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ABSTRACT

Daycare Enrollment Age and Child Development

Many parents return to work, placing their child in nonparental care before the age of one. Using variations in daycare vacancy rates, we estimate the causal effects of enrollment age in universal daycare on child development. In general, we find no evidence that earlier enrollment harms early child development, except for a temporary health shock. Children who enter later initially have fewer primary care visits, but the effects fade in preschool. Conversely, the results suggest some positive effects of early enrollment. Children who enter daycare later are more likely to demonstrate inadequate language skills by age five, particularly among boys.

JEL Classification: I00, J13, J24

Keywords: daycare, child development, health, cognitive skills

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1 Introduction

The availability of high-quality childcare that enables parents to enroll their children in a stimulating learning environment while returning to the labor market lies at the heart of concerns about establishing a healthy economy, such as the US Build Back Better framework.[1] A growing body of papers demonstrate that high-quality universal preschool for children aged 3 to 6 years has lasting effects on children's outcomes, for example Havnes and Mogstad (2011); Herbst (2017); Cornelissen et al. (2018); Garciá et al. (2021); Duncan et al. (2022); Cascio (2023); Gray-Lobe et al. (2023). However, in OECD countries, an increasing number of parents return to the labor market when their child is one year old or younger, and this situation has sparked the debate about the consequences of starting daycare at an early age.

This paper contributes to the emerging literature on nonparental daycare for children aged 0–2 on several important dimensions. First, using information on quasirandom assignment to daycare from unique administrative data on waiting lists for daycare centers (for birth cohorts 2009–2015) allows us to identify causal effects of *enrollment age*, which is a more policy-relevant parameter than daycare enrollment vs. parental care per se. Thus, we estimate the effects of early daycare on the intensive rather than the extensive margin. Second, our focus includes objective cognitive outcomes, such as language proficiency and school starting age, as well as proxies for health outcomes such as primary care visits and hospitalizations. Third, we investigate the effects of enrollment age on children's outcomes both for children with higher and lower educated parents, because the quality differences between formal care and parental care become important for interpreting the effects of enrollment age.

Parents face a trade-off between enrolling their child in nonparental care and prolonging parental care. Returning to the labor market can enhance potential long-term economic benefits through increased attachment and earnings to the labor market, potentially fostering child development in the long run (Dustmann and Schönberg, 2012; Rasmussen, 2010; Rossin, 2011). In contrast, prolonging the period the child is solely in parental care can benefit the

[1] The Build Back Better Framework, The White House. https://www.whitehouse.gov/build-back-better/.

child's development through parental time investments at a potentially vulnerable age where children are thought to be sensitive to environmental change (Cunha and Heckman, 2007). The transition from home to daycare can be particularly challenging for very young children. For example, Nystad et al. (2021) find that children who start daycare before 14 months of age experience a larger increase in their levels of stress hormone (cortisol) 4–6 weeks after enrollment compared to children who enroll at an older age.

In general, the existing literature on daycare enrollment and child development for children under two years of age shows mixed results. Disparities in quality between parental and nonparental care may contribute to explaining these mixed results. Fort et al. (2020), e.g., argue that results from Norway (Drange and Havnes, 2019) and Germany (Felfe and Lalive, 2018) show beneficial effects of early enrollment because the sample of parents studied was less affluent (i.e., the general education level was lower) compared to other samples, and thus the quality of daycare was likely to be higher than parental care. Similarly, Kottelenberg and Lehrer (2017) demonstrate that the universal daycare program in Quebec, Canada, has positive effects on development outcomes for children of disadvantaged single parents, although the Quebec daycare program had primarily adverse effects on child development (Baker et al., 2008). In contrast, results from Italy, using a sample of highly educated parents and relatively affluent, show detrimental effects of early enrollment, presumably because parental care was better than nonparental care at hand (Fort et al., 2020).

Other likely explanations for these divergent results include quality differences between daycare centers in these different countries (Gromada and Richardson, 2021) and the fact that, on the margin, the enrollment ages under investigation differ significantly.[2] A point also

[2]Fort et al. (2020) study a sample of children aged 4–36 months and a setting in which their first stage indicates that treated children receive 6 months more daycare or, equivalently, on average enrolled 6 months before. Drange and Havnes (2019) exploit an admission lottery lowering the enrollment age by 4 months from an average enrollment age of 19 months to an average enrollment age of 15 months. A Swedish study by van den Berg and Siflinger (2022) compares children enrolling in the calendar year they turn 2 with children enrolling in the calendar year they turn 3. Kottelenberg and Lehrer (2014) explicitly examine how the effects of the introduction of daycare in Quebec varies by child age. They see a large increase in enrollment between age 0 and age 1, measuring age in calendar years and not in days (aggregated to months). See also Jessen et al. (2020)

echoed by Kottelenberg and Lehrer (2014), who show that the negative effects of universal daycare in Canada was driven by children younger than 3 years.[3]

As the age of enrollment in daycare is endogenous, we exploit the quasi-random timing of daycare entry that is due to excess demand for daycare slots in Copenhagen, the capital of Denmark, within a two–stage least squares (2SLS) setup. The city's daycare office manages the allocation of vacant daycare slots for the Copenhagen city area. Through this office, parents apply for two daycare centers of their choice and register their preferred enrollment date, entering a waiting list for these specific daycare centers. Because most daycare centers are oversubscribed in the City of Copenhagen, slots become available mainly when older cohorts start school or move out of the city, and the waiting list system thus generates exogenous variation in actual enrollment age. We calculate the monthly vacancy rate in each daycare center considering the number of children leaving relative to the total number of slots in each center for the period 2009–2016. In the first stage, we used these vacancy rates from the two selected daycare centers to predict the enrollment age for each child on the waiting list. In the second stage, we use the predicted values of the enrollment age to estimate the causal effect of the enrollment age of the daycare on the subsequent health and cognitive development of the child. Furthermore, to mitigate potential quality differences between various daycare centers, we include the choice set of daycare centers as fixed effects in the model (Drange and Rønning, 2020; Gørtz et al., 2018). Thus we identify causal effects of daycare starting age by exploiting variation in vacancy rates over time within the chosen set of daycare centers.

Denmark is ideally suited for estimating the causal effects of daycare enrollment. First, selection into nonparental care is only a minor issue. Two-thirds of Danish children under three years of age participate in full-time formal care (30+ hours per week) (Eurostat Statistics, 2020), and with only 3.4% of children in informal care, Denmark has the second lowest

[3]Ding et al. (2020) further show that higher educated mothers in Quebec were significantly more likely to enroll their child early and pay the additional costs of an unsubsidized spot to secure access to one of the subsidized spots later on.

share of children in informal care among the OECD countries (Gromada and Richardson, 2021). Furthermore, Denmark is known for its high quality of daycare compared to other OECD countries (Datta Gupta and Simonsen, 2010; Esping-Andersen et al., 2012; Bauchmüller et al., 2014; Gørtz et al., 2018; Gromada and Richardson, 2021). Second, the selection of parental care is also a minor concern. Unlike, e.g., the US system, a generous parental leave system allows parents to be the primary caregivers during the first year providing 11.5 months of subsidized or fully paid leave after birth, which can be shared between parents. Third, no recall bias exists in the data as we use administrative data on a full sample of children and their parents residing in the City of Copenhagen. For all registered children, we combine detailed information from the waiting list system on preferred enrollment date and preferred center with administrative records of birth date (to calculate exact enrollment age), parental background, child health at birth, school enrollment, language proficiency test scores in preschool, hospital admissions, and visits to primary care physicians (PCP).

Overall, our results suggest that when it comes to cognitive outcomes and health, early enrollment is not harmful for young children. First, like Drange and Havnes (2019) and Felfe and Lalive (2018), we find some positive effects of earlier enrollment in daycare on child development, as children who are older at enrollment have a higher probability of inadequate language proficiency at the age of 5 (by 3.9%). The result is statistically significant at the level 10% for all children, but stronger for boys. Boys who start daycare are significantly more likely to undergo language testing and exhibit inadequate language proficiency than girls. However, we do not find any significant effect on being late for grade, neither for boys nor girls.

Second, for child health, we find that earlier enrollment age increases the number of PCP visits, but the effects fade out by preschool. Additionally, we find no effect on hospitalization. Together these results suggest that the increased number of PCP visits is likely tied to mild infections from exposure to peers when the immune system is still developing. These health effects are consistent with recent research by van den Berg and Siflinger (2022) investigating the impact of a significant Swedish daycare reform in 2002 that increased attendance rates from 70% to 85%. The study identified a strong and immediate increase in physical health conditions (e.g., ear infections) that diminishes with age. They also reported a notable reduction in mental health disorders among 4- to 7-year-old children, attributed this result to improvements in children's language and motor skills.

In contrast to several papers (van den Berg and Siflinger, 2022; Fort et al., 2020; Felfe and Lalive, 2018; Ding et al., 2020), our results show no disparities in results between children with mothers who hold a college or university degree and those without. This suggests that, with high-quality nonparental care, there are no notable downsides to early enrollment in terms of language proficiency at age 5, even for children from more affluent families, except for a temporary drop in health.

The paper proceeds as follows. Section 2 outlines the institutional background. Section 3 discusses the empirical strategy. Section 4 describes the data. Section 5 presents the results and Section 6 concludes and contextualizes the findings.

2 Institutional Background

Our identification strategy is based on exogenous variation in enrollment age within the daycare system in the City of Copenhagen. Since enrollment age is linked to the Danish parental leave system and local daycare options, we elaborate on both in this section.

