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The Interplay Between Child and Maternal Health: Reciprocal Relationships and Cumulative Disadvantage During Childhood and Adolescence*

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Abstract

While many studies use parental socioeconomic status and health to predict children's health, this study examines the interplay over time between child and maternal health across childhood and adolescence. Using data from women in the National Longitudinal Study of Youth 1979 cohort and their children (N = 2,225), autoregressive cross-lagged models demonstrate that at particular points during childhood and adolescence, there are direct effects of child activity limitations on maternal health limitations two years later and direct effects of maternal health limitations on child activity limitations two years later, net of a range of health-relevant time-varying and time-invariant covariates. Furthermore, there are indirect effects of child activity limitations on subsequent maternal health limitations and indirect effects of maternal health limitations on subsequent child activity limitations via intervening health statuses. This study examines how the interplay between child and maternal health unfolds over time and describes how these interdependent statuses jointly experience health disadvantages.

Background

The prevalence of childhood chronic conditions and activity limitations has substantially increased over the last several decades. Increases in the prevalence of many conditions are due to actual increases as well as the confluence of improved survival, greater awareness and detection of certain conditions, and better availability of certain treatments (Van Cleave, Gortmaker, and Perrin 2010). In the United States, the increasing prevalence of child health conditions and activity limitations has shifted the focus from children's survival to improving quality of life for children and their families.

Life course scholars and systems theorists highlight the embeddedness of individuals within institutions, social ties, and time (Bronfenbrenner 1977; Elder and Giele 2009). In these complementary frameworks, the notion that individual lives are linked means that one's health status is a potentially formative dimension of inequality in the lives of their family members (Elder 1985; Moen and Hernandez 2009). Research on the socioeconomic origins of adult health and mortality points to a range of prenatal and childhood conditions and experiences, shaped by parental health and socioeconomic status, that have far-reaching consequences for a child's health and socioeconomic status in their adulthood. With regard to maternal and child health, there is a link between the fetal environment and adult morbidity and mortality through physiological adaptations (see, e.g., Barker 1998), and more recent evidence that maternal depression is associated with children's risk of depression and chronic pain as an adult (Goosby 2013). In addition to adult outcomes, recent research points to the role of maternal physical and mental health in predicting a range of child health conditions and activity limitations during childhood (Hardie and Lansdale 2013; Turney 2011, 2012), in part through the impact of maternal physical and mental health conditions on parenting practices, the quality of parent-child

interactions, time spent with children, the ability to seek medical care, and economic resources (Frech and Kimbro 2001; Goodman 2007; Hogan 2007).

However, the intergenerational association may flow in the other direction, such that a child in poor health influences the physical and mental health of family members. Parents of children in poor health or with activity limitations experience greater care burden compared to parents of children with no health limitations: they are responsible for more of the physical care of their children; helping children cope physically and emotionally with their condition; negotiating medical, educational, recreational, and other services; and experiencing concerns about their child's well-being and future prospects (Hogan et al. 2012; Raina et al. 2004). The increased demands on parents of children in poor health are associated with role strain (Breslau, Salkever, and Staruch 1982; Pearlin and Schooler 1978; Vaughan et al. 2013; Waddington and Busch-Rossnagel 1992) and may further manifest in poor health behaviors as a means to cope with stress and due to time constraints (Hogan et al. 2012; Mezuk et al. 2013).

Clinical and population-based studies have demonstrated an increased risk of adverse physical and mental health outcomes for mothers of children with activity limitations, developmental disabilities, and chronic health conditions compared to mothers of healthier children (Early et al. 2002; Garbarski and Witt 2013; Kuhlthau et al. 2010; Raina et al. 2005; Seltzer et al. 2001; Singer 2006; Witt et al. 2009). The reasons that the majority of these prior studies look at maternal outcomes are both theoretical and practical, in that mothers, most often the primary caregivers of children, are more likely to be affected by poor child health as well as be the parent interviewed in parent-child data collection efforts. Studies by Kiecolt-Glaser and colleagues (1996, 2003) and Miller and colleagues (2002, 2008) show that caregivers of family members with health conditions exhibit biomarker measures associated with reduced immune

system functioning and increased inflammation compared to matched control subjects. Consistent with the stress process perspective, these studies document a potential biologic pathway through which exposure to caregiving stress contributes to the development and progression of poor health outcomes (see, e.g., McEwan and Seeman 1999; Pearlin 1989; Pearlin et al. 2005; Taylor and Seeman 1999; Thoits 2010).

In addition to concurrent associations between maternal and child health, many prior studies, particularly those focused on predicting child health, document associations that persist over time spanning from months to several years. The potential for the effects of child and maternal health on one another to persist over some period of time is consistent with the concept of cumulative disadvantage, a mechanism for inequality in which an adverse relative position at one point in time engenders relative disadvantages or inequalities in the future (see, e.g., Dannefer 1987; DiPrete and Eirich 2006; O'Rand 1996; Willson, Shuey, and Elder 2007). In particular, research concerned with the effects of maternal health on child health or vice versa has documented patterns consistent with *path-dependent cumulative disadvantage* or *chains of risk*, in which earlier health-relevant factors have direct effects on later health outcomes as well as indirect effects on later health outcomes via intervening mechanisms such as health behaviors, socioeconomic factors, or health status at an intervening point in time (see, e.g., Aneshensel 2009; Hartshorn, Whitbeck, and Hoyt 2012; Hayward and Gorman 2004; Kuh et al. 2003; Willson, Shuey, and Elder 2007).

Current study

In order to fully account for dimensions of inequality in individual health, it is necessary to account for the interdependence of individual lives with relevant others at particular stages in the life course. This study seeks to unite previous strains of research in a single model by

attending to the interplay, or the dyadic and dynamic relationship, between child and maternal health: dyadic in that the interdependence of maternal and child health is explicitly accounted for, and dynamic in that maternal and child health statuses can change vis-à-vis one another and over time. Based on previous research, which focuses on family health and socioeconomic factors predicting child health or child health predicting maternal health, it is expected that child and maternal health mutually influence one another during childhood and adolescence. Autoregressive cross-lagged models are used to examine the reciprocal relationship between child and maternal health during this period of the life course, delineating direct effects of child health on maternal health two years later net of prior maternal health and direct effect of maternal health on child health two years later net of prior child health. The use of autoregressive cross-lagged models highlights the potential for path-dependent cumulative disadvantage in the interplay between child and maternal health during childhood and adolescence in direct effects on health two years later as well as the indirect pathways through which child health affects subsequent maternal health and vice versa via intervening health statuses.

