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Article

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Abstract

Infant mortality is the most widely used indicator of a nation's health status and is associated with a plethora of maternal and socioeconomic factors. Although the association between young and old maternal age and the risk of infant mortality is well established, the link between paternal age and birth outcomes has received far less attention. This study seeks to examine the added impact of paternal age on infant mortality, above and beyond that of maternal age among married couples. Using the 2002 linked birth and infant death data set (*N* = 63,754), hazard odds ratios for the association between combined adolescent and adult maternal and paternal age and the risk of infant mortality were estimated. Maternal demographic characteristics, such as education and race/ethnicity were controlled. The findings indicate that, independent of maternal education and race/ethnicity, adolescent father adds additional risk, above and beyond that of maternal age, only when the mother is older (21-45 years; hazard ratio = 2.7). This study highlights that for married couples, adolescent fathers add to the risk of infant mortality when the mothers are older, providing insight into the role of paternal age in infant mortality. Implications for additional research are discussed.

Keywords

infant mortality, paternal age, public health, quantitative research, social determinants of health

Infant mortality is the most widely used indicator of a nation's health status and is associated with a plethora of maternal and socioeconomic factors (Centers for Disease Control and Prevention [CDC], 1991). In 2008, the U.S. infant mortality rate (IMR) ranked 30th in the world, tied with Slovakia and Poland (MacDorman & Mathews, 2008). In 2010, the United States ranked 32nd of 34 developed nations by the Organisation for Economic Co-operation and Development (OECD) in infant mortality, with that rate representing approximately 3 times that of nations with the lowest IMRs, Iceland (2.2 per 1,000 live births), Finland (2.3), and Japan (2.3; OECD, 2012). As of 2011, the U.S. IMR had declined to 6.05, largely due to medical technology. The IMR in the United States has gradually decreased over the past 80 years, but it remains higher than most industrialized countries. It has been speculated that a high U.S. preterm birth rate, which represents the highest in the industrialized world, and indirect influences from poverty, stress, and persistent racial and geographic disparities play major roles in the overall high IMR (OECD, 2012; Save the Children, 2013). The relatively poor international standing of the United States with regard to infant mortality has prompted a national focus on this health issue.

Of the many factors associated with infant mortality, maternal age is one of the most important. Infant death varies by maternal age, with young and older women at higher risk (Alio et al., 2012). Additionally, there is a higher miscarriage and stillbirth rate for very old and very young mothers (Liu, Zhi, & Li, 2010). However, the association between paternal age and birth outcomes has received far less attention. Few studies demonstrate that paternal age correlates with negative birth outcomes and some high case fatality diseases (Bujan, Mieusset, Mondinat, Mansat, & Pontonnier, 1988; Goriely, McVean, Rojmyr, Ingemarsson, & Wilkie, 2003; Misra, Caldwell, Young, & Abelson, 2010). Furthermore, growth and development of the placenta are largely influenced by paternal gene expression, which can by mutated as a result of advancing age in men (Reichman & Teitler, 2006). Undoubtedly, both paternal and maternal ages are important factors to consider with regard to infant

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mortality. Taking maternal age into account, the purpose of this research study is to investigate the influence of paternal age on infant mortality among married couples. To our knowledge, no study has investigated the additional risk for infant death that paternal age adds to maternal age. Using the 2002 linked birth infant death data set (CDC, 2002), estimates and associations between older and young paternal age and infant mortality among married couples were made. Poor prenatal care has been associated with adverse birth outcomes and may mediate the association between combined parental age and infant mortality (Goldenberg & Rouse, 1998; Krueger & Scholl, 2000). Therefore, a variable for prenatal care was included in the analysis as a mediator.

The following hypotheses were tested:

Hypothesis 1: Paternal age will have an additional risk, above maternal age, and be associated with a higher risk of infant mortality among married couples.

Hypothesis 2: The relationship between combined parental age and infant mortality will be mediated by adequacy of prenatal care.

Maternal Age

In general, young and older mothers experience the highest rates of adverse birth outcomes. Teenage mothers are at higher risk of infant mortality, preterm birth, and delivering low-birth-weight babies compared with mothers aged 20 to 34 years (DuPlessis, Bell, & Richards, 1997; Martin, Hamilton, Ventura, Menacker, & Park, 2002; Orvos et al., 1999). Higher infant mortality risk for younger mothers may be related to socioeconomic factors as well as biologic immaturity (Kirchengast & Hartmann, 2003). Additionally, young maternal age may be a marker for low socioeconomic status (Phipps, Blume, & DeMonner, 2002). Older maternal age is also associated with a higher risk of preterm birth and fetal death (Astolfi & Zonta, 1999; Bujan et al., 1988; Fretts & Usher, 1997; Raymond, Cnattingius, & Kiely, 1994).

