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Childhood deprivation and later-life cognitive function in a population-based study of older rural South Africans

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Abstract

Rationale—Little research has evaluated the life course drivers of cognitive aging in South Africa.

Objectives—We investigated the relationships of self-rated childhood health and father's occupation during childhood with later-life cognitive function score and whether educational attainment mediated these relationships among older South Africans living in a former region of Apartheid-era racial segregation.

Methods—Data were from baseline assessments of "Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community" (HAALSI), a population-based study of 5059 men and women aged ≥40 years in 2015 in rural Agincourt sub-district, South Africa. Childhood health, father's occupation during childhood, and years of education were self-reported in study interviews. Cognitive measures assessed time orientation, numeracy, and word recall, which were included in a z-standardized latent cognitive function score variable. Linear regression models adjusted for age, sex, and country of birth were used to estimate the total and direct effects of each childhood risk factor, and the indirect effects mediated by years of education.

Results—Poor childhood health predicted lower cognitive scores (total effect = −0.28; 95% *CI* = −0.35, −0.21, versus good); this effect was not mediated by educational attainment. Having a father in a professional job during childhood, while rare (3% of sample), predicted better cognitive

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scores (total effect = 0.25; 95% *CI* = 0.10, 0.40, versus unskilled manual labor, 29% of sample). Half of this effect was mediated by educational attainment. Education was linearly associated with later-life cognitive function score (0.09; 95% *CI* = 0.09, 0.10 per year achieved).

Conclusion—In this post-Apartheid, rural South African context, older adults with poor self-reported childhood health or whose father worked in unskilled manual labor had relatively poor cognitive outcomes. Educational attainment strongly predicted cognitive outcomes, and appeared to be, in part, a mechanism of social stratification in later-life cognitive health in this context.

Keywords

South Africa; Rural; Aging; Cognitive aging; Cognitive function; Education; Socioeconomic conditions; Self-rated health

1. Introduction

By 2050, over 70% of global dementia cases are projected to occur in low- and middle-income countries (Prince et al., 2013). However, little research has examined the drivers of cognitive health in the older populations of these countries (Lekoubou et al., 2014). In South Africa, life expectancy has been rising and HIV/AIDS mortality declining since the mid 2000s, supported by expanding public health programs and the introduction of antiretroviral treatments to manage the HIV epidemic (Bor et al., 2013). In 2015, average life expectancy at birth for men was estimated at 60.6 years and for women at 64.3 years (Statistics South Africa, 2015). These increasing life expectancies coincide with an epidemiological transition, whereby older adults are now more frequently developing chronic diseases associated with aging (Kabudula et al., 2014). From a life course perspective, the older population of South Africa is uniquely characterized by the experience of Apartheid (1948–1994) and its earlier precursors. Under Apartheid, much of the majority black population of South Africa was forcibly moved to specially designated 'homeland' areas in rural parts of the country, or, 'Bantustans', where educational opportunities were limited, health care services were often inadequate, and employment opportunities were scarce (United Nations, 1963). These societally determined exposures are likely to have shaped the cognitive and physical health of the older black South African population in ways that are not yet fully recognized.

Existing life course research from high-, middle-, and low-income contexts consistently demonstrates that early-life socioeconomic conditions and educational attainment are associated with cognitive function in later-life (Araújo et al., 2014; Chen, 2016; Clouston et al., 2012; Fors et al., 2009; Glymour et al., 2012, 2008; Horvat et al., 2014; Hurst et al., 2013; Kaplan et al., 2001; Lee et al., 2014; McEniry, 2013; Melrose et al., 2015; Onadja et al., 2013; Scazufca et al., 2008; Sisco et al., 2015). However, little research has been conducted in sub-Saharan African settings, such as in South Africa, where opportunities for social mobility were restricted by the state for the majority of the country's population. During Apartheid, opportunities to access education were limited for black children, who were provided with segregated 'Bantu' schools that taught different curriculum from white schools (Union of South Africa, 1953). School attendance was often dependent on whether a school was available within walking distance of the home and if families needed children to assist at home or in the labor force. Once in school, the quality of education was poor, with the curriculum primarily designed to keep blacks in subservient labor positions that paid very little (Christie and Collins, 1984). Teachers were in shortage in Bantu schools, with one teacher for every 55 pupils in 1960, and the teachers were often under-educated themselves with few having a high school-equivalent degree of their own (Abdi, 2002; Christie and Collins, 1984). School expenditures were grossly inadequate and inequitable: in the 1970s, for every $17 spent on the education of a white child, only $1 USD was spent on the education of a black child (Abdi, 2002). Thus, education in Apartheid South Africa should not be viewed as equivalent to education in higher-income countries in terms of its accessibility, curriculum, quality, or benefits to health and social mobility.