2.1 Parental leave

The generous parental leave system mitigates potential selection effects related to early or later enrollment in daycare and the use of informal care options. Most parents are eligible for subsidized parental leave until the child is 11.5 months old.[4] Additionally, parents on

[4] During our period of investigation, the Government earmarked most leave for the mother. After birth, the mother has the right to 3.5 months of maternity leave while the parents can share the final 8 months of leave. If parents receive any other form of social support, they do not receive additional parental leave benefits.

leave earn holiday savings paid by the employer, allowing many to extend their subsidized leave period to 12–13 months. Moreover, they can take unpaid leave until the child turns 1.4 years old and still have the option to return to their current job after their leave. Despite the generous parental leave system in Denmark, it does not provide full compensation for lost wages, leading some parents to choose a shorter parental leave period than what is available. The wage replacement rate varies across sectors, with many companies offering full pay for a portion of the period. For instance, public sector workplaces —-where approximately two in three women work – provide six months of full pay after birth. When considering holiday savings, these mothers have around 7.5 months of full pay leave[5] Since parents can defer 8–13 weeks of their leave until the child turns nine, there are no economic incentives to maximize the options of leave right after birth.

2.2 Daycare in Copenhagen

While our study is centered in Copenhagen, it reflects the structure of the daycare system found in other Danish municipalities (local areas). National regulations ensure uniform quality and minimize selection in daycare. Parents can choose between center-based or family-based daycare, both subsidized by the government at similar rates, particularly for low-income families.[6] As a result, the acceptance rate of formal subsidized daycare is nearly identical for low-income families (70%) and high-income families (76%).

Center-based daycare includes facilities for children aged six months to three years (referred to as nurseries) or facilities that combine daycare center and preschool for children aged six months to five years (also called age-integrated facilities[7]). In both types of facility, the staff composition varies, but typically includes early childhood educators (degree level of the Bachelor), assistants (with two years of training), and untrained personnel. The child-

[5]The maximum monthly parental leave subsidy was approximately EUR 2500 per month in 2021.

[6]The user fee for a slot in center-based daycare for children aged 0—2 was EUR 370 per month in Copenhagen in 2007 and EUR 440 per month in 2021 (Statistics Denmark, 2021).

[7]Children enrolled in age-integrated facilities are either in a daycare group or a preschool group, but are guarantied a slot in the preschool groups once they turn three.

adult ratio is 3.1 children per adult with group sizes of 11–13 children in our period. In Copenhagen, most children enroll in center-based care.

Family daycare involves a caregiver who cares for three to five children at home. Caregivers undergo a screening, but there are no educational requirements to become a caregiver.[8] To ensure quality, caregivers receive regular visits from an authorized daycare manager who oversees the well-being and development of children. In Copenhagen, approximately 4% of all children are enrolled in family daycare, less than the national average of 33% (Statistics Denmark, 2021).

2.2.1 The waiting list system

The City of Copenhagen daycare office manages allocations of daycare spaces through a waiting list system. Parents are encouraged to register their child in this system before the child turns four months to secure maximum seniority on the waiting list. Parents specify their two preferred facilities and the preferred enrollment date.[9] Based on this registration, the daycare office places children on the waiting list for each of the two preferred centers. A child's ranking on a center's waiting list is determined by birth date and preferred enrollment date. At any time, parents can access waiting lists for their chosen centers.[10] While the daycare allocation office does not guarantee that siblings can enroll in the same daycare center, parents are more likely to have direct contact with their preferred daycare center when enrolling younger siblings in the daycare center they already use.[11] Thus we examine if enrollment age impacts firstborns differently than younger siblings in section 5.4.1. As all children register for two facilities and waiting lists may seem long, anecdotal evidence suggests that parents often find it challenging to use the information on the waiting list to

[8]For example, the child-minder must have no criminal record, but must have experience working with children. The childminder's family home must also meet specific space and safety requirements.

[9]For family daycare, parents choose a district, not a specific child-minder.

[10]Parents are encouraged to visit daycare centers before signing up to obtain information about which daycare centers they prefer (Batsaikhan et al., 2024).

[11]A sibling guarantee was introduced April 1, 2019 allowing parents with two or more pre-school children to enroll younger siblings in the daycare center they already use.

predict their child's potential enrollment date. In particular, parents are unaware of future slot availability.

Table 1: Type of facility

	Nursery	Age-integrated	Family daycare	Total
Nursery	11.44	14.52	0.05	7,626
Age-integrated	21.71	51.69	0.25	21,590
Family daycare	0.10	0.22	0.00	95
Total	9,748	19,474	89	29,311

NOTE— The table shows a tabulation of the parents' choice of type of facility for the two waiting lists in percentages in addition to the total count by each type of facility.

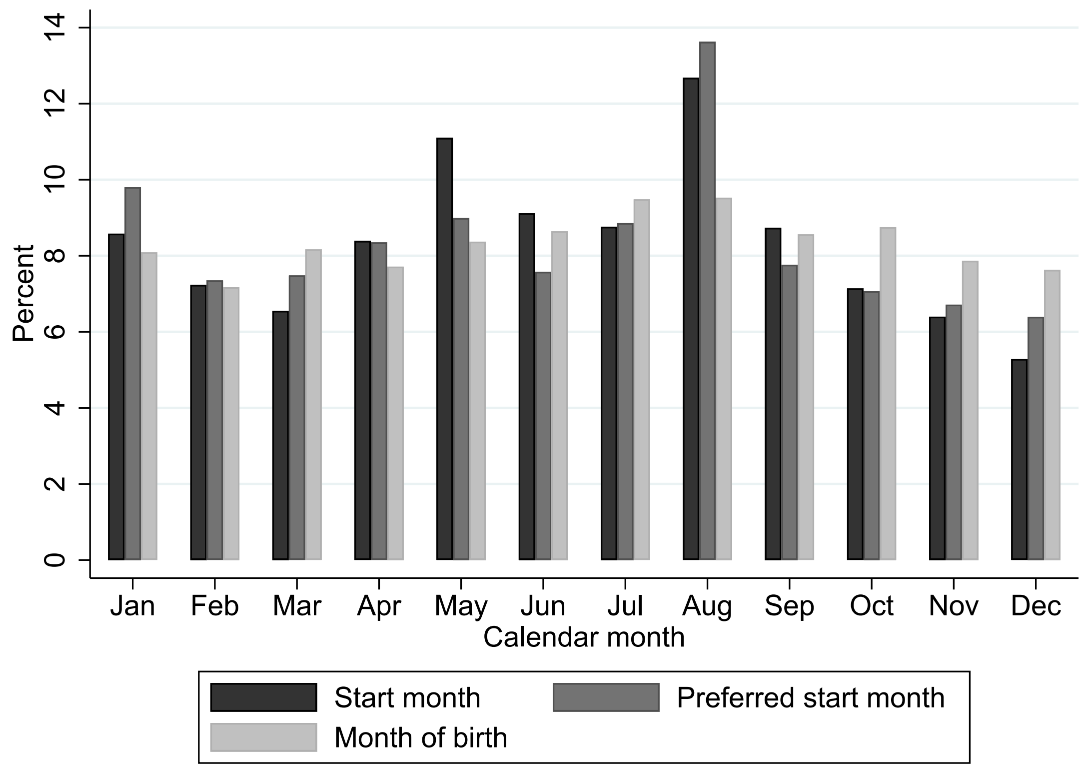
Table 1 shows the parents' choice of daycare type. A total of 11% choose two nursery facilities, more than 50% choose two age-integrated facilities, and around 35% choose a nursery and an age-integrated facility. Less than 1% choose family daycare in Copenhagen.

The waiting list system generates exogenous variation in enrollment age for three main reasons. First, most facilities are oversubscribed, leading to excess demand. Second, the majority of available slots open up in the summer months when older children transition to school, disadvantaging parents preferring winter enrollment. Third, in Copenhagen, children from the same preschool may attend different schools. Due to distinct school enrollment dates for public and private schools, older cohorts' schooling decisions cause variation in vacancy rates. Consequently, parents cannot fully control the enrollment date, but most receive offers within eight weeks of their preferred date.

Figure 1 illustrates enrollment patterns and the number of births per month. The darkest bars show the month of enrollment. Relatively more children enroll in May and August, reflecting higher vacancy rates due to school enrollment, while fewer children enroll in October, November and December.[12] The gray bars show the density of preferred month of enrollment. Although there is a notable spike in preferred enrollment in August, possibly due to parents returning from summer vacations, the overall pattern differs somewhat compared to actual enrollment. This suggests a mismatch between preferred and actual enrollment. Finally,

[12]In Denmark, it is common for public schools to enroll children into the school system three to five months before school actually begins in August (Hansen and Jensen, 2022).

Figure 1: Distribution of start month, preferred start month, and month of birth across calendar month



NOTE— The figure plots the distribution of calendar month of first enrollment (start month), preferred month of first enrollment (preferred start month), and month of birth for the children in the sample.

the light gray bars depict an almost constant distribution of birth months throughout the year with only a slightly higher number of births during the summer months. Patterns of birth months and preferred enrollment months do not align, and although there are more births during the summer, these births cannot account for the August spike in (preferred) enrollment.

2.2.2 Can parents game the system?

While we argue that the waiting list system introduces exogenous variation in the actual enrollment date, parents have some options to optimize their daycare situation. For example, if parents need a slot on a specific date, they can move one of their preferred centers to the 'guarantee list'. This separate waiting list requires the daycare to secure a slot within two months with the condition that parents cannot choose a specific location. Typically, a slot is offered within a 4–5 km radius from home, introducing uncertainty about possible longer commutes during rush hour and limiting the choice between family-based and center-based care. As demonstrated later on, this choice does not directly impact our identification strategy, as our instrument relies on variations in the vacancy rate in the preferred centers.

