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Does Childbearing Affect Cognitive Health in Later Life? Evidence From an Instrumental Variable Approach

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ABSTRACT Cognitive decline is a widespread concern as populations grow older. However, population aging is partly driven by a decrease in fertility, and family size may influence cognitive functioning in later life. Prior studies have shown that fertility history is associated with late-life cognition, but whether the relationship is causal remains unclear. We use an instrumental variable approach and data from the Survey of Health, Ageing, and Retirement in Europe to examine whether having three or more versus two children affects late-life cognition. Parents often prefer to have at least one son and one daughter. We thus exploit the sex composition of the first two children as a source of exogenous variation in the probability of having three or more children. Results indicate that having three or more versus two children has a negative effect on late-life cognition. This effect is strongest in Northern Europe, perhaps because higher fertility decreases financial resources yet does not improve social resources in this region. Future studies should address the potential effects of childlessness or having one child on late-life cognition and explore the mediating mechanisms.

KEYWORDS Cognitive functioning • Fertility • Aging • Instrumental variables

Introduction

Many studies have documented age-related declines in important components of cognition, such as processing speed, working memory, long-term memory (Zeisel et al. 2020), and particularly episodic memory (Salthouse 2013). However, such declines vary greatly across individuals and population subgroups. Innate and genetic differences, as well as varying life experiences (e.g., education, occupation, participation in cognitively stimulating activities), contribute to differences in late-life cognition. Identifying the factors that support optimal late-life cognition is critically important, given that cognitive health is highly related to quality of life, disability, productivity, and health-related expenditures (Albert et al. 2002; Tabert et al. 2002). Moreover, the success of many policies designed to alleviate the costs of population aging (e.g., raising retirement ages, extending the period of independent living) depends on the population's ability to maintain high cognitive functioning throughout adulthood and into old age (Prince et al. 2015; Skirbekk et al. 2013).

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Recently, a number of studies have suggested that family size is another factor related to late-life cognition (e.g., Read and Grundy 2017 and Saenz et al. 2021). Some of them try to isolate the causal relationship between the number of children and late-life cognition by statistically controlling for socioeconomic, health, and other characteristics in standard regression models. For instance, Read and Grundy (2017) compared individuals aged 50 or older with no children/one child, two children, or three or more children. They found that having two children as opposed to fewer or more children was associated with better cognitive functioning across a range of measures. However, the associations between having three or more children and late-life cognition generally weakened or disappeared once they statistically controlled for individuals' socioeconomic and health characteristics. Their results suggest that much of the apparent relationship between having more than two children and late-life cognition is due to confounders or selection effects.

From a methodological standpoint, statistically controlling for potential confounders in a traditional regression model might make the potential causal effect of fertility on late-life cognition somewhat more plausible. However, statistically controlling for all potential confounding factors is often unfeasible, particularly because many data sets lack information about even the most relevant confounders (e.g., parental preferences, innate cognition) or may measure such confounders inadequately. It is therefore difficult to disentangle selection effects (i.e., the extent to which people with higher fertility have characteristics that predispose them to better or worse late-life cognition) from causal effects (i.e., the extent to which higher fertility causes variations in late-life cognition) (Aaronson et al. 2014; Lovenheim and Mumford 2012; McCrary and Royer 2011; Monstad et al. 2008).

The instrumental variable (IV) approach offers a more stringent way of establishing causality. It entails using a source of variation in the explanatory variable of interest (in this case, the number of children) that is related to the outcome variable of interest (here, late-life cognition) only through its effect on the explanatory variable. This method relies on a number of assumptions about the source of variations, which we discuss later in the section devoted to the empirical strategy.

In the current study, we use an IV approach and data from the Survey of Health, Ageing and Retirement in Europe (SHARE) to examine the extent to which having three or more children versus two children causally affects late-life cognition. SHARE surveys representative samples of the older populations in 20 European countries and Israel, collecting extensive information on participants' children and obtaining objective cognitive test scores (Börsch-Supan et al. 2008). We exploit the sex composition of participants' first two children (same or mixed sex) as a source of exogenous variation in the probability of having three or more children. We can thereby estimate the effect of sex composition on late-life cognition by using the two-stage least-squares (2SLS) estimator and compare the results of the IV and traditional empirical approaches (e.g., the ordinary least-squares [OLS] estimator). To our knowledge, this is the first study to use an IV approach to study the causal effect of high fertility on late-life cognition. Further, we explore whether the effect of having three or more versus two children varies across four European regions and examine the extent to which having three or more versus two children is related to late-life financial (net worth and household income) and social resources (the frequency of contact with children).

Our study also contributes more generally to the literature on the effects of children on old-age health. A large body of the literature investigated the association between children and later-life health, but only a few studies addressed the issue of endogeneity regarding fertility choice. To our knowledge, only one study analyzed the effect of fertility on health outcomes in old age. Kruk and Reinhold (2014) used the first three waves of SHARE to investigate the effect of family size on depression in old age using an IV strategy based on multiple births and sex composition of the first two children. They found no effect of additional children on men's mental health but found that a third child can be detrimental to women's mental health. More precisely, the effect was significant when they used the multiple births as an instrument for having more children conditional on having at least two children but was not significant when they used the sex composition of the first two children as an instrument. Cáceres-Delpiano and Simonsen (2012) used U.S. data to investigate the effect of fertility on mothers' overall well-being, including health outcomes, with multiple births as a source of exogenous variation. They found that this unexpected increase in fertility increased the risk of obesity and high blood pressure among women aged 20–45.

