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INJURY IDENTIFICATION FOR A GEORGIA BIRTH COHORT: RETROSPECTIVE ANALYSIS OF EMERGENCY ROOM VISITS AND HOSPITAL DISCHARGES FOR CHILDREN AGE 0-3

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Master of Public Health

Global Epidemiology

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A thesis submitted to the Faculty of the
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Abstract

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Injury is one of the most under-recognized public health problems facing the Unites States health system. The prevention of child injuries deserves increased attention given the vulnerability and dependency of this age group. This study presents a retrospective cohort analysis of early childhood unintentional injury presenting to an emergency room setting for treatment. The dataset is constructed from deterministic record linkage of emergency room and hospital discharge records for a three-year period (2008-2010) to the 2007 Georgia birth cohort (n=154,025). Records were de-duplicated and linked using a unique identifier, which included sex, date of birth, and portions of first and last names. The analysis dataset included injury records for the first emergency room encounter per child over the three-year period. The data was restricted to children age 0-3. Of 42,539 records for children age 0-3 presenting with an injury diagnosis from 2008-2010, 32,927 (77%) linked to a Georgia Birth Record in 2007. A total of 8,451 children had multiple emergency room discharge records. The risk of unintentional injury requiring emergency room or hospital care was 21.4%. Males had 19% higher risk of injury than did females of the same age (95%CI: 1.17, 1.21, p<0.0001). Open wound of head, neck, and trunk was most common injury category (n=7,122, 21.6%) for this age group. Maternal age at birth was the strongest independent risk factor for childhood unintentional injury before the age of four. Risk of childhood injury decreased with increasing maternal age (CMH=198.6, p<0.0001). After adjusting for offspring sex, maternal educational level, and maternal first birth event, children born to mothers age 15 to 19 were 1.59 times more likely to present with an injury at an emergency room or hospital than children born to mothers age 25 to 29 (95%CI: 1.54, 1.64). This study adds to the growing body of literature employing childhood record linkage and argues for more focused research of childhood injury.

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Dr. John Carter
For pushing me to think more

And

To my family
For believing in me

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Background / Literature Review

Introduction

The purpose of this literature review is to provide a rationale for the analysis of a birth cohort to nonfatal, unintentional childhood injury that result in emergency department visits in the state of Georgia. To our knowledge, this is one of a few data linkage studies between hospital discharge data and birth certificate data for childhood injury. The literature on this subject is broad, yet specific—incidence rates and risks for emergency department visits vary widely by age categorization, geographic area of interest, injury type, injury cause, and method of data acquisition. There is limited information on birth certificate data and subsequent linkage to hospital discharge data for unintentional childhood injury; however, there is a breadth of studies examining overall injury burden, fatal and nonfatal injury, intentional and unintentional injury, and childhood injury. The following information will highlight current knowledge in descriptive epidemiology concerning childhood injury and record linkage, expose gaps in the literature, and argue for further elucidation of childhood injury epidemiology using birth certificate-linked records.

Injury

It is arguable that the most underappreciated facet of public health is injury and injury prevention. Injury burden has been designated a main challenge for public health in the next century (1), and the Centers for Disease Control and Prevention described injuries as one of the most under-recognized public health problems facing the United States health system(2). The magnitude and extent of injury is under-researched and under-appreciated in the literature and leaves the field without data on which to base priorities and research(1,3,4). Injury is a great equalizer since it affects all persons regardless of age, sex, race, socioeconomic status, or physical location.

Definition. In recent years, the distinction between the terms "injury" and "accident" has been disentangled in the literature. The distinguishing feature of injuries is that, unlike accidents, injuries are preventable(1). Krug defines injury as an organic-level lesion from acute exposure to energy in amounts that exceed threshold of physiological tolerance(1). The state of Georgia states that injury results in a body wound or shock from an abrupt physical injury, such as from accident or violence(5).

Categorization. Fatal injury is defined as an injury resulting in death whereas a nonfatal injury is any type of injury that results in morbidity, but not mortality. An important distinction is the separation of intentional injuries from non-intentional injuries. The National Committee for Injury Prevention and Control defined *unintentional* injuries as those not caused by person's intent to harm; *intentional* injuries are intended to inflict injury or death on oneself or another(6). This distinction is somewhat common sense, but can cause confusion since intentional and unintentional injuries can be the result of the same *cause* of injury(7). Intentional injuries include homicide via various mechanisms and suicide. Common unintentional injuries include: falls, fires, poisoning, asphyxia, drowning, and motor vehicle incidents.

Burden. Injuries are both a health concern and an economic problem (8). In 2000, the burden of injury in the United States resulted in an estimated lifetime cost of $406 billion--$80 billion for injuries and $326 billion for lost productivity(9). The overall death rate from injuries in 1998 was 97.9 per 100,000 population (1). Estimates of the burden of injury combine intentional and unintentional injury and account for injury fatality. The focus of this section is the burden of unintentional injury in childhood. In this regard, fatal and nonfatal injury for children 0-4 is responsible for $4.7 billion of lifelong medical costs—due to medical treatment and disability—and $14 billion for lost productivity costs—both of the child and the adult caregiver(10). CDC confirms this estimate; $17 billion is directed annually toward medical costs for children and adolescents experiencing injuries requiring medical attention(2). Though the focus on injury research is often mortality, there are more instances of hospital admissions, emergency department visits, physician visits, and cases of non-treatment(1).

Childhood Injury

Children are the most vulnerable, and therefore dependent, members of society and require a magnified intensity of study since childhood experience has implications for future health consequences(11). Close to 84% of children are medically treated for injury in the first 10 years of life(3). It is estimated that 3 in every 10 children experience an unintentional injury serious enough for medical attention or to result in a half day of restricted activity on an annual basis(8). Concurrently, the National Health Interview Survey calculated an injury rate of 25 per 100 children for age 0 to 21(9). The CDC Childhood Injury Report of 2008 reveals that of children 0 to 19 years, children 0 to 4 account for 25% of nonfatal unintentional injuries(2). Incidence of injury varies widely between age categories and sex.

Rates. When one considers the overall injury incidence rate for children between 0 and 4, the rate decreased from 2,259 per 10,000 to 1,740 per 10,000 children in the 15-year span from 1985 to 2000(10). From 2001 to 2006, the overall nonfatal unintentional injury rate for children 0 to 19 was 11,292 per 100,000 population (2). When stratified by age category, the rate drops to 5,870 per 100,00 population for children less than 1 but increases to 12,873 per 100,000 population for children 1 to 4 (2). This underscores the gravity of injury during physical and cognitive development in the early years of life.

Male and Female Disparity. It is well–established that males in every age category experience greater rates of intentional and unintentional injury; however, the mechanisms behind this gender disparity are not yet well understood. Males younger than age 24 are 30% more likely to have an injury than females in the same age category(10). The nonfatal unintentional injury rate for males age 1 to 4 is 14,444 per 100,000 children while the same rate in females sits at 11,228 per 100,000 children(2). In the state of Georgia, males in every age category had higher rates of hospitalizations and emergency room visits from 2002-2007; for children age 0-4, 231,527 males visited an emergency department while only 176,910 females visited an emergency department in the same five-year period(5).

Childhood Injury and the Emergency Department

A telling indicator of injury rate and burden is the number of individuals that seek medical treatment for an injury. This thesis will focus only on injuries resulting in treatment in an emergency department. Nearly 20% of the civilian, non-institutionalized population had at least one emergency department visit in 2007(12). In 1996, unintentional injuries accounted for 11% of hospital admissions for ages 1 to 19(8). The National Center for Health Statistics reports data on emergency department visits annually among children under 18 years of age; in 2010, 25.1% of white children under 6 years had at least one emergency department visit while 34.4% of black children under 6 years had at least one emergency department visit(13). Additionally, the South region—compared to the Northeast, Midwest, and West—had the highest percentage of children under 6 years with at least one emergency department visit at 30.4%(13).

Rates. Many studies have analyzed injury rates for children presenting in an emergency room; however, the resulting rates vary significantly based on the study design. This section will highlight the discrepancies of current research on this topic.

The first studies looking at childhood injury rates from hospital discharge data appeared close to 30 years ago. An analysis of hospital discharge data in North Carolina for the year 1980 focused on children under age 20; the resultant annual rate of trauma-related hospitalizations was 804 per 10,000 population (14). A study of medically related treated injuries in clinics and emergency rooms for the year 1984-1985 was performed in a population of cases enrolled in a Washington state-sponsored HMO; the rate of injuries treated in the emergency room was 100 per 1,000 population(4). The variation between rates in these two studies can be explained by the differences in sample size, population demographics, data ascertainment, and age categorization.