Parents also have alternative options to modify their preferences, but these come with costs and no assurance of an earlier enrollment date. Changing the preferred facility, for example, puts them at the bottom of the waiting list for the new center. Rejecting an offer carries the risk that subsequent offers are similar 'unattractive.' Additionally, consistently declining slots can cause the daycare to postpone the preferred enrollment date. Another option is to hire a private childcare provider (that is, a nanny), which is also subsidized and is used primarily as a temporary solution after parental leave.[13] In our data, 62% secure a slot in one of the two chosen daycare institutions, 17.5% in another center-based daycare, 2.8% in a family-based daycare and 17. 7% have a private caregiver arrangement as their first enrollment. We include all children registered in the waiting list system regardless of any changes in their preferences or the type of daycare they end up in, as these changes offer no guarantees that the actual enrollment date aligns with their preferred date of enrollment, and we are interested in children's first exposure to nonparental care.

2.2.3 Preferred versus actual enrollment age

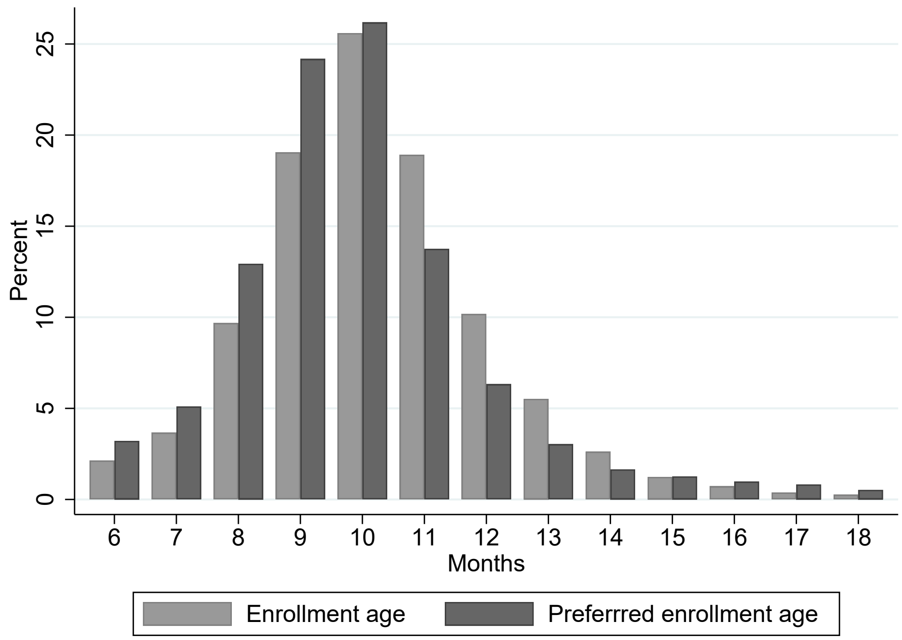
Our identification strategy is based on the presence of excess demand for daycare, resulting in children enrolled later than their parents prefer. This is demonstrated in Figure 2, which illustrates the distribution of the actual and preferred enrollment age. On the one hand, approximately 21% of the sample prefer an enrollment age of around 6–8 months, but only 16% are offered a slot at that age. Furthermore, while around 50% of the sample prefers to enroll their child when the child is 9–10 months old, only 40% actually enrolls their child at

[13] A private child-minder can care for up to 4 children in one's home. Parents pay the private childminder directly and apply for reimbursement from the municipality (up to EUR 1000 per month)

that age. On the other hand, while 29% prefers to enroll their child after 11 months, 44% of the children end up being enrolled at that age. Similarly, Appendix Figure A1 shows the distribution of the difference between the actual and preferred enrollment age. Figure 2 and Appendix Figure A1 thus illustrate that spots are, on average, offered later than parents' stated preferences in the waiting list system.

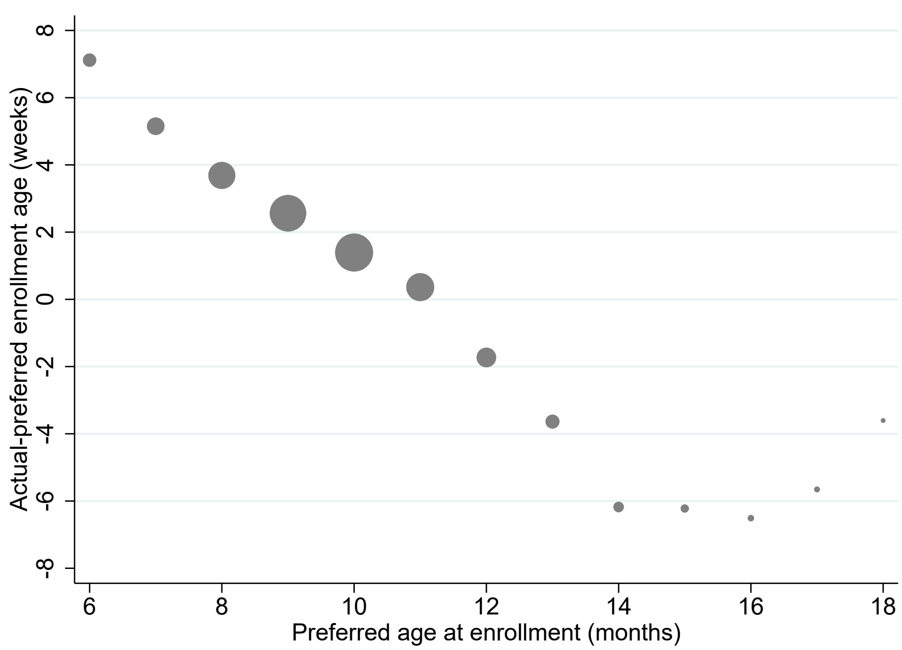
Although the waiting list system generates exogenous variation in the actual enrollment age, the difference between the actual and preferred enrollment age is likely to decrease as the preferred enrollment age increases. This is shown in Figure 3, which illustrates the correlation between the preferred age and the actual age of enrollment. The figure shows a downward trend. Parents who want to enroll at 6–8 months of age often wait 4–7 weeks, while those who prefer to enroll after 10–12 months typically receive a slot within two weeks of their preferred date. Furthermore, parents who favor enrollment after 12 months tend to enroll their child 4–6 weeks earlier than their preferences. Figure 3 thus illustrates that while excess demand is prevalent for most, on average it is not binding for those who prefer a starting age above 12 months.

Figure 2: Distribution of enrollment age and preferred enrollment age



NOTE— The figure plots the distribution of age at the first enrollment and the preferred age at the first enrollment measured in months.

Figure 3: Difference between actual and preferred enrollment age across preferred enrollment age



NOTE— The figure plots the average difference between the actual enrollment age and the preferred enrollment age by the preferred enrollment ages (aggregated in months). Dots are weighted by population size.

3 Empirical Strategy

As discussed earlier in this paper, parents face a trade-off between early and later daycare enrollment.[14] To account for the endogenous nature of enrollment age, we use a 2SLS model summarized in the following two equations:

$$y_{ict} = \beta \hat{age}_i + x'_{ict}\delta + \omega_c + \varepsilon_{ict} \tag{1}$$

$$age_{ict} = f(vac^{\tilde{c}}_{-1})\gamma + x'_{ict}\delta + \omega_c + \epsilon_{ict} \tag{2}$$

In our main equation (1), y_{ict} is child health or cognitive development at time t for child i signed up for daycare centers c. We include a vector, x'_{ict}, of the characteristics of individual children as covariates. The vector includes indicators for infant health (birth weight, gestational age, PCP visits prior to enrollment) and child demographics (gender, parental migration status, and sets of dummies for birth year, birth month, and birth order) in addition to the preferred enrollment age. ε_{ict} is the individual-specific error term clustered at the daycare choice level. The explanatory variable of interest, the age of enrollment, is defined as $\hat{age}_i$.

Equation (2) is the first stage of our 2SLS model, and the vacancy rate $vac^{\tilde{c}}_{-1}$ then serves as the instrument for the predicted value of the enrollment age—$\hat{age}_i$—in equation (1). We explain the instrument in detail in the next section. Otherwise, equation (2) includes the same covariates as equation (1). Central for equations (1) and (2) is the fixed effect of the choice set ω_c, referring to the combination of daycare options for which parents sign up. This fixed effect of the choice set captures preferences for the observed quality, such as

[14] Assuming age at enrollment positively affects child developmental outcomes, i.e., children who enroll later do better than children who enroll early, then, on the one hand, a simple OLS estimation of equation (1) would give positively biased estimates if, e.g., parents with unobserved characteristics (high ability) that contribute to better child outcomes systematically chooses to extend their leave period and enroll their children later. On the other hand, if these high ability parents are more attached to the labor market and consequently enroll their children at an earlier age, we would underestimate the effect of daycare enrollment age.

outdoor facilities, quality of management and staff, size and average vacancy rates, as well as other variables that are fixed during our period. As we control for choice-set fixed effects, identification effectively relies on variation in vacancy rates over time within the chosen set of daycare centers.

3.1 Instruments

We instrument the enrollment age by the vacancy rates in the two preferred daycare facilities. To build these instruments, we used information on the exit dates of older cohorts of children and the total number of daycare slots in each center. Specifically, we construct a monthly panel of center-level ratios between the number of children leaving each daycare and the total capacity of slots in the daycare. For each child, we generate the vacancy rates from each of the two preferred facilities and we generate these vacancy rates one month prior to their preferred (not actual) month of enrollment (i.e., for each child we use two instruments). Thus, our instrument depends mainly on the size of the preferred centers in combination with the timing of the older daycare cohorts transitioning into school.