Fertility and Cognitive Functioning in Later Life

Fertility may affect late-life cognition via several pathways. First, having an additional child often incurs considerable financial costs, such as the costs of extra food, clothes, leisure activities, transportation, schooling, and a car with more space or a larger house (Bradbury 2008, 2014; Dey and Wasoff 2010). Moreover, having an additional child reduces family income and increases the likelihood of falling below the poverty line (Cáceres-Delpiano and Simonsen 2012). Having an additional child can therefore decrease the standard of living for all family members and may cause financial worries and uncertainties, which could contribute to cognitive deterioration (Mani et al. 2013).

Second, having an additional child is causally related to women's lower labor market participation, fewer hours worked, and lower earnings (Aaronson et al. 2021; Rosenzweig and Wolpin 1980; Vere 2011). The negative effect is most evident when children are young, although it gradually vanishes or even becomes positive as children grow older (Cools et al. 2017). In turn, labor force participation (compared with retirement) positively affects cognitive functioning among men and women (Bonsang et al. 2012; Grotz et al. 2015; Rohwedder and Willis 2010).

Third, children can represent an important social resource, particularly in later life. Having children decreases the risk of social isolation among older individuals (Vlachantoni et al. 2015), which is a key risk factor for cognitive impairment and dementia (Ihle et al. 2018). Having more children could raise the level of social interaction and support, which can be protective against cognitive decline at older ages (Ertel et al. 2008; Zunzunegui et al. 2003).

Finally, having children can be stressful. Parents with more children can experience more stress, have less time to invest in cognitively stimulating leisure activities, and have less time to relax. Too much stress can also affect health risk behaviors and adversely affect adult cognitive development (Aggarwal et al. 2014; Prenderville et al. 2015). Moreover, having children often implies sleep deprivation for the parents

(Costa-Font and Flèche 2020; Richter et al. 2019), potentially leading to negative long-term effects on cognitive functioning (Richter et al. 2019; Virta et al. 2013).

In sum, higher fertility likely has both positive and negative effects on late-life cognition via its effects on financial and social resources, stress, and labor market experiences. It is difficult to predict which of these mechanisms might predominate or how these mechanisms may interact with one another. We also expect that the effect of having more children differs across countries characterized by varying institutional and cultural backgrounds.

Empirical Strategy

Estimation Method

The aim of the empirical analysis is to measure the effect of having more than two children (C_{ict}) on the cognitive functioning of the parent i living in country c at time t (Y_{ict}). The equation to be estimated is the following:

$$Y_{ict} = \beta_0 + \beta_1 C_{ict} + \boldsymbol{X'}_{ict} \boldsymbol{\beta}_2 + \alpha_{ct} + \varepsilon_{ict}, \tag{1}$$

where $\boldsymbol{X'}_{ict}$ is a vector of control variables that are likely to be related to cognitive functioning; β_0, β_1, and $\boldsymbol{\beta}_2$ are parameters to be estimated; α_{ct} are country–wave-specific fixed effects; and ε_{ict} is the error term. Under the assumption that the error term is uncorrelated with C_{ict} and $\boldsymbol{X'}_{ict}$, the parameter of interest (β_1) can be estimated by OLS. This assumption is unlikely to hold in the present context. The decision to have more children is clearly nonrandom and depends on several unobserved characteristics that are likely to be correlated with cognitive functioning in later life (e.g., childhood health, financial resources, labor market opportunities, innate cognitive and noncognitive skills).

To identify the causal effect of having more than two children on the parents' cognitive functioning, we use an IV approach. Equation (1) is therefore estimated by 2SLS. The first-stage equation is defined as follows:

$$C_{ict} = \gamma_0 + \gamma_1 Z_{ict} + \boldsymbol{X'}_{ict} \boldsymbol{\gamma}_2 + \tau_{ct} + \eta_{ict}, \tag{2}$$

where Z_{ict} is the instrumental variable defined as a dummy variable that is equal to 1 if the first two children have the same sex and 0 if they do not. We estimate each of the two equations for the full sample and separately for women and men. Given that our aim is to identify causal effects, we report unweighted estimates (see Solon et al. 2015). Because we have more than one observation for many individuals in the sample, we report cluster-robust standard errors at the individual level.

Identification Strategy Assumptions

Given that we cannot discard the hypothesis of treatment effect heterogeneity (i.e., the effect of having more than two children on cognition might differ across individuals), the 2SLS estimator allows us to identify a local average treatment effect (LATE), which is defined as the average treatment effect of the *compliers*—that is, the subpopulation that reacts to the instrument as intended. In such a setting, the instrument must meet four criteria (Imbens and Angrist 1994). First, the instrument must be related to the probability of having more than two children (the relevance assumption). Second, it should be as good as randomly assigned; that is, it should be independent of the potential outcomes and potential treatment assignments (the independence assumption). Third, although the instrument may have no effect on the probability of having more than two children for some individuals, all those who are affected should be affected the same way (the monotonicity assumption). Finally, the instrument should affect cognitive functioning only through its impact on the probability of having more than two children (the exclusion restriction assumption).

