison of health care costs associated with early preterm, late preterm, and full-term birth in the first 3 years after birth

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Abstract Preterm birth is one of the main causes for infant morbidity and mortality. Apart from negative health outcomes, preterm birth also produces significant health care expenditures. This study evaluates the costs associated with preterm birth in different health sectors during the first 3 years of infants' lives. In a retrospective observational study based on claims data from a German statutory health insurance company, average costs for medication, hospital treatment, ambulatory treatment, and non-medical remedies during the first 3 years after birth were analyzed for early preterm, late preterm, and full-term births. Costs associated with preterm births were generally higher than for full-term births, with the highest costs for the hospital treatment of early preterm births. Cost differences tended to decrease in the second and third year after birth except for ambulatory treatment costs, which decreased for late preterm and full-term births but not for early preterm births. The study shows that preterm birth is associated with increased health care costs, particularly during the first year after birth, indicating that the implementation of adequate programs and policies for preventing preterm birth is not only desirable from a medical but also from a health economic perspective.

Keywords Preterm birth · Full-term birth · Health care costs · Gestational age

JEL Classification I12

Introduction

Preterm birth, i.e., childbirth occurring prior to the completed 37th week of gestation, is one of the leading causes of infant morbidity and mortality [1, 2]. Apart from adverse health outcomes during the perinatal period (e.g., respiratory problems, infections or brain injury), the potential negative impact of premature delivery also extends to later life periods and may have long-term medical, psychological, behavioral, and social consequences [3–9].

The incidence of preterm birth ranges from 6.2% in Europe to 11.9% in African countries with a worldwide average of 9.6% [10]. The incidence has increased in the last decades [11, 12] although a more recent study reports a decline of preterm delivery in the United States since 2005 [13]. Possible factors contributing to the rising incidence of preterm delivery are the increasing occurrence of multiple births caused by assisted reproductive technologies, the use of in vitro fertilization and its increased risk of preterm birth as well as the generally increasing age of women giving birth; furthermore, health technology advances have contributed to an increasing survival rate of children born prematurely [14–16].

Although its etiology is not fully understood, a variety of factors have been shown to be connected with preterm birth, including infections or inflammations, multiple births, a low maternal body mass index, black race, a previous history of preterm birth, short cervical length, periodontal disease, psychological or social stress, tobacco use, demographic factors (e.g., low socioeconomic or

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educational status) or biological and genetic predispositions [1, 17–24].

Apart from the direct medical problems resulting from preterm birth and the psychological and emotional distress that parents and families of preterm infants are confronted with, premature births also have measurable economic consequences. Previous studies have provided estimates for increased costs associated with preterm birth and intensive neonatal care, and an inverse relationship between gestational age and hospital service costs has been identified [25–32]. Programs and policies designed to prevent the incidence of preterm birth are therefore not only valuable from a medical perspective but can also reduce health care expenses.

In Germany, Kirschner et al. [33] have estimated that—in comparison with full-term births—preterm birth is, on average, associated with a minimum of 10,550 EUR additional costs per case. However, only hospital costs of preterm infants that were admitted to neonatal care during the first 2 days after birth were included in the analysis.

While prior studies have shown that the majority of health care costs for preterm births arise in the hospital inpatient sector directly after birth, this study seeks to extend these findings by quantifying health care costs of preterm birth in Germany in different health care sectors and over a period of 3 years after birth [34, 35]. Based on claims data from a German health insurance company, health costs of full-term and preterm births (subdivided into early and late preterm births) were compared with regard to costs for medication, hospital treatment, ambulatory treatment, and non-medical remedies.

Methods

The study uses claims data from a German health insurance company. In a retrospective observational study, singleton live births in 2011 and 2012 for which complete insurance data for 3/2 years after birth were available (see below) or where infants deceased during this time period were included in the analysis. Only births from mothers with a minimum age of 18 years were considered.

The following costs were evaluated: (1) medication costs, (2) costs for hospital treatment, (3) costs for ambulatory treatment, and (4) costs for non-medical remedies (these are special remedies defined under the German law, including, for example, services provided by physical or occupational therapists).

