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Preterm birth lifetime costs in the United States in 2016: An update

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Abstract

The societal cost of preterm birth indicates potential economic gains from interventions that reduce the incidence of preterm birth. Changes in the epidemiology of preterm birth and healthcare costs require periodic updates to cost estimates. Previously reported incremental cost estimates for the United States in 2004 were updated. The discounted present value of the excess cost associated with prematurity for the 2016 US birth cohort was estimated to be $25.2 billion: $17.1 billion for medical care of persons born preterm, $2.0 billion for delivery care, $1.3 billion for early intervention and special education, and $4.8 billion in lost productivity due to associated disabilities in adults. The nominal and inflation-adjusted incremental costs per preterm birth increased by 26% and 4%, respectively, during 2004–2016. The aggregate cost decreased by 4%, associated with declines in overall births and the preterm birth rate and changes in the distribution by gestational age.

Keywords

Preterm birth; Economic costs; Infant mortality; Developmental disability

Introduction

Preterm birth is associated with well-documented, manifold adverse consequences to the affected individual, to the individual's family, and to the community and society at large. These consequences include a higher incidence of infant mortality,[1] medical conditions and developmental disabilities than prevail for term births.[2,3] Considerable resources (direct costs) are devoted to address those heightened risks, including medical care, special education,[4,5] early intervention services,[6] and caregiver time. Resources are also lost (indirect costs) through reduction in labor market and household productivity associated with premature mortality and heightened morbidity of preterm birth.[7]

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Supplementary materials

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The tabulation of the direct and indirect societal costs associated with preterm birth can serve as the basis for evaluating interventions to reduce it. US estimates of the societal costs of preterm birth were generated for the Institute of Medicine's (IOM) 2007 report on Understanding Preterm Birth,[3] which have been widely cited.[8–10] Those estimates, the most comprehensive to date, included medical costs; special education costs; lost labor market productivity associated with premature mortality and heightened morbidity; public provision of early intervention services; and maternal delivery costs. The lifetime incremental cost was estimated to be $51,600 per infant born preterm relative to an unaffected birth in 2005 dollars.[11] The aggregate estimate, reflective of the number of births and the preterm birth and infant mortality rates by gestational age in 2003 (the latest vital statistics available at the time) was $26.2 billion expressed in 2005 dollars. Lifetime medical care costs for individuals born preterm made up close to two-thirds of the total. In addition, per-person cost estimates for preterm births were stratified by gestational age (GA) (<28, 28–31, 32–36 weeks) relative to term or post-term births (≥37 weeks).

We estimate incremental costs of preterm birth in the United States in 2016 by adjusting the estimates in the 2007 IOM report for changes in prices for different cost components, numbers of preterm births, the distribution of preterm births by GA, and infant mortality by GA. We succinctly explain the derivation of the cost estimates in the 2007 IOM report as well as the updated estimates.

Projections of the economic gains associated with strategies that succeed in reducing the frequency of preterm birth are informed by cost estimates stratified by GA. Preterm births are heterogeneous, and specific risk factors and interventions may be differentially associated with earlier versus later preterm births. Increased GA can reduce costs, even if the birth remains earlier than 37 weeks. In order to evaluate the economic impact of policies or interventions, it is important to know how much impact they would have on GA.

Methods

Data sources and methods used to prepare the estimates for the IOM report are first briefly reviewed. All cost estimates are "incremental", that is, reflect resource use in excess of an average infant born term or post-term (≥37 weeks), the so-called "referent case". The per-child estimates of direct and indirect (productivity) costs of preterm birth by GA category (<28 weeks, 28–31 weeks, 32–36 weeks) from the IOM report were subjected to adjustments to reflect price inflation over time. These adjusted cost estimates were then used as multipliers applied to the 2016 birth cohort by GA category to generate aggregate cost estimates in the United States.