Data and Methods

Data

Data come from the National Longitudinal Study of Youth (NLSY) 1979 cohort, a nationally representative sample of 12,686 men and women who were between the ages of 14 and 22 when first surveyed in 1979 (http://www.bls.gov/nls/nlsy79.htm). Data were collected yearly from 1979 to 1994, and biennially from 1996 to the present (2008 was the most recent wave of data used in this analysis). Data on the children of NLSY 1979 female respondents come from the NLSY Child and Young Adult sample (http://www.bls.gov/nls/nlsy79ch.htm); these data have been collected biennially from 1986 to the present.

The sample was first restricted to children for whom data were collected during the course of their childhood through age 18, or children born between 1984 and 1991. There are 11,495 children of the NLSY 1979 women, and 41% of these children (4,694) were born in these cohorts. The data were pooled across time so that time 1 corresponded to children age 1 through 2 (because the data were collected biennially), time 2 to children age 3 through 4, and so on. Thus, time 1 was 1986 for children born in 1984 and 1985, 1988 for children born in 1986 and 1987, 1990 for children born in 1988 and 1989, and 1992 for children born in 1990 and 1991; time 2 was 1988 for children born in 1984 and 1985, and so on. The sample was then restricted to mother-child pairs in which information on the child's activity limitation status was reported during at least 6 of the 9 waves in which the child is between the ages of 1 and 18: 42% of the children born between 1984 and 1991 had data on their activity limitations in all 9 waves of interest, and another 18% were missing data in just one, two or three waves, yielding a sample of 3,348 children. In order to examine the interrelationship between child and maternal health over time, one child was randomly selected from mothers who reported on multiple children (so that the analysis included each mother exactly once), yielding a final sample of 2,225 mother-child pairs of data for analysis. The average age at birth of mothers in the analytic sample is slightly older than those who are not in the analytic sample (26.7 vs. 25.5) given that child data were not collected until 1986, when the women were aged 21 to 29.

Measures

Child activity limitation status. Researchers have begun to move away from categorical or disease-specific approach to defining child health based on evidence of commonalities across childhood illnesses in terms of child functional status and the experiences of the children's families (Kohen et al. 2007; Stein et al. 1993). Defining child health using survey questions about activity limitations captures how children are physically, emotionally, or cognitively

limited in a way that affects their age-appropriate activities, and improves upon the disease-specific approach in that measures of child health are not limited to those who have medical care. The present study uses child activity limitations as the measure of children's health status. Over the seven waves of data (from ages 1 or 2 to ages 13 or 14), mothers answered six questions about their child's activity limitation status: whether the child currently had a condition that limited regular school attendance, limited regular school work, limited usual childhood physical activities, required frequent attention or treatment from a health professional, required the use of medicine or drugs, or required the use of any special equipment. If any one of these items had a "yes" response in a particular wave of data, the child was coded as having an activity limitation for that wave of data. If all items had a "no" response in that wave of data, the child was coded as having no limitation. Children aged 15 and over reported on a slightly different set of activity limitations: whether they had a limitation that affected the amount or kind of work they did (or could do) for pay, an aggregated question about whether they had a limitation that limited school attendance or the ability to do school work, and an aggregated question about whether they had a condition that required medical attention, the use of drugs, or equipment.

Maternal health limitations derive from questions about maternal limitations in work due to health, the only health measures consistently collected in each wave of the NLSY 1979. Measures of health-induced work limitations are highly correlated with other self-reported health measures common in surveys and produce findings comparable to these measures when used as a dependent variable in multivariate analysis (Bound 1991). Measures of health-induced work limitations are also highly correlated with disability, although the measure tends to underestimate the prevalence of disability in the working-age population (Burkhauser et al. 2002). Mothers were coded as having a limitation in work due to their health if they answered "yes" to any of the

following questions: “[Are you/Would you be] limited in the kind of work you [could] do on a job for pay because of your health?”; “[Are you/Would you be] limited in the amounts of work you [could] do because of your health?”; (for those not working for pay) “Would your health keep you from working on a job for pay now?” Respondents reporting “no” to all three questions were coded as not having a limitation in work due to their health.

Covariates. A range of health-relevant time-varying covariates was included in the analysis. Household poverty status and household asset poverty status were included as broad measures of family socioeconomic status to account for the influence of socioeconomic factors on health (Adler et al. 1994; Link and Phelan 1995; Robert and House 2000). *Household poverty status* is a constructed dichotomous variable in the NLSY 1979 data, indicating whether the total family income is below (= 1) or above (= 0) the federal poverty level for households of the respondent’s reported size as issued by the U.S. Department of Health and Human Services. *Household asset poverty status* is defined as whether a household has enough net worth (= 0) or not (= 1) to subsist at the federal poverty level for the three months (Haveman and Wolff 2005). Asset poverty status was constructed using summary measures in the NLSY for household net worth and poverty levels for households of the reported size, using household net worth and poverty levels from the preceding wave when household net worth was not measured in the biennial survey (i.e., 2000 and 2004 in place of 2002 and 2006, respectively). Maternal labor force participation at each wave was measured as *any time spent unemployed* (1 = yes, 0 = no) and *any time spent out of the labor force* (1 = yes, 0 = no) in the last year. Time unemployed is defined as any time spent unemployed and available for work at least one week in the last year, while time out of the labor force is defined as any time spent unemployed and unavailable for work. “Unavailable” means that the person was not looking for work, for example because they

were engaged in housework, in school, unable to work because of long-term physical or mental illness, retired, or voluntarily idle. Thus mothers could be both unemployed and out of the labor force in a given year. Additional time-varying covariates include the *number of children* in the household, whether the mother is *married* (= 1) or not (= 0), maternal *body mass index* (BMI; using the normal weight, overweight, obese cutoffs recommended by the Centers for Disease Control and Prevention and including the very few underweight mothers in the normal weight category for analysis), whether the *mother is covered by health insurance* (= 1) or not (= 0), and whether the *child is covered by health insurance* (= 1) or not (= 0).

