Alternate Models of Sibling Status Effects on Health in Later Life

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Although siblings are thought to be influential in child development, little is known about the influence of sibling status on the health of older adults. Using structural equation modeling, the authors created and tested a series of models with data from a sample (N = 3,968) of 1957 high school graduates from the Wisconsin Longitudinal Study. The results indicated that socioeconomic status of origin, adolescent aptitude, and educational attainment did have significant total effects on health in later life, but sibling status did not. Adults who grew up in families of higher socioeconomic status and who had greater aptitude in high school attained more education, and this advantage, in turn, led to better health in later life. Although the final model was cross-validated, it was not equally plausible for men and women.

Keywords: siblings, health, aging

Sibling status has long been regarded as contributing to the developmental outcomes of children (Bjerkedal, Kristensen, Skjeret, & Brevik, 2007; Downey, 1995; Hertwig, Davis, & Sulloway, 2002). Sibling status reflects either within- or between-family processes that promote or constrain inequalities in sibling outcomes. Within-family sibling status effects are typically represented by birth order; between-family sibling status effects are typically represented by the number of siblings in a family, or sibship size. Overall, the sibling status literature indicates that firstborns or those with fewer siblings are generally found to have greater academic achievement (Blake, 1989; Downey, 1995) and better health outcomes (Angelillo et al., 1999; Barreto & Rodrigues, 1992; Elliott, 1992; Lewis & Britton, 1998; Li & Taylor, 1993) than middle- or later-borns, especially those with larger numbers of siblings.

Compared to the large body of research regarding sibling status effects during childhood and adolescence, there is little research regarding sibling status effects in later life. Recently, two lines of research have emerged that examine sibling status effects on mortality risk and exceptional longevity. First, in terms of mortality risk, Modin (2002) examined data from a cohort born between 1915 and 1929 in a Swedish hospital (N = 14,192) to determine whether birth order affected the likelihood of mortality during four life stages: infancy, childhood (ages 1–10), adulthood (ages 20–54), and older age (ages 55–80). After adjusting for such factors as mother’s marital status, age, and social class, Modin generally found that firstborns had lower mortality risk during the first three life stages. However, for the oldest life stage, women demonstrated no birth order effect, and the birth order effect found for men became nonsignificant after controlling for their own attained social class, education, and income. This finding for men in the oldest group fits into a large and growing body of research demonstrating that people who attain more social status as adults, in terms of greater education and wealth accumulation, live longer and have better health than those who do not (Adler et al., 1993; Adler & Snibbe, 2003; Backlund, Sorlie, & Johnson, 1999; Marmot, 2004).

The second line of research about sibling status effects involves investigations of birth order within samples of centenarians. Specifically, Gavrilov and Gavrilov (2005) examined birth order effects within a sample of centenarians (N = 991) born in the United States between 1875 and 1899 and found that firstborn daughters were more likely to survive to age 100 than were later-born daughters. However, for men, they found a U-shaped relation between birth order and the likelihood of surviving to the age of 100. Among men, firstborns and last-borns were more likely to survive to age 100.

In explaining these birth order effects in exceptional longevity, Gavrilov and Gavrilov (2000) favored biological factors. Specifically, they suggested that the advantage of firstborns might be explained by the relatively younger age of their parents. Because parents are older when they have their later-born children, the quality of their reproductive cells is lower (because of the accumulation of deleterious mutations in the parental germ cells), and this contributes to a biologically based disadvantage for later-borns that is expressed by a shorter life. On the other hand, Gavrilov and Gavrilov (2005) have explained the advantage of last-born men in terms of the positive association between parity and birth weight (Magnus, Berg, & Bjerkedal, 1985), which may protect them from developing such conditions as heart disease and diabetes later in life (Barker, 1992, 1994).

In short, the research literature regarding sibling status effects on mortality risk and extreme longevity provides contrasting explanations for possible sibling status effects on health in later life. Modin (2002) suggested that sibling effects on mortality risk in
later life are expressed indirectly via attained social status, as reflected in the educational attainment and accumulated wealth of the older adult. In contrast, Gavrilo and Gavrilo (2000) argued that sibling status effects on exceptional longevity are based partly on causal factors occurring before birth. This argument suggests that some sibling effects on exceptional longevity are direct, without mediation from the adult’s attained social status.