To evaluate mean cost differences associated with different gestational ages, infants were assigned to one of the three following groups depending on the ICD-10-GM (International Classification of Diseases, 10th Revision, German Modification) codes documented for them or their mother within the same hospital case: (1) infants with an ICD-10-GM code of P07.0 or P07.2 (i.e., a gestational age of less than 28 weeks or a birth weight below 1000 g) were assigned to the early preterm group (EPT); (2) infants with an ICD-10-GM code of P07.1, P07.3, O60.1, or O60.3 (i.e., with a gestational age of less than 37 weeks and more than 28 weeks or a birth weight between 1000 and 2499 g) were assigned to the late preterm group (LPT); (3) infants with an ICD-10-GM code of Z37.0!, Z38.0, Z38.1, or Z38.2 (i.e., full-term singleton births) were assigned to the full-term group (FT).

Costs were calculated separately for the first 3 years of the infants' lives. However, for infants born in 2012, insurance data were only available for the first 2 years after birth. Results reported for the third year thus only reflect the subgroup of infants born in 2011. Cost differences across the three groups (i.e., EPT, LPT, and FT) were assessed using Mann–Whitney U tests (a non-parametric test was chosen because costs cannot be assumed to be normally distributed). Due to the high number of statistical tests [3 group comparisons $\times$ 3 years $\times$ 4 health sectors + 3 group comparisons $\times$ 3 years for the total costs + 1 group comparison (with early and late preterm groups combined) $\times$ 3 years] a Bonferroni-corrected significance level of $\alpha = 0.001$ was chosen.

Results

A total of 5947 births were included in the final study group (for an overview of the study population, see Table 1). The incidence of preterm birth in the study group was 9.23% (early preterm birth: 0.39%; late preterm birth: 8.84%).

Total health costs differed considerably between gestational ages. Average health costs of early preterm infants during the first year after birth were 74,009 EUR, whereas they were much lower for late preterm infants with an average of 8565 EUR and full-term infants with an average

Table 1 Overview of study population

	N
Total number of individuals enrolled at least 1 day in 2011 or 2012	422,440
Infants born in 2011 or 2012	11,300
Infants born in 2011 or 2012 that could be assigned to the early or late preterm or full-term study group based on their ICD-10-GM codes	6759
Infants fully enrolled in the 3/2 years after birth	5947
Early preterm infants (EPT)	23
Late preterm infants (LPT)	526
Full-term infants (FT)	5398

Table 2 Total health care costs (in EUR) for infants of different gestational ages during the first 3 years after birth

	N	Median	Mean	95% CI	
First year					
Early PT	23	73,905	74,009	54,091	93,927
Late PT	526	3113	8565	6199	10,932
Full-term	5398	724	1590	1467	1714
Second year					
Early PT	23	3480	5341	1801	8882
Late PT	526	502	1603	922	2284
Full-term	5398	458	902	829	975
Third year[a]					
Early PT	11	1708	3390	−399	7179
Late PT	270	396	1053	762	1344
Full-term	2654	350	756	620	893

[a] Note that for the third year, only births from 2011 were considered

of 1590 EUR (see Table 2 and Fig. 1a; a complete overview of all calculated costs can be found in the Appendix). Importantly, the high cost average for early preterm birth was not distorted by outliers but provided an accurate summary of this subgroup (the median cost for early preterm birth was 73,905 EUR with the middle 50% of the group ranging from 53,823 EUR to 103,737 EUR). This means that during the first year, early preterm births accounted for 11.51% of the costs despite constituting only 0.39% of all births. The cost differences between the different gestational ages decreased in the second and third year (see Table 1 and Fig. 1a). Total health costs differed significantly between all three birth groups for all years except for the third year, for which only the costs of early preterm and full-term births differed significantly from each other (year 1: $Z_{\text{EPT-FT}} = 8.01$, $p < .001$; $Z_{\text{LTP-FT}} = 18.84$, $p < .001$; $Z_{\text{EPT-LPT}} = 7.02$, $p < .001$; year 2: $Z_{\text{EPT-FT}} = 5.42$, $p < .001$; $Z_{\text{LPT-FT}} = 3.41$, $p < .001$; $Z_{\text{EPT-LPT}} = 4.75$, $p < .001$; year 3: $Z_{\text{EPT-FT}} = 3.54$, $p < .001$).