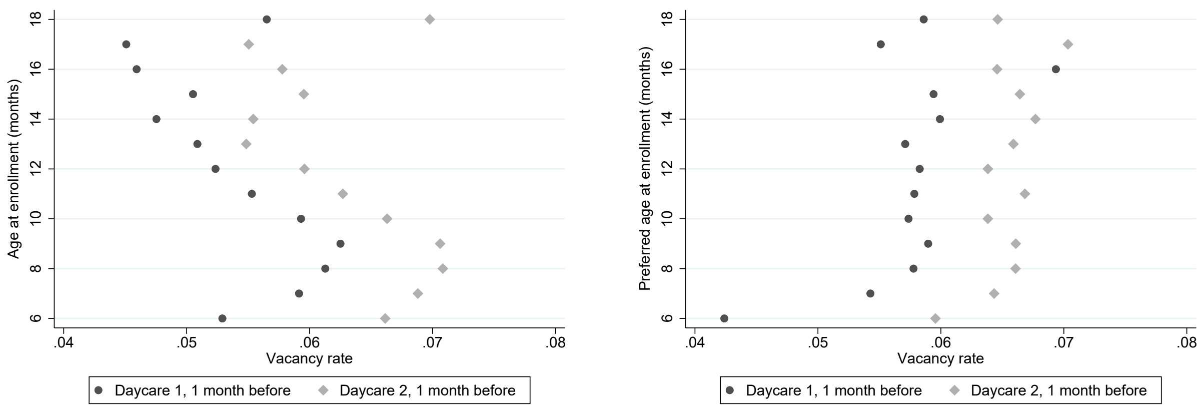
To validate these instruments, we show that the vacancy rates correlate with the actual – but not preferred – enrollment age.[15] Figure 4 shows the correlation between the vacancy rates on the vertical axes and the actual enrollment age (panel a) and preferred enrollment age (panel b) on the horizontal axes, respectively. Panel (a) shows a clear negative correlation between enrollment age and vacancy rates in the two daycare centers. Children waiting for a slot in daycare centers with lower vacancy rates (measured one month before preferred enrollment) are on average older at enrollment than children waiting for a slot in daycare centers with higher vacancy rates. The darker and lighter colored dots indicate that the correlations are similar for both preferred institutions. Equally important, panel (b) shows that the vacancy rates are not correlated with the preferred enrollment age. The absence of a clear negative relationship between the preferred enrollment age and vacancy rates suggests

[15]In section 5.1 we formally test the relevance of the instruments.

Figure 4: Vacancy rates by actual enrollment age (a) and preferred enrollment age (b)

(a) Enrollment age

(b) Preferred enrollment age



NOTE— Panel (a) plots the age at enrollment against the average vacancy rates. We measure vacancy rates one month before the preferred enrollment date in the two facilities that parents choose. Similarly, panel (b) plots the preferred age at enrollment against the average vacancy rates.

that parents who want to enroll their children at a young age do not systematically choose daycare centers with high vacancy rates. Similarly, panel (b) signals that parents are unable to predict vacancy rates over time (i.e., the time elapsed from when they signed their child up at the two daycare centers).

In addition to Figure 4, Table 2 formally tests whether vacancy rates at the two preferred facilities correlate with predetermined child and parental characteristics. Specifically, we test whether child gender, birth weight, gestational age (in weeks), the parents migration status, educational level (a dummy for both parents having only basic education and a dummy for at least one parent with a college degree), and valid information on the father jointly predict each of our two instruments. Most importantly, the F tests for these regressions show that the predetermined characteristics are jointly statistically insignificant. Thus, vacancy rates can create plausible exogenous variation in enrollment age.

Furthermore, for the instrument to be valid, vacancy rates must impact child development and healthcare use solely through the age channel at enrollment, conditional on observable factors. For example, the exclusion restriction would be violated if a high vacancy rate reflects the low quality of daycare, directly affecting child development. This concern is addressed

Table 2: Vacancy rates and predetermined characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
		Center 1			Center 2	
Boy	0.00141	0.00155*	0.00136	-0.00085	-0.00059	-0.00032
	(0.00091)	(0.00086)	(0.00089)	(0.00098)	(0.00092)	(0.00091)
Birth weight (kg)	0.00028	0.00066	0.00096	-0.00113	-0.00126	-0.00049
	(0.00114)	(0.00111)	(0.00116)	(0.00117)	(0.00109)	(0.00111)
Gestational age	0.00004	-0.00001	-0.00000	-0.00000	-0.00004	-0.00003
	(0.00005)	(0.00005)	(0.00006)	(0.00006)	(0.00005)	(0.00006)
Immigrated	0.00253	0.00041	0.00077	0.00286	0.00059	0.00070
	(0.00192)	(0.00182)	(0.00195)	(0.00208)	(0.00196)	(0.00190)
Basic educ.	0.00206	0.00199	0.00059	0.00003	0.00002	0.00138
	(0.00220)	(0.00207)	(0.00228)	(0.00229)	(0.00224)	(0.00247)
College	0.00180	0.00031	0.00011	0.00158	0.00009	0.00051
	(0.00128)	(0.00121)	(0.00135)	(0.00123)	(0.00116)	(0.00119)
No father id	-0.00301	-0.00032	-0.00100	-0.00479**	-0.00189	-0.00381*
	(0.00200)	(0.00206)	(0.00215)	(0.00197)	(0.00200)	(0.00215)
Observations	29311	29311	29311	29311	29311	29311
yob, mob, bo FE	No	Yes	Yes	No	Yes	Yes
Choice set FE	No	No	Yes	No	No	Yes
F-test	1.53	0.76	0.62	1.63	0.70	0.67
Prob > F	0.15	0.62	0.74	0.12	0.67	0.70

NOTE— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column presents estimates from separate regressions, where the vacancy rates in the two chosen centers are used as the dependent variable. Columns (1) and (4) include the variables listed in the table; columns (2) and (5) also include dummies for birth order (bo), year of birth (yob), and month of birth (mob). Fixed effects of the choice set are added in columns (3) and (6). Standard errors clustered at the choice level in parentheses.

by conditioning the choice set of daycare centers, essentially comparing children who were enrolled in the same two daycare centers.

The monotonicity assumption requires that a change in the vacancy rates (the instrument) lead to similar behavior for all affected individuals. In other words, individuals must either leave the treatment decision unchanged or change the treatment decision in the same direction (Fiorini and Stevens, 2021). Violation of the monotonicity assumption occurs if the vacancy rate leads some children to enroll earlier and other children to enroll later. As parents are offered a slot after their stated preferred start date,[16] the probability of an increase in the vacancy rate that leads some children to enroll later seems improbable. Even in hypothetical cases where parents manipulate their preferred enrollment date and receive an offer before their actual preference, rejecting the offer carries significant drawbacks. Such rejection would imply that the child loses all the seniority on the waiting list, potentially leading to a prolonged wait. Considering that most parents exhaust their subsidized leave period before enrolling their child, such a solution would be costly. Consequently, the combination of these factors minimizes our concerns about violating the monotonicity assumption.

Figure 3 in Section 2 also provides valuable information about the compliers in this natural experiment. The figure shows that the instrument is likely to affect children of a broad range of preferred enrollment ages. On average, the difference between the actual and preferred enrollment age is only close to zero for parents with a preferred enrollment age of 10-12 months. Approximately 23% of the sample receive a slot more than two weeks before their preferred enrollment date, 40% close to their preferred enrollment date (within two weeks), while 37% receive a slot more than two weeks after their preferred enrollment date (see the Appendix Figure A1).

[16]Exceptionally children may enroll before their preferred enrollment date, because of coinciding public holidays, where daycare centers are closed.

4 Data

The data set consists of 29,311 children born 2009–2015 residing in the City of Copenhagen and their parents. We combine various high-quality administrative data from two data sources. First, data includes information on a broad set of sociodemographic characteristics, infant health, health care use, and school enrollment collected and maintained by Statistic Denmark. Second, it includes administrative data from daycare applications and waiting lists, preschool language tests, and the total number of children enrolled in each daycare center, all from the administration in the City of Copenhagen. Through unique personal identifiers, we match the various data at the individual level, and the final data set contains information on actual and preferred enrollment age, number of slots per daycare center, parental background, demographic information, health indicators at birth, number of PCP visits, inpatient hospitalization, language test for children enrolled in preschool, and children's age at school enrollment.[17]

4.1 Sample

We use data from all children registered at the City of Copenhagen daycare office, including details on the actual and preferred enrollment dates and daycare centers. Our sample excludes children in private care and parental care, but is comparable with all children aged 0–3 born in the greater Copenhagen area.[18] We find only small differences between our sample and the rest of the families in the area of Greater Copenhagen. For infant health and birth year, the sample is similar, but our sample has a smaller share of ethnic minority parents (8% vs. 13%), a smaller share of families with basic schooling as their highest level of education

[17]All residents in Denmark receive a personal identifier just minutes after they are born. These personal identification numbers are used in all contacts with doctors, hospitals, schools, daycare centers, tax authorities, etc. Statistics Denmark provides access to these data to researchers—in anonymized form. Importantly, population registers also contain a link between parents and their children. This allows us to construct a rich set of child outcomes and family-level background variables.

[18]The greater Copenhagen area is the city of Copenhagen and the surrounding municipalities. Unfortunately, we cannot calculate the exact number of children in parental care or private care in the city of Copenhagen, because mobility between the City of Copenhagen and the surrounding areas generates a certain mismatch between the annual recorded residence data and the monthly daycare registration data.