Several theoretical models in psychology and sociology have been proposed to explain why sibling status is associated with differences in outcomes in childhood and adolescence, and these may be useful in expanding our understanding of how sibling status may create differences in health in later life. The most popular explanation is based on the dilution of family resources (Blake, 1981; Hertwig et al., 2002) as more children are added to the family. Children benefit when family resources are devoted to them; however, because family resources are finite, children with many siblings and children born later in the sibship are disadvantaged (Downey, 2001). A less well-known model, the admixture model (Page & Grandon, 1979), argues that families from lower social classes generally have more children than families from higher social classes, and consequently, the reduced outcomes of children with many siblings are caused primarily by their disadvantaged socioeconomic status (Gao & VanWey, 1999; Rodgers, 2001). Taken together, these two models and the literature regarding the social gradient in health (Adler & Snibbe, 2003; Marmot, 2004; Mirowsky & Ross, 2003) point to the importance of simultaneously considering an individual’s socioeconomic status of origin as well as status attainment when attempting to determine whether sibling status contributes to variations in health differences in later life.

Further, another well-known model of sibling status effects in childhood and adolescence, the confluence model (Zajonc, 2001; Zajonc & Markus, 1975), argues that because firstborns spend more of their early years in family environments predominated by adults, their intellectual abilities benefit. It is worth noting that some investigators of the social gradient in health have argued that intellectual ability is the fundamental cause. Specifically, Gottfredson and Deary (2004) explained that because intelligence reflects the ability to learn, reason, and solve problems, people with greater intelligence acquire more health knowledge, which in turn leads to the prevention of chronic disease and accidental injury, ultimately leading to better health in later life. Overall, then, the confluence model and the literature emphasizing the importance of intellectual ability in determining health outcomes point to the importance of considering intellectual ability when evaluating sibling status effects on health in later life.

This article has three broad goals. First, we create a simple model of sibling status effects on health in later life. The simple model simultaneously compares direct and indirect sibling status effects on health. If we find a significant direct effect on health, this will suggest that sibling status influences early biology, which ultimately affects health in later life. If we find a significant indirect effect on health, then this will suggest that sibling status influences educational attainment and wealth accumulation and these factors bring about variations in health in later life.

Second, we develop an intermediate model of sibling status effects on health that considers the socioeconomic characteristics of the adults’ family of origin and their aptitude as adolescents. A continuing debate within the research literature concerns the extent to which the effects attributed to sibling status actually reflect other factors, such as the socioeconomic status of the individual’s family of origin or the individual’s academic aptitude (Rodgers, Cleveland, van den Oord, & Rowe, 2000; Zajonc & Sulloway, 2007). Because socioeconomic status of origin and adolescent aptitude may influence not only educational attainment but also health in later life (American Psychological Association, 2007; Deary, Whiteman, Starr, Whalley, & Fox, 2004; Gottfredson & Deary, 2004), we created and tested an intermediate model that considered the contribution of sibling status, socioeconomic status of origin, and adolescent aptitude to educational attainment to subsequent wealth and health.

Third, we created our final model of sibling status effects on health in later life and cross-validated it using a multigroup modeling approach (Byrne, 2001; Jöreskog & Sörbom, 1993). Our final model added to the intermediate model the direct contributions of adolescent aptitude and educational attainment to health in later life in order to deepen our understanding of the long-term effects of these factors while considering sibling status. Thus, our final model examines whether adolescent aptitude and educational attainment have both direct and indirect effects on health in later life. After we cross-validate the final model, we determine whether it is equally plausible for men and women. As described above, recent studies of sibling status effects on mortality risk and extreme longevity (Gavrilo & Gavrilo, 2005; Modin, 2002) suggest the existence of gender differences in how sibling status influences health in later life.

Method

Participants

The longitudinal data used to test our models comes from the Wisconsin Longitudinal Study (WLS; Sewell, Hauser, Springer, & Hauser, 2004), which has been supported since 1991 principally by the National Institute on Aging. Originally, the WLS sample consisted of a random selection of 10,317 high school graduates from the total pool of 1957 Wisconsin graduates (Hauser, 2005). Born primarily in 1939, these graduates have been surveyed in 1957, 1964, 1975, 1992, and most recently 2004, when they were reinterviewed first by telephone and then by mail-in questionnaire. About 85% of the surviving graduates participated in the telephone phase of the 2004 survey. In terms of the most recent wave of data collection, the Institutional Review Board at the University of Wisconsin—Madison approved all instruments and operations. Consent was obtained by telephone at the start of the most recent interview, and participants were assured of confidentiality. Previous survey data about the graduates have been supplemented by

1 This research uses data from the WLS of the University of Wisconsin—Madison. Specifically, we used a version of the WLS data released November 1, 2006. Since 1991, the WLS has been supported principally by the National Institute on Aging (Grants AG-9775 and AG-21079), with additional support from the Vilas Estate Trust, the National Science Foundation, the Spencer Foundation, and the Graduate School of the University of Wisconsin—Madison. A public use file of data from the WLS is available from the WLS, University of Wisconsin—Madison, 1180 Observatory Drive, Madison, WI 53706 and at http://www.ssc.wisc.edu/wlsresearch/data/. The opinions expressed herein are those of the authors.
such information as the earnings of their parents from state tax records and the graduates’ adolescent ability test scores from educational records. Overall, the WLS sample of graduates is portrayed as broadly representative of White, non-Hispanic Americans who have completed at least a high school education (Wollmering, 2007).