Time-invariant covariates include whether the *child is female* (= 1), maternal *race* (black = 1, non-black = 0), *ethnicity* (Hispanic/Latina = 1, non-Hispanic/Latina = 0), *age*, *education* at time 1 (less than high school, high school, some college compared to college or more; time-invariant because education did not change much over the study period), and *propensity to be included in the analytic sample* based on certain characteristics from the first wave the NLSY79. Logistic regressions predicting inclusion in the analytic sample yielded predicted probabilities or propensities of inclusion in the analytic sample (Morgan and Sørensen 1999; Winship and Sobel 2004), which are used to model the missing data mechanism and correct the correlation of the error term with the covariates due to this missing data (Morgan and Sørensen 1999; Willson, Shuey and Elder 2007; Winship and Sobel 2004). To the extent that the inclusion model was correctly specified, it appears that selection bias does not change the results once the time-varying and time-invariant covariates are included, as there were neither substantive nor significant differences between the models reported here and the models without the inclusion adjustment (results available upon request). Table A.1 in Appendix A (available in an online supplement) presents the unweighted and weighted descriptive statistics for the analytic sample.

Methods

Autoregressive cross-lagged models were used to examine the interplay over time between child activity limitations and maternal health limitations. Models were estimated in Mplus Version 7, using the Theta parameterization and a weighted least squares estimator with robust standard errors (WLSMV) per the Mplus model specifications for endogenous variables being used as predictors (Muthén and Muthén 2012). Following Bollen and Curran (2006), autoregressive parameters are estimated within each measure and cross-lagged parameters are estimated between each measure, such that m_t (maternal health limitations at time *t*) is an additive combination of m_{t-1}, c_{t-1} (child activity limitations at time *t*-1), and time-specific residual, and c_t is an additive combination of c_{t-1}, m_{t-1}, and time-specific residual (see Figure 1):

$$m_{it} = \alpha_{mt} + \rho_{m_t m_{t-1}} m_{i,t-1} + \rho_{m_t c_{t-1}} c_{i,t-1} + \epsilon_{mit}$$

$$c_{it} = \alpha_{ct} + \rho_{c_t m_{t-1}} m_{i,t-1} + \rho_{c_t c_{t-1}} c_{i,t-1} + \epsilon_{cit}$$

Time-specific associations in the error terms are modeled such that ϵ_{mit} covaries with ϵ_{cit}. As seen in Figure 1, the initial measures of *m* and *c* are treated as exogenous variables such that

$$m_{i1} = \alpha_{m1} + \epsilon_{mi1}$$

$$c_{i1} = \alpha_{c1} + \epsilon_{ci1}$$

The WLSMV estimator yields a probit model in which the inverse standard normal distribution of the probability of the endogenous variable is modeled as a linear combination of predictors. Thus, the cross-lagged probit coefficients from this model are interpreted as the change in z-score for m_t given a one-unit change in c_{t-1} above and beyond the influence of m_{t-1}, and the change in z-score for c_t given a one-unit change in m_{t-1} above and beyond the influence of c_{t-1}. Autoregressive cross-lagged models can be used to trace indirect effects among repeated measures via intervening time points, e.g., the effect of child activity limitations at time 1 on

maternal health limitations at time 9 via the repeated measures in between (Selig and Preacher 2009). Parameter estimates for indirect effects in terms of the latent response variable y* were calculated in Mplus as the product of coefficients using the *model indirect* command (MacKinnon et al. 2007; MacKinnon 2007). Percentile bootstrap confidence intervals (95 percent) were estimated to test indirect effects (see, e.g., Fritz, Taylor, and MacKinnon 2012; Shrout and Bolger 2002); the bivariate autoregressive cross-lagged model is used to test indirect effects because bootstrap confidence intervals are not available for multiply imputed data. The variance explained for each repeated measure is estimated in terms of y*. The Theta parameterization in Mplus fixes the residual variance for the latent response variable to 1 at the first endogenous time point and freely estimates the variance of the latent response variable at other time points (Muthén and Muthén 2012), contributing to the low R-squared estimates at the first endogenous time point for each repeated measure.

In models with large samples, the chi-square test is often statistically significant, indicating that the model is not a good fit to the data. Thus, the evaluation of model fit considers goodness of fit statistics in addition to chi-square. A root mean square error of approximation (RMSEA) of less than 0.05 is considered a good fit, while values greater than .9 and close to 1 suggest good fit for the comparative fit index (CFI) and the Tucker-Lewis index (TLI) (Bollen and Curran 2006).

In models that include covariates, each repeated measure is regressed on the time-invariant and time-varying covariates described above. Covariates from the preceding wave were used in order to have a more exogenous measure of each covariate, although the results are substantively and significantly the same when time-varying covariates from the same wave are included in the model. Given that most cases were missing values for at least one of the time-

varying or time-invariant covariates, values for item-missing data were derived using multivariate imputation by chained equations in Stata Version 12. The results reported for models that include covariates are coefficients averaged across the five imputed datasets and adjusted standard errors using Rubin's (1987) formula that combines the estimated variability within and across replications with a small correction factor to the variance.

The analysis begins with the bivariate autoregressive cross-lagged model of child activity limitations and maternal health limitations, with listwise-deleted cases for those missing data on either measure at time 1. Chi-square difference tests are used to compare this model to 1) the model in which the autoregressive and cross-lagged parameters are constrained to be equal across time and 2) multiple group models comparing parameter estimates across maternal racial and ethnic groups (black non-Hispanic, Hispanic or Latina, and non-black non-Hispanic). The bivariate autoregressive cross-lagged model is then estimated with controls for time-invariant and time-varying covariates. The results of additional analyses are also discussed: models with each type of activity limitation included as the repeated measure to examine whether the results differ across the types of activity limitations, fixed effects analyses to examine whether child activity limitations and maternal health limitations exert their influence on one another net of unmeasured stable covariates, and models that replicate those presented in the results with the addition of the first available measure of depressive symptoms to examine one potential proxy for maternal reporting bias.