Incidence approach

An "incidence approach" to cost of illness was undertaken in the IOM report. Under the incidence approach, costs are estimated across the lifespan for all individuals newly acquiring or "diagnosed" with the condition of interest, and then aggregated. Costs at ages beyond the year of incidence (base year) are discounted back to that year, reflecting the economic principle that serves as the basis for the real interest rate: current consumption is valued over future consumption. In U.S. cost-of-illness analyses, it is recommended for costs beyond the base year to be discounted at a 3% rate, the rate adopted for the current analysis.[12]

Cohort estimates

The incident cohort is comprised of births in a given year stratified by GA. For each GA category, cost estimates for each subsequent year of life are discounted to present values. Survival estimates at each age for each GA category are used to estimate cohort sizes by GA category. Given significantly concentrated mortality and particularly high inpatient medical costs during the first few months of life for those born extremely preterm, cohort estimates during infancy were further adjusted for neonatal and post-neonatal mortality segments. Such precision was afforded by the availability of medical cost data by month during infancy. Mortality rates were assumed to revert to the general rate after infancy except for persons with one of four developmental disabilities that have lower life expectancy post-infancy, as described below. The base year for the updated analysis was 2016, as that is the latest year for which preterm birth and infant mortality rates were available at the time of analysis.

Categories of cost

Three categories of incremental cost relative to term (or post-term) births through various ages were estimated for all children born preterm: a) medical care services through age 5, b) inpatient maternal delivery services through discharge after delivery, and c) early intervention (EI) services through age 3. The medical costs for infants and children through age 5 and for mothers were derived from linked vital records (by GA) and administrative healthcare claims and reimbursement records during 1998–2004 for 23,631 births under a large regional (Utah) healthcare system followed for up to seven years. The costs of EI services stratified by GA were based on a published analysis of publicly funded Massachusetts (MA) EI data from 1999–2003 linked to vital records.[13]

Medical costs beyond age 5, special education costs beyond age 3, and productivity losses among adults in the IOM report were estimated based on the incremental prevalence of diagnosis among children born preterm with one of four developmental disabilities (DDs): intellectual disability (also known as mental retardation), cerebral palsy (CP), hearing loss, and vision impairment. That approach was necessitated by the paucity of data related to care received over the lifespan and reduced labor market productivity for the full cohort of those born preterm; data related to DDs, in contrast, were more readily available. The incremental prevalence (at ages 3–10 years) of DDs by GA in the IOM report associated with preterm birth was derived from 1991–1994 data from the Centers for Disease Control and Prevention (CDC) Metropolitan Atlanta Developmental Disabilities Surveillance. For example, the prevalence of CP was reported to be 5% among surviving children born at <28 weeks vs. 0.1% among children born at term.

Lifetime per-person costs beyond age 3 for education costs and age 5 for medical costs as well as productivity costs for each DD were derived from a published analysis by CDC and RTI International and included a) medical care, b) special education services and c) lost labor market productivity due to disability in adults and excess mortality from birth onwards.[14] Because it is common for individuals to have more than one DD and the published cost study did not adjust for the co-occurrence of DDs, the IOM study established a hierarchy of incremental prevalence of DDs: CP with or without another DD, intellectual disability without CP, hearing loss without intellectual disability or CP, and vision impairment alone. Cost estimates for the DDs with one exception were calculated as the average cost for individuals born with a specific DD relative to national costs for all persons in the age group (including those with DDs).[14] Incremental special education costs in the study by Honeycutt et al. were calculated relative to children who did not require special education services. The incremental costs for each DD from that study were multiplied by the incremental prevalence of each DD among the preterm population, stratified by GA, relative to children born at term or post-term to generate incremental preterm costs by GA for each DD in the IOM report. More details on data sources by cost category are provided in section A1 of the Appendix.

Cost adjustments

Cost adjustments from the 2005 dollar estimates in the IOM report were tailored to specific cost categories, some more narrowly than others (Appendix section A3). Given its pronounced importance in the cost estimates, medical service costs were adjusted separately from other cost categories.[15] Inflation adjustment for inpatient and outpatient medical care services were based on the Producer Price Index for General and Surgical Hospitals (PPI) and Personal Consumption Expenditures: Health Care Services (PCE), respectively.[16,17] The Bureau of Labor Statistics' government employee subcomponent of the Employee Compensation Index (ECI) was applied to special education and early intervention services.[18] The general ECI was used to update labor productivity losses to 2016 values as well as for long-term care, rehabilitation and therapy services, and assistive devices for persons with DDs.[11]