We selected our final sample by following a series of steps. First, for us to have data about the graduate’s health in later life, the graduates had to have provided complete health data in 2004, when they were 65 years of age. Overall, about 31% of the original sample did not provide complete health information in 2004. The largest group of graduates who did not provide health data was deceased (13%). The next largest group of graduates who did not provide health data in 2004 was contacted by the WLS staff, but they refused to participate at all (8%). In addition, about 4% of the original sample was not contacted in 2004 because they had not responded to requests for interviews since 1975, although they were known to be alive. The remaining 6% of the surviving graduates from the original sample did not provide complete health data for a variety of reasons.

To determine whether the omission of the graduates who did not provide health data in 2004 affected our results about sibling status, we compared the birth order and sibship size of graduates who provided complete health information with the birth order and sibship size of graduates who had not. The results of these analyses indicated that neither birth order nor sibship size was significantly associated with whether the graduate provided health data in 2004.

Second, we included in our sample only graduates who had provided information about their siblings and who reported growing up with both parents. This information was collected in 1975, and almost all of the graduates who completed this interview provided sibling information. We included in our sample only graduates who reported growing up with both parents; 90% of those graduates who responded to the question about parents indicated they had grown up with both parents.

Third, we included in our sample only graduates who provided information about their high school ranks and the educational attainment of their mothers and fathers. This information was requested in 1957 when the graduates were still in high school. About 8% of the original sample did not report information about their parents’ educational attainment, and about 7% did not provide information that allowed investigators to calculate a high school percentile rank. When investigators obtained parental income from 1957 state tax records, they were unable to locate the records of 3% of the original sample.

Missing data within the other variables included in our models did not greatly affect the selection of our final sample either because there was no missing data in these variables, such as high school IQ, or because the graduates who did not respond completely to the health questions in 2004 were also likely to not respond completely to the questions about household income and net worth in 2004.

Ultimately, our final sample consisted of 3,968 graduates. Our final sample was randomly divided into the calibration \( n = 1,984 \) and validation \( n = 1,984 \) subsamples. Table 1 shows the background demographic characteristics of the two subsamples: specifically, their gender, sibling status, and parents’ level of education. The mean age of the graduates in the calibration subsample was 65.12 \( (SD = 0.472) \); the mean age of the graduates in the validation subsample was 65.11 \( (SD = 0.471) \).

### Analysis Plan

We used latent variable structural equation modeling (SEM) to test the alternative models of sibling status effects on health in later life (Bollen, 1989; Byrne, 2001; Keith, 2006). SEM is a method for determining the magnitude of multiple possible causes on multiple outcomes. Our models represented the linkage of causes and outcomes, based on theory and previous research, and they were tested and evaluated in terms of fitting the data from the calibration subsample. Once we arrived at our final model, we cross-validated it using a multigroup modeling approach with data from both the calibration and validation subsamples. Similarly, we tested our final model to determine whether it was equally plausible for men and women using a multigroup modeling approach. We input correlations and standard deviations into the structural equation statistical program AMOS, Version 7.0 (Analysis of Moment Structures; Arbuckle, 2006).
Variables

The composition of all the latent variables used in our SEM analyses is presented in Table 2, along with the maximum and minimum scores based on our final sample. Table 2 also presents the coefficient $H$ (Hancock & Mueller, 2001) for each latent variable. Coefficient $H$ is based on standardized loadings ($\lambda$) and is regarded as an improved index of construct reliability because, unlike the alpha coefficient, additional indicators do not detract from $H$ and $H$ is never smaller than the reliability ($\lambda^2$) of the best indicators. As shown in Table 2, all of the coefficient $H$ scores are either above the recommended minimum of .70 or very near this minimum.

Sibling status. The latent variable sibling status was represented by two indicators, one representing the number of siblings within the graduate’s family of origin (sibship size) and the other representing the graduate’s order of birth (birth order). Because birth order and sibship size are highly related, many researchers (e.g., Falbo & Polit, 1986; Rodgers et al., 2000) have argued that both aspects of sibling status must be considered simultaneously to understand their effects on developmental outcomes.