Results

The interplay between child activity limitations and maternal health limitations during childhood and adolescence was examined in a bivariate autoregressive cross-lagged model. This model was a good fit to the data (X^2 = 316.58, df=112, RMSEA=.030, CFI=.978, TLI=.971),

although the chi-square test statistic was statistically significant. Multiple group models were used to test for differences in the model parameters across maternal racial and ethnic groups given the racial and ethnic disparities that exist across a range of health outcomes (see, e.g., Geronimus et al. 2006; House and Williams 2000, Kelley-Moore and Ferraro 2004). Chi-square difference tests showed no significant differences in the parameters across groups, thus one model was estimated for all mothers in subsequent analyses. Similarly, chi-square difference tests indicated that the model in which the autoregressive and cross-lagged parameters were freely estimated was a better fit to the data than the model in which each set of autoregressive and cross-lagged parameters were constrained to be equal over time (e.g., all child activity limitations autoregressive parameters are constrained to be equal over time). Thus, the relationship between child activity limitations and maternal health limitations varies over childhood and adolescence, and these parameters were freely estimated in subsequent models.

Model 1 in Table 1 gives the parameter estimates for the autoregressive cross-lagged model of child activity limitations and maternal health limitations with freely estimated parameters and no covariates. Child activity limitations are an important predictor of child activity limitations two years later, and maternal health limitations are an important predictor of maternal health limitations two years later. There are also statistically significant cross-lagged effects of maternal health limitations on child activity limitations and vice versa, such that maternal health limitations increase the probability of child activity limitations above and beyond the influence of prior child activity limitations, and child activity limitations increase the probability of maternal health limitations above and beyond the influence of prior maternal health limitations. For example, child activity limitations at time 1 (when the child is 1 or 2) are associated with a .365 change in the z-score of maternal health limitations at time 2 (when the

child is 3 or 4) above and beyond the influence of maternal health limitations at time 1. Other statistically significant cross-lagged effects in Model 1 include the effect of child activity limitations at time 4 on maternal health limitations at time 5 and the effect of maternal health limitations at times 2 and 3 on child activity limitations at times 3 and 4, respectively. The R-squared value steadily increases for each repeated measure with the exception of child activity limitations at time 8—precisely when the reporter switches from mother to child—offering evidence that mothers and children may be drawing on different information when reporting child activity limitations (see, e.g., Baca et al. 2010; Eiser and Morse 2001; Fosse and Haas 2009; Theunissen et al. 1998, for discussions about the size and direction of discrepancies in maternal and child reports across a range of health measures).

--Table 1 about here--

Model 2 in Table 1 shows the same parameter estimates in a bivariate autoregressive cross-lagged model of child activity limitations and maternal health limitations that regresses each repeated measure on relevant time-invariant and time-varying covariates. This model was a good fit to the data (X^2 = 1390.30, df=1232, RMSEA=.008, CFI=.979, TLI=.973; fit statistics are averaged across the imputed datasets for parsimony). The effect of maternal health limitations at time 2 on child activity limitations at time 3 is no longer statistically significant in Model 2, while both the effects of maternal health limitations at time 6 on child activity limitations at time 7 and child activity limitations at time 7 on maternal health limitations at time 8 are statistically significant. Although more of the variance is explained at the first endogenous time point (time 2) by the time-varying and time-invariant covariates compared to Model 1, the R-squared values for the repeated measures in Model 2 are only slightly larger than those in Model 1.

--Table 2 about here--

One contribution of the autoregressive cross-lagged modeling strategy is to illustrate the potential for the effects of child activity limitations and maternal health limitations on one another persist over time as more distal, indirect effects on later measures. For example, Table 2 shows the total indirect effects of child activity limitations on maternal health limitations at time 9 as well as the specific indirect pathways within the 95 percent confidence interval; Table 3 shows the same for the effects of maternal health limitations on child activity limitations at time 9. Overall, the specific indirect pathways through which child activity limitations influence subsequent maternal health limitations and vice versa can be characterized by the strength of the autoregressive relationships and particular statistically significant cross-lagged relationships.

--Table 3 about here--

Additional analyses

Types of activity limitations. To examine whether the cross-lagged and indirect effects vary by type of activity limitation considered, the analysis was replicated using each type of child activity limitation as the repeated measure of interest (results available upon request).[1] This set of analyses includes times 1 through 7 because children age 15 and over were asked aggregated questions about types of limitations. Also, because questions about school attendance and work were rarely asked at times 1 and 2—likely depending on whether daycare or preschool counted as "school"—the analysis of those specific limitations was limited to times 3 and 7.

The cross-lagged effect of child activity limitations at time 1 on maternal health limitations at time 2 was statistically significant for child activity limitations requiring treatment from a medical professional; the effect of child activity limitations at time 4 on maternal health limitations at time 5 was statistically significant for limitations that limit school attendance, limit school work, and require medication. The effect of maternal health limitations at time 3 on child

activity limitations at time 4 was statistically significant for limitations that limit school attendance, limit school work, require treatment from a medical professional, and require medication; the effect of maternal health limitations at time 6 on child activity limitations at time 7 was statistically significant for limitations that limit school attendance and limit physical activities. Specific cross-lagged relationships that were not found when using the global measure of child activity limitations include a positive effect of child limitations limiting school attendance at time 6 on maternal health limitations at time 7, and a negative effect of child limitations requiring medication at time 6 on maternal health limitations at time 7. Furthermore, there were no significant cross-lagged effects between limitations requiring special equipment and maternal health limitations, although a lack of statistical power for this and other less common types of limitations may lead to statistically nonsignificant associations.

Unobserved heterogeneity. While autoregressive cross-lagged models account for the temporal ordering of repeated measures to aid in causal interpretation, the association between maternal and child health may be overestimated due to shared environmental exposure, genes, and other unmeasured variables common to both mother and child. Model 2 controls for a range of time-invariant and time-varying covariates that could lead to a spurious relationship between child activity limitations and maternal health limitations, but the results may be overestimated to the extent that these controls are not exhaustive or are imperfect measures of the theoretical variables they proxy. Additional fixed effects logistic regression models were estimated to examine whether the effects of child activity limitations and maternal health limitations on one another remain when unmeasured time-invariant covariates are accounted for in addition to time-varying covariates. Lagged endogenous variables in a fixed effects analysis can bias results (Allison 2009), thus the autoregressive cross-lagged models were not estimated with fixed

effects. The additional analyses demonstrate that changes from no child activity limitation to a reported activity limitation increase the odds of maternal health limitations, and changes in maternal health limitation status increase the odds of child activity limitations, net of unmeasured stable covariates and relevant time-varying covariates (results available upon request).