In line with previous studies (e.g., Cools and Hart 2017; Kruk and Reinhold 2014), we argue that the sex composition of the first two children can be used as an instrument to estimate the causal effect of having more than two children (instead of two). The sex composition of the first two children meets the relevance assumption: parents generally prefer to have at least one son and one daughter as opposed to two children of the same sex (see, e.g., Ben-Porath and Welch 1976), and parents who have either two daughters or two sons are more likely to have a third child than parents who have one son and one daughter (e.g., Angrist and Evans 1998). The instrument also meets the independence assumption: the sex composition of the first two children is plausibly randomly assigned, and there is no reason to believe that the sex composition of the first two children would be related to any other characteristics related to late-life cognition (e.g., innate ability, preferences).

For the sex composition of the first two children to meet the monotonicity assumption, there should not be anyone who would prefer to have more children after having one son and one daughter but not after having two children of the same sex. Although we cannot rule out this possibility, de Chaisemartin (2017) showed that violations of the monotonicity assumption do not affect the results under either of two conditions: (1) the LATEs of compliers (people who react to the instrument as expected) and defiers (people who react the opposite way) do not differ too much; or (2) a subgroup of compliers accounts for the same percentage of the population as the percentage of defiers and has the same LATE, in which case the 2SLS estimator still allows identification of a LATE.

Finally, to meet the exclusion restriction assumption, the sex composition of the first two children should affect late-life cognition only via its impact on fertility. As Angrist and Evans (1998) discussed, one potential threat to the exclusion restriction assumption is that it is more likely to have two children of the same sex when the first child is a boy, given the slightly higher likelihood of having a boy than a girl (Markle 1974). Children's sex, in turn, is related to their health outcomes (MacLean et al. 2013), parents' labor market outcomes (Lundberg and Rose 2002), and parents' probability of divorce (Dahl and Moretti 2008). The sex composition of the first two children may therefore potentially affect late-life cognition through channels other than its impact on fertility. However, the potential correlation between the sex composition of the first two children and children's sex can be easily addressed by using dummy variables to statistically control for the sex of the first- and second-born children.

As an additional check, we use two alternate instruments: a dummy variable equal to 1 when the first two children are girls and another dummy variable equal to 1 when the first two children are boys. As Angrist and Evans (1998) explained, this alternative identification strategy allows us to perform an overidentification test to check whether the children's sex might bias the results. The motivation for using this test is that the bias due to an effect of child sex on cognitive functioning should be different according to the instrument used (i.e., two sons vs. two daughters). The null hypothesis of the overidentification test is that the two sons and the two daughters instruments produce the same estimates when we use them separately. For this test, we use the Hansen J statistic, which is assumed to be distributed as a chi-square with 1 degree of freedom under the null hypothesis.

The literature refers to two other potential threats to the exclusion restriction assumption. First, having same-sex children might affect child-rearing costs because, for example, parents may prefer that daughters and sons have separate bedrooms. Rosenzweig and Wolpin (2000) found that having mixed-sex children was associated with higher child-rearing costs in rural India, but Bütikofer (2011) found no meaningful differences in richer countries, such as the United Kingdom, Switzerland, Mexico, Bulgaria, and Albania. The sex composition of the first two children is therefore unlikely to meaningfully affect child-rearing costs in Europe, the focus of the current study. Second, because parents tend to prefer having at least one daughter and one son (which ensures the relevance of the instrument), the sex composition of the first two children may affect the well-being of parents who had two children of the same sex but did not have more children. In turn, lower well-being (e.g., depressive symptoms) may affect late-life cognition. Previous research, however, found no evidence that the sex composition of the first two children is related to late-life depression (Kruk and Reinhold 2014), and depressive symptoms do not always appear to be a risk factor for cognitive decline (Brailean et al. 2017).

In sum, the sex composition of the first two children is a reasonable instrument for establishing the causal effect of having three or more children versus two children on late-life cognition.

As in any IV strategy with heterogeneous treatment effects, our estimation method captures effects on individuals affected by the instrument (Angrist et al. 1996), which has some implications for the external validity of our estimates. In our case, our method identifies the causal effect of a planned change in fertility for parents who have preferences for mixed-sex offspring. Moreover, using the sex composition of the first two children as an instrument means that the analyses cannot determine the causal effect of having more children at lower parities (e.g., having one vs. no children, having a second child) on late-life cognition. Nevertheless, analyzing the effect of having three or more versus two children is highly relevant in the European context, given that much of the change in European fertility over the past decades has been due to a decrease in the proportion of people having three or more children. Fertility ideals and intentions in Europe have been declining, and more adults view two rather than three children as ideal (Sobotka and Beaujouan 2014).

Regional Heterogeneity Analysis and Mechanisms

To examine potential heterogeneity of the effect of fertility on cognitive functioning across the four European regions, we repeat the 2SLS regression analyses separately for each region. Because of sample size restrictions, we do not conduct separate estimations for men and women.

We also explore the potential role of financial and social resources as mechanisms linking higher fertility to late-life cognition. We conduct 2SLS analyses with high net worth, poverty, and frequency of contact with children as the outcome variables for the full sample and separately for each European region. Again, because of sample size restrictions, we do not conduct separate estimations for men and women in the regional analyses.

