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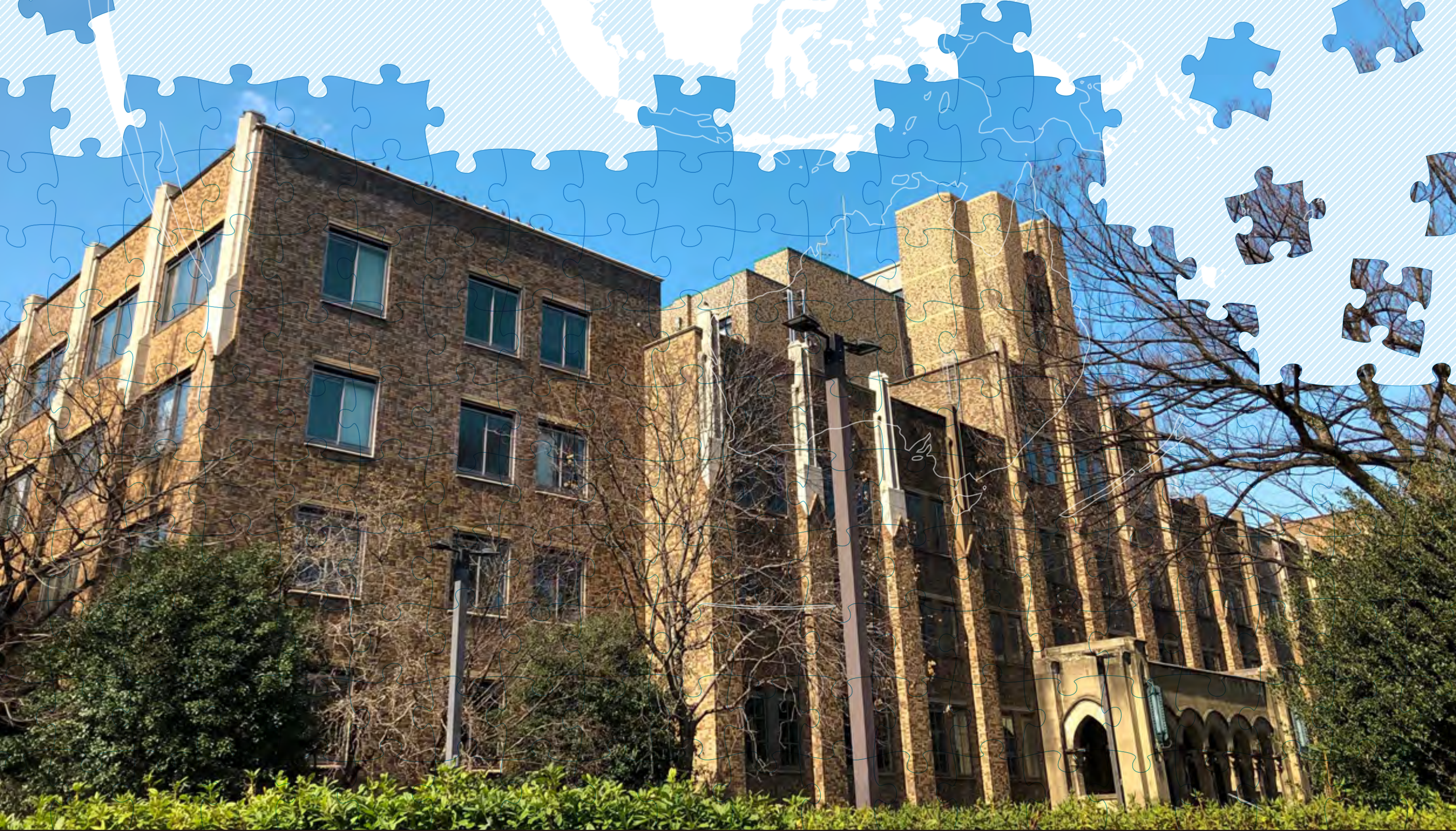
Early Demise for Highly Educated Grandparents Positively Affects Grandchildren's Achievement of Tertiary Education: Evidence from Contemporary Japan



No. 71

Date Jan. 2023

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Name Aguru Ishibashi

Early Demise for Highly Educated Grandparents Positively Affects Grandchildren's Achievement of Tertiary Education: Evidence from Contemporary Japan

Aguru Ishibashi (Senshu University)
ishi14.a@gmail.com
(7,927 words, contains 4 tables and 3 figures.)

Acknowledgments

The data for this secondary analysis, "National Survey of Social Stratification and Social Mobility, 2015, 2015 SSM Survey Management Committee," were provided by the Social Science Japan Data Archive, Center for Social Research and Data Archives, Institute of Social Science, The University of Tokyo. We thank the committee for their permission. A previous version of this paper was presented at the 32nd meeting of the Japanese Society of Family Sociology at Japan Women's University on September 3-4, 2022; at the 74th meeting of the Japanese Association for Mathematical Sociology at Tsukuba University on March 7-8, 2023; at the RC28 Spring Meeting held at Institut d'études politiques de Paris on May 24-26, 2023; and at a Quantitative Sociology Workshop on October 6, 2023. We would like to thank the participants and Masayuki Kanai for their helpful comments on the previous versions of this paper.

Abstract

Intergenerational mobility studies report that contacts between parents and children have parental resources transfer children and increase children's educational achievement. Recent studies beyond two-generational mobility have reported that long life expectancy makes contact between grandparents and children improve the association between grandparents and children's status, even when controlling for parental status. Using data from the 2015 Japanese Social Stratification and Social Mobility Survey, we investigated the effects of grandparent exposure on grandchildren's educational achievement in Japan, which has the longest life expectancy in the world. A highly educated grandfather who died before their grandchildren were born increased their grandchildren's education. However, the exposure time between a highly educated grandfather and grandchildren negatively impacts their grandchildren. Our results indicate that (1) competing for parental resources between a living grandfather and grandchildren has negative impacts on grandchildren's educational achievement, (2) we should distinguish mechanisms between contact and not, because dead grandparents can transfer resources through a bequest, and (3) Not always supported are conventional social mobility studies implicitly assume that prior generations transfer resources to the next generation, in a situation in which a developed country that has undergone long life expectancy and aging needs nursing care.

Keywords: intergenerational mobility, multigenerational mobility, contact, education

Introduction

The study of intergenerational mobility is fundamental to social stratification research. Many scholars have argued that children with high-status parents tend to become high-status children (e.g., Blau and Duncan 1967; Erikson and Goldthorpe 1992; Shavit and Blossfeld 1993). The primary mechanisms for these effects involve the transfer of parental resources to children through contact between parents and children (Bourdieu and Passron 1990; Coleman 1988; Jæger and Breen 2016; Lareau 2003; Smeeding et al. 2011).

Recently, studies on three-generational mobility that examine how grandparental status directly affects grandchild status have been on the rise, extending beyond conventional two-generational mobility studies (Anderson et al. 2018); these studies have considered contact between grandparents and grandchildren to be important. Mare, in his presidential address to the Population Association of America, asserted that the conventional two-generational mobility framework might omit important sources of family-based social inequalities of intergenerational continuities since parents have their own parents (Mare 2011). Moreover, the significance of grandparents within families has increased due to longer life expectancies, resulting in more overlapping time (contact[1]) between grandparents and grandchildren (Bengtson 2001; Mare 2014). As a result of these considerations, many social stratification scholars have examined three-generational mobility and found direct effects of grandparents on grandchildren (e.g., Song 2016; Chan and Boliver 2013). A plausible mechanism for these effects is the contact hypothesis (Anderson et al. 2018), which suggests that increased contact between grandchildren and grandparents with a high status may lead to the transfer of grandparental resources to grandchildren, ultimately contributing to the achievement of high social status (Knigge 2016; Neidhöfer and Stockhausen 2019; Song and Mare 2019; Zeng and Xie 2014).

However, for two reasons, we argue that the validity of the contact hypothesis supported by two- and three-generational studies may not always hold for three-generational mobility. First, grandparents who become frail due to aging and the need for nursing care may inadvertently compete with grandchildren who need parental resources for educational success for the same parental resources. Previous three-generational studies may have typically operated under the assumption informed by two-generational mobility studies that resources are transferred from the prior generation to the next generations through contact. Therefore, previous studies have

[1] We define overlapping time as "contact," in line with Knigge (2016). Similarly, Song and Mare (2019) refer to overlapping time as "exposure," which is synonymous with "contact."

assumed that increasing life expectancy increases the contact between grandparents and grandchildren and that increasing contact leads to positive effects for grandchildren. However, three-generational studies cover a broader timeframe than two-generational studies because they include the grandparental generation. The grandparental generation often consists of elderly individuals who may require nursing care and thus become recipients of their adult children's financial and time resources. The proportion of frail grandparents may be increasing, and these grandparents may have increased contact with their growing grandchildren, who need parental resources for status achievement in developed countries, where prolonged life expectancies and trends of delayed childbearing are common. In such cases, grandparents may find themselves aggressively competing with their grandchildren for access to parental resources (Tanskanen et al. 2017; Kreidl and Hubatková 2014), which could result in the younger generation not receiving adequate resources or not achieving desired outcomes (Pfeffer 2014). Thus, the early death of grandparents might increase grandchildren's educational attainment since subsequent bequests may allow parents to invest resources in their grandchildren's educational achievement.