Per capita estimates of two cost categories based on data from individual states were subjected to geographic adjustments to estimate nationally representative costs. First, estimates of medical care cost through age 5 and maternal delivery cost from Utah were converted to national costs using Utah-specific geographic adjustment factors calculated using data from the Centers of Medicare and Medicaid Services (CMS) Inpatient Prospective Payment System for inpatient services and the geographic practice cost indices under Medicare's 2016 Physician Fee Schedule for outpatient services.[19] The geographic adjustment factor applied to EI costs from MA to generate national estimates was based on a weighted average of American Chamber of Commerce Research Association cost of living indices for metropolitan and non-metropolitan areas in MA. Further details are available in Appendix section A3.

Incremental cost calculations

Total incremental cost of preterm births in 2016 was estimated in three steps. First, we estimate the lifetime per-child costs by cost type for the 2016 birth cohort stratified by weeks of GA (<28, 28–31, 32–36, and ≥37 completed weeks of gestation) accounting for differential mortality risks across GA groups. Second, for each cost type we calculate incremental per-child lifetime costs for preterm births in the <28, 28–31, 32–36 weeks groups relative to term or post-term births (≥37 completed weeks of gestation). Third, we multiply per-child incremental costs by the estimated numbers of births in each preterm GA group.

We also conducted a decomposition exercise to compare the national cost estimates for 2005 (2004 birth cohort) from the IOM report with our 2016 estimates (Appendix section B). That exercise adjusts the estimates for changes in prices and numbers of reported preterm births, the latter of which is a product of changes in the size of the overall birth cohort, changes in the proportion of infants born preterm using the same method of GA estimation from last menstrual period (LMP) to obstetric estimates (OE), and changes in GA distribution resulting from the change in method of GA estimation from LMP to OE.

Results

Table 1 provides summary results of the 2016 costs of preterm birth overall without stratification by GA. The total cost of preterm birth for the nation in 2016 was $25.2 billion ($64,815 per preterm birth) relative to term or post-term births. At $17.1 billion ($44,116 per preterm birth), medical care costs for those born preterm comprised the largest category of societal costs, two-thirds of the total. Furthermore, the inpatient portion of medical care during infancy comprised over 90% of medical costs for preterm infants. Medical costs of maternal delivery added close to an additional $2.0 billion, yielding a combined medical cost total for child and mother of $19.1 billion for all preterm births relative to term or post-term births. Estimated spending on EI and special education services were $700 and $620 million, respectively, contributing over $1.3 billion combined to total incremental costs. Indirect costs associated with lost labor market productivity due to premature mortality and heightened morbidity over the lifespan comprised the bulk of the remaining costs, about $4.8 billion.

There is significant skew in the distribution of costs. Table 2 reports incremental lifetime cost for infants born at varying GA categories relative to term and post-term births (≥37 weeks), as well as the percentage of those costs due to medical care over the lifetime. For example, infants born extremely preterm (GA<28 weeks) had mean incremental per birth cost of $344,355. That is over 12 times the $28,367 incremental cost of moderate preterm births (32–36 weeks). Comprising just 7% of the entire preterm cohort, those born extremely preterm incurred over one-third of the total $25.2 billion preterm birth cost.

The 2016 total national cost reflects a decrease in current-year dollars (i.e., without adjustment for inflation), from the IOM estimate for 2005 by $1 billion, from $26.2 billion to $25.2 billion (Table 3 and Appendix B). The lifetime cost per preterm birth increased by 26%, from $51,800 to $64,800, reflecting overall price increases. Had price increases been the sole source of change in the societal cost estimates in the IOM report, the total national cost of preterm birth would have been $32 billion in 2016, an increase of 22% over the earlier estimate.

The change in 2014 in the official method for assessing GA, from LMP to OE, contributed to the reduction between 2004 and 2016 in the reported incremental cost of preterm births.