Common rater bias. Common rater bias may influence the results, as mothers report on all measures except for child activity limitations at times 8 and 9. Additional analyses including the regression of each repeated measure on maternal depressive symptoms in 1992 (the first wave in which depressive symptoms were assessed) yield nearly identical results to those reported here, thus common rater bias is not a concern to the extent that depressive symptoms at one point in time capture dispositional traits such as the propensity to report positively or negatively to survey items. Similarly, the fixed-effects analyses predicting both child activity limitations and maternal health limitations assuage concerns about common rater bias to the extent that such common rater effects are time-invariant. However, future studies should continue to examine the potential for time-varying common rater bias and its role in studies about familial processes in which one person is reporting on all measures of interest.

Discussion

The notion that one's health is influential in the lives of their family members means that policy efforts to reduce adverse health outcomes for individuals may have additional health benefits for others in their social network (Christakis and Allison 2006; Umberson and Montez 2010). This study examines how the interplay between child and maternal health unfolds over time, supporting the notion that the interdependence of individual lives with relevant others at particular stages in the life course should be examined to fully account for the dimensions of inequality in individual health. By uniting child and maternal health in a single model, the results

of this study demonstrate that child activity limitations and maternal health limitations mutually influence one another during childhood and adolescence.

In particular, this study documents direct effects of child activity limitations on maternal health limitations two years later and vice versa at particular points during childhood and adolescence, net of health-relevant time-varying and time-invariant covariates. In addition, the analytic strategy illustrates the potential for indirect effects of child activity limitations on subsequent maternal health limitations and vice versa via repeated measures (see, e.g., Hartshorn et al 2012; Selig and Preacher 2009). Causal mediation methods (see, e.g., Muthen 2011) with extensions to repeated and dyadic measures will be important next steps for future research in terms of elucidating the patterns through which health effects persist over time.

Health status is dynamic, apt to experience several changes over even short periods of the life course (see, e.g., Van Cleave et al. 2010), requiring an analytic framework of stratification over time that accounts for the time-specific impact of formative life events or episodes. The use of autoregressive cross-lagged models to trace direct and indirect effects corresponds to one operationalization of cumulative disadvantage known as path-dependent cumulative disadvantage; however, several other operationalizations of cumulative disadvantage or cumulative inequality exist in the literature to describe accumulation within and across independent and dependent variables (see, e.g., Dannefer 1987; DiPrete and Eirich 2006; Ferraro, Shippee, and Schafer 2009; O'Rand 1996; Pearlin et al. 2005). These will be useful to consider in future research examining the over-time interplay between child and maternal health, particularly in terms of accounting for the chronicity and severity of maternal and child health conditions and the development of intraindividual health trajectories across the life course.

Additional analyses show that the interrelationships between types of child activity limitations and maternal health limitations coincide with the age of the child and the proposed parental resource, time, and stress mechanisms through which maternal and child health exert their influence on one another. For example, the relationship observed in the aggregate from child activity limitations at time 4 to maternal health at time 5 is linked to types of limitations that require parental resource and time investments, for example, in helping with school work or dealing with medications. In addition, the results are consistent with studies that find that maternal health is associated with a range of child health outcomes (see, e.g., Hardie and Lansdale 2013; Turney 2011, 2012), and identifies early school ages (time 3) and pre-adolescence (time 6) as times when maternal health is particularly influential for a range of subsequent child activity limitations. Overall, the results of this study point to places in the chain of risk where intervention (Aneshensel 2009) may reduce poor health in families and reduce the long term impacts of poor child health on later life health and socioeconomic outcomes (see, e.g., Haas 2006; Palloni 2006; Smith 2009a, 2009b).

As with any secondary data analysis, the analysis is restricted to the available variables, meaning that there may be some distance between the concept of interest and its operationalization. A measure of child activity limitations is likely more relevant for policy decisions in which functionality, rather than diagnosis, is the target. Furthermore, child activity limitation status captures more about what the child can do rather than a specific condition the child may have, with the former having arguably more important implications for maternal health in terms of the proposed resource, time, and stress process mechanisms. However, child activity limitation status incorporates a range of limitations with little information on their severity. Research shows that the total number of adverse events, stressors, or conditions is

associated with worse physical and mental health outcomes (see, e.g., Sameroff 1987; Seery, Holman and Silver 2010), thus measures of child health that contain information on the severity of limitations across multiple domains may yield more significant and graded relationships between child activity limitations and maternal health limitations. However, it is unclear whether severity could be meaningfully and objectively measured with parental-reported survey questions given that the severity ratings are potentially confounded with one's psychological or physiological response to the event or episode in question (Kessler 1997).

There are indirect measures of severity that demonstrate an association between child activity limitation severity and maternal health. The persistence of child activity limitations over two waves of data is associated with worse physical health and increased depressive symptoms in mothers compared with having a child with no, resolved, or newly reported activity limitations (Garbarski and Witt 2013). Furthermore, the number of additional children with activity limitations is associated with poor maternal mental—but not physical—health compared to having just one child with an activity limitation (Witt et al. 2009). The current study focuses on tracing the time-specific interplay between maternal and child health in a way that precludes incorporating the health of multiple children per mother or persistence over time. However, future research should focus on expanding models of the over-time interrelationships among family members' health and determinants thereof to incorporate information about different types of limitations and their severity among family members.

In addition, future research should attend to the intervening roles of socioeconomic status, relationship quality, and other resources and constraints in the relationship between child and maternal health. Previous research is equivocal about the effects of child health on potential intervening factors such as parental labor market outcomes and marital quality. Some studies

show that poor child health has a negative effect on labor market outcomes (Kuhlthau et al. 2010; Porterfield 2002; Powers 2001, Witt et al. 2009) while others do not (Kamp Dush, Schmeer, and Taylor 2013); Lukemeyer and colleagues (2000) note that the higher monetary costs reported for families of children with limitations renders the decision to work less clear in terms of offsetting financial costs or providing care. One study finds a moderating but not mediating association between child activity limitations and marital quality in predicting maternal physical and mental health (Garbarski and Witt 2013), and a meta-analysis finds that at least with respect to developmental disabilities, children's limitations have a smaller effect on parental marital quality than what was previously assumed in the literature (Risdal and Singer 2004).