Aggregating early and late preterm births into one group yielded a cost average of 11,307 EUR for preterm births and 1590 EUR for full-term births during the first year after birth. Again, differences decreased in the second and third year (see Fig. 1b). Differences between preterm and full-term births were significant for year 1 and 2 but not for year 3 (year 1: $Z_{\text{PT-FT}} = 19.97$, $p < .001$; year 2: $Z_{\text{PT-FT}} = 4.39$, $p < .001$).

Analyzing costs separately for the different health sectors revealed that the high costs associated with early preterm births during the first year were largely incurred by costs for hospital treatment which amounted to an average of 68,493 EUR compared with 7534 EUR for late preterm births and 852 EUR for full-term births. Figure 2 shows the average costs for the different groups of infants for different health sectors in the first 3 years after birth. For all health sectors and over the 3-year observation period, costs generally tended to be highest for early preterm births. However, as for the total costs reported above, cost differences between early preterm infants and the other groups generally decreased during the second and third year except for ambulatory treatment costs which declined for late preterm and full-term infants but not for early preterm infants.

Discussion

The present study investigated the costs associated with births of different gestational ages over the first 3 years after birth and for different sectors of the health care system (medication, ambulatory treatment, hospital treatment, and non-medical remedies). We found that health care costs were highest for early preterm births, especially with regard to hospital costs during the first year after birth. In line with previous findings, the largest share of the total

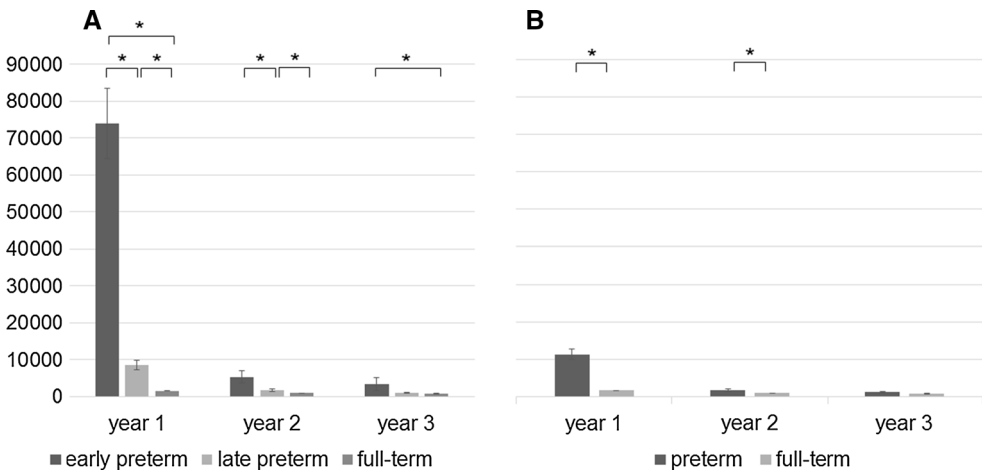

Fig. 1 Average health costs (in EUR) of preterm and full-term births: **a** early preterm vs. late preterm vs. full-term births; **b** preterm (*early* and *late* combined) vs. full-term births. Significant differences ($p < .001$) are marked with an *asterisk* (note that for the third year, only births from 2011 were included in the analysis)