Paternal Age

Previous studies have focused on older paternal age and reported links to sperm abnormalities, gene mutations (Glaser et al., 2003; Goriely et al., 2003), preeclampsia (Harlap et al., 2002), miscarriage (de la Rochebrochard & Thonneau, 2002), and some birth defects (Savitz, Schwingl, & Keels, 1991). Additionally, older paternal age is associated with a higher risk of spontaneous abortions (Astolfi, De Pasquale, & Zonta, 2004; Kleinhaus et al., 2006), stillbirth (Nybo-Anderson, Hansen, Andersen, & Davey, 2004), autism (Lauritsen, Pedersen, & Mortensen, 2005), and schizophrenia (Malaspina et al., 2001) in the offspring. The aforementioned studies identify the correlation of paternal age with a variety of diseases. As such, the possibility of paternal-age effects on birth outcomes has biologic plausibility, highlighting the importance and warranting further attention.

The effects of younger paternal age have not been well studied. Few studies report that the rates of preterm birth, low birth weight, and infant mortality were higher for younger fathers compared with older fathers (Abel, Kruger, & Burd, 2002; Fernandez, Ruch-Ross, & Montague, 1993; Liu et al., 2010; Misra & Ananth, 2002; Olshan, Ananth, & Savitz, 1995). Abel et al. (2002) identified that infants born to young fathers (<20 years) had higher risks of low birth weight and preterm birth compared with 20- to 25–year-olds. Olshan et al. (1995) reported similar findings for increased risk of preterm birth. It has been reported that both young parental age and advanced parental age are associated with birth defects and health problems (Fernandez et al., 1993; Liu et al., 2010; Misra & Ananth, 2002). Zhu, Vestergaard, Madsen, and Olsen (2008) emphasized that children of fathers younger than 25 years and of fathers older than 45 years had overall higher mortality than children of fathers aged 25 to 29 years.

Several factors may explain the neglect of a focus on paternal factors. First, maternal influences on infant and child health have been considered of higher importance than paternal factors, because maternal health behaviors directly affect the development of the fetus. Second, it is more convenient to investigate maternal effects on birth outcomes. Pregnant women routinely make prenatal visits to hospitals and clinics, which can facilitate the collection of information. Last, the mother of an infant is always known, yet paternal age is commonly missing from vital statistics records, making it more difficult to study (Misra et al., 2010).

Method

Sample

Deidentified data from the National Center for Vital Statistics Linked Birth and Infant Death 2002 data file was used for this study (CDC, 2002). Because missing information on paternal age was far more prevalent in unmarried women, the analytical sample was restricted to married individuals up to 45 years of age, who accounted for 63.75% of the sample ($N = 63,754$). Those individuals with missing data on maternal age, paternal age, maternal education, prenatal care status, and maternal race/ethnicity were excluded from the present study.

Measures

Dependent Variable. Infant mortality was defined as the death of an infant within the first 365 days of life.

Independent Variable. Maternal and paternal age for married couples was assessed in years at the time of birth as specified on the birth certificate. Combined parental age was used as the independent variable. An age variable with four categories was created: both adolescent parents (women and men 20 years and younger), adolescent mother and adult father, adult mother and adolescent father, and both adult parents (women and men between 21 and 45 years). The variable for older combined age was used as the reference because of the robust number of cases in those age ranges (n = 59,680). The age categories were selected as a function of the small number of infant births and deaths to men and women older than 45 years in this data set.

Control Variables

Maternal education. Mother's education was defined as the number of years of education as indicated on the birth certificate. A variable with four categories was created: Mothers with less than a high school education; mothers who graduated from high school; mothers with some college education; and college graduates. The 683 missing observations were deleted from the final analysis.

Maternal race/ethnicity. Maternal race/ethnicity was based on maternal self-report of Hispanic ethnicity and race from the birth certificate. The variable was created with five categories: non-Hispanic White, non-Hispanic Black, Hispanic, American Indian/Alaska native, and Asian. There were 492 observations missing, which were omitted from the analysis.