Table 2
Latent Variables With Indicators: H Coefficients and Ranges

<table>
<thead>
<tr>
<th>Latent and indicator variables</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sibling status ($H = .787$)</td>
<td></td>
</tr>
<tr>
<td>Sibship size</td>
<td>0</td>
</tr>
<tr>
<td>Birth order</td>
<td>1</td>
</tr>
<tr>
<td>Health ($H = .681$)</td>
<td></td>
</tr>
<tr>
<td>Self-rating (R)</td>
<td>1</td>
</tr>
<tr>
<td>Doctor’s report (R)</td>
<td>0</td>
</tr>
<tr>
<td>Physical symptoms (R)</td>
<td>0</td>
</tr>
<tr>
<td>Diagnosed illnesses (R)</td>
<td>0</td>
</tr>
<tr>
<td>Educational attainment ($H = .978$)</td>
<td></td>
</tr>
<tr>
<td>Years of education, 1975</td>
<td>12</td>
</tr>
<tr>
<td>Years of education, 1992</td>
<td>12</td>
</tr>
<tr>
<td>Wealth ($H = .749$)</td>
<td></td>
</tr>
<tr>
<td>Total household income$^a$</td>
<td>0</td>
</tr>
<tr>
<td>Net worth$^a$</td>
<td>-15</td>
</tr>
<tr>
<td>Parental SES ($H = .687$)</td>
<td></td>
</tr>
<tr>
<td>Mothers’ years of school</td>
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<tr>
<td>Fathers’ years of school</td>
<td>7</td>
</tr>
<tr>
<td>Parental income in 1957$^b$</td>
<td>1</td>
</tr>
<tr>
<td>Adolescent aptitude ($H = .781$)</td>
<td></td>
</tr>
<tr>
<td>High school IQ</td>
<td>61</td>
</tr>
<tr>
<td>High school rank</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. $N = 3,968$. The latent variable names and their Wisconsin Longitudinal Study variable names follow. Sibling status: birth order (bor), sibship size (sibstt). Health: self-rating (gx201re); doctor’s report, which combined responses to eight variables (gx341re, gx342re, gx346re, gx348re, gx351re, gx356re, gx360re, gx361re); physical symptoms (ix082re); and diagnosed illnesses (ix117re). All four health indices were reversed coded (R), so that higher scores represent better health. Educational attainment: years of education, 1975 (edegyr); years of education, 1992 (rh003red). Wealth: total household income 2004 (gp2600ce), net worth 2004 (gr100pc). Parental socioeconomic status (SES): mothers’ years of school (edmo57q), fathers’ years of school (edfa57q), parental income in 1957 (bmin1). Adolescent aptitude: high school IQ (gwiq_bm), high school rank (hsrankq).

$^a$ Total household income and net worth are presented in units of thousands of dollars. $^b$ Parental income is presented in units of hundreds of dollars.

Health. The latent variable health was represented by four indicators from data collected in 2004: self-rating, doctor’s report, physical symptoms, and diagnosed illnesses. We reverse coded the scores of all four indicators so that high scores represented better health. The first two health indicators were based on information obtained from the telephone interview. The first indicator (self-rating) represented the graduates’ self-rated health on the basis of a single item. The graduates were asked to rate their health on a 1 to 5 scale. This indicator is regarded as an excellent measure of health and is widely used in health assessments (Lorig et al., 1996). We created the second indicator (doctor’s report) of health by summing together each instance of the graduate’s report that a doctor had told them they had high blood pressure, diabetes, cancer (or a malignant tumor), a heart attack (or coronary heart disease, angina, congestive heart failure), arthritis (or rheumatism), high blood sugar, mental illness, or a stroke. Although this indicator had a theoretical range from 0 to 8, the data from the final sample indicated that the highest score any graduate accumulated was 5.

In contrast, the third and fourth health indicators were created by the staff of the WLS on the basis of information obtained from the mail-in questionnaire. Specifically, the third indicator (physical symptoms) of health was a composite count of all of the 25 possible physical symptoms (aching muscles, back pain, bone pains, chest pains, constipation, coughing, diarrhea, painful sex, dizziness, excessive sweating, exhaustion, headaches, lack of energy, neck–shoulder pain, numbness, pain in hands–wrists, pain in ankles–knees, palpitations, ringing in ears, shortness of breath, skin problems, stiff–swollen joints, trouble sleeping, upset stomach, urinary problems) the graduate reported. The fourth indicator (diagnosed illnesses) of health was also a composite count of all of the 14 possible diagnosed illnesses (allergies, asthma, chronic bronchitis–emphysema, chronic sinus problems, circulation problems, fibromyalgia, high cholesterol, irritable bowel syndrome, kidney–bladder problems, multiple sclerosis, osteoporosis, back trouble, ulcers, prostate problems) the graduates reported.