Second, competition may arise in families with high-status grandparents. In societies where parents bequeath assets to the child who cares for them, if grandparents are of high status, are perceived as having substantial resources, and become frail, parents who hope to receive bequests may assume the responsibility for caring for them. Allocating time to care for grandparents can reduce the time available for grandchildren. Consequently, these grandchildren might achieve poor educational outcomes. Previous studies (Tanskanen et al. 2017; Kreidl and Hubatková 2014; Pfeffer 2014) that have explored the mechanisms of competition did not investigate or focus on the varying effects of contact based on grandparental status or the extent of grandparental resources.

To explore the impact of grandparents' socioeconomic status on their grandchildren's educational achievement, we use contemporary Japanese data to examine whether contact between grandparents and grandchildren amplifies or attenuates these effects. Japan has the highest life expectancy globally (OECD 2018). If the assumptions of previous studies hold, Japan should experience positive effects from contact between grandparents and grandchildren on their grandchildren's educational achievement. However, Japan has an aging society, with a significant gap between life expectancy and healthy life expectancy, as well as delayed childbearing. Moreover, in Japan, parents tend to bequeath assets to children who care for them or who take over family businesses (Horioka 2002, 2020). Consequently, grandchildren may spend time with older and frail grandparents who require nursing care from their children. This could lead to negative impacts of contact between grandparents and grandchildren on their grandchildren's educational achievements.

We find that contact with a highly educated grandfather has a negative impact on grandchildren's educational achievement. Conversely, if a highly educated grandfather passes away before his grandchildren are born, there is a positive effect on their educational outcomes. This study makes three major contributions to the literature. First, we find that a shared lifetime between highly educated grandparents and grandchildren has a negative impact on grandchildren’s educational achievements in contemporary Japan, which has the longest life expectancy in the world. Second, we divide the mechanism into contact and noncontact mechanisms. Finally, our three-generational mobility study indicates that the assumption of conventional social mobility studies that prior generations transfer resources to the next generation is not always supported, especially in situations where a developed country has a long-life expectancy and an aging population requiring nursing care.

Theoretical background

Mechanisms of multigenerational effects

Previous studies on intergenerational mobility (e.g., Erikson and Goldthorpe

1992; Blau and Duncan 1967; Shavit and Blossfeld 1993) have assumed the presence of the Markov process. This process posits that the previous generation transfers resources to the current generation only. It assumes that the impact of three generations can be expressed as the second power of association between two consecutive generations (Bartholomew 1973; Becker and Tomes 1979; Zeng and Xie 2014). In fact, some studies on multigenerational mobility that support the Markov process have found null effects of grandparents on grandchildren when controlling for parental traits (Engzell et al. 2020; Erola and Moisio 2006; Bol and Kalmijn 2016; Warren and Hauser 1997).

However, other studies have identified direct effects of grandparents on grandchildren, even when controlling for parental factors (e.g., Erola et al. 2018; Lehti et al. 2018; Deindl and Tieben 2017; Sheppard and Monden 2018; Hällsten and Pfeffer 2017; Chiang and Park 2015); the most plausible mechanism for this influence is delineated by the contact hypothesis (Neidhöfer and Stockhausen 2019; Song and Mare 2019; Zeng and Xie 2014). The contact hypothesis proposes that prolonged contact between grandparents and grandchildren can enhance grandparents' status achievement. This contact can foster improved academic performance and cognitive ability in grandchildren (Falbo 1991; Sear and Coall 2011; Tanskanen and Danielsbacka 2018; Pong and Chen 2010). Thus, by raising grandchildren, grandparents can transfer valuable cultural resources (Møllegaard and Jæger 2015) and foster socialization through socioemotional support (Zhen and Xie 2014). Several empirical studies have shown that overlapping time (Knigge 2016; Neidhöfer and Stockhausen 2019; Song and Mare 2019) and coresidence (Zeng and Xie 2014) between highly educated or high-status grandparents and their grandchildren are positively correlated with grandchildren's educational achievements.[2] This effect is amplified by the increased shared lifetime between grandparents and grandchildren, which is a byproduct of greater longevity and reduced sibling competition due to lower fertility rates (Song and Mare 2019).

Moreover, these contact effects might be observable in contemporary societies because the increased advancement of women in the workforce and the rise of dual-income households necessitate grandparents to take on roles in caring for grandchildren (Bordone et al. 2017; Di Gessa et al. 2016; Geurts et al. 2014; Meyer and Kandic 2017). In such scenarios, grandparents who live with or near their grandchildren tend to offer more support to both grandchildren and their parents than do those who live far away.

[2] Zeng and Xie (2014) investigated the interaction between grandparents' education and the living arrangements measured at the time of the interview. However, their findings cannot be viewed as indicating a causal relationship, given that the living arrangements might have been established after the grandchildren attained their education. Furthermore, various studies have found that high-SES children can positively impact parental longevity (Wolfe et al., 2018; Friedman and Mare, 2014). As a result, coresiding with grandparents could suggest that parents with significant resources can provide care for both their children and their own parents.

However, grandparents who do not reside with or near their grandchildren can still influence them (Mare 2011; Song and Mare 2019). This is largely because parents' visits to their familial homes facilitate contact between grandparents and grandchildren, potentially affecting the latter's values. In this context, an extended shared lifetime between generations can lead to an increased number of encounters between grandparents and grandchildren. Furthermore, grandparents who are alive might offer financial assistance, especially when parents face adverse circumstances (AARP 2002; Coall and Hertwig 2010). Consequently, the contact hypothesis posits that living grandparents have a stronger influence on their grandchildren than do those who are deceased (Song and Mare 2019).

Hypothesis 1: A longer overlap time between highly educated grandparents and children positively affects grandchildren's educational achievement (positive contact hypothesis, Figure 1, solid line).

However, although a detailed discussion follows, contact with high-status grandparents may adversely affect their grandchildren's educational achievements. In families in which grandparents who become frail due to aging and delayed childbearing need care, grandchildren might compete for parental resources, especially if they are motivated by potential inheritances from their high-status grandparents. In contrast, if such grandparents pass away before their grandchildren reach college age, then inherited resources might be directed toward their grandchildren's education.

Considering both healthy life expectancy and delayed childbearing, grandchildren might have extended contact with older and frail grandparents. While both overall life expectancy and healthy life expectancy, which provides insight into the average number of years a person can expect to live in good health, are on the rise (Vaupel 2010; GBD 2013 DALYs and HALE Collaborators et al. 2015), a notable gap of approximately ten years exists between them (GBD 2013 DALYs and HALE Collaborators et al. 2015).[3] If this gap overlaps with growing grandchildren, then grandparents need nursing care and are rarely able to help rear grandchildren; contact with such older grandparents might not significantly positively influence their grandchildren (Mare 2014). The interaction between older grandparents and grandchildren does not seem to affect educational achievement (Lehti et al. 2018).[4]

[3] Between 1993 and 2013 in developed countries, the healthy life expectancy rose from 62.12 to 66.00 years for males and from 67.18 to 70.03 years for females. Overall life expectancy increased from 70.64 to 75.50 years for males and from 77.97 to 81.82 years for females (GBD 2013 DALYs and HALE Collaborators et al. 2015).

[4] Contrary to these suggestion, Fomby, Krueger, and Wagner (2014) observed a positive correlation between a grandparent's age at the birth of their own children and their grandchildren's verbal achievement. They posited that an older age at the birth of one's children suggests accumulated wealth and human capital.