Table 3 notes that the change from LMP to OE accounted for 16% lower costs in 2016 relative to what it would have been if the LMP estimates were still used in 2016. From 2007 to 2014, the OE preterm proportion fell from 10.4% to 9.6%; the preterm birth proportion in 2013 was 11.4% calculated using the LMP method vs. 9.6% using the more reliable OE method.[20] Other factors, including a decline in the national birth rate, a decline in the preterm birth rate, and a shift in the preterm birth composition, contributed in offsetting ways to the net decline in costs (Table 3; Appendix section B). During 2007–2013, the greatest reductions in preterm births occurred at 35 and 36 weeks of age,[21] and since costs are lower for late preterm births, the shift in the distribution by GA category among preterm births raised average costs per preterm birth, thereby counteracting part of the decline in costs due to the reduced number of preterm births. In addition, the reduction in infant mortality, especially at early gestational ages where costs are most pronounced, resulted in more preterm survivors and greater costs associated with preterm birth, other things constant.

Discussion

The need for updated cost estimates for preterm births in the United States is indicated by frequent citations of the IOM report's estimates. Researchers have used those cost estimates to quantify the potential economic gains from strategies that could reduce the occurrence of preterm births. For example, Peterson et al. estimated a preventable burden of $637 million in 2012 dollars for each annual birth cohort associated with preterm birth resulting from poorly controlled pregestational diabetes.[22] Given their wide citation and broad utilization, the updates provided here provide a critical service for continued use of these cost estimates.

Certain limitations with the study merit attention. The updated estimates reflect cohort, mortality, and price changes between 2004 and 2016 and do not reflect changes over time in the intensity or utilization of care. The study implicitly assumed that the associations of GA with resource utilization remained unchanged from the sources used for the IOM report (Appendix). Certain cost estimates, EI services and maternal delivery and early medical care, were based on comprehensive data from single states and then adjusted to the nation. In addition, incremental DD prevalence for preterm births was extrapolated from data for children born in metropolitan Atlanta. It would have been preferable to have data from a broader population to generate such estimates. However, the granular adjustments applied by GA, mortality, and price differences to standardize the state medical care estimates to the nation in a validation exercise provided in the IOM report demonstrated that the resulting estimates aligned well with other, less comprehensive published estimates based on different geographic areas.

While relatively comprehensive, the estimated societal costs in both this report and the IOM report are limited to certain categories of service utilization and societal cost. For example, productivity losses from infant mortality associated with preterm birth were not included in the IOM report nor in the present analysis, although infant mortality attributed to DDs was included. The costs associated with family caregiver time were also excluded.[8,9,23] It is well known that the primary caregivers of children with serious disabilities such as spina bifida or autism spectrum disorder are less likely to work for pay and foregone earnings constitute a substantial part of the total economic cost.[24,25] Similar analyses have not been conducted to assess the long-term effect of preterm birth on parental employment.[26] Other spillover costs to family members associated with the presence of a preterm infant in the household, which may extend beyond the neonatal period, also have not been incorporated.

As noted above, estimates of cost beyond age 5 were limited to the subset of those born preterm with four DDs. Two limitations arise from this method which leads to conservative or downwards bias in cost estimates.[8] First, there may be additional incremental costs for the general preterm population that have no identified disability. For example, Swedish children who were born very preterm are at increased long-term risk of heart failure.[27] Norwegian children born preterm were found to be at increased risk of severe asthma but decreased risk of severe atopic dermatitis.[28] Second, there are DDs other than these four for which an association with preterm birth has been established. For example, children with autism spectrum disorder, for which the lifetime incremental cost is likely to exceed that of other DDs, are more likely to have been born preterm.[29] Milder learning disabilities and developmental delays are also significantly more common among children born preterm.[30] Inclusion of a broader range of sequelae of prematurity could result in larger estimates of long-term costs associated with preterm birth. Finally, the estimates of special education costs associated with DDs in the study by Honeycutt et al. did not subtract the average cost of special education in the general pediatric population, unlike the incremental cost estimates for other DD cost types.