Educational attainment. The latent variable of educational attainment had two indicators, representing the number of years of education the graduate completed, assessed in 1975 and again in 1992 on the basis of the graduates’ responses to telephone interviews. In Table 2, these indicators are labeled Years of education, 1975 and Years of education, 1992.

Wealth. The wealth latent variable had two indicators: total household income and net worth. Both were based on data collected via the telephone interview in 2004 and were provided as composite scores by the WLS. Total household income represented the combined income from all household members. Specifically, the household income variable was a composite of the wages, salaries, and tips of the graduate, his or her spouse, and any other household member, as well as their income from other sources, including pensions, social security, and welfare. Net worth represented the graduates’ reports of their current assets minus their current debts. Specifically, the net worth variable was a composite of the equity that the graduates had in their homes, businesses or farms, other real estate, and vehicles, combined with the amounts they had in savings and retirement accounts, minus the amounts they owed in terms of mortgage and other loans.

Parental socioeconomic status. The latent variable parental socioeconomic status had three indicators, two representing the...
number of years of education completed by the graduate’s mother (mothers’ years of school) and father (fathers’ years of school), respectively, and the third representing parental income in 1957 (parental income, 1957).

Adolescent aptitude. This latent variable had two indicators, the graduates’ IQ scores (high school IQ), which were based on raw Henmon–Nelson test scores obtained from high school records, and the graduates’ reports of their grades (high school rank), which were percentile ranked.

Results

Correlational Analyses

Table 3 presents the correlations of the indicators included in the SEM analyses, separately by the calibration and validation subsamples. Means and standard deviations for all variables used in the SEM analyses are also shown in Table 3. Note that the indicators of each latent variable are significantly correlated with each other.

Simple Model

Our simple model is presented in Figure 1 and is focused on determining whether there are sibling status effects on health in later life. This SEM analysis aimed to determine whether sibling status had a direct effect on health or an indirect effect on health, mediated by educational attainment and wealth. The results of our SEM analyses indicated an adequate fit of the data from the calibration sample to the simple model: The comparative fit index (CFI) was .990, the Tucker-Lewis Index (TLI) was .985, the root-mean-square error of approximation (RMSEA) was .037, and the CMIN/DF was 3.7.

As shown in Figure 1, the standardized regression weight associated with the direct path from sibling status to health was not significant (p = .45), and the standardized regression weight associated with the path from sibling status to educational attainment was significant (p < .001), as were the standardized regression weights associated with the paths from educational attainment to wealth (p < .001) and wealth to health (p < .001).

Overall, these results suggest that there are sibling status effects on health in later life and that these effects generally influence health indirectly via educational attainment and wealth accumulation. That is, these results indicate that early-born adults and adults with fewer siblings were more likely to attain greater education, and this educational advantage facilitated their wealth accumulation and health in later life.

Intermediate Model

Our intermediate model is presented in Figure 2 and is aimed at determining whether sibling status effects on health persist when socioeconomic origins and adolescent aptitude are considered. The intermediate model adds two latent variables, parental socioeconomic status and adolescent aptitude, and removes the direct path from sibling status to health. The intermediate model simultaneously considers parental socioeconomic status and adolescent aptitude as having structural links to educational attainment and as covarying with sibling status.

The SEM results are presented in Figure 2 and indicate that the fit of the data from the calibration subsample to the intermediate model was somewhat improved compared with that of the simple model. Specifically, the CFI was .985, the TLI was .980, the RMSEA was .032, and the CMIN/DF was 3.05. Note that sibling status was found to be significantly and negatively related to parental socioeconomic status and adolescent aptitude, whereas adolescent aptitude was positively associated with parental socioeconomic status.

As shown in Figure 2, the standardized regression weights associated with the pathways between parental socioeconomic status and educational attainment (p < .001) and between adolescent aptitude and educational attainment (p < .001) were statistically significant. However, with these new structural pathways added to the model, the standardized regression weight associated with the pathway between sibling status and educational attainment was no longer significant (p = .74).

These results suggest that once parental socioeconomic status and adolescent aptitude were included in the model, sibling status effects on educational attainment, and ultimately wealth and health, no longer yielded significant standardized regression weights. This finding suggests that the effects of parental socioeconomic status and adolescent aptitude on health in later life may be more fundamental than sibling status effects.

Final Model

We could have selected the model in Figure 2 as our final model. However, we decided to deepen our understanding of the predictors of health in later life by considering whether adolescent aptitude and educational attainment had direct effects, as well as indirect effects, on health. Therefore, we added two structural paths to the intermediate model, from adolescent aptitude to health

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2 Preliminary SEM analyses indicated that the error terms generated by the third and fourth health indicators were significantly correlated and that we should include this correlation in the SEM analyses. The addition of this correlation between error terms was also justifiable on conceptual grounds because these two indicators were more alike than the other two health indicators, in that these had been created by the WLS staff on the basis of the responses from the mail-in questionnaire. We included this correlated error term in all the SEM analyses reported here.