Additional Robustness Checks

To test the robustness of our results, we check whether our main results change when we use data on only those individuals interviewed for either the first or last time; use the immediate recall, delayed recall, fluency, and the serial sevens test[1] (that was available only from Wave 4 onward) as separate outcome variables; use sample weights; and allow the effect of having three or more children to differ between men and women (i.e., a *male* × *three or more children* interaction) in the regional analyses.

Data

Analytic Sample

The analysis is based on pooled data from SHARE Waves 1, 2, 4, 5, and 6. We exclude data from (1) Wave 3 because it was a retrospective survey with no relevant data; (2) Israel because our focus is on Europe; and (3) Ireland because of its small sample size. Participants are from 19 European countries: Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Luxembourg, the Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, and Switzerland. Data were collected using a computer-assisted personal interviewing program, supplemented by a self-completion paper-and-pencil questionnaire. For more details, see Börsch-Supan et al. (2008).

The analytic sample includes all participants aged 65 or older ($N=127{,}036$) who had only biological children ($N=100{,}073$) and at least two children ($N=79{,}483$). We exclude individuals whose age at the first child's birth was below the 0.5 percentile of the gender-specific distribution and individuals whose age at the second child's birth was above the 99.5 percentile of the gender-specific distribution (leaving $N=77{,}178$). We exclude 478 participants who had missing values for one or more of the explanatory variables and 3,347 participants who had missing data on at least one cognitive measure. Thus, the final sample comprises 73,353 participants.

The level of missing data on the predictor variables is low, but missing values on the cognitive data are more substantial. Furthermore, missing cognitive scores are

[1] In the serial sevens test, the respondent is asked to subtract 7 from 100 five consecutive times. This test is part of the Mini-Mental State Examination (MMSE) test, which has been widely used to measure cognitive impairment (Folstein et al. 1975). The test score ranges from 0 to 5.

largely due to the use of proxy interviews, whereby an informant completes the questionnaire whenever the intended respondent is too physically or mentally impaired to complete the interview her- or himself. The systematic exclusion of people with lower physical and mental capacity may therefore bias our results. To assess the potential for bias due to missing cognitive data, we compare the characteristics of people with missing cognitive test scores and people without missing data. Table A1 in the online appendix and the accompanying discussion present descriptive statistics for people with and without cognitive data and explain why missing cognitive data could bias the OLS estimates but not the IV estimates. Because we pool data from multiple waves, some participants are observed more than once. We therefore also check whether the number of waves a person participated in is associated with the sex composition of the first two children.

The Measures of Cognitive Functioning

SHARE includes five measures of cognition: (1) immediate and delayed word recall, which measure episodic memory (i.e., memory of personal experiences); (2) verbal fluency to measure executive functioning, which regulates one's thoughts and directs behavior toward attaining a particular goal (see, e.g., Shao et al. 2014); (3) numeracy; (4) orientation in time; and (5) the serial sevens test. The numeracy and orientation-in-time tests were administered only for individuals who were interviewed for the first time, and the serial sevens test was assessed only in Wave 4. We thus focus on the immediate recall, delayed recall, and verbal fluency measures. Episodic memory and executive functioning are widely recognized to be sensitive to cognitive aging (Souchay et al. 2000).

In the immediate and delayed recall tasks, the interviewer recites 10 words. Participants are then asked to recite as many words as they can remember immediately (immediate recall) and once again after completing the verbal fluency and numeracy tasks (delayed recall). For the fluency task, respondents are asked to name as many animals as possible in one minute. We use principal components analysis to combine the scores from the three tasks into a general index of late-life *cognition*, defined as the first principal component. Before analysis, we normalize scores so that the mean is 0 and the standard deviation is 1.

The Number of Children and the Instruments

Information on participants' children is based on participants' first interview. We calculate the *number of children*. We use children's birth years to identify the two oldest children.[2] The sex composition of the first two children is our main instrument. We create a *first two children: same sex* dummy variable (1 = first two children are of the same sex, and 0 = first two children are of different sexes). We create four additional dummy

[2] The main results are similar when we use the information about fertility history from the SHARELIFE questionnaire collected in SHARE Waves 3 and 7. However, many SHARE respondents did not participate in these specific surveys, resulting in a 30% loss in sample size.

variables to use as statistical controls and to test overidentification (as described earlier): (1) *first two children: two sons*; (2) *first two children: two daughters*; (3) *firstborn daughter*; and (4) *second-born daughter* (all coded as 1 = yes, and 0 = no).

Sociodemographic Control Variables

Our model includes several control variables. Although the inclusion of control variables should not affect the consistency of the 2SLS estimates (because none of the variables are associated with our instrument, as we will show later), it can help to improve the estimates' precision. We control for a *cubic function of participants' age* to account for cognitive aging; we control for *age at second birth* because it was (positively) associated with late-life cognition in a previous study (Read and Grundy 2017). Age is measured in months (e.g., for an individual aged 70 years and two months, age = 70.1666). We also control for whether the respondent was *born abroad* (1 = yes, and 0 = no) and for participant *sex* (1 = male, and 0 = female). We control for *education* according to the ISCED-1997 classification (primary education or less, secondary education, tertiary education, or missing). Individuals with missing educational data account for 0.7% of the sample. To control for country–wave fixed effects, we create one dummy variable for each country–wave.