Existing evidence demonstrates that educational attainment is strongly associated with cognitive function among older adults in South Africa (Humphreys et al., 2017; Peltzer and Phaswana-Mafuya, 2012). However, given that Bantu schooling in Apartheid South Africa was of very poor quality, there may be early-life factors that would influence both of one's educational attainment and their later-life cognitive health. That is, that the relationship between education and later-life cognitive health may be confounded by early-life conditions, with the true relationship being weaker than in other contexts where education is of higher quality and more accessible. Across a range of low-, middle- and high-income countries, early-life factors including nutrition, living conditions, household economic resources, access to health care, and early-life learning are associated with outcomes including better cognitive development, higher educational attainment, and better adulthood socioeconomic position (Case and Paxson, 2009; Glymour and Manly, 2008; Hertzman, 1999; Kaplan et al., 2001; McEniry, 2013; Melrose et al., 2015; Richards et al., 1998; Walker et al., 2005). During Apartheid in South Africa, the role of socioeconomic factors in childhood may be particularly strong in influencing later-life cognitive outcomes due to the country's high degree of inequality and poverty. It was therefore hypothesized that greater household socioeconomic resources and better health during childhood would have direct effects on later-life cognitive health, as well as indirect effects on cognitive health through educational attainment.

The objectives of this study were to investigate the relationships of self-rated childhood health and father's occupation during childhood with later-life cognitive function score; and whether educational attainment mediated these relationships among older, rural South Africans living in a former region of Apartheid-era racial segregation.

2. Methods

2.1. Study setting

"Health and Aging in Africa: Longitudinal Study of an INDEPTH Community" (HAALSI) is a population-based study in the rural Agincourt sub-district in the Mpumalanga province in northeast South Africa near the Mozambique border (Kahn et al., 2012). HAALSI is an international sister study to the US Health and Retirement Study (HRS). Agincourt is part of a former 'homeland' region of South Africa – an area where black Shangaan-speaking South Africans were forcibly moved to during Apartheid. Employment opportunities within the 'homeland' areas were limited and remain limited, with men and less often though now increasingly, women frequently migrating to cities, mines, or industrial farms to find work (Collinson et al., 2014).

Social and economic conditions in the Agincourt area have markedly improved post-Apartheid, but there are still basic service gaps with a lack of electricity, piped water, and tarred road coverage in the Agincourt area (Kahn et al., 2012). Unemployment remains high and non-contributory old age pensions and child support grants often form an essential part of household income for families. In 2015, the Agincourt study area covered approximately 450 km^2, including 31 villages with a population of approximately 115,000 people. The Agincourt Health and Socio-demographic Surveillance System (HDSS) has collected vital statistics and complex health and social data annually for this region since 1992 (http://www.agincourt.co.za) (Kahn et al., 2012).

2.2. Study sample

The study sampling and recruitment methods are described in detail elsewhere (Payne et al., 2017). In brief, eligible participants were men and women aged 40 or over on July 1, 2014, who had lived in the study area for at least 12 months prior to the 2013 Agincourt HDSS Census. Although most HRS international sister studies enroll adults aged 50 years and older, inclusion of a sample earlier in middle age was deemed important to understand trajectories of health during aging in this context, given the shorter life expectancy in this region of South Africa. In total, 5059 eligible men and women aged 40 years or over consented to participate and were included in the baseline HAALSI sample (85.9% response rate). This sample was representative of the underlying Agincourt HDSS Census sampling frame, although men were oversampled in order to obtain an approximately even gender distribution in the HAALSI sample (Supplemental Table 1).

2.3. Data collection

Data were collected through in-home interviews with trained, local fieldworkers using a Computer Assisted Personal Interview (CAPI) system. Interviews were conducted in the local Shangaan language, with the interview materials translated from English and back-translated to ensure reliability. The interviews covered topics including demographics, education, employment, physical and cognitive functioning, social networks, self-reported health history, and HIV and non-communicable disease outcomes.

2.4. Measurements

2.4.1. Self-rated childhood health—Self-rated childhood health was assessed in the interview with the question, “How would you rate your health during childhood?” with response options of ‘very bad,’ ‘bad,’ ‘moderate,’ ‘good,’ and ‘very good’. This variable was dichotomized to ‘very bad/bad/ moderate’ (collectively referred to as ‘poor’) and ‘good/ very good’ (collectively referred to as ‘good’).