Thus, the relationship between poor health in families and potential intervening factors may be more nuanced than what is observed in the aggregate, with heterogeneity in adaptation to adversity with respect to labor force participation and household decision-making processes. Furthermore, social ties have both positive (as a source of support) and negative (as a source of stress) consequences for health (Umberson, Crosnoe, and Reczek 2010), and the accumulation of life course insults can be mitigated by resiliency (Seery, Holman, and Silver 2010) or through compensatory mechanisms (Ferraro and Kelley-Moore 2003), pointing to the need to examine subgroup trajectories of risk and resilience in the over-time development of familial health. Indeed, there are positive aspects of caring for persons with disabilities or in poor health that are often unmeasured in surveys and might contribute to patterns of resiliency in physical and mental health (Hogan et al. 2012). Latent variable modeling to analyze constellations of health and socioeconomic risks within families (see, e.g., Hardie and Lansdale 2013), attending to how these constellations move through time, and incorporating methodologies to examine causal

mediation within a repeated measures framework (see, e.g., Muthén 2011 for a review), are important avenues for future research.

Despite the potential limitations with respect to unobserved heterogeneity and maternal reporting bias, this study provides an account of the interplay between child activity limitations and maternal health limitations, delineating particular points during childhood and adolescence in which child activity limitation affect subsequent maternal health limitations and maternal health limitations affect subsequent child activity limitations. Moving the framework from within individuals to across family members, future research should examine health effects among other family members as well as the multiple pathways through which these interdependent relationships unfold over time vis-à-vis additional mediating and moderating factors. Such research could further make the case, for example, that child health is a fundamental cause of maternal health in that the effects operate through multiple mechanisms and persist even when these mechanisms change (Link and Phelan 1995).

Notes

[1] The distribution of the types of child activity limitations for children varies with age. (Note that the percentages do not add to 100% as more than one type of limitation could be reported in this survey instrument.) Time 1 (ages 1-2): limits school attendance (0%), limits school work (0%), limits physical activities (63%), requires medical attention (40%), requires medication (28%), or requires the use of special equipment (15%). Time 2 (ages 3-4): 6%, 8%, 38%, 54%, 44%, 21%. Time 3 (ages 5-6): 12%, 19%, 31%, 58%, 55%, 23%. Time 4 (ages 7-8): 12%, 29%, 26%, 62%, 68%, 18%. Time 5 (ages 9-10): 17%, 25%, 23%, 54%. 74%, 16%. Time 6 (ages 11-12): 13%, 25%, 19%, 45%, 68%, 12%. Time 7 (ages 13-14): 13%, 20%, 13%, 36%, 54%, 6%.

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Table 1. Parameter Estimates from Autoregressive Cross-lagged Model of Maternal Health Limitations and Child Activity Limitations, NLSY 1979 and Child and Young Adult Sample[a]

	Model 1[b]				Model 2			
	Coefficient	S.E.		R^2	Coefficient	S.E.		R^2
Regression of…								
Mother time 2[a] on				.140				.332
Mother time 1	1.740	.153	***		1.899	.188	***	
Child time 1	.365	.127	**		.399	.173	*	
Mother time 3 on				.658				.652
Mother time 2	1.253	.176	***		1.124	.160	***	
Child time 2	.202	.122			.080	.100		
Mother time 4 on				.629				.648
Mother time 3	.760	.112	***		.775	.108	***	
Child time 3	.008	.068			.000	.060		
Mother time 5 on				.700				.723
Mother time 4	.869	.111	***		.913	.114	***	
Child time 4	.185	.060	**		.169	.069	*	
Mother time 6 on				.740				.740
Mother time 5	.920	.109	***		.867	.115	***	
Child time 5	.014	.051			.016	.050		
Mother time 7 on				.764				.769
Mother time 6	.921	.107	***		.931	.123	***	
Child time 6	-.018	.052			-.073	.051		
Mother time 8 on				.782				.799
Mother time 7	.902	.104	***		.883	.120	***	
Child time 7	.096	.057			.144	.061	*	
Mother time 9 on				.782				.841
Mother time 8	.873	.099	***		.894	.130	***	
Child time 8	.074	.083			.081	.085		
Child time 2 on				.079				.225
Child time 1	.943	.118	***		.926	.160	***	
Mother time 1	.157	.175			.019	.215		
Child time 3 on				.465				.465
Child time 2	.850	.105	***		.785	.084	***	
Mother time 2	.200	.089	*		.126	.082		
Child time 4 on				.613				.580
Child time 3	.852	.096	***		.765	.096	***	
Mother time 3	.216	.055	***		.229	.058	***	
Child time 5 on				.699				.704
Child time 4	.961	.106	***		.987	.103	***	
Mother time 4	-.057	.057			-.066	.054		
Child time 6 on				.688				.716
Child time 5	.820	.089	***		.845	.090	***	
Mother time 5	-.022	.053			-.060	.050		
Child time 7 on				.671				.725
Child time 6	.778	.082	***		.782	.082	***	
Mother time 6	.064	.043			.147	.044	***	

Child time 8 on				.426			.455
Child time 7	.474	.057	***		.458	.052	***	
Mother time 7	.066	.037			.002	.035		
Child time 9 on				.468			.530
Child time 8	.722	.086	***		.741	.080	***	
Mother time 8	-.042	.042			-.060	.038		
Residual covariance of…								
Child time 2 with maternal time 2	.060	.077			.103	.063		
Child time 3 with maternal time 3	-.356	.150	*		-.346	.127	**	
Child time 4 with maternal time 4	.025	.137			.069	.116		
Child time 5 with maternal time 5	.000	.118			.175	.128		
Child time 6 with maternal time 6	.188	.128			.209	.130		
Child time 7 with maternal time 7	-.119	.127			-.058	.139		
Child time 8 with maternal time 8	-.076	.121			-.030	.122		
Child time 9 with maternal time 9	.231	.128			.319	.145	*	

Notes

S.E. = standard error

* = p < .05, ** = p < .01, and ***= p < .001 (two-tailed)

[a] Children are ages 1 or 2 at time 1, 3 or 4 at time 2, 5 or 6 at time 3, 7 or 8 at time 4, 9 or 10 at time 5, 11 or 12 at time 6, and 13 or 14 at time 7, 15 or 16 at time 8, and 17 or 18 at time 9.