Moreover, as the timing of childbearing has been delayed along with increased longevity, the timing of becoming a grandparent has also been delayed.[5] In industrialized societies, individuals often marry and have children when they accumulate sufficient resources and achieve financial stability (Hammarberg and Clarke 2005). This behavior contributes to delays in childbearing. Such delays further influence the likelihood of becoming a grandparent. Previous studies have reported that the age at which people become grandparents is increasing (Margolis and Verdery 2019; Leopold and Skopek 2015; Song and Mare 2019). In brief, growing grandchildren may have contact with older and frail grandparents because of childbearing delays and gaps between overall life and healthy life expectancies.[6]

Frail grandparents needing care may compete with growing grandchildren for parental resources and negatively impact their educational achievements. Some studies have shown that coresidence with an older grandmother or having a grandmother who requires care can negatively affect grandchildren (Black et al. 2002; Spieker and Bensley 1994; Tomlin 1998). Moreover, living with grandparents has been shown to

[5] However, many prior studies on the contact hypothesis (Knigge 2016; Neidhöfer and Stockhausen 2019; Zeng and Xie 2014; Braun and Stuhler 2018; Helgertz and Dribe 2021; Li and Cao 2023; Bol and Kalmijn 2016) have not addressed this trend.
[6] Higher educational level is linked to delayed childbearing (McLanahan 2004) and grandparenthood (Skopek and Leopold 2017), as well as lower mortality, longer lifespan (Meara et al. 2008), and better health (Elo 2009), than lower educational level. Therefore, the time span from becoming grandparents to frailty may not differ by education.

reduce grandchildren's educational ability (Tanskanen et al. 2017; Kreidl and Hubatková 2014). Tanskanen et al. (2017) attributed the negative impacts of living with grandparents on grandchildren to the local resource competition model, which refers to competition for limited resources within a population. Older grandparents may not be net producers and may rely on the resources of parents. Elderly grandparents often receive economic support and care from their own children (Suitor et al. 2015). To achieve educational success, children require both educational investment and regular interactions with their parents (e.g., Bourdieu and Passron 1990; Coleman 1988). Consequently, when grandparents and grandchildren compete for limited parental resources, insufficient resources can be allocated to grandchildren, negatively affecting their educational outcomes.

The mechanism of local resource competition may be more applicable to families in which frail grandparents possess significant resources, considering the models related to bequests and inheritance. Models related to bequests and inheritance can be categorized into three types. The first model is the life cycle model (Modigliani and Brumberg 1954; Bernheim et al. 1985; Cox 1987), which posits either leaving a sizable inheritance to children who care for their parents in old age or expending all available resources. Second, the dynasty model (Chu 1991) involves leaving a bequest for children to continue their family businesses. Third, the altruism model (Barro 1974; Becker 1981) promotes the equal distribution of bequests among children. In societies in which the first two models are dominant, individuals may care for their aging parents or take over the family business to secure parental bequests.[7] Consequently, individuals (parents) may be taking care of their frail grandparents who have affluent resources, so that grandparents deprive grandchildren of parents' resources.

Moreover, if grandparents pass away before their grandchildren reach the age of eligibility for tertiary education, grandchildren may use their grandparents' resources through bequests for their educational investments. Receiving a bequest can elevate the family's status, potentially allowing parents to allocate more time from work to child-rearing (Becker and Murphy 1988; Cremer and Pestieau 2001, Groneck 2017). Bequests result in greater wealth accumulation in recipient households than in nonrecipient households, especially in stabilizing and advancing a household's social status within the middle hierarchy (Korom 2018). Some may believe that the assumption that a bequest results in the transfer of resources from grandparents and parents can then be utilized for their children might not be perceived as the direct effect of grandparents on

[7] For instance, in societies that adhere to Confucian values, parents often intend to leave inheritances for their children who live with them and for their those who provide parents with material support, as per Ho's (2022) findings.

grandchildren, on which multigenerational studies have primarily focused (Anderson et al. 2018; Park and Kim 2019; Mare 2011). However, as discussed below, potential multigenerational effects stemming from the inheritance of wealth are highlighted.

The mechanisms underlying multigenerational effects encompass not only direct contact but also various other factors. For instance, Mare (2011) suggested that durable resources such as financial and physical resources can influence subsequent generations as they are handed down through the family line. By nature, institutions tend to endure beyond individual lifespans, thereby enabling ancestors to exert influence over their descendants (Mare 2011). This dynamic is observable in frameworks, such as inheritance laws and other legal structures (Coall and Hertwig, 2010; Madoff, 2010). Moreover, grandparents' prestige, such as their legacy systems, affects their descendants. Legacy systems that grant individual benefits based on their forebearers' affiliations, such as having a relative who graduated from or donated to Ivy League schools, can offer substantial advantages during the admission process (Karabel 2005; Mare 2011). In fact, several empirical studies (Knigge 2016; Hällsten and Kolk 2023) have indicated that ancestors from as far back as seven generations and great-grandfathers who hardly had contact with their great-grandsons can still increase their descendants' status attainment.

Hypothesis 2. A longer overlap time between highly educated grandparents and children negatively affects grandchildren's educational achievement (negative contact hypothesis; Figure 1, dashed line).

These direct contact effects may differ based on grandparents' gender. It is generally observed that women have a longer life expectancy and a more extended healthy lifespan than men (WHO 2019). Moreover, women often marry earlier, become grandparents sooner, and enjoy a longer healthy period, during which they can assist their families. Grandmothers typically engage more in helping with household chores, rearing grandchildren, and investing time and resources in both their children and grandchildren (Coall and Hertwig 2010; Silverstein and Marenco 2001), potentially leading to positive impacts on the latter. In contrast, men usually become grandparents later in life and have a shorter span of healthy years, which might foster competition between grandfathers and growing grandchildren for parental resources. Additionally, because men are often viewed as the primary holders of financial and physical assets, a grandfather's passing could substantially benefit grandchildren through inheritance. This dynamic might explain why some studies (Patterson et al. 2020) have shown a positive impact on grandchildren's educational outcomes following the death of a grandfather but a negative impact in the case of a passing grandmother.

Hypothesis 3. Contact effects may differ based on grandparents' gender.

The Japanese context

To test our hypotheses, we analyze data from contemporary Japan, which has the world's longest life expectancy, the world's longest healthy life expectancy, and shows trends toward delayed childbearing. Japanese life expectancy and healthy life expectancy were the longest in the world in 1978 (Ministry of Health and Welfare 1978) and still remain at the top of each list. The male life expectancy increased from 73.35 in 1980 to 79.55 in 2010. The female life expectancy increased from 78.76 in 1980 to 86.30 in 2010 (Figure 2 (a)). Japan also has the world's longest healthy life expectancy (GBD 2013 DALYs and HALE Collaborators et al. 2015). For males, the healthy life expectancy grew from 68.09 years in 1990 to 71.11 in 2010, while for females, it increased from 72.24 years in 1990 to 75.56 in 2010 (Figure 2 (b)). Along with increased longevity, the timing of childbearing has also been delayed. The mean age of childbearing for males increased from 30.1 in 1975 to 34.2 in 2021 (Figure 2 (c)), and for females, it increased from 27.4 in 1975 to 32.2 in 2021 (Figure 2 (c)). These trends are consistent with those observed in other East Asian societies (Raymo et al. 2015). This delay in childbearing can be attributed to later ages at first marriage and fewer instances of nonmarital childbearing (Anderson and Kohler 2013).[8] Given these factors, while longer life expectancies might increase the overlap time between grandparents and grandchildren, the age at which individuals become parents and grandparents is also delayed. Consequently, grandchildren are often exposed to frail grandparents.

Japan, traditionally known for its multigenerational coresidence and patriarchal family system (Kato 2013; Morgan and Hirosima 1983; Morioka 1993; Sugimoto 2010), similar to other Asian societies (Raymo et al. 2015), has recently experienced a decline in three-generation households and lived-with parental figures, as shown in Figures 2 (d) and (e). This finding contrasts with trends in China, where the contact effects of grandparents on grandchildren remain and where high coresidence rates with parents are consistently elevated (Zhen and Xie 2014). Moreover, in the U.S., both the contact effects of grandparents on grandchildren (Song and Mare 2019) and the prevalence of multigenerational coresidents are on the rise (Pew Research Center 2010).

In Japan, individuals are expected to live near their mothers, often within the

[8] Additionally, more highly educated individuals tend to marry later, further contributing to the delay in childbearing (Shirahase 1999).

same city, ward, or municipality (Figure 2 (e)). This trend is influenced by the anticipation of inheriting homes after the passing of parents due to the high costs of housing (Sugimoto 2010) and the need for assistance in childcare (Chitose 2021). Indeed, if a mother is employed, it is common for the grandmother to assist with childcare (Yoda and Shintani 2018). Often, grandmothers coreside with their families or live nearby (Sasaki et al. 2017). While grandmothers typically assume this role, grandfathers are less likely to do so (Yasuda 2018; Hirai 2022).

However, living close to one's parents also implies the responsibility to look after them as they age. Embedded in Japanese culture is the principle of filial piety, in which children are expected to respect and care for their elders (Hashimoto and Ikels 2005). This cultural value is also prevalent in many East Asian societies (Thornton and Lin 1994; Whyte 2004). When elderly care becomes necessary, it is traditionally the wife who takes up the mantle because of established gender roles. Juggling caregiving and child-rearing is not an easy task. In fact, a substantial number of married women in Japan find themselves caught between caring for young people and elderly people simultaneously (Koyama 2016).