3 In our SEM analyses of the simple model, we considered whether transformations of the indicators of sibling status and wealth would affect our results. In terms of sibling status indicators, we considered the possibility that this latent variable would be better represented by a combination of linear and nonlinear indicators of birth order and sibship size. Likewise, in terms of wealth, we considered the possibility that the indicators of total household income and net worth would be better represented as log transformations of the raw scores. We conducted additional SEM analyses to determine whether these changes in the indicators affected the fit of the data from the calibration subsample to the simple model. We found that the addition of nonlinear indicators of birth order and sibship size to tests of the simple model did not improve the fit of the data to the model. Consequently, we proceeded with solely linear indicators of sibling status in our models. We also found that log transformations of the wealth indicators did not alter the fit of the model to the data from the calibration subsample. Therefore, we proceeded with solely linear indicators of wealth in our models. For ease of presentation, we chose to report the wealth indicators in terms of units of thousands of dollars.
and from educational attainment to health, to create our final model.

Our final model is presented in Figure 3, along with the results of our SEM analyses of data from the calibration subsample. The fit of the data to this model was good. The CFI was .987, the TLI was .983, the RMSEA was .030, and the CMIN/DF was 2.74. The SEM results indicated that the standardized regression weight associated with the direct path between educational attainment and health was significant ($p < .001$). Consistent with the results from the tests of the previous models, the standardized regression weight associated with the path from educational attainment to wealth was also significant ($p < .001$). However, the standardized regression weight associated with the path from wealth to health was not significant ($p = .37$). Thus, the SEM results indicate that educational attainment has a direct but not indirect effect on health.

In contrast, whereas the standardized regression weight associated with the path from adolescent aptitude to educational attainment was significant ($p < .001$), the standardized regression weight associated with the path from adolescent aptitude to health was not ($p = .22$). Thus, the SEM results indicate that adolescent aptitude has primarily an indirect not a direct effect on health.

Table 4 presents the summary of the standardized direct, indirect, and total effects of each latent variable in the final model on health. We found that three latent variables had significant total effects on the health in later life. Specifically, parental socioeconomic status and adolescent aptitude had primarily indirect effects on health, mediated by educational attainment. Adults who grew up in families of higher socioeconomic status and who had more aptitude as adolescents were more likely to participate in postsecondary education, and this greater educational attainment benefited their health over time. In contrast, educational attainment had primarily a direct effect on health; that is, adults who attained more postsecondary education reported better health than those with had simply a high school degree.

**Validation.** We proceeded to cross-validate the final model by testing for structural invariance across the calibration and validation subsamples. To do this, we followed the approach offered by Byrne (2001), pooling the calibration and validation samples and conducting a baseline analysis in which the model was fitted to both samples without constraints. Then, we reran the analysis, constraining the structural paths to be equal. We conducted a chi-square difference test to determine whether the baseline and constrained models were significantly different. They were not ($\Delta \chi^2 = 6.9$, $\Delta df = 7$, $p = .44$). Therefore, we concluded that the structural model is invariant between the calibration and validation subsamples.

**Gender models.** The research literature regarding sibling status, mortality risk, and extreme longevity suggested that models of sibling status effects on health in later life might be different for men and women. To determine whether our final model was equally plausible for men and women, we tested for structural invariance across data from the men ($n = 1,779$) and women ($n = 2,189$) in our total sample. We conducted a chi-square difference test to determine whether the baseline and constrained models were significantly different. In this comparison, the baseline and constrained models were significantly different ($\Delta \chi^2 = 115.10$, $\Delta df = 7$, $p < .001$). The biggest difference between men and women was located in the path between adolescent aptitude and educational attainment. The standardized regression weight for
men ($\beta = .57, p < .001$) was much higher than that for women ($\beta = .37, p < .001$). The next biggest difference was found in the path from wealth to health. Here, the standardized regression weight for women ($\beta = .11, p = .003$) was higher than that for men ($\beta = .02, p = .47$). To test whether the gender difference resided in these two structural paths, we conducted three more multigroup analyses.\(^4\) These analyses indicated that the gender difference was located in these two structural paths and not the other five paths in the model.

To further elucidate differences between men and women in terms of the latent variables of our final model, we compared the mean scores of men and women on the indicators associated with adolescent aptitude, educational attainment, wealth, and health.\(^5\) We found that women had outperformed men in high school and had equivalent intellectual ability, but they were less likely to attain more education and accumulated less wealth over time than did their male counterparts. Perhaps as a consequence, men reported better health, at least in terms of two of the four health indicators.