In more recent years, the literature has seen a shift in childhood injury studies as the justification and rationale for age categorizations has been re-examined. A study of 1997 hospital discharge and death records from the state of California highlighted that using the standard age groupings of <1 year, 1 to 4 years, and 5 to 9 years, did not accurately represent the age of highest risk for many causes of childhood injury(9). The authors conclude "broad age aggregations for children mask wide variation within categories as a result of rapid changes in development and risk" (9). In 2006, a seminal paper out of Canada addressed this issue by classifying injury patterns in an emergency department setting by developmental stage; the rates of injury for each age category were: 0-11 months, 62 per 1,000 p-y; 12-35 months, 153 per 1,000 p-y; 36-59 months, 105 per 1,000 p-y; 60-83 months, 90 per 1,000 p-y(15). The authors argue that hazards for childhood injury are influenced by "physical and cognitive-social characteristics of different stages of development," so as a child transitions to the next developmental stage, physical development and cognitive/social development evolve(15). A replication study in 2008 out of Glasgow, Scotland assessed 17,793 injury records for children up to age 7 over a two-year period; the findings validate and resemble the rates from the 2006 Canadian study(16). Most recently, a study out of Australia in 2011 highlights that injury rates for children aged 0-4 mask differences in injury risk for smaller and more appropriate age intervals, and that there is differential risk of injury depending on age and sex(17). These studies support the argument that developmental stage directly influences injury type, injury cause, and injury risk and warrant further elucidation in the literature.

Type and Cause of Injury. Analysis of childhood injury presenting in an emergency department also varies study to study based on the type and cause of injury. Type of injury refers to the associated ICD-9 code assigned to the injury whereas the cause of injury is captured in E-codes (though cause of injury is less-often reported than type of injury). A 1985 study found the leading causes of injury for toddlers age 1 to 4 were poisoning, falls, and fires/flames(14) whereas the CDC Childhood Injury Report in 2008 found that falls account for the highest cause of injury among age 1 to 4(2). When age was categorized via developmental stages, children age 60-83 months had the highest proportion of head injuries, open wounds, and fractures(15). Reported types and causes of injury vary greatly depending on the study parameters.

Childhood Injury in the state of Georgia

In 2007, the leading cause of death in Georgia for ages 1-44 was unintentional injury, accounting for 29% of all deaths (5). The leading cause of death for age categories 1 to 4 and 5 to 14 was unintentional injury. For all age groups, unintentional injuries were the 3rd leading cause of death(5). Fall-related injuries were the leading cause of hospitalizations, and children 1 to 4 had a higher risk of drowning than children in any other age group(5). To our knowledge, there is no literature presenting a type-specific and age-specific analysis of childhood injury rates from emergency department records in the state of Georgia. This study aims to fill this gap and generate momentum for research and policy focus on unintentional, preventable injuries among children in the state of Georgia.

Record Linkage

Record linkage provides a mechanism to match disparate datasets and is a growing area of injury outcome studies (18,19). Record linkage currently exists in two flavors: deterministic and probabilistic. Deterministic linkage is based on exact linkage via personal identifiers whereas probabilistic linkage uses a set of common variables in two databases to calculate the probability that a given pair of records is a true match (18,20). This study will utilize deterministic linkage via a unique identifier in both datasets to match the birth certificate dataset and the hospital discharge dataset. Record linkage is an evolving method to build population-based injury databases across multiple databases from varying phases of care(21). To our knowledge, this research is one of a few examples of deterministic record linkage between hospital discharge data and birth certificate data for the purpose of unintentional injury analysis.

Record Linkage of Birth Variables to Childhood Health Outcomes. There is a growing body of literature using both deterministic and probabilistic record linkage to associate risk factors at and around the birth event to childhood health outcomes. A distinct area of research is the linkage of nonfatal maltreatment to early childhood injury mortality (19). This analysis used vital birth records, Child Protective Services records, and vital death records to establish a probabilistic linkage (19). Other probabilistic linkage studies linked birth defect registries to childhood hospital admissions (22), birth records to childhood cancer registries (23), and birth records to bone fracture (injury) records (24). The outcome variables of these studies reveal the wide breadth of data available using record linkage; outcome measures include young suicide (25), hospital admission for asthma (26), infectious disease hospitalization (27), childhood acute lymphoblastic and acute myeloid leukemia (23), and various measures of childhood injury mortality. All of these studies found elevated risk of outcome dependent on one or more exposure variables measured at birth.

Record Linkage of Maternal Birth Variables to Childhood Mortality. A common procedure to investigate childhood morality is linkage of death records to birth records in order to hypothesize and investigate risk factors for childhood injury mortality. In a retrospective cohort of 1,035,504 Tennessee children born between 1985 and 1994, the analysis found that there was a 50% increased risk of injury death if the mother had less than a high school education and was less than 20 years old (28). This paper suggested that maternal education level and maternal age are predictors of childhood mortality risk. Further evidence came from a retrospective cohort of North Carolina and Washington state births and deaths using 1968-1970 vital records (29). The analysis found that maternal age and education were inversely related to infant accident morality. These findings are further validated from a population-based case-control study of injury death before the age of 1, in which young maternal age (<20) was significantly associated (Odds Ratio=9.0) with infant injury death (30). There is some contradiction as to the strength of these associations; a study looking at crude and adjusted models of infant injury death found that unadjusted models showed significance of maternal age and educational level, but when birth weight and gestational age were adjusted for, the associations for maternal age and educational level disappear and were unrelated (31). Studies of birth parameters and childhood mortality suggest that maternal age at birth and maternal education level are significant predictors of childhood morality, but more thorough assessment of confounding is needed in the literature.

Record Linkage of Maternal Birth Variables to Childhood Unintentional Injury. Since maternal age at birth and maternal educational level were associated with childhood morality, the logic follows that maternal age and maternal education level would also be associated with childhood morbidity. The author identified three manuscripts written in the past ten years that studied the link between maternal age and unintentional childhood injury. The first was a prospective birth cohort of 800,012 Swedes born during 1987-1993 and followed until age seven (32). Exposure was birth to teenage mothers, and the outcome was both unintentional and violent injuries in preschool children. The results showed that children with teenage mothers had higher relative risk of hospital admissions for violent and unintentional injuries (32). A study of 26,087 Norwegian children and their mothers found that younger maternal age was a risk factor for hospital-attended injury, though it was one of many familial and child factors that predicted toddler injury (33). Of note is that parents self-reported injury outcome in this study, potentially biasing the results. The UK Millennium Cohort Study followed children born in 2001-2007 and assessed for injury at 9m, 3y, and 5y (34). The researchers hypothesized that maternal age was a risk factor for child unintentional injuries and hospital admissions; the results showed that risk of unintentional injury requiring medical attention or hospital admissions declined with increasing maternal age (34). This study defined medical attention as presentation to a nurse, general practitioner, hospital, or medical clinic. The current research project will focus only on injuries presenting to an emergency room (ER).

The literature on maternal age and its association with both childhood unintentional mortality and morbidity led to a hypothesis for this study that increasing maternal age is associated with decreasing childhood injury risk for children under the age of four in the state of Georgia.

METHODS

DATASET CONSTRUCTION

Data Sources

The Georgia Birth Certificate Dataset was obtained through the Georgia Department of Public Health. All identifying variables were de-linked and removed from the dataset before analysis. The 2007 birth cohort in Georgia contains 154,025 records. Georgia Hospital Discharge Data (HDDS) is collected by the Georgia Hospital Association (GHA) and maintained by the Office of Health Indicators for Planning (OHIP) of the GA Department of Public Health. HDDS includes only emergency room visits and hospital discharges. Given that the analysis was restricted to only births in 2007 and hospital discharge records from 2008 to 2010, the age of children in this cohort is restricted to 0-3. For linkage bias analysis, 42,539 records were extracted from HDDS that represented unduplicated children age 0-3 with at least one ER-recorded hospital discharge in 2008-2010.