Regarding the intergenerational transmission of economic resources, Japanese individuals tend to have a lower intention to inherit and are more suitable for selfish life-cycle models or dynasty models than their U.S. counterparts are (Horioka 2002; Horioka 2020). However, in Japan, the prevalent ownership of homes means that inheritance occurs frequently. Often, when a person passes away, their home is automatically transferred to their child. In Japan, bequests typically represent 40–60% of net household assets, with the primary component being the owned home. This is because housing values are heavily influenced by land prices, which have historically been high in Japan (Shimono and Ishikawa 2002). Moreover, if a bequest occurs, the average value is 14,334,000 yen (= 122,324.63 USD[9]) (Horioka, 2008). If grandparents were to pass away while their grandchildren were still enrolled in educational institutions, parents might direct the inherited resources toward educational expenses. While adult children often receive financial assistance from their parents (Shirahase 2005), the converse is true: parents can receive financial support from their adult children (Shirahase 2005; Chitose 2010). Therefore, grandparents' financial position plays a multifaceted role in Japan. Their mere existence can be either a boon or a burden for parents, depending on the financial dynamics. However, the inheritance they leave behind upon passing can have a substantial impact.

[9] We utilize data from the end of January 2006, which is based on the Bank of Japan (2024). This is because the reference (Horioka 2008) uses data collected in 2006, and 1 USD = 117.18 yen at the end of January 2006.

Data and methods

Data

Our data were sourced from the 2015 Japanese Social Stratification and Social Mobility Survey (SSM), which is a cross-sectional study. A nationwide random sample comprising of men and women aged 20-79[10] years was selected using a two-stage stratified random sampling procedure. The data were collected through face-to-face interviews and complemented by a self-administered questionnaire provided to the same respondents. The total sample size was 7,817, for an effective response rate of 50.1%. The SSM is a longitudinal national survey that has been conducted decennially since 1955 and serves as a rich resource for scholars investigating social stratification, inequality, and mobility in Japan. Notably, the SSM2015 data encompass educational information, birth years, and death years across three generations, rendering it a suitable dataset for our investigation. Our study aimed to ascertain whether the overlap time between grandparents and grandchildren influences grandparents' impact on their grandchildren's educational achievement in Japan.

The analytic sample for this study comprises 8,582 cases, specifically focusing

[10] The study targeted individuals aged 20 to 79 as of December 31, 2014, but data collection from January 31 to July 26, 2015, also captured cases of 80-year-olds.

on respondent's children aged ≥20 years. The original SSM2015 dataset was structured with units based on respondents, encompassing information on their parents and children nested within. We restructured the dataset such that the analytical units were centered around respondent's children aged >20 years. This reorganization was predicated on two notable aspects of tertiary education in Japan. First, compared to other countries, Japan has a lower dropout rate of 10% from tertiary education (OECD 2013). Second, it is common for individuals to retake university entrance examinations in the subsequent year or, in rare cases, the year after if they fail to secure admission to their first-choice institution. The rate of retaking the examination was 30% in the 1990s and decreased to just over 10% in the first half of the 2010s (Kagawa 2022). Given these considerations, we deemed it appropriate to define the analytic units as respondents aged ≥20 years. This approach acknowledges that entering tertiary education in this context is tantamount to attaining a degree because of the low dropout rate and the potential delay in enrollment age arising from retaking examinations. This reorganization yielded an analytical sample size of N=8,582.

We used multiple imputation to address the missing cases in our data, as illustrated in Table 1, which displays the missing data rate. Omitting all missing cases reduced the sample size to 5,015, representing a 58.4% decrease. This reduction is problematic because it introduces recall bias (Mare 2011). Therefore, we employed multiple imputation, as outlined by Rubin (1987), to impute the missing values. We used the “mi” package in Stata for this purpose, with the number of imputations set at M=100 and the seed value set at 1. As a robustness check, we conducted a complete case analysis using listwise deletion to omit all missing cases.[11]

Moreover, our data may exhibit survival biases, particularly among older respondents, given that our dataset included respondents from a parental generation aged ≤80 years. Yoda (2018) identified survival biases, revealing more than 30% of males and more than 20% of females aged 70 years, utilizing the Human Mortality Database and Vital Statistics. There is a potential for bias within the respondents' children's generation owing to these survival biases, as deceased individuals are not represented among the respondents. Considering this, Yoda (2018) recommended a robustness check that compares all cases with a subset of cases that omits respondents aged over 70 years when examining variables pertaining to the respondents' children's generation. In alignment with Yoda's (2018) suggestion, we conducted a robustness check, analyzing 5,660 cases while omitting respondents aged older than 70 years.

[11] This approach is recommended by van Buuren (2018), who developed the “mice” package for multiple imputation, suggesting a comparison of multiple imputation results with complete case results to assess the adequacy of the imputation.

Variables

Outcome variable: Grandchildren's education (entering tertiary education or not).

We used the respondents' children's education as grandchildren's ones. The number of lower secondary, upper secondary, and vocational schools was zero. Junior college, university, and graduate school all had a value of 1. Answers of "do not know," and "no answer" were treated as missing.

Main explanatory variables: Grandparents' education and overlap time between grandparents and grandchildren.

The primary explanatory variables in this study were grandparents' educational level and the overlap period between grandparents and grandchildren. For the education level of the grandparents, we used the educational information of the respondent's father and mother to represent the education of the grandfather and grandmother, respectively. We used the same procedure for grandparent's education as grandchildren's education. While our data include education and the number of years of death of a respondent's parents, they lack information on the respondent's spouse's parents. Consequently, the coefficients derived in our results represent the influences of a mixture of paternal and maternal grandparents because male respondents represent the paternal lineage, whereas female respondents represent the maternal lineage.

Overlapping time was defined as the duration during which grandparents and grandchildren lived together regardless of their coresidence. Specifically, we subtracted the grandchildren's birth years from their grandparents' death years. If the difference was negative, that is, if grandparents died before their grandchildren were born, the overlap time was defined as zero. The integer range of the values is between 0 and 19.[12] A value of zero years was assigned if the grandparents passed away before the grandchildren were born, implying no contact. In addition, a value of 0 years was assigned if the grandchildren were born in the year the grandparents passed away, although there may have been slight contact.

Control variables

We controlled for the grandparental birth year. This is because the difference in grandparents' birth years might vary the overlap time between grandparents and grandchildren, as our dataset reconstructed the analytical units centered around the

[12] The precision of this measure is limited due to the data not specifying the exact months of births and deaths. The maximum value is 19 years, since in Japan, the eligibility age for taking entrance examinations for tertiary education is 18, and a value of 19 years confirms the grandparents were alive until the entrance examination was taken.

respondent’s children. For example, the younger generation of grandparents typically becames grandparents at an earlier age, leading to an extended period of overlap between the lives of grandparents and grandchildren. We used the respondents’ parents’ birth years to represent their grandparents’ birth years.

As parental traits, we controlled for respondent's education[13], birth year, eldest sibling status, number of siblings, gender, age when the first child was born, education[14] and birth year of the respondent’s spouse. As status measures, to avoid potential bias from incorporating other parental measures, we focused solely on parental education to represent the status of the middle generation (Breen 2018).[15] We factored in the respondent’s number of siblings and eldest sibling status because the number of siblings can influence the allocation of parental time and economic resources (Coall and Hertwig 2010). Given Japan's emphasis on the right of inheritance and the norm of coresidence with parents for the eldest child (Sugimoto 2010), the eldest child may inherit more than their siblings, even if bequests are legally shared equally among them. The age at which the first child was born was determined by subtracting the respondent’s first child’s

[13] We used the same procedure as grandchildren's education.
[14] We used the same procedure as grandchildren’s education, and if a respondent was divorced or widowed, we used the divorced or deceased spouse’s information.
[15] Even when we control the current occupation of respondents’ and spouses, we get the same results (refer to Appendix).

birth year from the respondent's birth year.[16] Our primary measure of interest was the interaction between grandparents' education level and the number of years they overlapped with their grandchildren. As families from lower socioeconomic strata tend to have children at younger ages (McLanahan 2004) and grandparents from such families are likely to have more interactions with their grandchildren (Song and Mare, 2019), subtle biases can be introduced (Breen 2018). To counter this bias, we controlled for the age at which the first child was born.[17] We also considered the respondent's living district at age 15 to account for potential neighborhood effects that might bias the influence of grandparents (Breen 2018).[18][19]

We controlled for the grandchildren's sex, birth year, number of siblings, and birth order.