(2% vs. 5%), and a marginally higher share of families with at least one college-educated parent (74% vs. 60%). This suggests a small overweight of more educated and native Danish families in our sample (see Appendix Table A1).

4.2 Variables of interest

Our primary variable of interest is the enrollment age defined as the difference between the birth and the enrollment date. By employing specific dates, rather than yearly daycare attendance records, we accurately capture exact enrollment age, avoiding comparisons like enrollment at age two versus age three. To instrument the enrollment age, we use center vacancy rates in the two selected daycare centers one month before the preferred enrollment, considering the chosen daycare centers as conditioning factors.

The longitudinal nature of the data from the registry enables us to investigate whether the enrollment age has immediate or lasting impacts on developmental outcomes and healthcare utilization. Our first two outcomes are the result of the mandatory language proficiency screening at age five, which evaluates the child's vocabulary and communication skills on the day of the test. The Danish proficiency test is developed by Danish and international researchers (Bleses, Jensen, Makransky, Dale, Højen and Vach) and is inspired by several existing language proficiency tests such as the MacArthur-Bates Communicative Development Inventory test (Bleses et al., 2017).[19]

For each child, a total score is calculated based on a list of questions. This total score is then adjusted for age and sex, that is, compared with a sizable random sample of children of the same sex and the same age (in months). The adjusted age and sex score can be divided into three meaningful categories. The first category represents 16–100% correct answers, resembling the level of 'normal' language proficiency. The second category is the correct

[19]The Danish proficiency test consists of three to seven different sub-tests such as word knowledge, language comprehension, rhymes, and letter knowledge. These sub-tests all reflect important communicative development skills related to reading later in life (Ministry of Education, 2019). The test is conducted in a one-to-one session between the child and the preschool teacher or another professional. The test consists of a series of pictures, and the child answers by pointing at the picture. For example, the preschool teacher says 'horse' and the child must find the horse among the different pictures.

6—-15% answers, indicating that children need a focused language intervention. The third category is the 0—-5% correct answers, which means that children need a highly focused language intervention.

From this language proficiency test, we create two dummy variables. The first variable takes the value one if the child is tested and zero otherwise. We define this variable because daycare centers typically test only children who have some language difficulties. The second variable takes the values one if the child has fewer than 16% correct answers, otherwise zero. These cognitive outcomes are not measured at a specific point in time, but during a broader time interval (that is, the spring). Consequently, the interpretation of the effect of enrollment age also includes any effects of the number of months the child has attended daycare instead of being at home.

The third outcome is a binary variable indicating whether a child is late for grade, taking the value one, if parents delay compulsory school enrollment by one year, and zero otherwise. In Denmark, compulsory schooling begins in August of the year in which the child turns six. However, adherence to this rule is not mandatory, allowing parents the flexibility to hold the child back one year or enroll the child one year earlier (Gørtz et al., 2018). The decision is made through individual evaluations of the child and dialogues between parents and representatives of the regional school authority. We observe school entry for six of the seven birth cohorts (2009–2014 cohorts).

The fourth result is the number of PCP visits serving as a proxy for the frequency of the child's illnesses each quarter of a year from birth to five years after daycare enrollment. In Denmark, the PCP serves as the primary access point to the health care system. Therefore, parents consult the PCP if their child is not well. We exclude regular check-ups and vaccinations (conducted at ages 5 weeks, 5 months, 12 months and 15 months). In particular, since PCPs are reimbursed for the number and type of visits, the count of PCP visits is meticulously calculated.

The fifth outcome is a binary variable that indicates hospitalizations, serving as an indicator of more serious health issues. We define hospitalization as the number of recorded inpatient contacts. We exclude outpatient contacts, mainly reflecting routine and planned doctor visits, as well as emergency room contacts. Importantly, all health care is free in Denmark, ensuring that our health outcomes are independent of parents' financial resources.

The interpretation of the effects of enrollment age on PCP visits and hospitalization is the direct effect of enrollment age, as we measure both health outcomes in quarter of a year time intervals since first enrollment for every child, and we include month-of-birth dummies to account for the fact that children who enroll later will be older at each point in time since first enrollment.

4.3 Descriptive statistics

Table 3 presents descriptive statistics for the full estimation sample according to the type of daycare; center-based care and family-based care, including enrollment in the subsidized private option. Overall, the table shows some minor differences, albeit minor, between families and children in the two types of daycare. We account for these differences by including the choice set fixed effects in our estimation strategy.

Panel A of Table 3 shows that on average children enroll in center-based care when they are around 10.8 months old, and approximately 14 days younger when they enroll in family-based daycare. The preferred enrollment age is 10.2 months when parents register their child for center-based daycare, but 11.1 months when parents register their child for family-based care. Thus, on average, parents who register for center-based care are more likely to wait longer, while parents who register for family-based care on average get a slot three weeks earlier.

Panel B shows that there are only minor differences in birth order, gestational age, and birth weight between children who enroll in center-based or family-based care. There is a slight indication for parents to choose family-based care when their children have low birth weight. A higher percentage of lower-educated parents enroll their children in center-based care, whereas the percentage of families with at least one college-educated parent is lower in center-based care. Similarly, a higher percentage of ethnic minority parents and families with unknown father registration enroll their children in center-based care.

Panel C reveals that more than one-third of all children undergo the language proficiency screening test at age 5, with 3—- 6% showing inadequate language proficiency. During preschool, a higher number of children previously enrolled in center-based care undergo tests and exhibit inadequate language skills. Additionally, three percent of children delay school enrollment by one year.

Table 3: Summary statistics by type of daycare

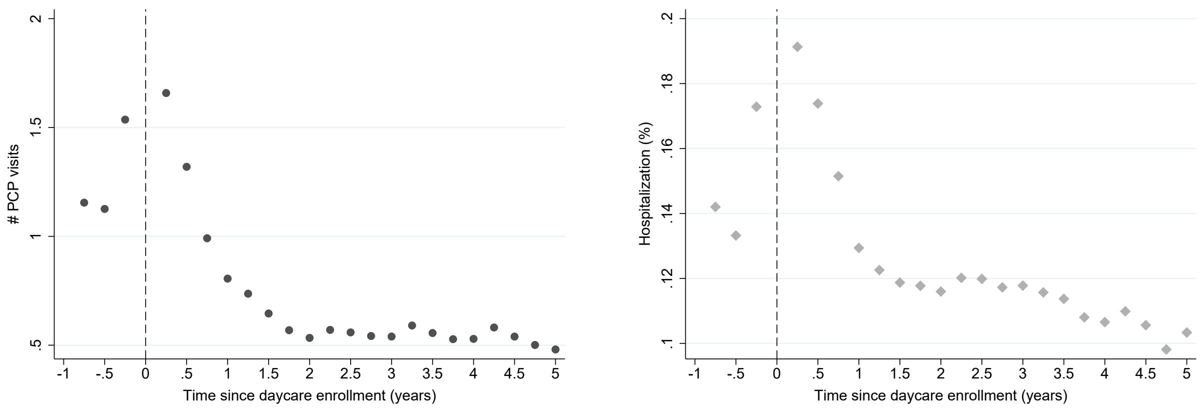
	(1) Center-based care	(2) Family-based care or private sub.	(3) Diff.
Panel A: Variables of interest			
Age at first enrollment	10.84	10.33	0.511***
	(1.92)	(1.70)	(18.96)
Preferred enrollment age	10.16	11.08	-0.920***
	(1.72)	(2.70)	(-32.63)
Panel B: Covariates			
Month of birth	6.67	6.19	0.479***
	(3.31)	(3.54)	(9.95)
Year of birth	2012.11	2011.29	0.819***
	(2.01)	(1.82)	(28.99)
Boy	0.52	0.52	-0.00404
	(0.50)	(0.50)	(-0.56)
Birth order	1.45	1.43	0.0133
	(0.63)	(0.62)	(1.49)
Low birth weight	0.03	0.06	-0.0259***
	(0.18)	(0.24)	(-9.39)
Gestational age (days)	279.43	278.22	1.205***
	(10.83)	(12.26)	(7.54)
Both parents basic education only	0.06	0.04	0.0224***
	(0.24)	(0.20)	(6.63)
At least one college educated parent	0.73	0.81	-0.0775***
	(0.44)	(0.39)	(-12.49)
No registered father	0.05	0.04	0.00870***
	(0.22)	(0.20)	(2.79)
Parents immigrated	0.09	0.05	0.0425***
	(0.28)	(0.21)	(11.01)
Panel C: Outcome variables			
Tested at age 5	0.37	0.33	0.0394***
	(0.48)	(0.47)	(5.47)
Age 5 low language score	0.06	0.03	0.0235***
	(0.23)	(0.18)	(7.17)
Late for grade	0.03	0.03	-0.00136
	(0.17)	(0.17)	(-0.50)
Observations	23145	6166	29311

Note— The table shows mean values and standard deviations in parentheses for the variables of interest (panel A), covariates (panel B) and outcome variables (panel C). Column (1) shows summary statistics for children in center-based care. Column (2) shows the summary statistics for children in family-based daycare or subsidized private care. Column (3) shows the differences in means between columns (1) and (2). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In addition to Table 3, Figure 5 shows the average number of PCP visits (a) and the percentage of hospitalized children (b) per quarter of a year from birth to five years after enrollment in daycare. The vertical dotted line indicates the quarter of a year for first-time enrollment. The figure shows that the average number of PCP visits and the percentage of children hospitalized are higher around enrollment but decrease over time.

Figure 5: Quarterly PCP visits and hospitalization rate

(a) PCP visits (b) Hospitalizations (%)



NOTE— Panel (a) plots number of PCP visits per quarter of a year while panel (B) plots the percentage of children hospitalized per quarter of a year. The vertical dotted line defines time at enrollment in nonparental daycare.