2.4.2. Father’s occupation during childhood—Father’s occupation was assessed in the interview with the question, “What was your father’s main occupation?” Thirty occupational categories were recorded, in addition to ‘Don’t know’ responses and those who reported an occupation that did not match any of the thirty most common categories (grouped together as 'other' occupations). As Supplemental Table 2 shows, 30 recorded occupations were grouped into nine major occupational categories and then further into four skill levels according to the International Standard Classification of Occupations 2008 (ISCO-08) (International Labour Organisation, 2012). The skill levels in our sample represented: manual laborers (skill level 1; lowest skill), mining and service sector workers (skill level 2), traditional healers and small business assistants (skill level 3), and professionals (skill level 4; highest skill). Categories were also included for 'Don't know' father's occupation and 'other' occupation; these latter two categories were treated as dummies in the regression analyses and their coefficients are not shown in results tables.

2.4.3. Educational attainment—Years of education achieved were evaluated as the potential mediator. Education was assessed in the interview with the question, "What is the highest level of education that you have attained?" Years of education achieved was coded continuously, with partial and complete levels of each of tertiary and university education collapsed and treated as one year each, due to the very small numbers of people who had achieved these levels of education.

2.4.4. Later-life cognitive function—Cognitive functioning was assessed in the study interview using validated measures derived from the U.S. Health and Retirement Study that were adapted for cultural relevance and administered in the study interviews. These measured: orientation (ability to state the present year, month, date, and name of the current South African president; one point for each); immediate word recall (the number of words correctly recalled, out of ten, from a list read aloud by the interviewer; ten points); delayed word recall (the number of words correctly recalled from the original list of ten words after a 1 min delay during which the respondent was asked unrelated questions; ten points); forward count (the ability to count correctly from 1 to 20; one point); and number skip pattern (the ability to complete the final digit of the number skip pattern beginning with 2, 4, 6, administered if the participant was able to correctly count from 1 to 20; one point).

2.4.5. Covariates—Covariates included in this analysis were: age group (40–49, 50–59, 60–69, 70–79, 80 + years), sex, and country of birth (South Africa or any other). Age groups were used, rather than a continuous variable, to account for outliers at the upper end of the age range. Country of birth was an important covariate, as Agincourt is home to a significant number of people who came to South Africa as refugees during the 1977 to 1992 civil war in Mozambique (Sartorius et al., 2013). Variables indicating adulthood socioeconomic status were not included, as they were thought to lie on the causal pathway between education in earlier life and cognitive health in later life. Self-reported ability to read or write and current employment status were, however, included for descriptive purposes.

2.5. Statistical analyses

2.5.1. Factor analysis of cognitive outcome data—Confirmatory factor analysis with a robust weighted least squares estimator was used to obtain a single factor model incorporating the cognitive battery measures (Muthén and Muthén, 2017). The output of the single factor model was a continuous, *z*-standardized latent cognitive function score variable. This method allowed for non-linear relationships between scores on the cognitive measures and overall cognitive function and only utilized common covariation between the tests to construct the latent variable, reducing measurement error (Muthén and Muthén, 2017). The immediate and delayed recall measures were entered as continuous variables; the other measures were entered as categorical variables. Individuals who were unable to count were coded as ‘incorrect’ for both numeracy measures, which were combined to create a single ordered measure with a range of 0–2.

The single factor model allowed the error terms of the word recall items to co-vary due to their high correlation. Model fit was assessed using standard thresholds for fit statistics: root mean square error of approximation (RMSEA) of <0.05, comparative fit index (CFI) of >0.95, and Tucker-Lewis index (TLI) of >0.95 (Hu and Bentler, 1999). Within the factor model, the outcome variable was estimated using all available information from individual cognitive tests even if some observations were missing (Muthén and Muthén, 2017). The confirmatory factor analysis was conducted using Mplus 7.2 and the ‘runmplus’ command in Stata 14.1 (College Station, TX).

2.5.2. Regression modeling and mediation analysis—The relationships of each childhood risk factor with educational attainment were estimated in linear regression models, adjusted for age, sex, and country of birth. Good self-rated childhood health and father’s occupation skill level 1 were the reference categories. The total effects (TE) of each childhood risk factor on latent cognitive function score were estimated in a linear regression model adjusted for age, sex, and country of birth (Model 1). The mediator, years of education, was then included in a second modeling step (Model 2). This second step gave the natural direct effect (NDE) of each childhood risk factor, interpreted as the effect of each on latent cognitive function score that was not mediated by educational attainment. The natural indirect effect (NIE) of each childhood risk factor that was mediated by years of education was estimated, which, in linear regression models, equals the TE minus the NDE. Nonparametric bootstrapping with 1000 replications was used to calculate bias-corrected 95% confidence intervals for the NIEs (Vanderweele, 2015).