Analytical strategy

Three models of the linear probability model (LPM) of whether grandchildren enrolled

[16] Our data contain adopted children. As a robustness check, we obtain the same results when using only the cases of biological children (refer to Appendix).
[17] Many previous studies (Knigge 2016; Neidhöfer and Stockhausen 2019; Zeng and Xie 2014; Braun and Stuhler 2018; Helgertz and Dribe 2021; Li and Cao 2023; Song and Mare 2019) focused on the contact hypothesis did not control for age at firstborn child.
[18] Even if we omit this variable, we obtain the same results (refer to Appendix).
[19] Our data contain respondent's current living district. However, this information might be varied after children achieve their educational status. Hence, we did not use respondent's current living district.

in tertiary education were conducted as the dependent variable: (1) not controlling for the traits of middle generation, (2) controlling for the traits of middle generation, and (3) controlling for the traits of middle generation and introducing the interaction term. The rationale for using the LPM is its straightforward interpretation (Ai and Norton 2003). Additionally, the results from the LPM are consistent with those from binary logit models if the linearity assumption does not substantially alter the outcomes (Mood 2010).[20]

$$Y = \beta_0 + \beta_1 GF + \beta_2 GM + \beta_3 GFC + \beta_4 GMC + \beta_5 W \qquad (Model\ 1)$$

Model 1 used the education level of grandparents and the overlap time between grandparents and grandchildren without controlling for parental traits. The coefficient of grandparents' education in this model indicates the gross effects of grandparents on the educational achievements of grandchildren due to the lack of control of parental traits. Furthermore, this coefficient combines the effects of grandparents who passed away before the birth of their grandchildren and those who were alive after their grandchildren were born. Here, "Y" represents the predicted probability of

[20] We obtain the same results with a binary logit model (refer to Appendix).

grandchildren achieving a higher education. "GF" denotes the education level of the grandfather, while "GM" represents the education level of the grandmother. "GFC" and "GMC" represent the overlapping years between the grandchildren and the grandfather and grandmother, respectively. "W" refers to the covariates concerning the grandparents and grandchildren.

$$Y = \beta_0 + \beta_1 GF + \beta_2 GM + \beta_3 GFC + \beta_4 GMC + \beta_5 W + \beta_6 Z \qquad (Model\ 2)$$

Model 2 introduced parental traits "Z" as the controlling factors in the middle generation. The goal of three-generational mobility studies is to investigate the circumstances under which grandparents can directly affect their grandchildren while controlling for parental traits (Anderson et al. 2018; Mare 2011; Park and Kim 2019).

$$Y = \beta_0 + \beta_1 GF + \beta_2 GM + \beta_3 GFC + \beta_4 GMC + \beta_5 GF \cdot GFC + \beta_6 GM \cdot GMC + \beta_7 W + \beta_8 Z \qquad (Model\ 3)$$

Model 3 introduces the interaction between grandparents' education level and their overlap with grandchildren into Model 2. Positive coefficients of the interaction signify that the positive effects of grandparents' education are stronger for longer overlapping times between grandparents and their grandchildren. The negative coefficients of the interaction signify that the positive effects of grandparents' education are weaker for longer overlap times. Incidentally, if highly educated grandparents pass away before their grandchildren are born, then the effect on grandchildren's educational achievements is represented solely by the grandparents' education coefficient (either β_1 or β_2) since both the overlap time and the value of the interaction are zero. This interaction allows us to distinguish between the duration of contact and the noncontact effects of highly educated grandparents on their grandchildren's educational achievements.

Our estimand involves the interaction between grandparents' education level and the number of overlapping years they have with their grandchildren. If the coefficient of this interaction is significantly positive, our results will support Hypothesis 1, as illustrated by the solid line in Figure 1. Conversely, if the coefficient is significantly negative, our results will support Hypothesis 2, as depicted by the dashed line in Figure 1. Throughout our analysis, we utilized a .05 significance level with two-tailed tests. Furthermore, we employed cluster robust standard errors at the family level, which is a necessary step given that our data come from the parental generation and present a nested hierarchical structure involving grandchildren.

Results

Basic characteristics

Table 1 displays the descriptive statistics. For the dependent variable of grandchildren's education, 50.61% of the grandchildren achieved tertiary education. Regarding the primary independent variables, 13.07% of grandfathers and 5.07% of grandmothers had attained a tertiary education. Additionally, the mean duration of overlap between grandfathers and grandchildren was 12.47 years, whereas that between grandmothers and grandchildren was 16.39 years. This implies that grandmothers have a longer duration of overlapping years with their grandchildren than do grandfathers.

Results of contacts between highly educated grandparents and grandchildren

As shown in Table 2, the coefficient for grandfather education was statistically significant across all the models. In Model 3, which included interaction terms and controls for parental traits, the coefficient for grandfathers' education was 0.163. This suggests that grandchildren with highly educated deceased grandfathers are more likely to enter tertiary education, showing a 16.3-point advantage over those with less-educated deceased grandfathers. However, the interaction between the grandfather's education and the overlapping year yielded a coefficient of -0.007. If a highly educated grandfather is alive until the grandchild reaches the eligible age for tertiary education, the advantage conferred by the grandfather's education decreases to approximately 3.0 points, as the interaction term coefficient of -0.007 multiplied by 19 equals -0.133. In contrast, the coefficients pertaining to grandmothers' education and the interaction term were not statistically significant. Therefore, our results supported the negative contact hypothesis (Hypothesis 2). In addition, Hypothesis 3 was supported since the contact effects were found to differ between grandparents' genders.

It is worth noting that there was a difference in the coefficients for grandfathers' education between Models 2 and 3. In Model 2, the coefficient for grandparents' education, net of parental characteristics, was 0.084. This suggests that for grandchildren with a highly educated grandfather, the probability of entering tertiary education increases by approximately eight percentage points. However, this coefficient may blend with the effects of the various mechanisms. On the other hand, in Model 3, which included interaction terms, the coefficient for grandparent education, net parental characteristic, was 0.163. This is nearly double the coefficient of Model 2. Since the coefficient for grandfather's education in Model 3 reflects omitted contact between highly educated grandfathers and grandchildren, this coefficient indicates the effects of having a highly educated grandfather but no contact.

By examining the role of grandmothers, we discovered that a longer duration of overlap in years increased the likelihood of grandchildren achieving tertiary education across all the models. In Model 2, while accounting for parents' traits, an increase in overlapping years by one year raised the probability of advancing to tertiary education by approximately 0.3 points. If the grandmother lives until the grandchild reaches the age eligible for tertiary education, then the advantage associated with the grandmother increases to approximately 5.7 points, as the overlapping year coefficient of 0.003 multiplied by 19 equals 5.7. However, as mentioned earlier, the coefficients of grandmother's interaction are not statistically significant, indicating that grandmothers' resources do not appear to be transferred to grandchildren.

Sensitivity analysis

To perform a robustness check, the sample was reanalyzed, excluding respondents older than 70 years (Table 3). These results are largely consistent with our main findings. However, in Model 2, the coefficient for grandfather's education was 0.043, reaching statistical significance at the 0.1 level. Moreover, in Model 3, which included interaction terms, the coefficient for grandfather education was 0.135, with a significance level of 0.01. Additionally, in Model 3, the interaction effect between grandfather's education and the number of years spent overlapping with grandchildren was -0.007 and statistically significant at the 0.05 level. The education level of the grandmother and the interaction between her education level and the number of years of overlap with her grandchildren did not significantly differ. The number of years of overlap between grandmothers and grandchildren had a significant positive impact on grandchildren's educational achievement across all the models. Thus, we concluded that survival bias did not affect our results.

To further corroborate our findings, a second robustness check involving a complete case analysis with listwise deletion was conducted, affirming the consistency of the results (Table 4). Hence, we concluded that missing case bias did not affect our results. Figure 3 illustrates the marginal effects of the grandfather's education derived from the complete case analysis.

Discussion

Our analysis of the 2015 SSM data revealed that a longer overlap in years between highly educated grandfathers and grandchildren decreases the likelihood of grandchildren accessing tertiary education. In particular, if a highly educated grandfather lives until his grandchildren reach the age of tertiary education enrollment, the advantage associated with the grandfather's education vanishes. The presence of deceased, highly educated grandfathers positively affect grandchildren’s educational achievement. Conversely, highly educated grandmothers do not exhibit these effects. However, regardless of the grandmother’s education, a longer overlap between the grandmother and grandchildren increases the likelihood of grandchildren accessing tertiary education. Therefore, Hypothesis 1 was not supported, whereas Hypothesis 2 was supported. In addition, Hypothesis 3 was supported.