Financial and Social Resources

As described earlier, higher fertility is likely to affect late-life cognition via several mechanisms. Of the presumed mechanisms, SHARE data include reliable indicators for only financial and social resources. Detailed information about respondents' work histories is available in SHARELIFE, a retrospective survey included in Waves 3 and 7. However, the questionnaire was administered to a much smaller and more selective subsample of participants (as noted in footnote 2).

We used the *frequency of contact with children* per month as an indicator of participants' social resources. This measure is based on a question asked for each child of the respondent: "During the past twelve months, how often did you (or your husband/wife/partner) have contact with *child name*, either personal, by phone or mail?" For each of the six response options, we impute the number of contacts per year: daily = 365; several times per week = 156; about once per week = 52; about every two weeks = 26; about once per month = 12; less than once per month = 6; and never = 0. We then sum the total number of contacts with each child and divide it by 12 to obtain the average number of contacts with all children per month over the last 12 months.

We use household net worth and income as indicators of participants' financial resources. Household net worth corresponds to the sum of the household net financial assets (gross financial assets minus financial liabilities) and household real assets. Household income is measured as the yearly total net household income. Household income primarily reflects the amount of pension income. We use equivalent household income by dividing household income by the square root of household size. All amounts are measured in euros and are adjusted for purchasing power parity and denominated in prices obtained in Germany in 2005.

Household income and net worth were imputed for a significant proportion of respondents, which may decrease the accuracy of the results and bias the estimates toward 0 because the imputation procedure did not take the sex composition of the children into account (Bollinger and Hirsch 2006; Hirsch and Schumacher 2004). To minimize bias due to imputation and to decrease the influence of outliers, we use the household income and net worth data to define two dichotomous variables. First, we define a dichotomous *poverty* variable, with 1 equal to equivalent household income below 60% of the country–wave-specific median and 0 equal to equivalent household income at or above the 60% of the country–wave-specific median (a commonly used definition of poverty; see, e.g., Filandri and Struffolino 2019). Second, we define a dichotomous *high net worth* variable, with 1 representing net worth higher than the country–wave-specific median and 0 representing net worth below the country–wave-specific median.

Results

Descriptive Statistics

Table 1 presents the descriptive statistics for the full analytic sample and separately by the sex composition of participants' first two children. As expected, people whose first two children are of the same sex have more children than people whose first two children are of mixed sex (2.80 vs. 2.68 children, respectively); they are also more likely to have three or more children relative to their peers whose first two children are of mixed sex (48% vs. 41%, respectively). People whose first two children are of the same sex also have worse late-life cognition (combined index), immediate recall, and fluency; there are no significant differences with respect to delayed recall. Further, we find no other statistically significant differences between the two groups of parents. The descriptive evidence suggests that the sex composition of the first two children is relevant and randomly assigned and that having three or more versus two children is related to worse late-life cognition.

First-Stage Results

Table 2 presents the first-stage OLS estimates of the effect of first having two children of the same sex on having three or more children (vs. having two children). The results are presented for the full sample and for men and women separately. Consistent with previous studies (Angrist and Evans 1998; Kruk and Reinhold 2014), the results confirm that parents whose first two children are of the same sex are seven percentage points more likely to have three or more children than other parents. The effect is very similar for men and women. The findings do not differ by whether the first or second child is a girl versus a boy or by whether the parent first has two sons versus two daughters. It is worth noting that the effect of first having two daughters on having three or more versus two children is slightly larger than the effect of first having two sons, suggesting a slight preference for sons. However, the difference is not statistically significant.

Table 1 Descriptive statistics of the full sample and by the sex composition of the first two children

	Full Sample (N=73,353)	First Two Children: Mixed Sex (N=36,752)	Same Sex (N=36,601)	Difference (p value)
Number of Children (mean)	2.74	2.68	2.80	.000
3+ Children (%)	44	41	48	.000
First Two Children (%)				
Same sex	50	0	100	.000
Two sons	26	—	51	.000
Two daughters	24	—	49	.000
Cognition (mean)				
Combined index	0.00	0.009	–0.009	.018
Immediate recall	4.65	4.67	4.64	.016
Delayed recall	3.17	3.18	3.16	.169
Fluency	17.99	18.05	17.93	.025
Women (%)	56	56	55	.448
Age (mean)	74.27	74.31	74.24	.147
Age at Second Birth (mean)	29.45	29.48	29.43	.168
Born Abroad (%)	8	8	8	.321
Education (%)				
Primary or less	35	35	35	.677
Secondary	45	45	44	.549
Tertiary	20	20	20	.182
Missing	1	1	1	.673

Note: The cognitive combined index is based on a principal components analysis of scores on the immediate recall, delayed recall, and fluency tasks.

Table 2 Results of the ordinary least-squares analysis of the effect of the sex composition of the first two children on the probability of having three or more versus two children

	Full Sample (N=73,353)		Women (N=40,722)		Men (N=32,631)	
First Two Children						
Same sex	.070***		.069***		.070***	
	(.006)		(.007)		(.008)	
Two sons		.066***		.066***		.065***
		(.010)		(.010)		(.012)
Two daughters		.073***		.072***		.074***
		(.008)		(.010)		(.012)
Firstborn Daughter	.008	.005	.013†	.010	.003	–.002
	(.006)	(.008)	(.007)	(.010)	(.008)	(.012)
Second-Born Daughter	.003		.003		.004	
	(.006)		(.007)		(.008)	
Difference, Two Sons Versus Two Daughters (p value)		.543		.674		.595

Notes: All models include statistical controls for country–wave-specific fixed effects, a third-order polynomial in age, age at second birth, born abroad, and education. Cluster-robust standard errors (at the individual level) are shown in parentheses.