5 Results

In this section, we present the empirical results of our analysis of the marginal effects of age of enrollment in daycare on out outcomes. We begin by providing first-stage estimates of the relationship between vacancy rates and enrollment age. Subsequently, we display the second-stage estimations on child outcomes and explore the heterogeneous effects across parental education and child gender. Finally, we present a series of sensitivity analyzes to assess the robustness of our results.

5.1 First-stage results

Table 4 shows estimates from two separate first-stage regressions, where column (1) shows the first stage and column (2) shows a placebo first-stage estimation. The model contains a set of characteristics of the child and parent, a set of dummies of the year of birth and the month of birth, and fixed effects of the center choice (estimates not shown in Table 4).

The results suggest that the vacancy rates in the two preferred centers measured one month prior to the preferred enrollment date determine the age at first enrollment. The first-stage results in column (1) show a robust negative correlation between both instruments and age at first enrollment. This indicates that a one percentage point increase in either of the vacancy rates reduces age at first enrollment by 0.48–0.62 months, equivalent to 14–19 days. Furthermore, first-stage F-test statistics indicate that the instruments exhibit reasonably strong characteristics. Table 4 reports the standard Kleibergen-Paap F statistic and the Montiel-Pfluegger effective F statistic along with the critical values for a 5% worst-case bias. The Montiel-Pfluegger test is robust to heteroscedasticity, serial correlation, and clustering (Montiel Olea and Pflueger, 2013) and thus the appropriate test in our setting. The null hypothesis of weak instruments is rejected for large values of the effective F statistics[20] As the effective F statistics exceed the critical values, we conclude that the instruments are reasonably strong.

To examine whether serial correlation in the vacancy rates confounds our first-stage estimates, we performed a placebo first-stage test in column (2). Similar to column (1), column (2) displays the regression of age at the first enrollment in the vacancy rates in the two chosen daycare centers, but the vacancy rates are measured much earlier—when the child is four months old.[21] Column (2) indicates that the vacancy rates measured when the child is four months old do not predict age at the first enrollment. The estimates are smaller than in column (1), not statistically significant, and the F test is very low (below 1). Thus, serial

[20]Specifically it tests the null hypothesis that the Nagar bias exceeds 10% of a worst case bias with a size of 5% (Montiel Olea and Pflueger, 2013).

[21]To secure maximum seniority on the waiting lists, parents must register their preferences for daycare centers before their child turns 4 months old.

Table 4: First stage regressions

Vacancy rate measured	(1) First stage one month before	(2) Placebo first stage at age 4 month
Daycare 1	-0.618***	-0.220
	(0.158)	(0.175)
Daycare 2	-0.476***	-0.053
	(0.139)	(0.189)
Observations	29311	29311
Kleibergen-Paap F statistic	19.09	0.92
Montiel-Pflueger effective F statistic	16.20	0.78
Critital values ($tau = 5\%$)	9.096	5.489

NOTE— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table shows estimates from two separate first-stage regressions. Column (1) shows the first stage estimates of age at the first enrollment regressed on the vacancy rates in the two chosen daycare institutions measured one month before the preferred enrollment month. Column (2) shows the estimates of a placebo first-stage regression of age at first enrollment on the vacancy rates in the two chosen daycare intuitions measured when the child was four months old. The table reports the Kleibergen-Paap rk Wald F statistic and the effective F statistic by Montiel Olea and Pflueger (2013). All regressions include a set of child and parent characteristics, a set of year of birth and month of birth dummies, and fixed effects from the choice set. Standard errors clustered at the choice set are shown in parentheses.

correlation in the vacancy rates does not seem to confound our first-stage estimates. The placebo first stage also suggests that parents cannot predict future vacancy rates when they register on waiting lists at the time when their child is four months old.

5.2 Second-stage results

We next turn to the second stage results of the enrollment age and its impact on cognitive outcomes. In Table 5, panel A shows the effects of the second stage on the outcomes related to preschool language proficiency and being late for school. Our findings do not reveal a statistically significant effect of age at enrollment on the probability of undergoing testing. Although statistically significant only at the level 10%, we also find that being one month older at the beginning of daycare enrollment increases the probability of having a low level of language proficiency by 3.9%.[22] Regarding being late for grade, we find a negative but

[22]We also test the effect of enrollment age on language proficiency at age three. Fewer children are tested at age three, and our first stage estimates are mostly weak in this analysis. Therefore, we exempt these

Table 5: Effects of daycare enrollment age on test taking, language scores and being late for grade

	(1) Age 5: Tested	(2) Age 5: Low score	(3) Late for grade
Panel A: IV			
Age at first enrollment	0.0707	0.0386*	-0.0037
	(0.0433)	(0.0206)	(0.0177)
Kleibergen-Papp F statistics	17.79	17.79	12.65
Montiel-Pflueger effectice F statistics	14.85	14.85	10.46
Critical values ($tau = 5\%$)	9.289	9.289	6.225
Panel B: OLS with Fixed Effects			
Age at first enrollment	0.0055***	0.0037***	-0.0001
	(0.0019)	(0.0009)	(0.0009)
Observations	24961	24961	20015

NOTE— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table shows IV estimates of age at first enrollment on cognitive outcomes. Column (1) result is a dummy variable for child tested for language proficiency at age five, column (2) outcome is a dummy variable for a low score on the test, and column (3) outcome is a dummy for being late for grade. All regressions include a set of child and parent characteristics, a set of year-of-birth and month-of-birth dummies, and choice-set fixed effects. Standard errors clustered in the choice set are shown in parentheses.

statistically insignificant effect of enrollment age. In Table 5, panel B, we present the OLS results with the fixed effects of the choice set. These results are generally smaller than the IV estimates, reflecting the LATE nature of the IV estimates. When disregarding children for whom the waiting list is very restrictive (i.e. focusing on children enrolled within 12 weeks of the preferred enrollment age), we find more robust and statistically significant effects on both the probability of being tested and the display of a low test score (Appendix Table A5).[23]

We then turn to the effects of age at enrollment on health care use. Figure 6 illustrates IV estimates of the enrollment age on the number of quarterly PCP visits, spanning from birth to five years after enrollment. The vertical dotted line in the figure signifies the quarter of the year that the child first enrolls in daycare. As expected, enrollment age does not have a significant effect on the number of PCP visits prior to enrollment. However, children who enroll later have more PCP visits at the time of enrollment and 1 year after enrollment. At

results from the paper.

[23]Sample size is reduced by 9%.

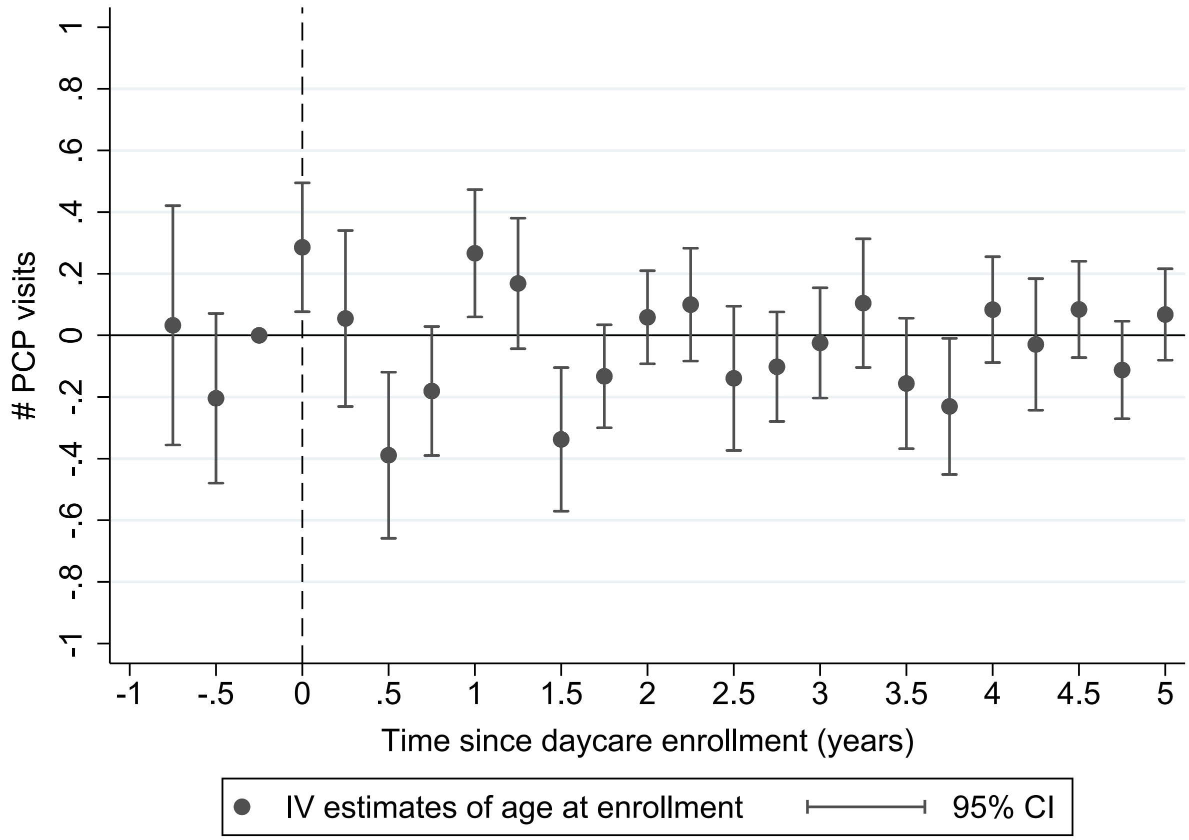
the same time, we also observe that children who enroll later have fewer PCP visits six months and 1.5 years after enrollment in daycare compared to their playmates who enrolled earlier. From 1.75 years after enrollment, the effects hover close to zero throughout the remaining observation period.[24] While none of these results remain significant when using the Romano-Wolf procedure to adjust for multiple hypothesis testing (Romano and Wolf, 2005; Clarke, 2021),[25] we investigate if the variability of the results are linked to enrollments during flu outbreaks in Figure A8. Similarly, Figure A2 illustrates IV estimates of age at enrollment on the probability of inpatient hospitalization. The results indicate that the enrollment age does not have significant effects on more serious diseases that require hospitalization.