Discussion

From the outset, we acknowledge that the generalizability of our findings is limited by the relatively narrow range of sociodemographic characteristics present in our sample. Although the original sample was based on a random selection of over 10,000 graduates from a pool of all Wisconsin high school graduates of 1957, it is at best reflective of the experiences of non-Hispanic Whites who have at least a high school education. In addition, we limited our sample to solely those graduates who provided health data when they were 65 and who had lived with both parents while growing up. It is possible that our findings regarding sibling status effects on health in later life might have been different if our sample was not limited in these ways.

Note also that the people in the sample used to test our models had just matured into later life, arriving at the age of 65 years during the 2004 data collection. Other studies of sibling status effects, such as, Modin (2002) and Gavrilova and Gavrilov (2005), have included older adults in their samples. It is possible that tests of models of sibling status effects on health in later life might have yielded different results if the sample included participants who were older. It is generally understood that diseases follow varying developmental trajectories (Chen, Matthews, & Boyce, 2002), and some may not have emerged yet in this sample.

Further, even though the health indicators reflected a broad range of diseases and symptoms, the results of this study are limited by the fact that all our health indicators were based on self-descriptions. It is possible that the tests of our models might have yielded different results if we used as indicators the results of medical tests and we focused on specific illnesses, such as diabetes or cardiovascular disease.

With these caveats in mind, we note that sibling status effects on health in later life were found, but only when the model was simple, excluding parental socioeconomic status and adolescent aptitude. Further, when sibling status effects were found, they influenced health indirectly. That is, we found that adults who were born earlier and/or came from smaller sibships were more likely to attain more education, which was related to better health in later life.

Note that all three of the exogenous latent variables in the final model were found to be significantly interrelated in ways that are consistent with the findings of previous research. For example, consistent with the findings of Blake (1989), we found that graduates with lower numbers on sibling status, such as firstborns and/or those from small sibships, were more likely to come from families of higher socioeconomic status. Likewise, consistent with the early work of Anastasi (1956), we found that those with lower numbers on sibling status were more likely to have higher scores on adolescent aptitude. Finally, consistent with the findings of Page and Grandon (1979), we found that adults who came from families of higher socioeconomic status were more likely to have higher aptitude scores in adolescence. When the covariation between these three exogenous variables was included in the model, and when the direct effects of socioeconomic status of origin and aptitude on educational attainment were also included in the model, then the effect of sibling status on educational attainment and subsequent wealth and health in later life diminished to non-significance.

Overall, these findings are consistent with the idea that sibling status is probably not the fundamental cause of variations in educational or health outcomes, but rather a proxy reflecting various processes that are sensitive to variations in sibling status as well as determinative of variations in these outcomes (Guo &

\(^4\) Three multigroup analyses were conducted to determine the location of the gender differences. First, for the path from adolescent aptitude to educational attainment, we reran the analysis constraining this path to be equal, while allowing the other paths to be unconstrained. We conducted a chi-square difference test to determine whether the initial and the one-path constrained models were different. They were ($\Delta \chi^2 = 90.72, \Delta df = 1, p < .001$). Second, for the path from wealth to health, we reran the analysis constraining this path to be equal, while allowing all the other paths to be unconstrained. We then conducted a chi-square difference test to determine whether the initial and the one-path constrained models were different. They were ($\Delta \chi^2 = 4.86, \Delta df = 1, p = .03$). These results indicated that the gender difference was located in these two paths. To determine whether there was equivalence on the other five pathways in the final model, we reran the analysis constraining all but these two pathways to be equal and conducted a chi-square difference test to determine whether the initial and constrained models were different. They were not ($\Delta \chi^2 = 7.34, \Delta df = 5, p = .20$). This pattern of findings suggests that the gender difference did not reside in the structural paths between sibling status and educational attainment, parental socioeconomic status and educational attainment, educational attainment and health, educational attainment and wealth, and adolescent aptitude and health. Instead, these findings support the idea that the paths from adolescent aptitude to educational attainment and from wealth to health differed for men and women.