These findings contradict the findings of previous studies (Knigge 2016; Neidhöfer and Stockhausen 2019; Zeng and Xie 2014; Song and Mare 2019), which have reported that contact between high-status grandparents and grandchildren positively affects the educational achievements of the latter. Our findings implicitly challenge the assumptions of conventional research. It is commonly assumed that earlier generations provide resources for subsequent generations. However, as individuals age, become frail, and require nursing care, they often shift from being net producers to being recipients, drawing resources from younger generations. Given the trend toward increasing longevity and delayed childbearing in developed countries, this phase of dependency coincides with the growth period of grandchildren. Consequently, grandparents may compete with their grandchildren for limited parental resources (Tanskanen et al. 2017). This competition arises in families with high-status grandparents because if grandparents are of high status and become frail, parents who hope to receive bequests may assume responsibility for caring for them. Previous research may have overlooked this outcome due to its narrow focus. Three-generational studies, when approached from a two-generational lens, can inaccurately uphold the assumption that earlier generations always provide for subsequent generations. Typically, two-generational mobility studies concentrate on the development of children and the circumstances of middle-aged parents, whereas three-generational studies embrace a broader temporal scope.

Furthermore, our findings suggest that bequests and the absence of direct interactions may be key factors that influence grandparents' influence on their grandchildren. These mechanisms could corroborate Mare's (2011) proposition that durable resources such as financial and physical resources have the potential to shape subsequent generations when passed down familial lines. Additionally, the prestige or status of grandparents may conceivably affect their grandchildren. If these findings are indeed driven by bequests, then they imply that policy measures might be more effective if they reduce the taxable amount for inheritance tax while increasing the tax rate.

While grandmothers have neither positive nor negative impacts, the interplay between a grandfather's education and the amount of time he shares with his grandchildren has predominantly negative effects. Conversely, the amount of time a grandmother spends with her grandchildren is positively correlated with their outcomes. These patterns can be attributed to distinct roles in the household and varying life expectancies by sex (GBD 2013 DALYs and HALE Collaborators et al. 2015). Women generally have a longer and healthier life expectancy (GBD 2013 DALYs and HALE Collaborators et al. 2015) and tend to start their families earlier than men do (Martinez and Daniels 2023). This leads women to become grandparents at a younger age, thus allowing for an extended period of active grandparenting. Consequently, grandmothers are less likely to exhaust resources meant for their children. A healthy grandmother often assists in child-rearing and domestic tasks. Previous research has highlighted that grandmothers are more inclined to undertake these roles than are grandfathers (Coall and Hertwig 2010; Yasuda 2018; Hirai 2022). Consequently, the shared time between grandmothers and their grandchildren augments the educational achievements of the latter.

While some previous studies have reported no significant effects of grandparents' SES on grandchildren's status achievement (Engzell et al. 2020; Erola and Moisio 2006; Jæger 2012; Warren and Hauser 1997), failing to differentiate between living and deceased grandparents could explain these null findings. The overlap of an ancestor's life with that of a descendant can demarcate mechanisms of direct interaction from non-direct influences, such as inheritance or prestige (Knigge 2016). By not making this distinction, the coefficients may conflate the mechanisms of both contact and noncontact, potentially misrepresenting the true influence of grandparents on grandchildren.

Additionally, several studies that have focused on grandparents living nearby (Bol and Kalmijn 2016) and overlapping periods with grandparents (Braun and Stuhler 2018; Helgertz and Dribe 2021; Neidhöfer and Stockhausen 2019; Li and Cao 2023) have reported no discernible effects of grandparents on grandchildren. Given the documented positive outcomes of contact (e.g., Song and Mare 2019; Zhen and Xie 2014) and the local resource competition model (Tanskanen et al. 2017), the coefficients related to contact effects in these studies may have blended both positive and negative contact influences. This amalgamation can be attributed to variations in life expectancy, healthy life expectancy, the timing of childbearing, and coresidence rates across different times, regions, and societal contexts.

This study has three limitations. First, we used education as the sole measure of status. As highlighted by previous studies, which also rely on a singular status measurement, there are various measures of status, such as occupation, income, and wealth (Song and Mare 2019). The relevance of these status measures might be influenced by the overlapping periods between grandparents and grandchildren (Erola et al. 2018). Moreover, the observed effects of grandparents on grandchildren could be attributed to insufficient control of the characteristics of the intervening generation (Bol and Kalmijn 2016; Engzell et al. 2020). Second, we did not differentiate the contexts of the overlapping time between grandparents and grandchildren. Consequently, our estimation of this overlapping time conflated coresidence, living nearby, and living further away. Future studies should consider these distinctions and investigate whether nursing care for grandparents deprives the growing children of essential parental resources. Third, we did not account for lineages because our data included respondents' parents but excluded the parents of their spouses. This is a challenge known as the "missing half" (Daw et al. 2016). Therefore, our results may be susceptible to potential bias. In Japan, paternal grandparents are more likely to coreside than maternal grandparents (Kato 2013; Sugimoto 2010; Raymo et al. 2015). Furthermore, in general, maternal lineages provide greater emotional and economic support than paternal lineages (Yasuda 2018; Danielsbacka and Tanskanen 2012; Eisenberg 1988; Coall and Hertwig 2010). Consequently, lineage can influence the effects of interactions between grandparents and grandchildren.

Our findings may be relevant to various developed countries that are experiencing an increased life expectancy, an aging population, and more parents taking on roles in nursing care. For instance, since 1980, the U.S. has witnessed a rise in coresidence rates with parents (Pew Research Center 2010). Additionally, one in four individuals caring for parents aged 65 and older also tends to have children under 18 years; the number of these cases, which are collectively referred to as the "sandwich generation" (Chisholm 1999), are increasing (Lei et al. 2022). The overall life expectancy in the U.S. is 78 years, and the healthy life expectancy is 65 years; the disparity between these figures is the largest globally (WHO 2019). Delays in childbearing have also been reported (Song and Mare 2019). Consequently, the overlap between frail grandparents and growing grandchildren might indicate that both groups compete for parental resources. East Asian societies, such as Japan, which exhibit delayed childbearing, increasing life expectancies, and values of filial piety (Zhen and Xie 2014; Raymo et al. 2015), might also experience competition between frail grandparents and growing grandchildren for parental resources. While other countries might exhibit patterns such as those examined in this study, based on demographic statistics, the strong sense of filial piety in the Japanese context could intensify caregiving responsibilities and potential negative contact effects. Therefore, it is imperative to replicate this research design in different societal contexts.

Table 1. Descriptive statistics

Variable	Obs.	Mean	S.D.	Min	Max	Missing Rate
Grandchildren's education	8,428	50.61%		0	1	1.79%
Grandparents' variables						
Grandfather's education	6,838	13.07%		0	1	20.32%
GF birth year	6,640	1918.70	12.18	1869	1955	22.63%
Overlapped time between GF and GC	6,817	12.47	7.90	0	19	20.57%
Grandmother's education	7,004	5.07%		0	1	18.39%
GM birth year	7,122	1922.60	11.19	1870	1955	17.01%
Overlapped time between GM and GC	7,259	16.39	5.71	0	19	15.42%
Parents' variables						
Respondent's education	8,577	23.84%		0	1	0.06%
R's birth year	8,582	1950.09	8.69	1935	1976	0.00%
R's sex (male = 1)	8,582	44.33%		0	1	0.00%
R's number of siblings	8,571	3.81	1.82	1	12	0.13%
R's eldest children	8,536	32.06%		0	1	0.54%
Age at firstborn child	8,578	26.13	3.72	10	45	0.05%
Living district at age 15						
Hokkaido/Tohoku	8,540	15.54%		0	1	0.49%
Kanto		24.47%		0	1	
Hokuriku		6.45%		0	1	
Tokai		11.98%		0	1	
Kinki		13.31%		0	1	
Chugoku		8.51%		0	1	
Shikoku		4.34%		0	1	
Kyushu/Okinawa		15.34%		0	1	
Foreign		0.05%		0	1	
Spouse's education	8,431	26.24%		0	1	1.76%
Spouse's birth year	8,510	1950.36	9.10	1924	1995	0.01%
Grandchildren's variables						
Birth year	8,582	1978.25	9.24	1950	1995	0.00%
Sex (male = 1)	8,547	52.01%		0	1	0.41%
Number of siblings	8,582	2.49	0.78	1	7	0.00%
Birth order						
First	8,582	46.59%		0	1	0.00%
Second		38.69%		0	1	
Third		12.99%		0	1	
Fourth or higher		1.74%		0	1	

Table 2. The results of the LPM

	Model 1	Model 2	Model 3
(Intercept)	-11.279***	0.518	0.318
	(1.440)	(1.618)	(1.619)
GF education	0.204***	0.084***	0.163***
	(0.020)	(0.020)	(0.033)
GM education	0.050	-0.014	0.067
	(0.032)	(0.029)	(0.081)
Lifetime overlap with GF and GC	0.002*	0.000	0.001
	(0.001)	(0.001)	(0.001)
Lifetime overlap with GM and GC	0.004**	0.003**	0.003**
	(0.001)	(0.001)	(0.001)
GF education × lifetime overlap with GF and GC			-0.007**
			(0.002)
GM education × lifetime overlap with GM and GC			-0.004
			(0.005)
Control parents' traits	No	Yes	Yes
Observations	8,582	8.582	8,582

Note: Standard errors in parentheses. † < 0.1, * < 0.05, ** < 0.01, *** < 0.001 (two-tailed tests). We use cluster robust standard errors at family level. We use Stata 17 software, the "mi" package; seeds=1, number of imputations = 100

GF: Grandfather, GM: Grandmother, GC: Grandchildren. Controls are grandfather's and grandmother's birth years, grandchildren's birth years, gender, birth order, and number of siblings in all models. Parents' traits are the respondent's and spouse's education, birth year, respondent's gender, number of siblings, whether a respondent is the eldest child, living district at age 15, and age at firstborn child.