In summary, children who enroll later are more prone to experiencing some language difficulties at 5 years of age compared to peers in their daycare center who enrolled earlier and have attended daycare for a longer period. In contrast, however, to recent research from Sweden, which examined the health effects of daycare exposure from age one, we find no evidence that age at the first daycare enrollment affects the use of healthcare (van den Berg and Siflinger, 2022).

[24]In addition to Figure 6, Appendix figure A3 shows the OLS estimates of the effects of enrollment age on PCP visits. For PCP visits, we find negative age effects of enrollment age, and the estimates are similar in size but more precisely estimated. From two years after enrollment, the effects are close to zero.

[25]Results not shown in paper.

Figure 6: The effects of daycare enrollment age on quarterly PCP visits



NOTE— The figure plots IV estimates of enrollment age on the number of PCP visits. Each dot represents separate regressions, and the 95 percent confidence interval. The vertical dotted line indicates the quarter of the year the child enrolls in daycare.

5.3 Heterogeneity by child gender and maternal education

In this section, we examine whether the effects of enrollment age are heterogeneous by child gender and maternal education.

5.3.1 Effects of enrollment age by gender

Existing literature suggests that the effects of daycare enrollment on child outcomes may vary by gender, and boys may benefit more than girls from access to high-quality daycare (Felfe and Lalive, 2018; Gørtz et al., 2018). Consequently, we explore whether the effects of the age of enrollment in daycare vary by gender. We find that age at enrollment has a significantly higher effect on the probability of a boy being tested at age 5 compared to that of a girl's probability of being tested (see Panel A in Table 6). A plausible explanation is that boys generally exhibit lower language proficiency than girls. Thus, we would anticipate that more boys undergo testing. Moreover, we find that boys have a significantly higher probability of a low score in (gender-adjusted) language proficiency relative to girls.

Table 6: The effects of daycare enrollment age on test taking, language scores and being late for grade by maternal education and sex of the child

	(1) Age 5: Tested	(2) Age 5: Low score	(3) Late for grade
Panel A: Sex of child			
Age at first enrollment	0.020	0.018	-0.009
	(0.045)	(0.021)	(0.017)
Age*Boy	0.097**	0.044**	0.020
	(0.045)	(0.020)	(0.019)
Boy	-1.028**	-0.468**	-0.191
	(0.483)	(0.219)	(0.200)
Observations	24961	24961	20015
Kleibergen-Paap F statistic	9.67	9.67	6.73
Panel B: Maternal education			
Age at first enrollment	0.077	0.051*	0.012
	(0.050)	(0.028)	(0.022)
Age*Mom college degree	-0.016	-0.013	-0.018
	(0.047)	(0.023)	(0.019)
Mom college degree	0.147	0.111	0.187
	(0.503)	(0.245)	(0.205)
Observations	24961	24961	20015
Kleibergen-Paap F Statistic	9.01	9.01	6.19

NOTE— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table shows IV estimates of age at first enrollment on cognitive outcomes by sex of the child (panel A) or by maternal education (panel B). Column (1) result is a dummy variable for child tested for language proficiency at age five, column (2) outcome is a dummy variable for a low score on the test, and column (3) outcome is a dummy for being late for grade. All regressions include a set of child and parent characteristics, a set of year of birth and month of birth dummies, and fixed effects from the choice set. Standard errors clustered in the choice set are shown in parentheses.

Furthermore, Figure A5 illustrates that the effects on PCP visits do not differ significantly between girls and boys. In general, we find some evidence that boys benefit more than girls by enrolling at an earlier age in high-quality daycare in terms of cognitive outcomes, while there are no differences in health care use.[26]

5.3.2 Effects of enrollment age by maternal education

To assess the effects of formal daycare on child development, it is essential to consider the quality of nonparental care received in the daycare center in comparison to the parental care provided at home. Consequently, the results of entering formal daycare may vary between parents with different educational levels. For example, Fort et al. (2020), suggests that variations in educational levels between different estimation samples might partially explain the somewhat mixed results found in the existing literature. Another possible explanation is the quality discrepancies between daycare institutions in different countries, such as differences in the child-to-adult ratio and the number of trained personnel (Gromada and Richardson, 2021).

As an indicator of a potentially higher quality and more stimulating home environment, we use a dummy for mothers with a college or university degree, interacting this dummy with enrollment age. We compare children from families where the mother has at least a college degree to those where the mother does not have a college degree. For the three cognitive outcomes—testing at age 5, language proficiency, and being late for school—we observe minimal differences based on maternal education. Therefore, our findings suggest that if the quality of daycare is high, early daycare enrollment benefits all children equally, regardless of the educational level of their parents (see panel A in Table 6).

For PCP visits, the interaction term is nearly zero, indicating that the impact of enrollment age for children with college or university educated mothers is comparable to that of children with mothers possessing less than a college degree. For children with mothers lacking a college degree, we observe, similar to the main results, that an increase in enrollment

[26] We also investigate whether the impact of enrollment age differs for ethnic minority children compared to other children. Similar to boys, ethnic minority children are more likely to exhibit a lower level of language proficiency at age five. Therefore, we might anticipate that ethnic minority children could potentially benefit more from early enrollment compared to non-minority children. However, our findings provide no clear evidence that age at enrollment is more critical for ethnic minority children than ethnic Danes. As only 9 percent of the children are ethnic minorities, this could be the reason for our statistically insignificant results.

age leads to a decrease in PCP visits six and 18 months after enrollment (see Figure A4).[27]

5.4 Sensitivity tests

We proceed to evaluate the robustness of our main results. Initially, we examine whether the effects of enrollment age are sensitive to potential special circumstances for siblings. Subsequently, we test whether our results are influenced by quality differences between the type of daycare. Finally, we investigate whether our results are contingent on enrollments occurring during the flu season.

5.4.1 Siblings

The daycare allocation office does not guarantee sibling enrollment in the same daycare center during the period under analysis, but anecdotal evidence suggests efforts to accommodate siblings together. This effort improves parents' direct contact with their preferred daycare center when enrolling younger siblings, potentially aiding the transition from parental care to daycare for these younger siblings. Furthermore, younger siblings are likely to be exposed to more infectious diseases at a young age before first enrollment in daycare through their older siblings (Daysal et al., 2021). Therefore, we examine whether enrollment age has a more pronounced impact on cognitive outcomes and health for the firstborn compared to younger siblings. Our findings reveal no statistically significant differences in the effects of enrollment age on language proficiency and being late for grade between firstborn and later-born children. Although some evidence suggests more PCP visits for first-born compared to later-born children, the differences are modest and only marginally statistically significant (see Table A2 and Figure A6).

[27] Similar to the main results, we also find no effects of enrollment age on inpatient hospitalization by maternal level of education.

5.4.2 Type of daycare facility

We also examine the sensitivity of our results by excluding children who use family-based daycare or private nannies, which constitute 20% of the sample. There are distinct differences between center-based and family-based care, such as the size and the level of education of caregivers. For cognitive outcomes, our findings align closely with the main results, suggesting that center-based care institutions might have more resources for language development screening. In terms of PCP visits, the impact of enrollment age is slightly stronger in center-based care, possibly due to larger group sizes leading to increased exposure to infections (see Table A3 and Figure A7).

5.4.3 Enrollments during flu outbreaks

Finally, we explore whether the health outcomes of enrollment age are influenced by the season of enrollment with a higher risk of illnesses during flu outbreaks. Using data from the World Health Organization (WHO) on influenza-like illnesses (ILI), we examine differences between the influenza and non-flu periods.[28] We find that the results of PCP visits are influenced by flu outbreaks (the interaction terms between flu and enrollment age are statistically significant in many cases, see Figure A8). These results suggest that the effects of enrollment age are close to zero during flu outbreaks, possibly because many children become infected during this period regardless of enrollment age. For test taking, language proficiency, and being late for grade, our main results in Table 5 mirror the effects of enrollment age during the non-flu periods, although the main effects are stronger when including the interaction term (see first row, Table A4).

[28]The dummy for flu outbreaks is defined using weekly information about ILI activity from WHO (https://www.who.int/tools/flunet). Flu outbreaks usually occur between October and March

5.5 Summary and discussion of results

Overall, we find little evidence that early enrollment age is harmful for children. On the contrary, we find some evidence that earlier enrollment ages might even be advantageous for child development, especially for boys. The idea that boys may benefit more from high-quality daycare than girls is in line with existing evidence (Felfe and Lalive, 2018; Gørtz et al., 2018).

We do not find heterogeneous effects by parental education, indicating that the impact of enrollment age does not vary significantly for children from more or less affluent families. Although this result contrasts the findings of some previous studies (Drange and Havnes, 2019; Felfe and Lalive, 2018; van den Berg and Siflinger, 2022), it signals that there is limited scope for reducing inequality through high-quality daycare.