In the context of the research question, any potential confounders of exposure-outcome, exposure-mediator, or mediator-outcome relationships would have to arise early in life. Although childhood cognitive ability may influence both educational attainment and later-life cognition, the model makes the assumption that the confounding effect of this factor is minimal given the low access to education and educational advancement in rural South Africa during Apartheid. Adulthood socioeconomic factors were not included, as they were assumed to account for part of any causal effect of education on latent cognitive function score. The proposed mediation model is shown below in Fig. 1. The paths corresponding to the NIE, TE, and NDE are visualized as *ab*, c, and c', respectively. Note that in linear regression models the multiplication of paths a and b (*ab*) is equivalent to the TE minus the NDE. This study evaluated whether there were statistical interactions between each of childhood health and education, and father’s occupation and education. Finally, the study calculated the proportion of the total effects mediated by educational attainment as (NIE/TE) × 100%. The regression analyses were conducted using Stata 14.1 (College Station, TX).

2.6. Missing data

Only 3% or fewer of participants were missing data on the variables of interest. Data were therefore analyzed on a complete-case basis, with a final analytical sample of 4902/5059 (97%).

2.7. Sensitivity analysis

A post-hoc sensitivity analysis was conducted, including adult height as a covariate to help account for any residual confounding by childhood risk factors. Adult height has a genetic component and is also a marker of childhood nutrition and growth (Deaton, 2007). Because of missing data for this variable (7%; 365/5059), a sensitivity analysis was included to avoid potentially biasing the main analysis due to missing data.

3. Results

3.1. Sample characteristics

Table 1 shows the characteristics of the study sample.

3.2. Childhood risk factors

Only 3% of participants had a father who worked in the highest occupational skill level 4, which consisted of professional and managerial jobs such as small business owner, teacher, priest or pastor, or health care worker (Table 1). Similarly, 3% of participants had a father who worked in skill level 3. This category was predominantly comprised of traditional healers (91%; 138/151), and the remainder was classified as small business assistants. Just under half of participants had a father in skill level 2; the most common job in this level was mine work (51%; 1106/2187), followed by a range of service sector jobs. Just less than one-third of participants had a father in skill level 1, which included manual farm laborers and other types of unskilled manual labor. Supplemental Table 2 shows the full list of recorded father's occupations in this sample and their categorizations into ISCO-08 skill levels.

Most participants reported being in 'very good' (69%; 3501/ 5059) or 'good' (19%; 933/5059) health in childhood (Table 1). Mean years of education was low in this sample (4.63; *SD* = 4.28), but was slightly higher among people with poor self-rated childhood health than those with good childhood health (5.07 [*SD* = 4.31] versus 4.64 [*SD* = 4.3] years; $p = 0.01$). Mean years of education was 4.60 (*SD* = 4.25) in those whose fathers were manual laborers, 5.07 (*SD* = 4.37) in those whose fathers were miners or service workers, 4.16 (*SD* = 4.26) in those whose fathers were traditional healers or assistants, and 6.49 (*SD* = 4.82) in those whose fathers were professionals.

3.3. Latent cognitive function scores

Scores on individual cognitive function measures, and their loadings onto the z-standardized latent cognitive function variable are shown in Supplemental Table 3. The model was of a good fit to the data, with an RMSEA of 0.032 (95% *CI* = 0.025, 0.039), CFI of 0.998, and TLI of 0.997. Mean latent cognitive function scores were −0.06 (*SD* = 1.00) in those whose fathers were manual laborers, 0.13 (*SD* = 0.99) in those whose fathers were miners or service sector workers, −0.13 (*SD* = 1.03) in those whose fathers were traditional healers or assistants, and 0.30 (*SD* = 1.05) in those whose fathers were professionals. The cognitive scores were approximately normally distributed, and mean scores were approximately linearly associated with years of education (Pearson $r = 0.55$; $p < 0.0001$; Fig. 2).

3.4. Childhood risk factors, years of education, and later-life cognitive function

Having poor self-rated childhood health was associated with lower cognitive scores (TE = −0.28; 95% *CI* = −0.35, −0.21, vs. good; Table 2). The NDE not mediated by education was −0.30 (95% *CI* = −0.37, −0.23). The NIE was 0.02 (bias-corrected 95% *CI* = −0.005, 0.05), indicating a non-statistically significant 7% mediation by years of education. Having a father who worked in mining or in the service sector versus manual unskilled labor was associated with a higher cognitive score (TE = 0.15; 95% *CI* = 0.09, 0.21; Model 1, Table 2). The NDE not mediated by education for skill level 2 was 0.12 (95% *CI* = 0.07, 0.17; Model 2, Table 2). Having a father who worked in a professional job versus unskilled manual labor was associated even more strongly with cognitive function score (TE = 0.25; 95% *CI* = 0.10, 0.40; Model 1, Table 2). The NDE not mediated by education for professional jobs was 0.13 (95% *CI* = 0.00, 0.27; Model 2, Table 2). When adding statistical interaction terms to the mediation models, there was no evidence that years of education modified the NDE of either self-rated childhood health ($p = 0.28$) or father's occupation during childhood ($p = 0.98$). Independently of the childhood risk factors, educational attainment was positively associated with cognitive score (0.09; 95% *CI* = 0.09, 0.10 per year of education).