Mediation Analysis: Prenatal Care

Poor prenatal care has been associated with adverse birth outcomes and may mediate the association between combined parental age and infant mortality (Goldenberg & Rouse, 1998; Krueger & Scholl, 2000). Therefore, a variable for prenatal care was included in the analysis as a mediator. The Kessner-modified adequacy of prenatal care index was used to measure prenatal care. The index combines information about the month in which prenatal care started, gestational age at delivery, and the number of prenatal care visits (Kessner, Singer, Kalk, & Schlesinger, 1973). Three categorical variables were created and were defined as adequate, intermediate, and inadequate care. A total of 2,241 observations were missing and were omitted from the analysis.

Analysis

Frequencies and proportions of all the variables were examined. Bivariate analyses examining the relationship between age and adequate prenatal care used crosstab and chi-square statistics. This study is well-suited for survival analysis since the dependent variable, infant mortality can be measured as survival time and allows for an estimation of the probability that an infant will survive for 1 year. Event history analysis was conducted using the Cox's proportional hazard model to study the association between infant mortality and the independent variables. All the control variables were added to the models and all the analyses were weighted. Prenatal care was included as a mediator. We used Baron and Kenny's (1986) analytical methods to guide the mediation analysis, and we conducted a separate Cox proportional hazard model to test the mediation of prenatal care. The categorical variable for prenatal care shown in Table 1 was entered into the model and inadequate care was the reference group (Tarver-Carr et al., 2002). All tests were two-tailed and p value of .05 was chosen as the level of statistical significance. The analysis was performed using SAS 9.3 software. Institutional review board approval for this study was granted from the University of Maryland, College Park.

Results

The descriptive statistics for married couples in the analytic sample are detailed in Table 1. Of all married couples, couples where both parents were between 21 and 45 years made up the largest proportion of the sample (93.61%). Couples made up of an adolescent mother and adult father accounted for 4.27%, couples with an adult mother and adolescent father accounted for a very small percentage of the sample (0.54%). Couples who were both 20 years old or younger made up 1.57% of the sample. More than a third of mothers had a college degree and above (36.58%). Most women accessed adequate prenatal care (88.75%). The sample included a majority of non-Hispanic White (67.25%), 19.07% of Hispanic, 6.6% of Asian mothers, 6.54% of non-Hispanic Black, and 0.54% of American Indian/Alaska Native.

The relationship between combined parental age and adequate prenatal care are illustrated in Table 2, and Table 3 describes the cumulative fraction of infants born to the four parental age-groups who have died within 360 days. The smallest proportion of infants who die at 30 days was to adult couples. Couples with an adult mother and adolescent father (OldmYoungf) experience the largest proportion of infants who die at the 30-day mark, which stayed constant up until 360 days. Couples who were both adolescent experienced a slight increase in the proportion of infant deaths over the 360-day period. There was a statistically significant difference in the survivor function of the four parental-age variables ($p < .05$).

The results from the Cox proportional hazard analysis (Model 1) are presented in Table 4. Compared with couples that were both adult (BothOld), couples where the mother was adult, and the father was an adolescent

Table 1. Description of Sample Demographic Variables (n = 63,754), Unweighted Percentages.

Characteristic	n (%)	Standard error
Combined parental age (years)		
Both young (≤20)	1,002 (1.57)	0.124
Both older (21-45)	59,682 (93.61)	0.244
Young mother/old father (≤20/21-45)	2,723 (4.27)	0.2
Old mother/young father (21-45/≤20)	347 (0.54)	0.073
Maternal education		
Less than high school (0-11 years)	8171 (12.96)	
High school graduate (12 years)	16,896 (26.79)	
Some college education (13-15 years)	14,930 (23.67)	
College graduate plus (≥16 years)	23,074 (36.58)	
Prenatal care		
Adequate care	54,591 (88.75)	0.316
Intermediate care	5,310 (8.63)	0.281
Inadequate care	1,612 (2.62)	0.159
Race/ethnicity		
Black	4,140 (6.54)	
White	42,543 (67.25)	
Hispanic	12,062 (19.07)	
Native American/Alaska Native	340 (0.54)	
Asian	4,177 (6.6)	

Table 2. Description of Sample Age by Adequate Prenatal Care (N = 54,591).

Characteristic	n (%)
Combined parental age (years)	
Both young (≤20)	762 (1.4)***
Both older (21-45)	51,597 (94.52)***
Young mother/old father (≤20/21-45)	1,981 (3.63)***
Old mother/young father (21-45/≤20)	251 (0.46)***

***p < .0005.

Table 3. Cumulative Fraction of Infant Death for Combined Parental Age (N = 63,754).