†$p<.10$; ***$p<.001$

Results From the 2SLS Estimators

Table 3 presents the results of the OLS and 2SLS estimates of the effect of having three or more versus two children on late-life cognition, as well as the results of the endogeneity and overidentification tests. The first two columns of Table 3 present the OLS estimates without and with the inclusion of the sociodemographic control variables, respectively. The OLS estimates indicate that parents who have three or more children have worse late-life cognition than parents with just two children.[3] Controlling for participants' sociodemographic characteristics weakens the association, but the effect of having three or more versus two children remains significantly different from 0 at the 0.1% level. Neither the sex of the firstborn child nor that of the second-born child is related to late-life cognition. The negative association between having three or more versus two children and late-life cognition is similar for men and women.

The last two columns of Table 3 present the 2SLS estimates, with first having two children of the same sex as one instrument and first having two sons or two daughters as separate instruments. In all cases, the *F* tests of the excluded instrument(s) confirm the results from Table 2: having two children of the same sex, having two sons, and having two daughters each strongly predicts the probability of having three or more children. The *F* tests suggest that the 2SLS estimates are unlikely to suffer from bias owing to weak instruments. Table 3 also shows that the endogeneity tests[4] reject the null hypothesis that the number of children is exogenous, justifying the use of the 2SLS to estimate the causal effect of having three or more versus two children on late-life cognition. Furthermore, we conduct an overidentification test (see Angrist and Evans 1998) for which the null hypothesis is that the effect of having more than two children on cognitive functioning does not differ by whether the *two sons* instrument versus the *two daughters* instrument is used. The motivation for this test is that the bias due to an effect of child sex on cognitive functioning should differ according to the instrument used. To test the null hypothesis, we use the Hansen *J* statistic, which is assumed to have a chi-square distribution with 1 degree of freedom. The overidentification matest does not reject the null hypothesis and suggests that the estimated effects are not sensitive to whether the two first children of the same sex are girls versus boys.

The results presented in the last two columns of Table 3 clearly indicate that having three or more versus two children is detrimental for late-life cognition, and the negative cognitive effect is large in magnitude. Based on the estimated impact of the control variables, the negative effect is similar to being 6.2 years older (for an individual aged 74.3, the average age in our sample), or about 90% of the advantage in

[3] A follow-up analysis estimating the same baseline model that Read and Grundy (2017) used for England provides comparable results. The estimated coefficient for men is –.05 for parents of three children and –.11 for parents of more than three children in Read and Grundy (2017), compared with –.04 and –.14, respectively, when the model is estimated with our data. For women, their estimates are –.09 for parents of three children and –.21 for parents of more than three children, compared with –.07 and –.16 when estimated with our data.

[4] The endogeneity test consists of including the residuals of the first-stage equation, Eq. (2), as additional regressor in Eq. (1). Under the null hypothesis of exogeneity, the coefficient should not be statistically different from 0.

Table 3 Results of the ordinary least-squares (OLS) and two-stage least-squares (2SLS) analyses of the effect of having three or more versus two children on late-life cognition

	OLS		2SLS	
Instrument(s) for 3+ Children	—	—	Same sex	Two sons, two daughters
Sociodemographic Control Variables	No	Yes	Yes	Yes
All (*N*=73,353)				
3+ children	–.147***	–.049***	–.325**	–.324**
	(.010)	(.009)	(.116)	(.116)
Firstborn daughter	—	.003	.005	.005
		(.008)	(.008)	(.008)
Second-born daughter	—	.002	.002	—
		(.008)	(.008)	
F test of the excluded instrument(s)	—	—	160.706	80.473
Endogeneity test (*p* value)	—	—	.015	.016
Overidentification test (*p* value)	—	—	—	.786
Women (*N*=40,722)				
3+ children	–.161***	–.052***	–.311*	–.308†
	(.013)	(.012)	(.158)	(.158)
Firstborn daughter	—	.004	.007	.007
		(.011)	(.011)	(.011)
Second-born daughter	—	.004	.004	—
		(.011)	(.011)	
F test of the excluded instrument(s)	—	—	88.589	44.361
Endogeneity test (*p* value)	—	—	.096	.101
Overidentification test (*p* value)	—	—	—	.698
Men (*N*=32,631)				
3+ children	–.131***	–.048***	–.355*	–.356*
	(.014)	(.013)	(.171)	(.171)
Firstborn daughter	—	.001	.001	.001
		(.012)	(.012)	(.012)
Second-born daughter	—	–.001	–.000	—
		(.012)	(.012)	
F test of the excluded instrument(s)	—	—	70.891	35.524
Endogeneity test (*p* value)	—	—	.064	.063
Overidentification test (*p* value)	—	—	—	.979

Notes: All models include statistical controls for country–wave-specific fixed effects, a third-order polynomial in age, age at second birth, born abroad, and education. Cluster-robust standard errors (at the individual level) are shown in parentheses.

†$p<.10$; *$p<.05$; **$p<.01$; ***$p<.001$

late-life cognition associated with having completed secondary versus primary education.[5] The impact is similar for men and women.