[b] Model 1 is the autoregressive cross-lagged model of child activity limitations and maternal health limitations with no covariates and listwise-deleted cases for those missing maternal health limitations or child activity limitations at time 1 (N = 2,093). Model 2 is estimated using multiply-imputed data with each repeated measure regressed on child sex, maternal race, ethnicity, age, education at time 1, propensity to be included in the analytic sample, and time-varying measures of household poverty status, household asset poverty status, children in the household, maternal marital status, maternal BMI, maternal time out of the labor force, maternal time unemployed, maternal health insurance coverage, and child health insurance coverage (N=2,225).

Table 2. Indirect Effects of Child Activity Limitations on Maternal Health Limitations at Time 9 in an Autoregressive Cross-lagged Model of Maternal Health Limitations and Child Activity Limitations, NLSY 1979 and Child and Young Adult Sample[a,b]

	Coefficient	Lower Bound CI[c]	Upper Bound CI	
Total indirect effect, time 7 child activity limitations	.118	-.024	.257	
Total indirect effect, time 6 child activity limitations	.078	-.049	.203	
Total indirect effect, time 5 child activity limitations	.074	-.050	.190	
Total indirect effect, time 4 child activity limitations	.196	.064	.335	[d]
C4→M5→M6→M7→M8→M9	.123	.028	.240	[d]
Total indirect effect, time 3 child activity limitations	.171	.009	.331	[d]
C3→C4→M5→M6→M7→M8→M9	.105	.025	.190	[d]
Total indirect effect, time 2 child activity limitations	.244	.036	.425	[d]
C2→C3→C4→M5→M6→M7→M8→M9	.089	.021	.164	[d]
Total indirect effect, time 1 child activity limitations	.464	.249	.694	[d]
C1→C2→C3→C4→M5→M6→M7→M8→M9	.084	.018	.159	[d]
C1→M2→M3→C4→M5→M6→M7→M8→M9	.012	.001	.033	[d]
C1→M2→M3→M4→M5→M6→M7→M8→M9	.201	.056	.388	[d]

Notes

* = p < .05, ** = p < .01, and ***= p < .001 (two-tailed)

[a] Children are ages 1 or 2 at time 1, 3 or 4 at time 2, 5 or 6 at time 3, 7 or 8 at time 4, 9 or 10 at time 5, 11 or 12 at time 6, and 13 or 14 at time 7, 15 or 16 at time 8, and 17 or 18 at time 9.

[b] Model 1 is the autoregressive cross-lagged model of child activity limitations and maternal health limitations with no covariates and listwise-deleted cases for those missing maternal health limitations or child activity limitations at time 1 (N = 2,093).

[c] 95 percent bootstrap confidence interval.

[d] Confidence interval does not contain 0.

Table 3. Indirect Effects of Maternal Health Limitations on Child Activity Limitations at Time 9 in an Autoregressive Cross-lagged Model of Maternal Health Limitations and Child Activity Limitations, NLSY 1979 and Child and Young Adult Sample[a,b]

	Coefficient	Lower Bound CI[c]	Upper Bound CI	
Total indirect effect, time 7 maternal health limitations	.010	-.082	.090	
Total indirect effect, time 6 maternal health limitations	.031	-.054	.108	
Total indirect effect, time 5 maternal health limitations	.023	-.063	.095	
Total indirect effect, time 4 maternal health limitations	.007	-.074	.072	
Total indirect effect, time 3 maternal health limitations	.051	-.008	.109	
M3→C4→C5→C6→C7→C8→C9	.045	.019	.080	[d]
Total indirect effect, time 2 maternal health limitations	.101	.017	.185	[d]
M2→C3→C4→C5→C6→C7→C8→C9	.036	.002	.078	[d]
M2→M3→C4→C5→C6→C7→C8→C9	.057	.025	.095	[d]
Total indirect effect, time 1 maternal health limitations	.201	.039	.340	[d]
M1→M2→C3→C4→C5→C6→C7→C8→C9	.062	.004	.133	[d]
M1→M2→M3→C4→C5→C6→C7→C8→C9	.099	.040	.165	[d]

Notes

* = p < .05, ** = p < .01, and ***= p < .001 (two-tailed)

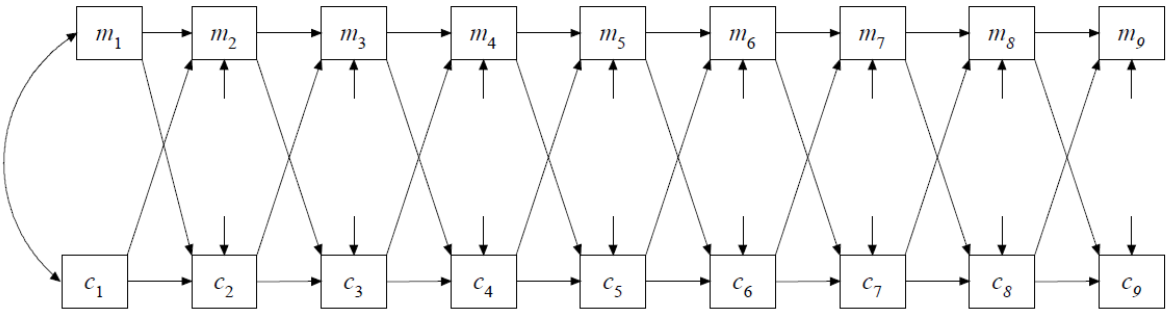
[a] Children are ages 1 or 2 at time 1, 3 or 4 at time 2, 5 or 6 at time 3, 7 or 8 at time 4, 9 or 10 at time 5, 11 or 12 at time 6, and 13 or 14 at time 7, 15 or 16 at time 8, and 17 or 18 at time 9.

[b] Model 1 is the autoregressive cross-lagged model of child activity limitations and maternal health limitations with no covariates and listwise-deleted cases for those missing maternal health limitations or child activity limitations at time 1 (N = 2,093).