Age at death (days)	Cumulative fraction			
0	BothYoung	BothOld	YoungmOldf	OldmYoungf
30	0.00399	0.00327	0.00477	0.00865
60	0.00599	0.00365	0.00514	0.0144
90	0.00599	0.00392	0.00588	0.0144
120	0.00599	0.00421	0.00624	0.0144
150	0.00599	0.00439	0.00661	0.0144
180	0.00599	0.00444	0.00661	0.0144
210	0.00599	0.00452	0.00661	0.0144
240	0.00599	0.00459	0.00698	0.0144
270	0.00599	0.00467	0.00734	0.0144
300	0.00599	0.00473	0.00734	0.0144
330	0.00599	0.00476	0.00734	0.0144
360	0.00599	0.00479	0.00734	0.0144

(OldmYoungf) had the highest risk of infant mortality, which was statistically significant (hazard ratio = 2.67, p < .05). For couples that were both adolescents, compared with those both adult, the hazard risk for infant mortality was lower by 10.4%. Married couples with an adolescent mother and adult father (YoungmOldf) had an infant mortality risk of 1.26 times higher than that of adult couples.

Table 4. Parental Age and Factors Predicting Infant Mortality for Married Couples (N = 63,754).

	Hazard ratio	
Characteristic	Model 1	Model 2
Combined parental age		
BothYoung	0.896	0.97
YoungmOldf	1.262	1.192
OldmYoungf	2.671*	2.775
BothOld	Reference	Reference
Adequate prenatal care		0.367***
Intermediate prenatal care		0.82
Mother's education	0.829**	0.91
Maternal race/ethnicity		
White	Reference	Reference
Non-Hispanic Black	2.386***	2.146***
Hispanic	0.827	0.844
Asian	0.615	0.575
Native American/Alaska Native	1.714	1.643

*p < .05. **p < .005. ***p < .0005.

As maternal education increases by 1 unit, the risk of infant mortality decreased by 17.1%. This was also a statistically significant finding. Non-Hispanic Black mothers had an infant mortality risk that was 2.5 times that of White women and was statistically significant. Native

American/Alaskan native mothers were also at an increased risk for infant mortality but to a lesser extent than non-Hispanic Black women. Native American/Alaskan native mothers were at an approximately 1.68 times the risk of infant mortality compared with White mothers. Contrastingly, Asian mothers had a 35.4% decrease in infant mortality risk compared with White mothers. Hispanic mothers were also at a 15% decreased risk of infant death. None of the findings were significant for race except for mothers who were Black.

Table 4 also provides results from the Cox proportional hazard analysis with prenatal care as a mediator (Model 2). When the mediator was added, the association between combined parental age was no longer statistically significant and as a result, a calculation of the risk of infant death explained by adequate prenatal care was not necessary.

Discussion

The findings indicate that independent of maternal education and race/ethnicity, adolescent fathers adds additional risk, above and beyond that of maternal age, only for adult mothers (21-45 years). Adolescent couples had a decreased risk of infant mortality and adult fathers added only a slight risk for infant mortality. Additionally, the latter association was significant, providing support for the first hypothesis, although the effect was only observed for adult mothers.

The mediation analysis showed that adequate prenatal care did not significantly mediate the relationship between combined parental age and infant mortality. Although prenatal care generally mediates the risk of infant mortality, there may be social and environmental factors, not taken into account in this study, that affect either the timing or frequency of prenatal care.