The 2SLS estimates of the effect of having three or more children are larger than the OLS estimates, indicating positive selection of those having more than two children. In other words, individuals who have three or more versus two children appear to have unobserved characteristics that partially protect them from the negative impact

[5] These comparisons are calculated using the estimated coefficients for age and level of education.

Table 4 Results of the two-stage least-squares analyses of the effect of having three or more versus two children on late-life cognition across four European regions

	Northern Europe	Western Europe	Eastern Europe	Southern Europe
3+ Children	–.781*	–.269	–.211	–.204
	(.344)	(.228)	(.201)	(.194)
Endogeneity Test (*p* value)	.01	.31	.48	.57
First-Stage Estimates (DV=3+ children)				
First two children: Same sex	.079***	.059***	.080***	.073***
	(.016)	(.009)	(.010)	(.011)
F test of the excluded instrument	23.175	41.745	64.074	43.053
N	9,419	29,460	17,110	17,364

Notes: All models include statistical controls for the country–wave-specific fixed effects, a third-order polynomial in age, age at second birth, born abroad, and education. DV=dependent variable. Cluster-robust standard errors (at the individual level) are shown in parentheses.

$^{*}p<.05$; $^{***}p<.001$

of having more children on late-life cognition. Nevertheless, the OLS estimates are negative, indicating that the negative causal effect still outweighs the selection effect. The difference between the OLS and 2SLS estimates of having three or more versus two children may also be partly due to the sample selection bias of the OLS estimator, as discussed in section 1 of the online appendix. The main results are highly similar when we use each cognitive test score as a separate dependent variable, weighted estimates, or data from those individuals interviewed for either the first or last time (see sections 2–4 of the online appendix).

In follow-up analyses, we found some evidence of positive selection: individuals who were in a household with 100+ books at age 10 were more likely to have three or more children ($p<.01$; see section 5 of the online appendix). This result suggests that individuals who have more than two children share other unobservable characteristics that are positively correlated with cognitive functioning in later life.

Regional Heterogeneity

We now investigate whether the effect of having more than two children on cognitive functioning in later life differs across European regions: Northern Europe (Denmark and Sweden), Western Europe (Austria, Belgium, France, Germany, Luxembourg, the Netherlands, and Switzerland), Eastern Europe (Czech Republic, Poland, Hungary, Slovenia, Estonia, and Croatia), and Southern Europe (Italy, Spain, Portugal, and Greece). This aggregation was used in earlier studies (Fernández-Carro and Vlachantoni 2019; Jerez-Roig et al. 2018; Nielsen et al. 2017). Table 4 presents the results from the 2SLS analyses of the effect of having three or more versus two children on late-life cognition for each of the four European regions. The first-stage estimates indicate a preference for mixed-sex offspring in all regions.

Given the smaller sample sizes, the estimated effects of the 2SLS regional analyses are less precise than the analyses based on the full sample. The estimated effect of having three or more versus two children is negative across each of the four regions,

Table 5 Results of the two-stage least-squares analysis of the effect of having three or more versus two children on high net worth, poverty, and contact with children across four European regions

	All Countries	Northern Europe	Western Europe	Eastern Europe	Southern Europe
High Net Worth					
3+ children	–.142†	–.458†	–.234	.163	–.128
	(.083)	(.248)	(.166)	(.135)	(.157)
Endogeneity test (*p* value)	.112	.028	.134	.159	.622
F test of the excluded instruments	105.769	15.151	27.558	44.452	27.349
N	73,353	9,419	29,460	17,110	17,364
Poverty					
3+ children	–.012	.157	–.054	–.025	–.047
	(.051)	(.099)	(.095)	(.094)	(.112)
Endogeneity test (*p* value)	.305	.141	.362	.430	.354
F test of the excluded instruments	99.646	17.795	26.983	37.732	24.283
N	73,353	9,419	29,460	17,110	17,364
Frequency of Contact With Children					
3+ children	24.530***	10.973	24.987***	22.060***	36.705***
	(3.612)	(6.726)	(6.858)	(5.680)	(8.332)
Endogeneity test (*p* value)	.036	.870	.084	.269	.338
F test of the excluded instruments	156.392	22.835	40.807	63.803	40.577
N	72,160	9,385	29,203	16,849	16,723

Notes: All models include statistical controls for country–wave-specific fixed effects, a third-order polynomial in age, age at second birth, born abroad (dummy variable), and education. High net worth refers to net worth above the country–wave median. Poverty refers to income below 60% of the country–wave median. Cluster-robust standard errors (at the household level for income and net worth and at the individual level for frequency of contact with children) are shown in parentheses.

†$p < .10$; ***$p < .001$

but the effect is larger and is significantly different from zero only in Northern Europe. The results therefore suggest that having three or more versus two children is particularly detrimental for late-life cognition in Northern Europe compared with the other European regions. We find no evidence that the effect of having three or more versus two children differs for men relative to women (see section 6 of the online appendix).

In a follow-up analysis based on data from only Western, Eastern, and Southern Europe, we found the negative effect of three or more versus two children on late-life cognition to be significant at the 10% level ($p = .079$). Thus, although the effect appears to be more salient in Northern Europe, the estimated overall cognitive effect of having three or more versus two children is not solely driven by the relationship observed in this region.