HHDS to Birth Record Linkage

Deterministic linkage was employed to establish links between HHDS and Birth Record based on LONGID. LONGID is a personal identifier defined by GHA for each record and included in the dataset maintained by OHIP. LONGID includes the first two letters of both the first and last name, date of birth, and sex of the individual. If data used to generate LONGID is collected consistently and accurately, then an identical LONGID should be assigned at each encounter with an ER or hospital. Linkage from HHDS to Birth Record required perfect agreement between LONGID in both datasets. From this deterministic linkage, 32,927 out of 42,539 records (77%) with a hospital discharge in 2008, 2009, or 2010 matched to a Georgia birth record in 2007. This includes only records of an initial visit to the ER. LONGID and other personal identifiers were removed from dataset before analysis. This dataset was used to determine the presence of bias in the linking process.

Birth Record to HDDS Record Linkage

To link birth records to HDDS records, HDDS records were restricted to ER encounters between 2008 and 2010. HDDS for latter years (2011 and 2012) has not yet been released, thus the analysis is restricted to ER records from 2008-2010. Additionally, this limits analysis to children age 0-3, given a 2007 birth event and a last possible ER event in 2010. These yearly files were merged together into a single dataset (n=42,539) and linkages were determined by linking LONGID from birth certificate dataset to restricted HDDS dataset. This process resulted in 21.3% of the 2007 GA birth cohort linking to an HDDS record between 2008 and 2010. The final dataset for this analysis contains 154,025 birth records and represents the GA birth population in 2007. This birth cohort with linked injury data was used for the analysis of associations between birth variables and injury occurrence.

Multiple ER Records

Of the 32,927 injured children linked to the 2007 GA birth cohort, 8,451 received medical treatment at an ER on more than one occasion between 2008 and 2010. One injury may result in repeated ER visits or hospitalizations for child. A child may also return to the ER with an unrelated injury to the 1st injury during the study time frame. The dataset required de-duplication of records in order to perform risk estimation for a child presenting with an injury requiring medical attention. LONGID was used to de-duplicate the dataset by identifying children with multiple ED visits in any year (2008, 2009, and 2010) and over the three-year period. One child may have multiple visits in the same year, or may have multiple visits over the three-year period without having two visits in any one year. A variable for multiple admission status was created in the final dataset to differentiate children with one ER encounter versus children with more than one ER during the study time frame. From the de-duplication, 25.7% (n=8,451) of children in the study presented to an ER multiple times between 2008 and 2010.

Ethical Considerations

This study is secondary data analysis of two datasets obtained from OHIP at the Georgia Department of Public Health. Permission to use the data was obtained from OHIP. This study is classified as non-human subjects research for IRB consideration.

Variables

A total of 154,025 observations were recorded from the 2007 GA birth cohort dataset. All variables in final dataset were derived from either the 2007 birth record or HDDS record. Selected variables were recoded as categorical variables to facilitate appropriate statistical analysis. Identifying information (LONGID) was removed from the dataset prior to analysis to ensure non-use of Protected Health Information (PHI).

The dependent variable of interest was reception of medical attention at an ER for a nonfatal, unintentional injury as recorded based on the principal diagnosis. The *International Classification of Disease*, Ninth Edition, Clinical Modification (ICD-9-CM) was used to assign diagnosis codes to injuries presenting to an ER. Injury is recorded as codes 800-999; the analysis was restricted to HDDS records with an ICD code of 800 through 999. Principal diagnosis was categorized into 24 categories of similar-natured injury for analysis.

Missing Values in Birth Cohort

Parameters measured at birth varied in the quantity of unknown or missing values recorded in the dataset. Preterm birth was defined as a birth event 20-36 weeks inclusive, with term birth representing a birth event at week 37 or greater. Missing values for week of gestation at birth accounted for 2.0% of the data (n=2,473). Given the large sample size of the cohort (n=154,025), this exclusion was considered reasonable for analysis. Number of fetuses born to mother at birth event had missing values for 0.06% of data (n=97); this percentage was considered negligible for data analysis. Record of mother's first birth event was recorded as: Not Applicable, Unknown, No, and Yes. Mothers that responded Not Applicable or Unknown account for 3.8% of observations (n=5,905). Self-report of maternal education level resulted in 3.8% missing observations (n=5,948). Reporting of number of prenatal care visits resulted in missing values for 13.7% of the data (n=21,131). The number of prenatal care visits was used to generate frequencies, but not used in further analysis due to the high percentage of missing values.

STATISTICAL ANALYSIS

Dataset construction occurred in Access 2010 (Microsoft, Richmond, WA, 2010). Data management and statistical analysis was performed in SAS (v9.3, Cary, NC, 2010). An α of 0.05 was used for all statistical testing. The association of birth parameters with subsequent childhood injury was examined using contingency tables, chi-square analysis for associations, and logistic regression. Frequencies and other descriptive epidemiology were generated using PROC FREQ options. Crude, unadjusted risk ratios (RRs) with 95 percent confidence intervals were calculated for estimated risk of overall childhood injury based on exposure and demographic data. Cochran-Mantel-Haenszel (CMH) procedures were used to assess trend among ordinal variables. For bias analysis in record linkage, percent linkage was calculated as number of linked observations divided by the total number of observations.

Birth weight was categorized as extremely low (<500 grams), very low (500-1,499 grams), low (1,500-2,499 grams), and normal (≥2,500 grams). We assumed that fetuses born weighing less than 500 grams had a low probability of survival (Lau). These 290 births with low birth weight were excluded from exposure-specific estimation of risk.

Regression Analysis

To model injury as a function of birth parameters, logistic regression was employed. The exposure of interest for regression analysis was maternal age, stratified by 5-year intervals. Maternal age as an exposure variable was identified from previous research suggesting associations between maternal age at birth and suicide at a young age (25). This led to the hypothesis that maternal age is associated with a child's ER injury presentation. The null hypothesis was that maternal age had no association to a child's injury presentation to an ER. No missing values were recorded for maternal age. Stratification of maternal age into 5-year age categories was an *a priori* decision based on previous literature and experience. Maternal age group 25-29 was used as the reference category for all analysis because the mean and median age of mothers in the dataset was 26.8 and 26.0, respectively. The lowest frequencies for levels of maternal age occurred at the extremes: 10-14 and 45-55. Only 17 birth events occurred in mothers age 50 and above—the highest observations occurred at age 55-- and so these observations were merged with the 45-49 maternal age group.

In the unadjusted logistic model, the risk of injury presentation to an ER among children born in 2007 was compared to children with no presentation to an ER for injury. Adjusted models controlled for offspring sex, maternal age, maternal education level, and maternal first birth event. Model were run in PROC GENMOD with link=log in order to generate RRs. Results are reported as RRs with 95 % confidence intervals (CI) and chi-square associated p-value.

Unadjusted model:

Injury = β_0 + β_1 mage1014 + β_2 mage1519 + β_3 mage2024 + β_4 mage3034 + β_5 mage3539 + β_6 mage4044 + β_7 mage45up

Where:

Mage(xxxx)= indicator variable for 5-year maternal age categories, reference group 25-29

Adjusted model:

Injury = β_0 + β_1 mage1014 + β_2 mage1519 + β_3 mage2024 + β_4 mage3034 + β_5 mage3539 + β_6 mage4044 + β_7 mage45up + β_8 mtheducCAT + β_9 offspringsex + β_{10} firstbirthevent

Where:

Mage( )= indicator variable for 5-year maternal age categories, reference group 25-29 mtheducCAT= 0 if maternal education less than high school education; 1 if high school graduate or beyond

offspringsex= 0 if child is male; 1 if child is female

firstbirthevent= 0 if birth event is not first birth event for mother; 1 if birth event is first for mother

The adjusted model dropped 11,420 observations. Missing observations are resultant from missing values for maternal education status and maternal report of first birth event. There were no missing observations for maternal age or offspring sex. The adjusted model included 30,892 injury records (events) and 142,605 birth records (trials).

Results

Representativeness of Linkage

Linkage results between HDDS and the 2007 birth cohort are presented in Table 1. Of 42,539 unduplicated observations for children aged 0-3 presenting with an injury diagnosis from 2008-2010, 32,927 (77%) linked to a Georgia birth record in 2007. Males and females were equally represented in the link, as both genders linked between 77 and 78 percent of observations. Disparity in linkage of race was evident for Native Hawaiian / Pacific Islander with only a 40% linkage compared to an 80% linkage for White; however, the 60% unlinked observations of Native Hawaiian / Pacific Islander represent only 0.2% of the distribution of race that did not link.

Bias in linking of Hispanic ethnicity was also present in the data. Both non-Hispanic and unknown ethnicity linked close to 80% where Hispanic ethnicity under-linked at 54% linkage., and only 54% of reported Hispanic children linked with the birth cohort. Linkage percentage decreases the further the ER event occurs from birth. Children that present to an ER for injury at age 0 linked back to a birth record with a frequency of 80% whereas children presenting to an ER for injury at age 3 only linked back to a birth record with a frequency of 73% ($CMH=145.4$, $p<0.0001$).