Fig. 3 shows the final mediation model. Because the indirect effect for self-rated childhood health through years of education indicated no mediation and because father's occupation in skill level 3 was not associated with cognitive function, the paths are parameterized for father's occupations in skill levels 2 (mining and service sector work) and 4 (professional occupations) only. Participants whose fathers worked in mining or the service industry had an average of 0.5 more years of education than those whose fathers worked in manual labor. The NIE associated with this difference in education was 0.03 (bias-corrected 95% *CI* = 0.01, 0.05), representing 21% of the total effect of this occupational category on later-life cognitive function (Fig. 3). Participants whose fathers worked in a professional occupation had an average of 1.9 more years of education than those whose fathers worked in manual labor. The NIE associated with this difference in education was 0.12 (bias-corrected 95% *CI* = 0.05, 0.18), representing 48% mediation of the total effect of this occupational category on later-life cognitive function (Fig. 3). In the sensitivity analysis adjusted for adult height, the results for the mediation analysis were minimally altered, indicating minimal residual confounding by the genetic and nutritional factors represented by adult height (see Supplemental Table 4).

4. Discussion

In this post-Apartheid context of aging in Agincourt, reflecting rural settings in much of South Africa, self-rated childhood health and father's occupation during childhood were associated with cognitive function scores in later life. Education was strongly and positively associated with cognitive scores, despite the poor quality of educational conditions during Apartheid. In this under-educated sample that had an average of just over four and one-half years of education, having a father who worked in mining or the service sector was associated with an additional half-year of schooling, and having a father who worked in a professional occupation was associated with nearly two additional years of schooling, compared to a father in unskilled manual labor. These additional years of schooling mediated, respectively, one-fifth and half of the effects of having a father in these occupational categories. In contrast, education did not appear to explain the association between self-rated childhood health and later-life cognitive function. This study is one of the first to examine the cognitive health of older South African adults from a life course perspective, capturing early life exposures that mostly occurred during a long period of Apartheid that resulted in widespread poverty, low access to education, and a lack of social mobility among the majority of the country's population.

Given these extremely poor social conditions, it is perhaps surprising that, at first glance, our results are consistent with those from predominantly higher-income countries confirming the importance of education for cognitive performance in later life (Araújo et al., 2014; Clouston et al., 2012; Fors et al., 2009; Glymour et al., 2012; Horvat et al., 2014; Lee et al., 2014; Onadja et al., 2013; Scazufca et al., 2008; Sisco et al., 2015). In the US population aged ≥50 years, each additional year of education attained was associated with a 0.09 *SD* increase in word recall scores, similar to that observed here of a 0.09 *SD* increase (Glymour et al., 2008). In the Victoria Longitudinal Study in Canada, each additional year of education was associated with a 0.06 *SD* improvement in working memory and a 0.08 *SD* improvement in verbal episodic memory (Zahodne et al., 2011). Education is crucial to cognitive development among children and adolescents, and during aging it is thought to protect from degenerative neurological injury through allowing synaptic growth and the ability to engage in new cognitive strategies to complete familiar tasks (Whalley et al., 2004). An alternative, but not mutually exclusive explanation is that educational experiences improve older adults' test-taking abilities through providing familiarity with testing situations. In the context of HAALSI, where nearly half of the study participants had no formal education and lacked literacy skills, this effect of education of conferring familiarity with testing situations may be particularly strong in explaining education's association with cognitive test performance.

The cognitive measures in HAALSI assessed orientation in time and place, basic numeracy, and immediate and delayed word recall. Previous research robustly links such measures with educational attainment across diverse settings. Even schooling of extremely poor quality, such as that provided to black South Africans during Apartheid, would have taught basic literacy, numeracy, and general cognitive skills to children (Christie and Collins, 1984). Such education may also have set children on a path to greater cognitive demands throughout life, for example via work that required literacy skills. However, we cannot rule out that the association between education and cognitive score in this study is confounded by childhood cognitive ability. Children with higher pre-schooling cognitive abilities may still have been able to achieve higher levels of education, despite the limitations imposed by Apartheid, and may display these abilities throughout their lives. Even if this were true for some children, we remain confident in our assumption than the link between childhood cognitive ability and educational attainment is weaker in the HAALSI cohort than generally assumed in other studies.