Exploring the Potential Mechanisms

Table 5 presents the results of the 2SLS analyses of the effect of having three or more versus two children on high net worth, poverty, and frequency of contact with children. Overall, having three or more versus two children decreases the probability of having high net worth, although the effect is significant at the 10% level, but does not significantly affect the probability of poverty. Having three or more versus two children also increases the frequency of contact with children—an effect that is significant at the 0.1% level.

However, the results also indicate that having three or more versus two children has different consequences for financial and social resources across the four European regions. Namely, having three or more versus two children decreases the probability of having high net worth in Northern Europe ($p < .10$), whereas no effect is evident in the other European regions. Similarly, we find some suggestion that having three or more versus two children increases the likelihood of late-life poverty in Northern Europe (a nonsignificant finding; $p = .112$) but decreases the likelihood of late-life poverty elsewhere. Because our measure of poverty primarily reflects the amount of pension income received, the trend may reflect that having three or more versus two children has a more negative impact on lifetime earnings in Northern Europe. Having three or more versus two children is associated with more contact with children in Eastern, Western, and especially Southern Europe, but not in Northern Europe.

Together, the results of the effect of having three or more versus two children on late-life financial and social resources suggest that the effect of having more than two children is particularly detrimental for late-life cognition for parents in Northern Europe because higher fertility more negatively affects their financial resources but does not improve their social resources. However, in the absence of mediation analyses, this conclusion remains highly tentative.

Discussion and Conclusion

Understanding the factors that contribute to optimal late-life cognition is essential for ensuring successful aging at the individual and societal levels—particularly in Europe, where family sizes have shrunk and populations are aging rapidly. For individuals, late-life cognitive health is essential for maintaining independence and being socially active and productive in late life; studies have linked cognitive health with quality of life, disability, and health-related expenditures and care needs (Albert et al. 2002; Tabert et al. 2002). For societies, ensuring the cognitive health of the older population is essential for extending work lives and reducing health care costs and care needs.

Compared with other factors, such as education or occupation, fertility has not received much attention as a potential predictor of late-life cognition. Fertility may affect late-life cognition via several mechanisms, including financial and social resources, labor market experiences, and stress. Previous studies have suggested that higher fertility is related to worse late-life cognition (e.g., Read and Grundy 2017). However, evidence of a causal effect has been lacking.

To the best of our knowledge, our study is the first to demonstrate a causal effect of higher fertility on late-life cognition. Using an IV approach, we found that having three or more versus two children causes worse late-life cognition in Europe for both men and women. The negative effect of having three or more versus two children is large in magnitude, equivalent in our sample to being 6.2 years older and nearly the same as the cognitive advantage associated with having completed secondary versus primary education. Our results suggest that the decrease in the proportion of Europeans having three or more children may have positive implications for the cognitive health of the older population. Given the magnitude of the effect, future studies on late-life cognition should also examine fertility as a predictor alongside more commonly researched predictors, such as education, occupational experiences, physical exercise, and mental and physical health. We also need more information on the types of interactions, supports, and conflicts that occur between parents and children, which may influence cognitive outcomes.

We found evidence that the negative cognitive effect of having three or more versus two children was largest in Northern Europe relative to the other European regions. Although standards of living in the Nordic countries are very high, so are costs. Estimates based on purchasing power parities suggest that the prices of goods and services are up to three times higher in the Nordic than in other European countries (Eurostat 2020). Housing costs in the Nordic countries are also among the highest in the world (Bengtsson et al. 2017). Having a third child in Northern Europe may therefore incur more financial costs (and potentially higher financial stress) than in many other regions. Moreover, the expectation that children should care for their aging parents may be lower in Northern Europe, where institutions are expected to provide support (Marckmann 2017).

Future research should address what the current study has not been able to analyze. First, we examined the *average* effect of having three or more versus two children on late-life cognition for individuals affected by the instrument (i.e., the sex of the first two children). It is plausible, however, that some parents or subpopulations will not have a preference for mixed-sex offspring, which has implications for the external validity of our results.

Our research focuses only on the transition from two to three or more children. Future studies should investigate the effects of having an additional child at lower parities (the transition to first and second births), which may differ from the effect of having three or more versus two children. Read and Grundy (2017) estimated the association between the number of children and cognitive functioning in later life and found that being childless (compared to having two children) is related to worse late-life cognition for women. They argue that having children provides a source of interactions and promotes social activities that are associated with better cognitive functioning. However, other aspects of childlessness could have positive consequences for late-life cognitive functioning by posing fewer financial and time constraints during adulthood relative to having children. Following delayed and postponed fertility, more Europeans are remaining childless (particularly in Central, Northern, and Western Europe) or having only one child (particularly in Eastern Europe). Understanding the effects of transitioning to parenthood or to a second child is therefore of increasing importance in the European context (Kreyenfeld and Konietzka 2017; Zeman et al. 2018).

Our results also provide the first evidence that having three or more versus two children may affect late-life cognition by affecting parents' late-life financial and social resources. However, the evidence is only suggestive; methodological problems and data limitations made it impossible to conduct a formal mediation analysis. Future studies should examine other potential mediators (e.g., stress, emotional support) and test mediation more stringently. Future research should also examine the effect of higher fertility on cognitive *change* as opposed to late-life cognition at a single point in time, given that predictors of decline may differ from predictors of change. ■

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