[c] 95 percent bootstrap confidence interval.

[d] Confidence interval does not contain 0.

Figure 1. Autoregressive Cross-lagged Model of Repeated Measures of Maternal Health Limitations and Child Activity Limitations



Appendix A. Descriptive statistics for repeated measures and covariates

Table A.1. Descriptive Statistics of Repeated Measures and Covariates, NLSY 1979 and Child and Young Adult Sample, N = 2,225

	Mean or Proportion (Unweighted)	S.D.	Mean or Proportion (Weighted[a])	S.D.	N
Child activity limitations (yes = 1)					
Time 1	.11		.11		2141
Time 2	.08		.09		2170
Time 3	.09		.10		2162
Time 4	.11		.12		2155
Time 5	.13		.13		2061
Time 6	.16		.17		1967
Time 7	.18		.20		1907
Time 8	.11		.12		1981
Time 9	.11		.12		2045
Maternal health limitations (yes = 1)					
Time 1	.05		.06		2139
Time 2	.06		.05		2166
Time 3	.08		.07		2190
Time 4	.10		.09		2198
Time 5	.10		.09		2179
Time 6	.12		.11		2141
Time 7	.13		.11		2109
Time 8	.14		.14		2066
Time 9	.15		.15		2046
Household poverty status (yes = 1)					
Time 1	.26		.18		1896
Time 2	.24		.17		1877
Time 3	.23		.16		1901
Time 4	.23		.16		1845
Time 5	.23		.17		1809
Time 6	.19		.14		1757
Time 7	.19		.13		1779
Time 8	.18		.13		1781
Time 9	.16		.11		1801
Household asset poverty status (yes = 1)					
Time 1	.40		.30		2112
Time 2	.38		.28		2106
Time 3	.36		.26		2112
Time 4	.35		.26		2081
Time 5	.32		.23		2056
Time 6	.30		.22		2035
Time 7	.27		.19		2020
Time 8	.25		.18		2007
Time 9	.23		.17		1993

Maternal any time out of the labor force (yes = 1)			
Time 1	.74	.73	2122
Time 2	.59	.58	2135
Time 3	.54	.53	2153
Time 4	.49	.48	2172
Time 5	.43	.42	2154
Time 6	.37	.36	2129
Time 7	.33	.32	2088
Time 8	.31	.30	2008
Time 9	.30	.28	1974
Maternal any time unemployed (yes = 1)			
Time 1	.19	.16	2122
Time 2	.18	.15	2135
Time 3	.17	.14	2153
Time 4	.16	.13	2172
Time 5	.14	.12	2154
Time 6	.10	.08	2129
Time 7	.10	.08	2088
Time 8	.09	.08	2008
Time 9	.10	.08	1974
Maternal marital status (married = 1)			
Time 1	.70	.80	2186
Time 2	.67	.76	2202
Time 3	.64	.74	2211
Time 4	.63	.72	2200
Time 5	.64	.72	2181
Time 6	.63	.70	2142
Time 7	.62	.69	2108
Time 8	.61	.69	2067
Time 9	.61	.68	2047
Maternal body mass index[b]			
Time 1			2108
Normal weight	.60	.65	
Overweight	.25	.23	
Obese	.15	.13	
Time 2			2117
Normal weight	.56	.62	
Overweight	.27	.24	
Obese	.17	.14	
Time 3			2097
Normal weight	.52	.57	
Overweight	.28	.26	
Obese	.20	.17	
Time 4			2054
Normal weight	.48	.54	
Overweight	.29	.26	
Obese	.23	.20	
Time 5			2028
Normal weight	.46	.52	
Overweight	.29	.27	

Obese	.25		.21		
Time 6					1987
Normal weight	.42		.49		
Overweight	.29		.27		
Obese	.28		.24		
Time 7					1973
Normal weight	.40		.47		
Overweight	.30		.27		
Obese	.30		.26		
Time 8					1945
Normal weight	.37		.44		
Overweight	.31		.29		
Obese	.32		.27		
Time 9					1925
Normal weight	.34		.40		
Overweight	.32		.31		
Obese	.34		.29		
Maternal health insurance status (yes = 1)					
Time 1	.86		.89		2165
Time 2	.86		.88		2183
Time 3	.85		.87		2210
Time 4	.85		.87		2198
Time 5	.84		.86		2179
Time 6	.85		.87		2139
Time 7	.85		.88		2107
Time 8	.85		.87		2065
Time 9	.83		.86		2044
Child health insurance status (yes = 1)					
Time 1	.88		.91		2164
Time 2	.89		.91		2179
Time 3	.90		.92		2187
Time 4	.90		.92		2175
Time 5	.89		.90		2165
Time 6	.88		.91		2131
Time 7	.89		.92		2103
Time 8	.89		.90		2056
Time 9	.89		.91		2022
Children in the household (in numbers)					
Time 1	2.00	1.01	1.88	.92	2186
Time 2	2.19	1.04	2.11	.94	2202
Time 3	2.31	1.05	2.23	.96	2211
Time 4	2.41	1.09	2.33	1.01	2200
Time 5	2.44	1.09	2.36	1.03	2181
Time 6	2.39	1.09	2.32	1.05	2143
Time 7	2.32	1.09	2.27	1.06	2109
Time 8	2.16	1.07	2.13	1.05	2067
Time 9	2.01	1.10	1.99	1.09	2047
Child sex (female = 1)	.49		.49		2225
Maternal age (in years)	26.65	3.04	27.00	3.04	2225
Maternal race (1=black, 0=non-black)	.30		.15		2225

Maternal ethnicity (1=Hispanic, 0=non-Hispanic)	.21		.07		2225
Propensity to be included in the analytic sample	.38	.10	.34	.08	1927
Maternal education					2183
Less than high school	.16		.11		
High school	.47		.48		
Some college	.24		.24		
Four or more years of college	.14		.18		

Notes

[a] Weights are calculated to account for the multiple survey years from which the data were drawn as well as the oversampling of blacks and Hispanics in the NLSY 1979. Full documentation is available at https://www.nlsinfo.org/content/cohorts/nlsy79/using-and-understanding-the-data/sample-weights-clustering-adjustments.

[b] May not sum to 1 due to rounding.