The cognitive measures used in this study are strong predictors of not only dementia risk but also the physical health and wellbeing of older adults (Folstein et al., 1975; Mitchell, 2009). Although the latent variable approach means that the scale of the outcome variable does not translate to a clinically defined outcome of cognitive impairment or dementia, it captures the full range of inter-individual variation in cognitive function covered by any item in the battery, as was intended in this study. It reduced measurement error in the individual cognitive items by using their covariation to inform the latent cognitive function variable. The differential weighting of individual measures onto the latent variable according to their factor loading also improved the precision of the outcome variable over a simple composite summary score. This latter approach would, for example, equate knowledge of the present date (1 point) with an additional word being recalled from the list of ten words (1 point), although one item may be more difficult than the other and have greater relevance for daily functioning and future health outcomes (Rockwood et al., 2004).

Our results for father's occupation are consistent with those from studies conducted in several other countries on early-life socioeconomic conditions and later-life cognitive health (Araújo et al., 2014; Chen, 2016; Fors et al., 2009; Hurst et al., 2013; Horvat et al., 2014; Kaplan et al., 2001; Melrose et al., 2015). Father's occupation may have affected the study participants' later-life cognitive health through affecting living circumstances, nutrition, and health and health care accessibility during childhood, especially in this context of frequent poverty (Walker et al., 2007). Father's occupation may also have influenced adulthood socioeconomic circumstances through the transfer of assets and through influencing the individual's likelihood of receiving education and their own subsequent adulthood occupation. Adulthood occupation may, in turn, affect cognitive health through the types of tasks carried out at work, the leisure activities and health-related behaviors engaged in outside of work, and through improved access to health care services (Lang et al., 2008; Sabia et al., 2009).

Father's occupation is a commonly used indicator of household socioeconomic conditions during childhood (McEniry, 2013). In South Africa, blacks did not and, in vast majority, still do not have the same labor force opportunities as whites (Wilkinson et al., 2017). In rural parts of the country, migratory labor was necessary as people were forcibly moved to 'homelands' during Apartheid while many jobs remained in cities or in underground mines that were located away from these areas (Collinson et al., 2014). For these reasons, many HAALSI study participants had fathers who worked in some form of manual labor. Only three percent of the sample had a father who worked in a professional occupation. The intergenerational 'stickiness' of socioeconomic disadvantage, within this broader context of persistent poverty caused by a long history of colonization culminating in a period of Apartheid, is evident in our results by the low educational attainment and reduced later-life cognitive function scores associated with having a father who worked in unskilled manual labor. This profound economic vulnerability of Agincourt residents is still evident in younger generations today: An interview study of recent school leavers in 2013 in Agincourt found that only 38% of men and 12% of women aged 18 to 24 were employed (Wilkinson et al., 2017).

Our results are also consistent with studies indicating that childhood health is directly associated with later-life cognitive function (Araújo et al., 2014; Case and Paxson, 2009; McEniry, 2013; Scazufca et al., 2008; Zhang et al., 2010). Poor health during childhood can directly impede cognitive development (Walker et al., 2005), and this effect may last through later life (Hertzman, 1999; Richards and Hatch, 2011), as supported by our results. Contrary to our hypothesis, educational attainment did not appear to mediate the relationship between self-rated childhood health and later-life cognitive function. We had no specific measures of disease diagnoses in childhood, so our ability to detect any association between childhood health and educational attainment may have been limited, although US-based studies have found associations with similar self-rated measures (Haas, 2007). It might be that, in our sample, few children had such poor health that it limited their capacity to attend school. Rather, the primary determinants of school attendance in this setting appeared to have been socioeconomic in nature.

4.1. Limitations and strengths

A limitation of this study is that we did not have more precise measures of household income or material resources for study participants during their childhoods. Further information could not be derived about the father's occupations recorded in the 'other' category or those who did not know their father's occupation. These responses could be due to a number of reasons, such as not having a father present during childhood, which may have been common due to the migratory nature of work that was available to black men during Apartheid. Having a father who died before the study participant was age 18 (23% of those with data for this variable; 507 out of 2203) was not associated with 'don't know' responses ($p = 0.51$). We suspect that the effect estimate for father's occupation is an underestimate due to the potential for recall error and noise introduced into the variable through the categories imposed during the study interview. It is also possible that the ISCO-08 classification is not ideal for the Agincourt setting, where occupations such as traditional healer were common. This occupational category was associated with worse cognitive scores than would be expected according to the ISCO-08 definition of skill level 3. We also did not have information on mother's education or the roles of mothers in teaching their children, which could have contributed to later-life cognitive health (Hertzman, 1999).