Linkage was assumed to be random and non-systematic. Under-linkage and linkage bias will be further elucidated in the discussion section.

Descriptive Statistics

Selected characteristics of the 2007 Georgia birth cohort linked to ER Injury Diagnosis from 2008-2010 are presented in Table 2. In the cohort as a whole, the risk of first encounter at an ER for injury was 21.4% (n=32,927) over a 3-year period. Of the 32,927 children in this study with a first ER encounter injury diagnosis, 55.4% (n=18,249) were male and only 44.6% (n=14,678) were female. Of males in the birth cohort, 23.1% had an ER injury event while only 19.5% of females in the birth cohort had an ER injury event from 2008-2010. Table 2 also reveals differences in frequency of injury given maternal age at birth, suggesting differential risk of injury given maternal age category.

Frequencies and percentages of principal diagnostic categories are presented in Table 3. The most frequent injury category was Open Wound of Head, Neck, and Trunk (n=7,122, 21.6%). The most common external cause of Open Wound of Head, Neck and Trunk was falls (n=3,820, 53.6%) followed by being stuck or a cut/pierce (data not shown).

Overall risk for injury by birth parameters is presented in Table 4. Chi-square analysis was used to assess statistical differences in the distribution of maternal and child characteristics among children that presented to the ER with an injury diagnosis in reference to the full 2007 GA birth cohort. In the crude, unadjusted analysis, male risk of injury increased 19% compared to females (95% CI: 1.17, 1.21). Risk of injury by race varied depending on race: Black or African American children had slightly increased risk of ER injury (RR=1.08, 95% CI: 1.06, 1.10) whereas Asian and Native Hawaiian / Pacific Islander children experienced a significant decreased risk of ER injury. Maternal age at birth event revealed differential risk among 5-year age categories. Mothers younger than 25-29 had increased risk of their child having an ER injury while mothers older than 25-29 had decreased risk of their child presenting to an ER with injury. Of note, children born to mothers aged 15-19 increased injury risk by 34% (95% CI: 1.30, 1.39). Children born in the very low birth weight category (500-1499 grams) actually had a decreased risk of ER injury (RR=0.84, 95% CI: 0.77, 0.91).

Single v. Multiple Admissions

In Table 5, the analysis of injury by birth parameters is stratified by a child's multiple discharge status. The results show statistically significant differences between children with a single discharge record during the study time frame and children with multiple discharge records during the study time frame. Offspring sex, maternal race, maternal ethnicity, and maternal education level all showed significant chi-square associations ($p>0.0001$), meaning that the distribution of children for these parameters is different depending on if the child had a single discharge record or multiple discharge records. Trend testing for maternal age revealed significant differences for single versus multiple discharge status dependent on maternal age at the birth event (CMH=198.57, $p<0.0001$).

Regression Analysis

Table 6 reports the estimates from the two logistic regression models used to examine the association between maternal age at birth and a child's ER injury. In the crude model, the dependent variable is a child's first encounter with an ER for injury between the ages of 0-3. The adjusted model controls for covariates described in the methodology section. Both the crude and adjusted model reported the same trend in maternal age: mothers less than 25-29 had increased risk of taking their child to the ER for an injury diagnosis whereas mothers older than 25-29 showed decreased risk for taking their 0-3 year old to the ER for an injury. The adjusted model, controlling for offspring sex, maternal education level, and maternal first birth event, yielded slightly higher RRs and 95% CIs (i.e. crude RR=1.44, adjusted RR=1.59 for maternal age group 15-19). Table 7 stratifies the maternal age / injury model by offspring sex. No meaningful differences were presented in males or females, regardless of model selection. When stratified by maternal age category, males and females show no difference in risk of injury presentation to an ER.

Discussion

To our knowledge, this study is one of the first examples of deterministic record linkage between a birth certificate cohort and hospital discharge database for the purpose of childhood injury analysis. The cohort contains all birth events recorded in the state of Georgia in 2007 and was used for for demographic and covariate measures. HDDS is a comprehensive database of all ER discharges in the state of Georgia and is a suitable tool to assess frequencies of injury diagnosis receiving medical attention at an ER. This outcome of this analysis was restricted to childhood injury events presenting at an ER and did not account for childhood injury events that receive care at urgent care centers, clinics, and physician offices, nor did it represent childhood injury events that elicit no medical care outside the home. Because the population using ERs for injuries that are not actually emergencies may be different from the population using physicians or clinics, the injury cohort may not comprise a representative population.

De-duplication of multiple ER records was necessary to create a dataset that contained only one ER record per child; in other words, only the first ER record from 2008-2010 for a child born in 2007 was included in the final analysis. The de-duplication process was arbitrary, and having no access to personal identifiers led to the inability to assess sensitivity and specificity of de-duplication. Further, inclusion of only the first ER visit for children with multiple admissions may underrepresent the risk of injury. For a child with multiple admissions, the second, third, or subsequent trips to the ER may be follow-up for the same injury, or multiple admissions could represent multiple, independent injuries. The second, third, or fourth ER presentation for independent injury events may be more severe than the first presentation, thus underrepresenting injury frequencies for this dataset.

The results revealed a significant association between maternal age and ER-presented childhood injury between the ages of 0 and 3. Categorization of maternal age by 5-year age groups suggests that the association varies in magnitude depending on maternal age category. Younger mothers (with reference of 25-29 years old) had higher risk of their child receiving treatment at an ER for injury while mothers older than 29 had a decreasing trend of risk for ER-presenting injury. These findings are consistent with the limited studies that report an association between maternal age and child nonfatal, unintentional injuries (32–34).

In a longitudinal cohort following UK children born between 2001 and 2007 and measuring outcome at 9 months, 3 years, and 5 years of age, risk of unintentional injury requiring medical attention or hospital admittance declined with increasing maternal age (34). In contrast to the present study, however, the UK study broadly defined medical attention as any care received by a nurse, general practitioner, hospital, or medical clinic. The current analysis was restricted to hospital records. In the UK study, risk of children being admitted to the hospital dropped from 27.1% (for a 20-year old mother) to 21.6% (for a 40-year old mother) (34). Findings in the present analysis were analogous: ER admittance for children 0-3 dropped from 29% (for a 20-year old mother) to 17% (for a 40-year old mother). Two other studies also found higher risk of hospital-attended childhood injury dependent on maternal age, both for children up to age 7 (32) and children between 18 and 36 months of age (33). A prospective birth cohort of 800,912 Swedish children born to teenage mothers revealed higher RRs of hospital admissions for both violent and unintentional injuries (32). Concurrently, a prospective birth cohort study of 26,087 Norwegian children found that maternal age is one of many factors that predict toddler injury, though the study relied on parental reporting of outcome as opposed to hospital databases (33). Findings in current study of the association between maternal age and childhood injury are in agreement with the limited literature on maternal age as a risk factor for childhood morbidity.

Our database did not include records of mortality resulting from childhood injury, but association studies of maternal age and infant injury death further strengthen the role of maternal age as a risk factor for childhood injury outcomes. The literature is largely in agreement: low maternal age is inversely related to infant injury mortality (28–30,35). In a study of North Carolina and Washington births from 1968-1980, maternal age, maternal education, and maternal parity all had an effect on infant accident mortality (29). In a population case-control study of children born in Washington from 1981-1990 that died of injury before age one, young maternal age (<20 years old) was significantly associated with infant injury death (OR=9.0; 95%CI: 4.5, 17.9) (30). There is some contradiction as to the strength of the association between maternal age and infantile injury death; in a retrospective cohort study of 54,447 linked pairs in California, maternal age and maternal race were significant predictors of childhood injury mortality. Introduction of birth weight and gestational age into the adjusted model results in the associations between maternal age and infant death and maternal race and infant death disappear and are unrelated (31). Overall, studies of maternal age and childhood injury mortality are evidence of the inverse trend between increasing maternal age and decreasing childhood injury outcomes.

Young mothers, defined in this study as mothers between the ages of 10-24, exhibited upwards of 34% increased risk of a child's presentation to an ER for injury as compared to mothers 25-29 years of age. Though this trend follows established literature (32–34), it may misrepresent actual injury risk. Increased risk of injury by maternal age may be inflated by utilization of ER by young mothers as compared to old mothers. Late entry into prenatal care for adolescent mothers is linked to greater use of the ER (36). Low-income status also increases utilization of ER (37). On average, infants of adolescent mothers utilize the ER more times per year than infants of older mothers (38). The author thinks that increased risk of injury for children born to young mothers is not associated with inadequate childcare, but with greater utilization of the ER due to socioeconomic factors such as income, insurance status, family structure, and paternal involvement.