Table 3. Robustness check (respondent age under 70)

	Model 1	Model 2	Model 3
(Intercept)	-17.036***	-2.833	-3.083
	(2.270)	(2.442)	(2.442)
GF education	0.175***	0.043†	0.135**
	(0.026)	(0.025)	(0.046)
GM education	0.037	-0.012	0.057
	(0.037)	(0.033)	(0.106)
Lifetime overlap with GF and GC	0.003*	0.001	0.002
	(0.001)	(0.001)	(0.001)
Lifetime overlap with GM and GC	0.006***	0.004**	0.005**
	(0.002)	(0.002)	(0.002)
GF education × lifetime overlap with GF and GC			-0.007*
			(0.003)
GM education × lifetime overlap with GM and GC			-0.004
			(0.006)
Control parents' traits	No	Yes	Yes
Observations	5,660	5,660	5,660

Note: Standard errors in parentheses. † < 0.1, * < 0.05, ** < 0.01, *** < 0.001 (two-tailed tests). We use cluster robust standard errors at family level. We use Stata 17 software, the "mi" package; seeds=1, number of imputations = 100

GF: grandfather, GM: grandmother, GC: grandchildren. Controls are grandfather's and grandmother's birth years, grandchildren's birth years, gender, birth order, and number of siblings in all models. Parents' traits are the respondent's and spouse's education, birth year, respondent's gender, number of siblings, whether a respondent is the eldest child, living district at age 15, and age at firstborn child.

Table 4. Robustness check (complete case analysis)

	Model 1	Model 2	Model 3
(Intercept)	-10.877***	1.398	1.273
	(1.900)	(2.130)	(2.131)
GF education	0.198***	0.082***	0.147***
	(0.023)	(0.023)	(0.039)
GM education	0.008	-0.051	-0.022
	(0.039)	(0.035)	(0.119)
Lifetime overlap with GF and GC	0.002†	0.001	0.001
	(0.001)	(0.001)	(0.001)
Lifetime overlap with GM and GC	0.004*	0.003*	0.0032*
	(0.002)	(0.002)	(0.0015)
GF education × lifetime overlap with GF and GC			-0.005*
			(0.003)
GM education × lifetime overlap with GM and GC			-0.002
			(0.006)
Control parents' traits	No	Yes	Yes
R-squared	0.0540	0.1447	0.1455
Adj R-squared	0.0517	0.1401	0.1405
Observations	5,015	5,015	5,015

Note: Standard errors in parentheses. † < 0.1; * < 0.05; ** < 0.01; *** < 0.001 (two-tailed tests). We use cluster robust standard errors at family level.

GF: grandfather, GM: grandmother, GC: grandchildren. Controls are grandfather's and grandmother's birth years, grandchildren's birth years, gender, birth order, and number of siblings in all models. Parents' traits are the respondent's and spouse's education, birth year, respondent's gender, number of siblings, whether a respondent is the eldest child, living district at age 15, and age at firstborn child.

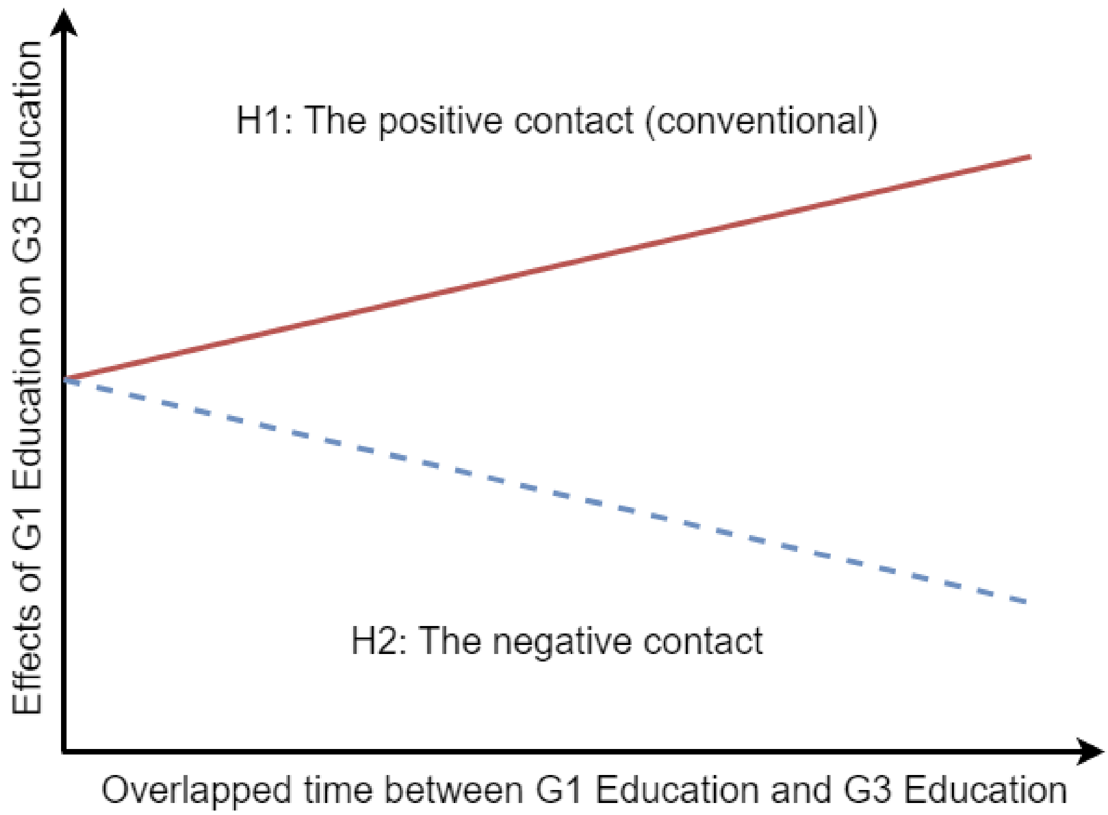

Figure 1. Two types of contact effects

Note: G1 represents grandparents. G3 represents grandchildren.

Figure 2. Trends in Japan

Notes. (a) Values were retrieved from the Complete Life Table (National Institute of Population and Social Security Research, https://www.mhlw.go.jp/toukei/saikin/hw/life/life22/dl/life22-09.pdf). We relied on data from GBD 2013 DALYs and HALE Collaborators et al. (2015) for 1993, 2005, and 2013, as the National Institute of Population and Social Security Research lacked information for these years. LE indicates life expectancy. HALE indicates healthy life expectancy.

(b) Statistics for Japan (https://www.e-stat.go.jp/dbview?sid=0003411844).

(c) Statistics of Japan (https://www.e-stat.go.jp/dbview?sid=0003411609).

(d) Statistics for Japan (https://www.e-stat.go.jp/dbview?sid=0003410424) from 1980 to 1990. Statistics for Japan (https://www.e-stat.go.jp/dbview?sid=0003414255) from 1995 to 2020. Two data sources were used because the family patterns changed according to the classification.

(e) Fifteenth Japanese National Fertility Survey, 2015 (https://www.ipss.go.jp/ps-doukou/j/doukou15/NFS15_report4.pdf). This study targeted couples in which both spouses were in their first marriage. The denominator for the couple's proportion includes all cases, even those where cohabitation or a separate living status with the mother is unknown and cases where both mothers have passed away. If either the husband's or wife's mother cohabits or lives separately, they belong to the respective category. Cohabitation includes cases in which people live on the same property but in separate accommodations. Living nearby refers to living separately but within the same city, ward, town, or village.