Another important limitation is the cross-sectional nature of this study, with retrospectively assessed exposure variables. Any recall error in the self-reported childhood exposure variables could have biased the effect estimates. Current health status could bias recall of childhood health status, but it was not adjusted for as current health could lie on the causal pathways that were under study (Haas, 2007). Mortality in the target population prior to study enrollment, if caused by either of childhood risk factors, would lead to underestimates of the effects of risk factors on cognitive outcomes in our study. We were unable to distinguish between age effects and birth cohort effects in this study, which is important as educational quality may have changed across birth cohorts during Apartheid in South Africa. Any improvements in educational quality or attainment over birth cohorts would relate to improved cognitive function over subsequent birth cohorts. This phenomenon has been observed in several industrialized countries and is referred to as the "Flynn Effect", which may be occurring in rural South Africa as educational attainment increases over time

(Trahan et al., 2014). The cross-sectional nature of the study meant that this study could not assess age-related cognitive change as an outcome. Planned longitudinal follow-up of the HAALSI cohort, with these findings providing a baseline, will allow for investigation of the drivers of cognitive change in this sample.

Strengths of this population-based study include its large sample size and inclusion of some of the "oldest old" South African adults. This study was conducted in a rural, post-Apartheid context where the life course drivers of cognitive aging have not been previously explored. The cognitive measures in this study were adapted for cultural relevance from validated measures used in other longitudinal cohort studies of aging, and translated and back-translated to ensure reliability. Missing data were rare (<3%). This study identifies several important areas for future research on the life course predictors of later-life health in low-income settings. The role of education, as well as factors such as adulthood occupation, social mobility, and social networks in relation to aging-related cognitive decline and dementia incidence has not yet been investigated in rural, low income South African settings. Gender differences in the effects of socioeconomic conditions should also be investigated. This work, which is planned for in future longitudinal follow-up of the HAALSI cohort, would have to be undertaken with the understanding that a quantitative variable for 'education' does not represent a homogeneous construct, despite its ubiquity as an exposure or control variable in most social epidemiologic research. This question is still of great relevance today in post-Apartheid South Africa, as structural barriers to education remain in place for black adolescents, especially those who come from poor families or who live in rural regions like the Agincourt sub-district, limiting their future social mobility (Ndimande, 2016; Odhav, 2009).

5. Conclusions

In conclusion, in this post-Apartheid context of aging in rural South Africa, older adults whose father worked in unskilled labor had relatively poor cognitive outcomes, partly because they received very little, if any formal education. Educational attainment explained between one-fifth and one-half of the effects of father's occupation during childhood on later-life cognitive function. Poor self-rated health in childhood also predicted lower later-life cognitive function scores in this sample, an association that was not explained by educational attainment. Planned longitudinal data collection in the HAALSI will allow for the study of life course socioeconomic factors in relation to a range of health outcomes over time, including cognitive decline.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.socscimed.2017.08.009.

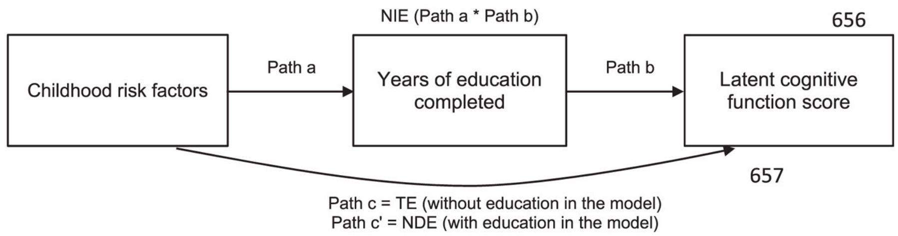

Fig. 1.
Proposed mediation model.