In this study, father's race as reported in the dataset was used as a proxy for presence of father's name on the birth certificate, and thus, paternal involvement. We found a small difference in risk for childhood injury between children with a value for father's race and children with no value for father's race. Interestingly, a prospective birth cohort following 4.3 million California births revealed that children with early childhood injury morality (based on nonfatal maltreatment) were more likely to be missing paternity information (19). The role of paternal involvement alone and in conjunction with other birth parameters is worth further exploration.

Deterministic record linkage was utilized to link birth records to hospital discharge records with a high percent agreement (77%) between hospital discharge injury records and the 2007 GA birth cohort. Both deterministic (based on exact match linkage via personal identifiers) and probabilistic (based on weights/scores of multiple variables when no personal identifiers are available for link) have been employed to investigate associations in maternal and child health (20). The availability of advance computer software to link records is expanding the utilization of record linkage. Multiple studies have utilized probabilistic and deterministic record linkage to assess associations between variables captured at birth and childhood health outcomes such as young suicide (25), hospital admission for asthma (26), infectious disease hospitalization (27), bone fractures (24), childhood acute lymphoblastic and myeloid leukemia (23), and injury death (28). Linkage has also examined the association between nonfatal maltreatment and early childhood injury mortality (19) and the association between birth defects and childhood hospital admission (22). Results of the current study indicate slight association of maternal race, singleton birth status, paternal involvement, and birth weight with injury outcome, warranting further research via record linkage. The present analysis adds evidence to the growing body of literature that record linkage is a validated and effective method to study risk factors and health outcomes captured on multiple datasets over varying periods of time.

Children with very low birth weight (500-1,499 grams) showed an unexpected significant risk reduction of 16% in the analysis (95%CI: 0.77, 0.91). This suggests that babies with a very low birth weight are at decreased risk of ER-treated injury in the first three years of childhood. Babies born at a low birth weight (1,500-2,499 grams) had no association with injury outcome (95% CI: 0.97, 1.04). The significant association between very low birth weight and ER-injury outcome might not be a meaningful measure. Babies with very low birth weights are at increased risk of severe outcomes such as infectious disease hospitalization (27) and childhood lymphoblastic and myeloid leukemia (23). Additionally, the leading cause of death for children in high-income countries age 0-4 years is perinatal conditions at a rate of 104.3 per 100,000 (1). Very low birth weight (defined as <1,500 grams) babies contributed 54.8% to the infant mortality and neonatal mortality measures by the end of 2005 (39). Since babies at very low birth weight are at increased risk of neonatal and infantile death, the risk reported in the study is subject to selection bias. Only those very low birth weight babies that survive were at risk in our study; infantile death during the three-year study period was not accounted. Risk adjusted for infantile death rates for each weight category would give a more accurate picture of the risk of birth weight to childhood ER-treated injury.

Falls, being struck by an object, and medical were the three most frequent external causes in this cohort analysis. Falls accounted for 36.7% of injury in the study. Our findings are in agreement with the 2008 CDC Childhood Injury Report, which found that falls account for the highest rate of unintentional injury among ages 1 to 4 (2). Georgia also reported fall-related injuries as the leading cause of hospitalizations throughout the state (5). Infants studied through developmental age categories in Canada also had highest proportion of external cause as falls (15). From an economic standpoint, 79% of the total costs of injury for ages 0-4 are explained by the five leading causes of injury for this age group, which are falls, being struck by/against, motor vehicle traffic, burn/anoxia, and cut/pierce (8). Cause-specific and injury-specific morbidity rates vary by developmental age (15) and study design (4,9,14). As a child transitions between developmental stages, physical development (height, reach, strength, and dexterity) and cognitive development (curiosity, judgment, hazard recognition) evolve, thus changing the nature and cause of injuries (15). Injury type could not be broken out by age in this study—the child's age at ER incident was unavailable in the final dataset. It is assumed, though, that injury pattern by age would closely mirror trends found by other developmental studies (9,15–17).

Differential risk for childhood injury is dependent on both age and sex. It is well established in the literature that males have higher risk and rate of injury than females (1,3,5,10,15). In Georgia, males in every age category, including age 0-4, had higher rates of emergency room visits and hospitalizations from 2002-2007 (5). The current analysis revealed that 55.4% of injury in children age 0-3 was attributable to males compared to 44.6% for females. Males had a 19% increase in risk as compared to females. These findings are compatible with the literature, suggesting that males engage in more risky activities than do females.

Maternal race and ethnicity paint an interesting picture of differential risk. This study found varying risk of childhood injury dependent on maternal race. Scholer and colleagues, in a historical cohort study of maternal characteristics as risk factors for injury death for children age 0-4, found that race was not significantly associated with mortality (28). However, race was a binary classification in that study, described as either African-American or White/other. Our analysis measured six distinctions of race: White, African-American/black, Asian, Native Hawaiian/Pacific Islander, Native Alaskan/Indian, and multiracial. African-Americans were the only category in which risk increased (8%) compared to White. It is documented that frequency of ER visits varies by white or African-American status—in 2010, 25.1% of white children under age 6 had at least one ER visit while 34.4% of African American children under age 6 had at least one ER visit (13). Significant decreased risk was reported in Asian (RR=0.50) and Native Hawaiian/Pacific Islander (RR=0.49) as compared to White, each with approximately 50% reduction of risk. These significant reductions are an interesting find; it suggests that mothers with culture rooted in Asia or the Pacific Islands, do not utilize the ER for injuries. The samples size for Native Hawaiian/ Pacific Islander was small, with only 174 observations (compared to 92,020 observations for the White reference category). Asian American children are less likely to miss school because of injury or illness and have chronic conditions compared with non-Hispanic whites (40). In the same study, however, utilization of healthcare among immigrant Asian population was inversely associated with the reported positive health outcomes (40). More detailed research is needed to disentangle injury risk by maternal race.

This study found that maternal Hispanic ethnicity was associated with a 52% reduction in childhood injury risk. Of note is the bias, both in linkage and ER utilization, apparent in Hispanic ethnicity. Controlling for health insurance coverage and SES status, Mexican American children had lowest health care access and utilization compared to non-Hispanic blacks and non-Hispanic whites (41). In the current analysis, maternal Hispanic ethnicity linked 20% less often that maternal non-Hispanic ethnicity or unknown maternal ethnicity. This discrepancy in linkage could be attributed to human error in data entry, though such a large gap is not expected due to data entry error alone. Date of birth could be recorded incorrectly at the ER event, but this alone also does not explain the wide discrepancy. Low proportion (54%) of Hispanic linkage is most likely due to inconsistency in LONGID between the birth event and subsequent childhood ER incident. It is common in Hispanic culture for a son's name to be based off of a father's name. Substitution of the child's given name for the child's common name could account for linkage bias for Hispanic ethnicity. A combination of these mis-recorded events is likely responsible for the 20% decrease in linkage status of children with maternal Hispanic ethnicity.

In conclusion, this study found that older maternal age reduces risk of ER injury presentation for children age 0-3. In conjunction with other birth parameters of interest, this analysis suggests that birth parameters can be utilized as risk factors for childhood injury events. Record linkage is an evolving method to promote linked pair analysis of exposure and disease over time, where records are maintained in different administrative datasets.

STRENGTHS AND WEAKNESSES

This analysis was bolstered by the large sample size in the 2007 Georgia birth cohort (n=154,025). This cohort represented all live births in the state of Georgia over a 12-month period. The completeness of this dataset allowed for an accurate and reliable calculation of risk since this cohort was the population at large. Multiple variables collected on the birth record and at hospital discharge contributed to the thoroughness and scope of the analysis. Additional analysis on more variables in the birth dataset would have further strengthened results, but time limited the breadth of this study. Data are relevant within the last five years and can be used to guide policy decisions, further maternal-child record linkage research, improve data collection procedures, and highlight health disparities that necessitate intervention.