Another limitation in the present study is that the referent group consists of all infants with gestational age of 37 weeks or greater, which includes early term births (37–38 weeks), full and late term births (39–41 weeks), and post-term births (greater than 42 weeks). If comparison were made to full-term births, the excess cost associated with preterm birth would be greater than what is reported here. For medical costs to age 5, the IOM report used 37–41 weeks as the reference age; in this update we combined the 37–41 and ≥42 weeks groups, which had a trivial effect on spending for the referent group (a difference of $23). The difference in costs between early-term and full-term infants, associated with more morbidity in the former, is consequential.[31] Mean cost per birth hospitalization in California during 2009–2012 was reported to be $3374 at 37–38 weeks and $2433 at 37–41 weeks.[32] Therefore, our estimates of incremental costs of preterm births can be considered conservative, and incremental costs relative to full-term births would be modestly higher.

An additional limitation is that the study assumed separability of costs beyond age 5 by DD and GA, i.e., it was assumed that costs for individuals with a DD such as CP are the same for those born preterm as for those born at term. However, medical costs are typically much higher for infants with disabling conditions born preterm than for those born at term.[33] If non-medical costs and costs beyond early childhood for children with DDs are also relatively higher among those born preterm, an unknown portion of excess costs for children with DDs might be attributable to more of them having been born preterm.

Conclusion

The cost of preterm birth estimates provided here update the most comprehensive national estimates to date to 2016. They provide an indication of the significant magnitude of the societal economic burden of preterm birth. They can be used to assess the economic value from specific interventions tailored to reduce that burden.

Still, these estimates should be regarded as a floor. They do not include caregiver costs, for example, which are likely substantial. Nor do they include lifetime costs of additional disabilities associated with preterm birth beyond the four conditions included in this study. As future work freshly addresses these components and others, the societal economic burden of preterm birth will invariably be larger than the estimates provided here.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1 –

National aggregate and per birth incremental cost of preterm births by category of cost, 2016.

Category of Cost	Total ($)	Per Preterm Birth ($)
Medical Care for Affected Child	17,126,625,946	44,116
Maternal Delivery Costs	1950,230,570	5024
Early Intervention Services (EI)	702,014,493	1808
Special Education Services	622,589,060	1604
Assistive Devices	10,820,563	28
Lost Labor Market Productivity	4750,215,975	12,236
Total	25,162,496,608	64,815

Notes: All reported costs are “incremental”, that is above and beyond the average costs of term births.

Table 2 –

Per Preterm infant incremental lifetime cost and percent of that cost due to medical care, by gestational age, 2016.

Gestational Age	Per Preterm Infant Birth ($)	% Medical
< 28 weeks	344,355	82%
28–31 weeks	186,731	79%
32–36 weeks	28,367	67%
All Preterm (<37 weeks)	64,815	76%

Notes: All reported costs are “incremental”, that is above and beyond the average costs of term births.

Table 3 –

Decomposition of change in aggregate national cost of preterm birth from 2004 to 2016 by factor responsible for the change.

Description	Difference in Cost ($ Billions)	Total Cost ($ billions)
Cost in 2005		**26.2**
Cost in 2016	***− 1.0***	***25.2***
Decomposition (all estimates in 2016 dollars)		
Pure Price Change from 2005 to 2016	**+ 5.8**	**32.0**
Reduction in the Number of Births from 2004 to 2016	**− 1.3**	**30.7**
Switch to the 2016 LMP from the 2003 LMP	**− 1.4**	**29.3**
Lower Preterm Birth Rate	− 2.4	–
Change in the Distributions of PTB and Infant Mortality by GA	+ 1.0	–
Switch to the 2016 OE from the 2016 LMP	**− 4.1**	**25.2**
Lower Preterm Birth Rate	− 4.8	–
Change in the Distributions of PTB and Infant Mortality by GA	+ 0.7	–

Abbreviations: GA – gestational age; LMP – last menstrual period; OE – obstetric estimates; PTB – preterm birth.

Notes: The total cost of preterm birth in the IOM report was expressed in 2005 dollars but was based on the preliminary number of births in 2004 and the 2003 LMP preterm birth rate by GA (the latest vital statistics available at the time). The 2016 OE and LMP estimates of preterm births in 2016 were taken from the linked infant and births records in CDC Wonder. All reported costs are “incremental”, that is above and beyond the average costs of term and post-term births.