\(^5\) We found that men and women did not differ significantly in terms of their adolescent IQ, $F(1, 3967) = 1.75, p = .19$, but women outscored men in high school grades, $F(1, 3967) = 266.78, p < .001$. Nonetheless, men attained more education than women, as measured in 1975, $F(1, 3967) = 229.34, p < .001$, and in 1992, $F(1, 3967) = 159.02, p < .001$. Not surprisingly, then, men reported higher household income in 2004, $F(1, 3967) = 121.58, p < .001$, as well as greater net worth, $F(1, 3967) = 81.14, p < .001$. However, the health indicators yielded mixed results. In terms of self-rating, $F(1, 3967) = 0.53, p = .47$, and doctor’s report, $F(1, 3967) = 0.20, p = .65$, no differences between the genders were observed. In contrast, men reported better health in terms of physical symptoms, $F(1, 3967) = 52.46, p < .001$, and diagnosed illnesses, $F(1, 3967) = 38.91, p < .001$. 
VanWey, 1999; Rodgers et al., 2000; Zajonc & Mullally, 1997). For example, the type and amount of resources parents invest in their children are influenced by both the age and number of children in their families (Hertwig et al., 2002). Likewise, the qualities of the metacognitive environments produced by families are affected by the age and number of the children in them (Zajonc & Markus, 1975). In turn, parental investments in children and the quality of the metacognitive environments provided within the family influence the development of the children (Hertwig et al., 2002; Zajonc & Mullally, 1997). Such factors launch children along different developmental trajectories that lead to variations in educational attainment in adulthood and health in later life.

Our finding that sibling status has no significant influence on the health of older adults does not mean that siblings have no connection to health outcomes later in life. Sibling relationships can enhance the well-being of the elderly (Avioli, 1989; Bedford, 1999).

Figure 1. Simple model. Numbers in the figure are standardized regression weights derived from the structural equation modeling analysis of the data from the calibration subsample. All the weights associated with indicators of the latent variables are significant. The error terms for the indicators are not depicted. The significance of the weights associated with structural paths is indicated. * p < .01. ** p < .001.

Figure 2. Intermediate model. Numbers in the figure are standardized regression weights derived from the structural equation modeling analyses of the data from the calibration subsample. All the weights associated with indicators of the latent variables are significant. The error terms for the measured indicators are not depicted. The significance of weights associated with the structural paths is indicated. HS = high school; SES = socioeconomic status. * p < .01. ** p < .001.
Other sibling factors, such as gender composition or disability, may also contribute to variations in health outcomes between siblings later in life (Conley, 2004). Further, some aspects of sibling relations early in life may represent risk factors for health problems later in life. For example, Waldinger, Vaillant, and Orav (2007) found that men who reported distant or destructive relationships with siblings prior to age 20 were more likely to exhibit significant depression by age 50.

The results of the tests of the final model support the conclusion that socioeconomic status of origin, adolescent aptitude, and educational attainment influence health in later life. We found that the effects of socioeconomic status of origin and adolescent aptitude on health were primarily indirect. Specifically, people who came from families of higher socioeconomic status attained more education after high school, thereby promoting their health outcomes later in life. Likewise, people with greater academic aptitude were also found to attain more education after high school, which promoted their health in later life. Educational attainment was the only factor in our final model exhibiting a significant and direct effect on health in later life. This finding is consistent with the conclusion of Mirowsky and Ross (2003) that better education has positive consequences on health throughout life, accumulating over the life course. They argued that better educated people more consistently avoided working and residing in undesirable environments; instead, better educated people pursued health-promoting lifestyles that included marriage and employment. Furthermore, Ross and Wu (1996) argued that the benefits of higher education influence biology so that, over time, the aging process of better educated people is slower. Nonetheless, the amount of variance accounted for by the final model was small, suggesting that other factors may provide a better explanation of health disparities at age 65.

We found that the final model was not equally plausible for men and women. The failure of our final model to fit data from men and women equally well is consistent with the findings of Modin (2002) and Gavrilova and Gavrilov (2005). Although most of the

![Figure 3](image-url) Final model. Numbers in the figure are standardized regression weights derived from the fitting of the final model to data from the calibration subsample. All weights associated with indicators of latent variables are significant. The error terms for the measured indicators are not depicted. The significance of weights associated with the structural paths is indicated. HS = high school; SES = socioeconomic status. * p < .01. ** p < .001.

<table>
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<th>Predictor variable</th>
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<th>Total effect</th>
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<tr>
<td>Wealth</td>
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</table>

Note. These results are based on analyses of data from the calibration subsample. *** p < .001.
structural pathways in our final model were of similar magnitude for men and women, gender comparisons for two pathways yielded significant differences. Most important, for men, there was a stronger link between adolescent aptitude and educational attainment, a finding that probably reflects the greater opportunities for men to obtain higher education in 1957. In contrast, we found that the link between wealth and health was stronger for women than men. It is possible that because the women in this sample did not obtain as much education, their social status was more closely related to their wealth accumulation than their educational attainment, thereby leading to a stronger connection between wealth and health for women.

In conclusion, the results of this research suggest that sibling status effects on health in later life can be found, but they probably are best understood as reflective of other, more primary factors, particularly educational attainment and the factors that promote educational attainment, notably higher socioeconomic status of origin and aptitude.

References


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