Another strength was the high-percentage link between the HDDS database and the birth cohort, which achieved close to 80% matching. Record linkage studies differ in their match probability (18,21), but this study provided enough links to ensure overall reliability in strength of associations. Conversely, a weakness of this study was linkage bias resulting from unmatched or mismatched observations. Record linkage of HDDS to birth certificate records relied on deterministic, or exact, record matching based on a subject's Longitudinal ID (LONGID). LONGID includes the first two digits of the first name, the first two digits of the surname, the last two digits of the surname, date of birth, and sex (M/F). LONGID was used in both de-duplication of multiple admissions and in linkage of hospital discharge records to birth records. Though 100% matching is desirable in a deterministic linkage due to accuracy of personal identifiers, the frequency or infrequency of different names, variations in spelling, presence of nicknames or abbreviations, surname changes due to parental marriage or divorce, and missing values in data lines increase the complexity and inaccuracy of linkage (18,20). Success of deterministic record linkage relies of consistent and accurate maintenance of LONGID. In this analysis, 77% of hospital discharge records for children under age four with an injury diagnosis matched to a birth certificate in 2007. This means that 23% of injury records either truly unmatched (out-of-state or unrecorded birth event) or falsely unmatched. Any bias in unmatched records was assumed to be random and non-systematic. Linkage bias led to underrepresentation of some covariates (maternal Hispanic mortality, for instance) in this analysis. Mismatches or unmatched data was shown to introduce bias in risk measures (20). Linkage was a competing strength and weakness in this analysis.

Of concern was the proportion of missing values for individual variables in the birth certificate dataset. Data for this cohort study was collected retrospectively, and analysis relied on variables collected both at birth and any subsequent ER incident for each child. Missing values were of note for selected maternal variables. Maternal measures that relied on self-report were more likely to record missing values in the birth dataset. While maternal race had no missing values, maternal ethnicity was unknown for 1.6% (n=2,473) of the cohort. Maternal education level was missing values for 3.9% of the cohort (n=5,948), and maternal first birth event (yes/no) recorded "unknown" or "not applicable" for 3.8% of the data (n=5,905). Only 432 observations record missing values for both maternal education level and maternal first birth event, meaning missing observations are largely mutually exclusive. All other maternal variables were reported completely or had percentage of missing values (<1%) deemed negligible in the analysis.

Generalizability of this study is limited due to the restriction on age. Only the 2007 GA birth cohort was used for births, and hospital discharge records were only available for 2008 through 2010 (2011 and more current years have not yet been released for distribution). This restricted the analysis to children under the age of four. Previous studies of hospital discharge records for childhood injury often defined a child between the ages 0 to 19 (2,4,9,14) or 0 to 6 (15,16). Injury risk and type varies by developmental age (2,15), so the results from this study are only applicable to infants and toddlers under the age of four. Results are most useful at the GA state level to inform and guide further epidemiologic and policy research.

Of the 154,025 GA births in 2007, 32,927 received ER attention for an injury before the age of four. This translates to a 21.4% risk of injury presenting to an ER for children age 0-3 in the state of GA. Gauging if this risk is analogous to other similar studies is challenging given the *a priori* geographic and outcome restrictions and the varied reporting of risk versus rate for injuries in the literature. Also, this estimated risk underrepresents the true risk in the 2007 GA birth cohort due to left-censoring. A child born on Jan 1, 2007 was at risk of injury for a near 12-month period in 2007; if the child received injury treatment at an ER anytime in 2007, the injury record was left-censored from the study database since hospital discharge records were only retrieved for the years 2008, 2009, and 2010. A child born on Dec 31, 2007 is at no risk of injury in the year 2007, so any ER-presented injury for this child was captured in the hospital discharge dataset. Left-censoring of children born in 2007 and receiving ER injury treatment in 2007 underestimates injury risk for infants less than 12 months of age in this cohort. Birth date was not included in the final dataset, so consideration of left-censoring was not possible for the current analysis.

As mentioned in the discussion section, significant associations of maternal age to ER injury presentation and maternal race to ER injury presentation were observed; however, a weakness of this study is that the actual risk of injury versus utilization of ER services could not be disentangled. Also, the limited scope of this study could not account for all potential confounding from maternal variables.

FUTURE DIRECTIONS

Injury represents one of the most under-recognized areas in public health (2). The key message in injury research is that injuries are preventable. Dedicated educational campaigns and risk-reduction initiatives (seatbelts, helmets) are effective tools to inform and elicit injury prevention behavior. Before programs and initiatives can be successful, though, the research must be in place. The sentinel book *Injury in America*, published in 1985, pressed injury researchers to define the extent of the problem, as "a prerequisite for the scientific study of injury is the acquisition of data on which to base priorities and research" (4).

The evolution of injury research necessitates epidemiologic studies of injury frequency and risk factors for injury types. Research presented in this study adds to the literature on injury risk for children, especially vulnerable members of society. This study was unique in that it employed deterministic linkage to establish linked pairs between a birth cohort and hospital discharge records, allowing for the generation of hypotheses relating maternal and partum variables to childhood injury cases that presented to an ER. Our findings were consistent with other studies that found an inverse relationship between maternal age and hospital-attended injuries (32–34). Granted, this analysis was limited in scope and could not account for all possible sources of confounding. Future research of maternal age at birth and childhood injury should focus on building adjusted models of injury risk based on pre-determined confounders. As mentioned previously, the true risk of injury versus ER utilization also needs disentangling.

Various studies in the literature highlight the utility of record linkage in maternal-child health research, and this study adds to the growing body of literature validating record linkage as an evolving, necessary tool to move the field forward. The associations drawn between birth records and other health records (death, hospital discharge, disease registries) are vital to understanding the dynamic process of a child's health during the rapid physical, cognitive, and social growth experienced during childhood and adolescence. Further record linkage should link multiple health databases in an effort to evaluate the physical and socioeconomic environment that influences a child's risk of injury over the life course. The field of injury research will be further advanced by the inclusion of socio-contextual factors that influence injury risk.

This research opens a dialogue for the maternal health community to start considering the relationship between variables captured at birth and subsequent medical care events, whether at an emergency room, physician visit, or other clinical settings. The literature is rich with associative studies of birth weight and subsequent developmental outcomes (23,24,27,35). It is plausible, then, that a combination of already-existent variables in the literature could function as a childhood injury indicator. Scholer developed a Child Injury Risk Score for children age 0 to 4, with points assigned for different values of maternal education, maternal age, and the number of other children of the mother (28). This measure should be further expanded as more associative studies link maternal and birth variables to childhood injury. A novel childhood injury risk indicator could serve as an educational tool for parents, especially first-time parents, at birth. Unintentional childhood injury research will be further advance when the epidemiology is linked to prevention.

In this analysis, 8,451 children with injuries had multiple admissions to the ER between 2008 and 2010. The scope of this analysis prevented a detailed analysis of injury frequencies and risk for this subset. An important future direction is parsing out of multiple admissions, whether for the same injury or different injuries. Any differences between children with repeat ER visits for the same injury (follow-up) between children with repeat ER visits for multiple, independent injuries should be investigated.

Nonfatal, unintentional injury is unpredictable but not unpreventable. Nonfatal childhood injury follows distinct patterns of incidence given a child's age and developmental milestones (15–17). Interventions should focus on injury prevention, as childhood injury remains a leading cause of morbidity and mortality for 18 and under (5). Injury epidemiology should be guided by prevention. Educated prevention is the best deterrent to unintentional injury incidence.