Although paternal age has an effect on infant mortality independently, this study contributes to the literature by examining the effect of paternal age above and beyond maternal age using a combined parental age variable. Much of the literature on parental age and birth outcomes has focused on maternal age. Several studies have shown that young and older mothers have an increased risk of serious birth and infant health outcomes, such as preterm birth, low birth weight, and infant mortality. Studies examining the role of paternal age are slowly building momentum but have not garnered the magnitude or attention that research on maternal age has. This study highlights the importance of adolescent paternal age as a significant factor in the risk of infant death. These findings align with the few studies that have examined the impact of younger fathers on adverse birth outcomes (Chen et al., 2008; Lian, Zack, & Erickson, 1986; Olshan, Schnitzer, & Baird, 1994). Although the mechanisms by which young paternal age can affect infant death are not clear, we suggest several possible explanations of our findings. The difference in age between adult mothers and adolescent fathers may add an additional layer of complexity to the relationship and increase maternal stress. Higher levels of maternal stress have been associated with an increase in the risk of preterm birth and infant death (Hobel, Goldstein, & Barrett, 2008). Additionally, anxiety during pregnancy is linked to adverse birth outcomes (Brooke, Anderson, Bland, Peacock, & Stewart, 1989; Gorsuch & Key, 1974; Molfese et al., 1987) and shorter gestation periods (Rini, Dunkel-Schetter, Wadhwa, & Sandman, 1999). The multiple social factors accompanied by adolescence may lead to maternal stress that is on the causal pathway to infant mortality. Adolescent fathers are more likely to have employment and economic challenges and are more likely to be economically disadvantaged compared with adult fathers (Lerman, 1993a, 1993b). Research suggests that paternal involvement, which has been recognized as contributing to child development and health for many decades, is likely to affect infant mortality through the mother's well-being, primarily her access to resources and support (Alio et al., 2011). With regard to the support that fathers provide for mothers during the pregnancy, studies suggest that the relationship between mothers and fathers is correlated with the risk for poor birth outcomes (Alio et al., 2011). These challenges may affect adolescent fathers' relationship with the mother of their unborn child by adding stress to an already difficult situation, resulting in an anxiety-filled pregnancy, thus increasing the risk of infant death. Additionally, the dynamics of the relationship may be affected by domestic violence or lack of financial or emotional support that negatively influences mothers' anxiety, physical and emotional health. Overall, the current social climate and fragmented social policies do not encourage father's involvement as the mother is often seen as the most important individual during pregnancy (Alio et al., 2011).

Although this study has produced interesting findings, it is not without limitations. One limitation is in the way the combined parental age variable was defined. Researchers must build on this study by disaggregating the age categories and further refining the age measurements. Furthermore, the number of missing data on fathers in addition to the restriction of the analysis to married couples limits our ability to generalize the findings to unmarried couples. The data set did not include information on paternal education or income and so these variables were not included in the analysis. Young fathers are more likely to have lower educational attainment (Kiernan, 2007), so, analyzing the contribution of this variable may have yielded significant findings.

Despite these limitations, this study has important strengths. Although previous research on paternal age and infant mortality have used a nationally representative sample, this study is the first of its kind to combine paternal age and examine any additional risk that paternal age supplies to maternal age in the relationship with infant mortality. This research adds new and valuable information to the body of literature examining the relationship between paternal age and infant mortality. Although the mechanisms by which adolescent fathers may add to an increased risk of infant mortality are not entirely clear, our speculations provide some insight into the plausibility of this association. Additional research is needed to examine the biological plausibility of the link between adolescent paternal age and infant mortality by investigating the cause of infant death.

Conclusion

Adolescent fathers face excess stress in their lives as they are challenged with not only the transition into a new stage of life that comes with puberty and navigating new levels of social relationships, but also fatherhood and parenting and the associated responsibilities. For young fathers, the transition from adolescence to fatherhood can be challenging and add excess stress to their lives (Lerman, 1993b). This study highlights the need to examine young paternal influences on pregnancy and birth outcomes. Clinicians and policy makers must take paternal biological and social factors into account when designing interventions and programs to reduce infant mortality rates in the United States. This article suggests that more research is needed to understand the role of paternal age in the risk of infant mortality. Interventions would benefit from taking into consideration the different needs that adolescent fathers face as opposed to middle-aged fathers as well as those of older fathers. This study speculates that age difference between partners may add an additional layer of stress and complexities to the paternal and maternal relationship, which can influence birth outcomes gestationally, and even within the first years of the life of the newborn. Addressing these special issues can produce increased benefits for participants and ultimately positively influence current and future infant mortality rates. With regard to social support throughout the pregnancy period, the addition of programs to increase paternal support throughout the pregnancy period has been shown to mitigate the effects of stress and lower the risk of preterm birth for the mother (Alio et al., 2011). Finally, research has shown that when women receive more support during their pregnancy, they are more likely to receive early prenatal care (Alio et al., 2011).

This study highlights the importance and benefits of further education for both parents. Higher parental education levels have been revealed to lend toward more advantageous health outcomes. Lower paternal education poses economic challenges and barriers related to health and employment, with consequences reaching as far as mental and emotional health, beyond the physical and material needs. Increased education can provide a means for more stable employment, stable or higher income, and therefore increased access and hopeful utilization of health care, especially prenatally.

Declaration of Conflicting Interests

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