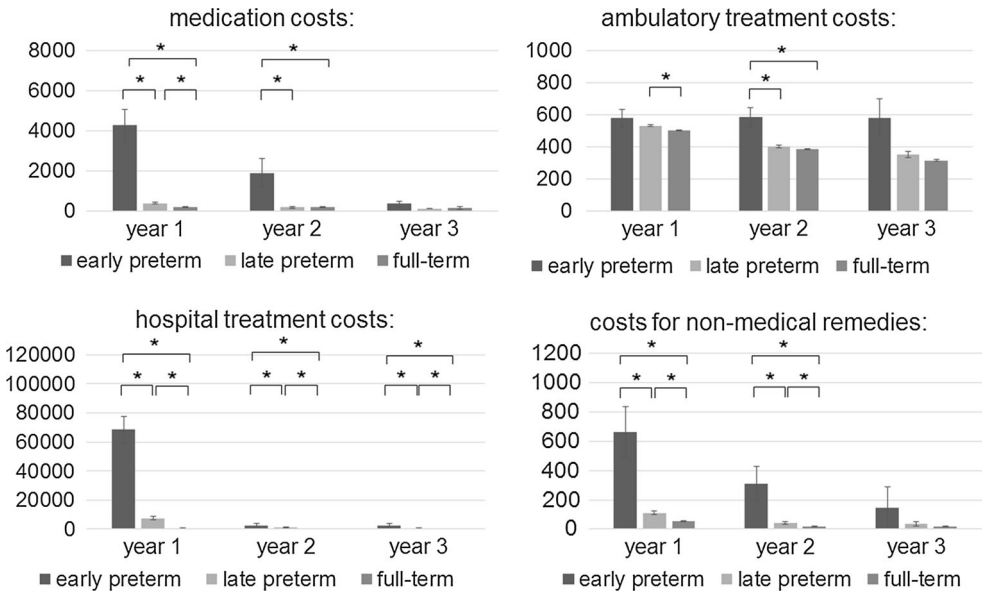

Fig. 2 Average costs (in EUR) (with standard errors) and their temporal development over 3 years for births at different gestational ages shown for the different health sectors. Significant differences ($p < .001$) are marked with an *asterisk* (note that for the third year only births from 2011 were included in the analysis)

costs could be attributed to hospital inpatient costs [26, 34, 35]. The cost differences found between preterm and full-term births were also similar to the ones reported in other studies [33, 36, 37].

In line with other studies also investigating costs stratified by different gestational ages, our results showed that the costs associated with early preterm births (born prior to the completed 28th week of gestation or with a birth weight of less than 1000 g) highly exceed the costs of later preterm births. Ringborg et al. (2006) reported mean first-year hospital costs between 117,010 EUR and 13,007 EUR for infants born in gestational weeks 22 and 36, respectively [36].

Moreover, our findings indicated that cost differences, with the exception of ambulatory costs, generally decreased in the second and third year after birth, suggesting that the increased health costs associated with preterm birth become less significant over time. However, this does not necessarily imply that cost differences will eventually level out. As mentioned previously, preterm birth can have persisting negative health effects, and some of these adverse effects (such as psychological or cognitive impairments) may only become apparent in later life stages. To evaluate costs associated with these health issues during later life periods, further long-term studies reaching beyond the 3 years considered in our study are required (for a study modeling the long-term cost effects of preterm births throughout childhood see [26]).

Interestingly, the general decrease of cost differences between births of different gestational ages in the second and third year was not observed for ambulatory costs, which remained relatively constant over the 3 years for early preterm births while they decreased for late preterm and full-term births. Early preterm births thus appear to require medical ambulatory treatment over a longer time period, whereas the demand for treatment in other health sectors seems to decrease (however, note that the absolute magnitude of these ambulatory costs is still relatively low, and the absolute costs for hospital treatment of early preterm births largely exceed ambulatory costs even in years 2 and 3).

Importantly, costs associated with preterm births are not restricted to the health sector but extend to educational, social, and other areas (parents, for example, may leave the workforce to care for their child; cf. [38]). This makes it difficult to assess the full economic impact of preterm births, and costs reported by studies like ours can only provide a lower limit of the actual costs related to preterm birth. However, even these conservative estimates show that preterm births are associated with significant expenses, suggesting that screening programs that help to prevent the incidence of preterm birth are not only valuable from a medical perspective but can also reduce costs in different sectors of the economy.

Conclusions

The present study shows that health care expenses associated with childbirth generally increase with decreasing gestational age at the time of birth. Particularly high costs were observed for the hospital treatment of early preterm births during the first year after birth. The increased costs associated with preterm birth may provide an incentive for policy-makers and health care providers to implement adequate research programs and preventive strategies contributing to the decrease of preterm birth rates, thus

reducing the adverse health outcomes and increased costs produced by premature delivery.

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