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Tables

Table 1. Characteristics of a Cohort of Children Presenting to ED with Injury Linked to Georgia Live Births From 2007 Birth Certificate Data (n=42,539)

	Total		Linked to 2007 GA Birth Certificate Data (n=32,927)		Unlinked to 2007 GA Birth Certificate Data (n=9,612)		Linked to Birth Certificate
	No.	**%**	**No.**	**%**	**No.**	**%**	**Proportion**
Sex							
Male	23,643	55.6	18,249	55.4	5,394	56.1	**0.77**
Female	18,896	44.4	14,678	44.6	4,218	43.9	**0.78**
Race							
White	22,729	53.4	18,102	55.0	4,627	48.1	**0.80**
Black or African American	15,075	35.4	11,964	36.3	3,111	32.4	**0.79**
Asian	580	1.4	362	1.1	218	2.3	**0.62**
American Indian/Alaska Native	54	0.1	41	0.1	13	0.1	**0.76**
Native Hawaiian / Pacific Islander	10	0.0	4	0.0	6	0.1	**0.40**
Multiracial	4,091	9.6	2,454	7.5	1,637	17.0	**0.60**
Ethnicity							
Unknown	14,049	33.1	11,286	34.28	2,808	29.2	**0.80**
Non-Hispanic	26,104	61.4	20,371	61.87	5,733	59.6	**0.78**
Hispanic	2,341	5.5	1,270	3.86	1,071	11.1	**0.54**
ER Payor							
Unknown	286	0.7	195	0.6	91	1.0	**0.68**
Public	23,702	55.7	18,303	55.6	5,399	56.2	**0.77**
Self-Pay	4,680	11.0	3,214	9.8	1,466	15.3	**0.69**
Commercial Insurance	13,068	30.7	10,599	32.2	2,469	25.7	**0.81**
Other	803	1.9	616	1.9	187	2.0	**0.77**
Age at 1st ER Event[a]							
0	5,472	12.9	4,432	13.5	1,040	10.8	**0.81**
1	17,673	41.6	13,966	42.4	3,707	38.6	**0.79**
2	14,096	33.1	10,652	32.4	3,444	35.8	**0.76**
3	5,298	12.5	3,877	11.8	1,421	14.8	**0.73**
Total Linkage							**0.77**

[a]Cochran-Mantel-Haenzel trend test: CMH=145.4, p>0.0001

Table 2. Characteristics of 2007 GA Birth Cohort by Linkage Status to HHDS Presenting to ER with Injury Diagnosis 2008-2010 (n=154,025)

	Total		Injury (n=32,927)		No Injury (n=121,098)	
	No.	**%**	**No.**	**%**	**No.**	**%**
Sex						
Male	78,785	51.2	18,249	55.4	60,536	50.0
Female	75,240	48.9	14,678	44.6	60,562	50.0
Maternal Race						
White	92,020	59.7	19,522	59.3	72,498	59.9
Black or African American	51,919	33.7	11,891	36.1	40,028	33.1
Asian	5,548	3.6	594	1.8	4,954	4.1
American Indian/Alaska Native	385	0.3	70	0.2	315	0.3
Native Hawaiian / Pacific Islander	174	0.1	18	0.1	156	0.1
Multiracial	3,979	2.6	832	2.5	3,147	2.6
Maternal Ethnicity						
Unknown	2,473	1.6	572	1.7	1,901	1.6
Non-Hispanic	126,908	82.4	29,578	89.8	97,330	80.4
Hispanic	24,644	16.0	2,777	8.4	21,867	18.1
Maternal Age						
10-14	294	0.2	70	0.2	224	0.2
15-19	18,345	11.9	5,277	16.0	13,068	10.8
20-24	41,947	27.2	10,228	31.1	31,719	26.2
25-29	42,252	27.4	8,423	25.6	33,829	27.9
30-34	31,757	20.6	5,591	17.0	26,166	21.6
35-39	16,026	10.4	2,755	8.4	13,271	11.0
40-44	3,183	2.1	546	1.7	2,637	2.2
45 and up	221	0.1	37	0.1	184	0.2
Week of Gestation at Birth[b]						
Preterm	21,783	14.1	4,647	14.1	17,136	14.2
Term	132,242	85.9	28,280	85.9	103,962	85.9
Weight[c]						
Extremely Low	290	0.2	8	0.0	282	0.2
Very Low	2,594	1.7	468	1.4	2,126	1.8
Low	11,867	7.7	2,558	7.8	9,309	7.7
Normal	139,274	90.4	29,893	90.8	109,381	90.3
Number of Fetuses Born						
Single	148,884	96.7	31,903	96.9	116,981	96.6
Twin	4,854	3.2	969	2.9	3,885	3.2
Triplet	182	0.1	33	0.1	149	0.1
Quadruplet	8	0.0	1	0.0	7	0.0
Unknown	97	0.1	21	0.1	76	0.1
Maternal First Birth Event						
Not Applicable	2,546	1.7	516	1.6	2,030	1.7
Unknown	3,359	2.2	582	1.8	2,777	2.3
No	89,730	58.3	18,930	57.5	70,800	58.5
Yes	58,390	37.9	12,899	39.2	45,491	37.6
Maternal Education Level						
Unknown	5,948	3.9	1,004	3.1	4,944	4.1
Primary / Lower Secondary	35,511	23.1	7,800	23.7	27,711	22.9
High School Graduate / GED	45,711	29.7	10,988	33.4	34,723	28.7
College / University	66,855	43.4	13,135	39.9	53,720	44.4
Father's Race						
Not Present on Birth Certificate	26,852	17.4	5,579	16.9	21,273	17.6
Present on Birth Certificate	127,173	82.6	27,348	83.1	99,825	82.4

[b] Preterm birth defined as birth 20-36 weeks inclusive
[c] Extremely Low = less than 500 grams; Very Low=500-1499 grams; Low=1500-2499 grams; Normal=greater than or equal to 2500 grams

Table 3. Injury Categories and Frequencies for 2007 GA Birth Cohort With Link to First Incident for ED Injury Record, 2008-2010 (n=32,927)

	ICD9 Code Categories	No.	%
Fracture Of Skull	**800-804**	225	0.7
Fracture Of Neck And Trunk	**805-809**	5	0.0
Fracture Of Upper Limb	**810-819**	1,184	3.6
Fracture Of Lower Limb	**820-829**	572	1.7
Dislocation	**830-839**	1,399	4.3
Sprains And Strains Of Joints And Adjacent Muscles	**840-848**	779	2.4
Intracranial Injury, Excluding Those With Skull Fracture	**850-854**	462	1.4
Internal Injury Of Thorax, Abdomen, And Pelvis	**860-869**	14	0.0
Open Wound Of Head, Neck, And Trunk	**870-879**	7,122	21.6
Open Wound Of Upper Limb	**880-887**	1,190	3.6
Open Wound Of Lower Limb	**890-897**	515	1.6
Injury To Blood Vessels	**900-904**	0	0.0
Late Effects Of Injuries, Poisonings, Toxic Effects, And Other External Causes	**905-909**	2	0.0
Superficial Injury	**910-919**	3,225	9.8
Contusion With Intact Skin Surface	**920-924**	4,661	14.2
Crushing Injury	**925-929**	105	0.3
Effects Of Foreign Body Entering Through Orifice	**930-939**	2,052	6.2
Burns	**940-949**	1,277	3.9
Injury To Nerves And Spinal Cord	**950-957**	3	0.0
Certain Traumatic Complications And Unspecified Injuries	**958-959**	4,523	13.7
Poisoning By Drugs, Medicinal And Biological Substances	**960-979**	1,089	3.3
Toxic Effects Of Substances Chiefly Nonmedicinal As To Source	**980-989**	936	2.8
Other And Unspecified Effects Of External Causes	**990-995**	1,180	3.6
Complications Of Surgical And Medical Care, Not Elsewhere Classified	**996-999**	407	1.2

Table 4. Unadjusted Estimated Incidence Proportions (Risk), Risk Ratios (RR), and 95% Confidence Intervals (CI) for Nonfatal, Nonintentional Injury in Cohort of 2007 GA Live Births Linked to HDDS 2008-2010

	Injury N	Total N	Risk	RR	95% CI
Sex					
Female[a]	14,678	75,240	0.20	1.00	Referent
Male	18,249	78,785	0.23	1.19	(1.17, 1.21)*
Maternal Race					
White[a]	19,522	92,020	0.21	1.00	Referent
Black or African American	11,891	51,919	0.23	1.08	(1.06, 1.10)*
Asian	594	5,548	0.11	0.50	(0.47, 0.55)*
American Indian/Alaska Native	70	385	0.18	0.86	(0.69, 1.06)
Native Hawaiian / Pacific Islander	18	174	0.10	0.49	(0.31, 0.76)*
Multiracial	832	3,979	0.21	0.98	(0.93, 1.05)
Maternal Ethnicity[b]					
Non-Hispanic[a]	29,578	126,908	0.23	1.00	Referent
Hispanic	2,777	24,644	0.11	0.48	(0.47, 0.50)*
Maternal Age					
10-14	70	294	0.24	1.16	(0.94, 1.43)
15-19	5,277	18,345	0.29	1.34	(1.30, 1,39)*
20-24	10,228	41,947	0.24	1.18	(1.15, 1.21)*
25-29[a]	8,423	42,252	0.20	1.00	Referent
30-34	5,591	31,757	0.18	0.90	(0.87, 0.93)*
35-39	2,755	16,026	0.17	0.88	(0.85, 0.92)*
40-44	546	3,183	0.17	0.88	(0.81, 0.95)*
45 and up	37	221	0.17	0.86	(0.64, 1.16)
Week of Gestation at Birth[c]					
Preterm	4,647	21,783	0.21	1.00	(0.97, 1.03)
Term[a]	28,280	132,242	0.21	1.00	Referent
Weight[d]					
Very Low	468	2,594	0.18	0.84	(0.77, 0.91)*
Low	2,558	11,867	0.22	1.00	(0.97, 1.04)
Normal[a]	29,893	139,274	0.21	1.00	Referent
Number of Fetuses Born[e]					
Single[a]	31,903	148,884	0.21	1.00	Referent
Twin	969	4,854	0.20	0.93	(0.88, 0.99)
Triplet	33	182	0.18	0.85	(0.62, 1.15)
Quadruplet	1	8	0.13	0.58	(0.09, 3.65)

Table 4, cont.