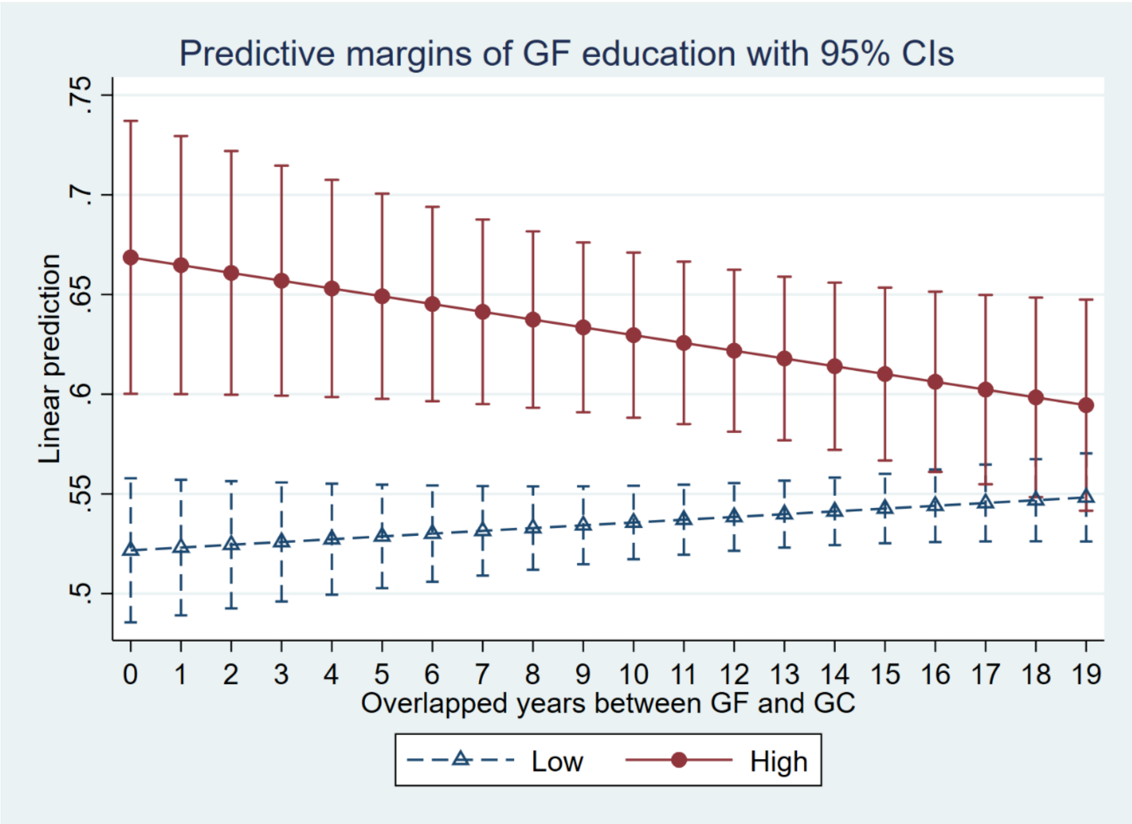

Figure 3. Margins plot of the grandfather

Note: Vertical bars represent 95% confidence intervals. The solid line indicates highly educated grandfathers. The dashed line indicates grandfathers with a low education level.

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Appendix

A1. Results of LPM (including current occupation of respondent and respondent's spouse)

	Model 1	Model 2	Model 3
(Intercept)	-11.226***	-1.665	-1.875
	(1.440)	(1.861)	(1.866)
GF education	0.206***	0.076***	0.155***
	(0.021)	(0.020)	(0.035)
GM education	0.050	-0.014	0.052
	(0.032)	(0.029)	(0.085)
Lifetime overlap with GF and GC	0.002*	0.0003	0.001
	(0.001)	(0.0009)	(0.001)
Lifetime overlap with GM and GC	0.004**	0.003**	0.003**
	(0.001)	(0.001)	(0.001)
GF education ×lifetime overlap with GF and GC			-0.007**
			(0.002)
GM education ×lifetime overlap with GM and GC			-0.004
			(0.005)
Control parents' traits	No	No	Yes
Observations	8,582	8,582	8,582

Note: † < 0.1, * < 0.05, ** < 0.01, *** < 0.001 (two-tailed tests). Parentheses are standard error. We use robust cluster standard errors at family level. We use Stata 17 software.
GF: grandfather, GM: grandmother, GC: grandchildren. Controls are grandfather's and grandmother's birth years, grandchildren's birth years, gender, birth order, and number of siblings in all models. Parents' traits are the respondent's and spouse's education, birth year, current occupation, respondent's gender, number of siblings, whether a respondent is the eldest child, living district at age 15 and age at firstborn child.

A2: Results of the LPM (only for biological children)

	Model 1	Model 2	Model 3
(Intercept)	-11.165***	-0.580	0.378
	(1.415)	(1.635)	(1.635)
GF education	0.204***	0.085***	0.163***
	(0.021)	(0.020)	(0.033)
GM education	0.052	-0.010	0.071
	(0.032)	(0.029)	(0.081)
Lifetime overlap with GF and GC	0.002*	0.0004	0.001
	(0.001)	(0.0009)	(0.001)
Lifetime overlap with GM and GC	0.004***	0.003**	0.004**
	(0.001)	(0.001)	(0.001)
GF education ×lifetime overlap with GF and GC			-0.007**
			(0.002)
GM education ×lifetime overlap with GM and GC			-0.004
			(0.005)
Control parents' traits	No	Yes	Yes
Observations	8,404	8,404	8,404

Note: † < 0.1, * < 0.05, ** < 0.01, *** < 0.001 (two-tailed tests). Parentheses are standard error. We use robust cluster standard errors at family level. We use Stata 17 software, the "mi" package; seeds=1, number of imputations =100
GF: grandfather, GM: grandmother, GC: grandchildren. Controls are grandfather's and grandmother's birth years, grandchildren's birth years, gender, birth order, and number of siblings in all models. Parents' traits are the respondent's and spouse's education, birth year, respondent's gender, number of siblings, whether a respondent is the eldest child, living district at age 15 and age at firstborn child.

A3: Results of the LPM (omitting living district at age 15)

	Model 1	Model 2	Model 3
(Intercept)	-11.243***	1.244	1.053
	(1.434)	(1.624)	(1.627)
GF education	0.204***	0.086***	0.161***
	(0.021)	(0.021)	(0.034)
GM education	0.050	-0.016	0.054
	(0.032)	(0.029)	(0.082)
Lifetime overlap with GF and GC	0.002*	0.0004	0.001
	(0.001)	(0.0009)	(0.001)
Lifetime overlap with GM and GC	0.004**	0.003**	0.003**
	(0.001)	(0.001)	(0.001)
GF education ×lifetime overlap with GF and GC			-0.007**
			(0.002)
GM education ×lifetime overlap with GM and GC			-0.004
			(0.005)
Control parents' traits	No	Yes	Yes
Observations	8,582	8,582	8,582

Note: † < 0.1, * < 0.05, ** < 0.01, *** < 0.001 (two-tailed tests). Parentheses are standard error. We use robust cluster standard errors at family level. We use Stata 17 software, the "mi" package; seeds=1, number of imputations =100

GF: grandfather, GM: grandmother, GC: grandchildren. Controls are grandfather's and grandmother's birth years, grandchildren's birth years, gender, birth order, and number of siblings in all models. Parents' traits are the respondent's and spouse's education, birth year, respondent's gender, number of siblings, whether a respondent is the eldest child, living district at age 15 and age at firstborn child.

A4. Results of the binary logit

	Model 1	Model 2	Model 3
(Intercept)	-49.738***	-0.294	-1.065
	(6.165)	(7.491)	(7.513)
GF education	0.896***	0.445***	0.837***
	(0.096)	(0.105)	(0.179)
GM education	0.248	-0.052	0.358
	(0.158)	(0.161)	(0.485)
lifetime overlap with GF and GC	0.009*	0.002	0.006
	(0.004)	(0.004)	(0.005)
lifetime overlap with GM and GC	0.018**	0.015**	0.016**
	(0.005)	(0.005)	(0.006)
GF education ×lifetime overlap with GF and GC			-0.035**
			(0.012)
GM education ×lifetime overlap with GM and GC			-0.022
			(0.027)
Control parents' traits	No	Yes	Yes
Observations	8,582	8,582	8,582

Note: † < 0.1, * < 0.05, ** < 0.01, *** < 0.001 (two-tailed tests). Parentheses are standard error. We use robust cluster standard errors at family level. We use Stata 17 software.

GF: grandfather, GM: grandmother, GC: grandchildren. Controls are grandfather's and grandmother's birth years, grandchildren's birth years, gender, birth order, and number of siblings in all models. Parents' traits are the respondent's and spouse's education, birth year, respondent's gender, number of siblings, whether a respondent is the eldest child, living district at age 15 and age at firstborn child.