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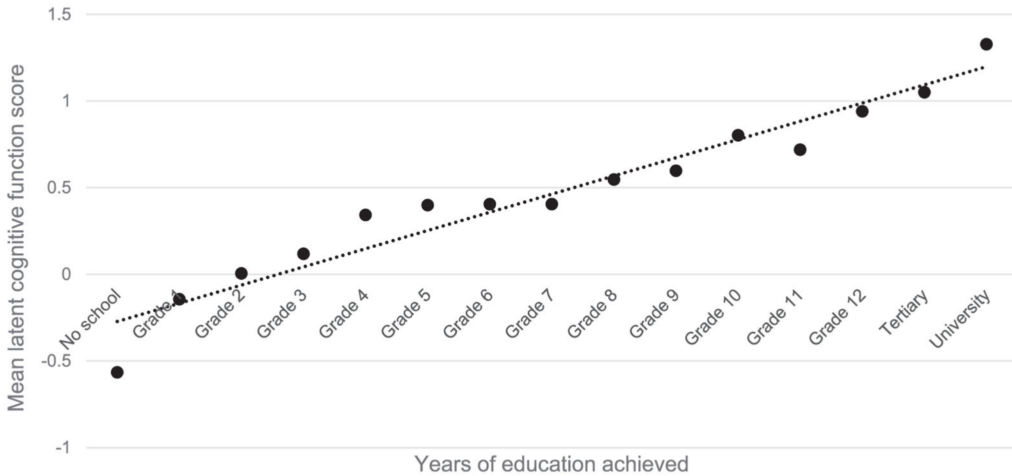

Fig. 2.

Mean latent cognitive function scores according to years of education achieved. (N = 4902).

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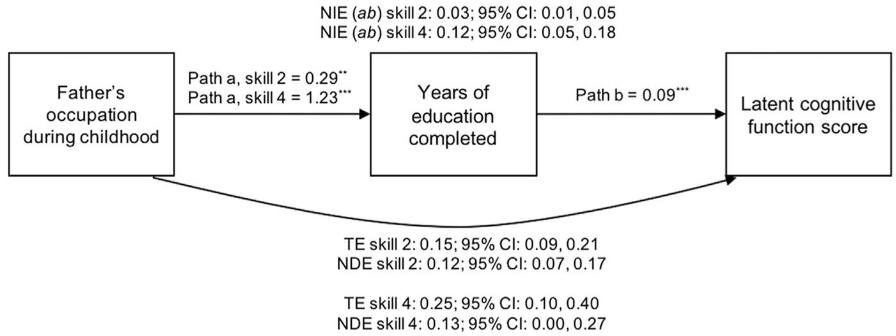

Fig. 3.

Final mediation model, adjusted for age, sex, country of birth, self-rated childhood health, and father's occupation. **$p < 0.01$. ***$p < 0.0001$.

Table 1

Characteristics of the sample, HAALSI, Agincourt, South Africa. (N = 5059).

Characteristic	Total *N* (%)
Age	
40–49	918 (18%)
50–59	1410 (28%)
60–69	1304 (26%)
70–79	878 (17%)
80+	549 (11%)
Mean (*SD*)	61.7 (13.1)
Sex	
Male	2345 (46%)
Female	2714 (54%)
Country of birth	
South Africa	3528 (70%)
Mozambique or other	1526 (30%)
Self-reported literacy	
Can read or write	2948 (58%)
Cannot read or write	2108 (42%)
Employment status	
Employed (part- or full-time)	805 (16%)
Not working	3719 (74%)
Homemaker	521 (10%)
Years of education	
Mean years of education (*SD*)[a]	4.63 (4.28)
Self-rated childhood health	
Very good	3501 (69%)
Good	933 (19%)
Moderate	296 (6%)
Bad	164 (3%)
Very bad	161 (3%)
Father's occupation during childhood	
Skill level 1 (unskilled manual labor; lowest skill)	1446 (29%)
Skill level 2 (mining and service industry)	2187 (43%)
Skill level 3 (traditional healers and assistants)	151 (3%)
Skill level 1 (professional and managerial; highest skill)	141 (3%)
Other occupation	575 (11%)
Doesn't know father's occupation	547 (11%)

Note: Cells may not add to 5059 due to missing data.

[a]Nearly half the sample (46%; 2307/5059) had no formal education.

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Table 2

Adjusted linear regression predicting z-standardized latent cognitive function scores, HAALSI, Agincourt, South Africa. (*N* = 4902).

Characteristic	Model 1[a]	Model 2[b]
	Total Effects (95% *CI*)	**Natural Direct Effects (95% *CI*)**
Self-rated childhood health		
Good	Reference	Reference
Poor	−0.28 (−0.35, −0.21)	−0.30 (−0.37, −0.23)
Father's occupation		
Skill level 1 (unskilled manual labor)	Reference	Reference
Skill level 2 (mining and service industry)	0.15 (0.09, 0.21)	0.12 (0.07, 0.17)
Skill level 3 (traditional healers and assistants)	−0.04 (−0.18, 0.11)	−0.03 (−0.16, 0.11)
Skill level 4 (professional)	0.25 (0.10, 0.40)	0.13 (0.00, 0.27)
Adjusted model R^2	0.29	0.39

[a]Adjusted for age, sex, country of birth, self-rated childhood health, and father's occupation.

[b]Adjusted for age, sex, country of birth, self-rated childhood health, father's occupation, and education.