	Injury N	Total N	Risk	RR	95% CI
Maternal First Birth Event[f]					
No[a]	18,930	89,730	0.21	1.00	Referent
Yes	12,899	58,390	0.22	1.05	(1.03, 1.07)*
Maternal Education Level[g]					
Less than High School Graduate	7,800	35,511	0.22	1.02	(1.00, 1.04)
High School Graduate or higher[a]	24,213	112,566	0.22	1.00	Referent
Father's Race					
Not Present on Birth Certificate	5,579	26,852	0.21	0.97	(0.94, 0.99)*
Present on Birth Certificate[a]	27,348	127,173	0.22	1.00	Referent

[a] Reference Group

[b] Missing values represent 2.0% of data (n=2,473)

[c] Preterm birth defined as birth 20-36 weeks inclusive

[d] 290 total observations with extremely low birth weight (<500 g) excluded from analysis

[e] Missing values account for 0.06% of data (n=97)

[f] "Not applicable" and "unknown" excluded from analysis; account for 3.8% of data (n=5,905)

[g] Unknown observations account for 3.9% of data (n=5,948)

*p<0.001

Table 5. Unadjusted Risk, Risk Ratios (RR), and 95% CI for Injury Records, Stratified by Single or Multiple Admission Status per child, 2008-2010

	Single Discharge Record for Injury, 2008-2010 (n=24,476)		Multiple Discharge Records for Injury, 2008-2010 (n=8,451)		
	No.	**%**	**No.**	**%**	**Chi-Square**
Sex					
Female	11,191	45.72	3,487	41.26	χ^2 = 50.6
Male	13,285	54.28	4,964	58.74	p<0.0001
Maternal Race					
White	14,406	58.86	5,116	60.54	
Black or African American	8,899	36.36	2,992	35.4	
Asian	488	1.99	106	1.25	χ2 = 30.03
American Indian/Alaska Native	51	0.21	19	0.22	p=<0.0001
Native Hawaiian / Pacific Islander	18	0.07	0	0	
Multiracial	614	2.51	218	2.58	
Maternal Ethnicity[b]					
Non-Hispanic	21,881	89.4	7,697	91.08	χ2 = 30.87
Hispanic	2,188	8.94	589	6.97	p<0.0001
Maternal Age					
10-14	57	0.23	13	0.15	
15-19	3,654	14.93	1,623	19.20	
20-24	7,310	29.87	2,918	34.53	
25-29	6,416	26.21	2,007	23.75	CMH=198.57
30-34	4,384	17.91	1,207	14.28	p<0.0001
35-39	2,207	9.02	548	6.48	
40-44	421	1.72	125	1.48	
45 and up	27	0.11	10	0.12	
Week of Gestation at Birth[c]					
Preterm	3,412	13.94	1,235	14.61	χ2 = 2.35
Term	21,064	86.06	7,216	85.39	p=0.13
Weight[d]					
Very Low	335	1.37	133	1.57	CMH=0.18
Low	1,918	7.84	640	7.57	p=0.67
Normal	22,218	90.77	7,675	90.82	
Number of Fetuses Born[e]					
Single	23,740	96.99	8,163	95.59	
Twin	692	2.83	277	3.28	CMH=3.37
Triplet	26	0.11	7	0.08	p=0.07
Quadruplet	1	0	0	0	
Maternal First Birth Event[f]					
No	14,155	57.83	4,775	56.5	χ2 = 3.22
Yes	9,530	38.94	3,369	39.87	p=0.07
Maternal Education Level					
High School Graduate or higher	3,997	16.33	1,582	18.72	χ2 = 89.17
Less than High School Graduate	20,479	83.67	6,869	81.28	p<0.0001

[b] Missing values represent 2.0% of data (n=2,473)

[c] Preterm birth defined as birth 20-36 weeks inclusive

[d] 290 total observations with extremely low birth weight (<500 g) excluded from analysis

[e] Missing values account for 0.06% of data (n=97)

[f] "Not applicable" and "unknown" excluded from analysis; account for 3.8% of data (n=5,905)

Table 6. Adjusted Risk Ratios (RR) for Offspring ER Injury According to Maternal Age, Georgia, 2007 Birth Cohort

			Crude		Adjusted[a,b]	
Characteristic		No. of Injuries	RR	95% CI	RR	95% CI
Maternal Age						
	10-14	70	1.19	(0.97, 1.47)	1.41	(1.14, 1.75)
	15-19	5.277	1.44	(1.40, 1.49)*	1.59	(1.54, 1.64)*
	20-24	10,228	1.22	(1.19, 1.25)*	1.26	(1.22, 1.30)*
	25-29[a]	8,423	1.00	Referent	1.00	Referent
	30-34	5,591	0.88	(0.86, 0.91)*	0.86	(0.83, 0.89)*
	35-39	2,755	0.86	(0.83, 0.90)*	0.83	(0.80, 0.87)*
	40-44	546	0.86	(0.79, 0.93)*	0.83	(0.77, 0.90)*
	45 and up	37	0.84	(0.63, 1.13)	0.71	(0.49, 1.02)

[a] Adjusted for offspring sex, maternal education level, and maternal first birth event

b There were only 30,892 injuries included in the adjusted analysis as a result of missing data on maternal education level and maternal first birth event

* p<0.001

Table 7. Adjusted Risk Ratios (RR) for Offspring ER Injury According to Maternal Age, Stratified by Offspring Sex, Georgia, 2007 Birth Cohort

			Crude		Adjusted[a,b]	
Offspring Sex		No. of Injuries	RR	95% CI	RR	95% CI
Males						
Maternal Age						
	10-14	41	1.15	(0.88, 1.51)	1.39	(1.05, 1.84)
	15-19	2,932	1.42	(1.37, 1.48)*	1.58	(1.51, 1.65)*
	20-24	5,610	1.21	(1.17, 1.25)*	1.25	(1.20, 1.29)*
	25-29[a]	4,666	1.00	Referent	1.00	Referent
	30-34	3,129	0.88	(0.85, 0.92)*	0.86	(0.83, 0.90)*
	35-39	1,549	0.88	(0.83, 0.92)*	0.85	(0.80, 0.89)*
	40-44	303	0.88	(0.79, 0.97)	0.85	(0.76, 0.95)[#]
	45 and up	19	0.78	(0.78, 1.18)	0.62	(0.37, 1.05)
Females						
Maternal Age						
	10-14	29	1.23	(0.89, 1.79)	1.45	(1.03, 2.02)
	15-19	2,345	1.46	(1.40, 1.53)*	1.60	(1.52, 1.69)*
	20-24	4,618	1.24	(1.19, 1.29)*	1.27	(1.22, 1.32)*
	25-29[a]	3,757	1.00	Referent	1.00	Referent
	30-34	2,462	0.88	(0.84, 0.92)*	0.86	(0.82, 0.90)*
	35-39	1,206	0.84	(0.79, 0.90)*	0.82	(0.77, 0.87)*
	40-44	243	0.84	(0.75, 0.95)	0.81	(0.50, 1.36)
	45 and up	18	0.91	(0.60, 1.39)	0.82	(0.89, 0.95)*

[a] Adjusted for offspring sex, maternal education level, and maternal first birth event

*p<0.001

p=0.004

Appendices

Abbreviations

ER= Emergency Room
HDDS= Georgia Hospital Discharge Data
OHIP= Office of Health Indicators for Planning
DECAL= Department of Early Care and Learning

ER Payor Classifications (see Table 1)

Public	Commercial Insurance
Medicaid Managed Care	Blue Cross / Blue Shield
Champus	Georgia Better Health
Medicaid	HMO / Managed Care
Medicaid Applicants	Commercial Insurance
Medicare	Other non-specified Managed Care
Other Government Assistance	PPO
Medicare Managed Care	POS
PeachCare	