While determining an optimal enrollment age is beyond the scope of this paper, our results suggest that children are insensitive to smaller changes in age at first enrollment (-/+ one month) around the average age of 10.5 months.[29] Previous studies report significant outcomes; however, this observation could indicate that children may be more responsive to substantial changes in the age at which they initially encounter a shift in the mode of care. For example, Fort et al. (2020) study an Italian case where the average enrollment age was reduced by six months for children aged 0–2. Although they do not specify the average enrollment age, their findings indicate that enrolling six months earlier resulted in a lower intelligence quotient and lower scores on positive personality traits. In contrast, Drange and Havnes (2019), using data from an admission lottery in Norway that reduced the enrollment age by four months (from an average enrollment age of 19 months), discovered that children who enrolled earlier—at 15 months rather than 19 months—had higher cognitive test scores at age seven.

Similarly, multiple articles examine the effects of extended parental care; the results

[29] Although we estimate the policy-relevant marginal effects of enrollment age in a setting where we avoid conflating parental care and informal care (as almost all children enroll in formal daycare), a limitation to our findings is that our identification strategy relies on relatively small changes in enrollment age.

of these studies should, in essence, align with studies of nonparental care but with opposite findings. Generally, these findings also vary, possibly due to investigations that span different periods of leave, various outcomes, and various daycare options (Baker and Milligan, 2015; Danzer et al., 2022; Carneiro et al., 2015; Dustmann and Schönberg, 2012; Houmark et al., 2022; Huebener et al., 2019; Rasmussen, 2010; Stearns, 2015). For example, Carneiro et al. (2015) studied an extension of the maternity leave period from 0 to 4 months in Norway in the late 1970s and found that the extension of paid leave reduced high school dropout rates and increased children's wages at age 30. In constrast, Dustmann and Schönberg (2012) found no evidence of extended maternity leave on child outcomes, using three major expansions in maternity leave coverage in Germany in the 1970s-1990s. In addition, the importance of the counterfactual mode of care is highlighted by Danzer et al. (2022) through their analysis of an Austrian reform that extended parental leave from one to two years. They split their sample based on the local availability of formal daycare, and their results suggest that substituting informal care with maternal care improves child outcomes, while substituting formal daycare with maternal care contributes to similar outcomes.

As existing results are quite sensitive to the quality of care at hand, the period of investigation, and the population under investigation (age and background), further studies are needed to draw conclusions about the optimal enrollment age. Even for Denmark and within similar periods and similar age groups, the results vary. A recent Danish study, which investigates a rather large extension of the leave period from 24 to 46 weeks that changed the average maternity leave from 7.5 to 10 months (Houmark et al., 2022), finds that children whose mothers had access to extended leave displayed higher levels of non-cognitive skills in school age. Although their institutional settings appear similar to ours, the results are still not directly comparable, as informal (and lower quality) care played a greater role in their setting.[30] However, differences in the results could also arise from the substantial change

[30] While Houmark et al. (2022) argue that the counterfactual mode of care was daycare, only about 16% of all children under 1 year of age (between 0 and 1 year) and 70% of all children between 1 and 2 years of age (1 year old) were enrolled in daycare during their period (Statistics Denmark, 2011).

in age at first enrollment (one month versus 2.5 months), or the critical age for enrollment being less than 10 months. Closer inspection to sort out the impact of these important key components seems needed to draw conclusions about the optimal age of enrollment.

6 Conclusion

A significant proportion of parents return to the labor market when their child is one year old or younger, sparking the debate about early-age daycare. This paper evaluates the causal effects of enrollment age in daycare for children aged 6 to 18 months. The Danish context, characterized by high attendance at daycare, minimal selection into informal care, and generally high quality daycare, provides a unique setting for this assessment.

Our paper makes important contributions along several key dimensions. First, we directly address concerns about the non-random nature of the timing of returning to work and daycare choice. To establish causal effects of age at first daycare enrollment, we employ an identification strategy based on the excess demand for daycare slots in the City of Copenhagen. Parents who opt for universal (and subsidized) daycare register their daycare preferences and preferred enrollment date at the municipal daycare office, which administers the allocation of all available daycare slots in the city through a waiting list system. Our two-stage least squares (2SLS) setup uses monthly vacancy rates as instruments for enrollment age. This approach enables us to estimate the effects of the age at first daycare enrollment at the intensive margin rather than the extensive margin (formal daycare or not). Second, using comprehensive administrative data, we consider a range of objective measures of both health and cognitive outcomes. Third, our high-quality data allow us to explore the heterogeneity of the results on the socio-demographic traits: child gender and parental education level.

The empirical investigations provide a number of interesting insights that contribute to the ongoing debate about pros and cons of early enrollment in daycare. As the take-up rate of private care options was minimal in our period, our results also contribute to the medium-term implications of an early return to the labor market.

Our main result suggests that being older at enrollment can worsen language skills when the child reaches preschool age, as later enrollment increases the probability of scoring low on a language proficiency test at age 5, especially among boys. For boys and girls together, the probability of a low language proficiency score increases by 3.9% (statistically significant at the 10% level), but for boys alone, the effect is 4.4%. Moreover, later daycare enrollment does not have any significant effect on being late for grade, neither for boys nor girls.

We also demonstrate that enrollment age has little impact on health care use. Specifically, we find no permanent effects on PCP contacts over the subsequent five years after enrollment. In addition, the effects on hospitalizations are minimal, suggesting that these modest infections have no far-reaching consequences on the child's health.

Overall, our results suggest that early enrollment is not harmful for young children, beyond a temporary change in health care use, when focusing on the marginal effects of age at first enrollment on use of health care and cognitive outcomes. Unlike other papers, we find similar results for children from more and less affluent families. A significant factor explaining the relatively modest effects of early enrollment in daycare for children from both less and more affluent families lies in our focus on the Scandinavian setting, where the quality of formal daycare is relatively high compared to many other OECD countries.

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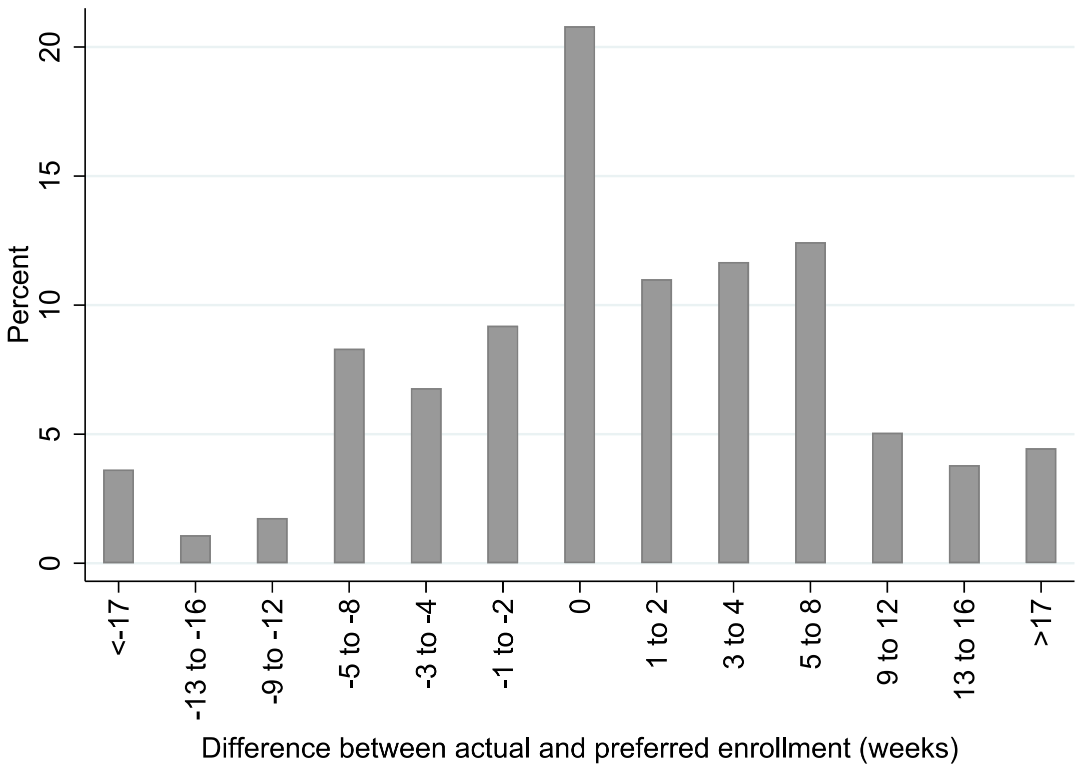
A Appendix

Table A1: Sample selection - Greater Copenhagen

	(1) Greater Cph.	(2) Not in sample	(3) Sample	(4) Diff.
Year of birth	2011.95	2011.96	2011.94	0.0211
	(2.00)	(2.01)	(2.00)	(1.37)
Boy	0.52	0.51	0.52	-0.00255
	(0.50)	(0.50)	(0.50)	(-0.66)
Low birth weight	0.04	0.05	0.04	0.00757***
	(0.20)	(0.21)	(0.19)	(4.75)
Gestational age (days)	278.36	277.77	279.15	-1.388***
	(12.17)	(12.80)	(11.21)	(-14.82)
Both parents basic education only	0.04	0.05	0.02	0.0267***
	(0.19)	(0.22)	(0.15)	(18.09)
At least one college educated parent	0.66	0.60	0.75	-0.150***
	(0.47)	(0.49)	(0.43)	(-41.62)
No registered father	0.05	0.05	0.05	0.00194
	(0.22)	(0.22)	(0.22)	(1.14)
Parents immigrated	0.11	0.13	0.08	0.0544***
	(0.31)	(0.34)	(0.27)	(22.61)
Observations	68880	39569	29311	68880

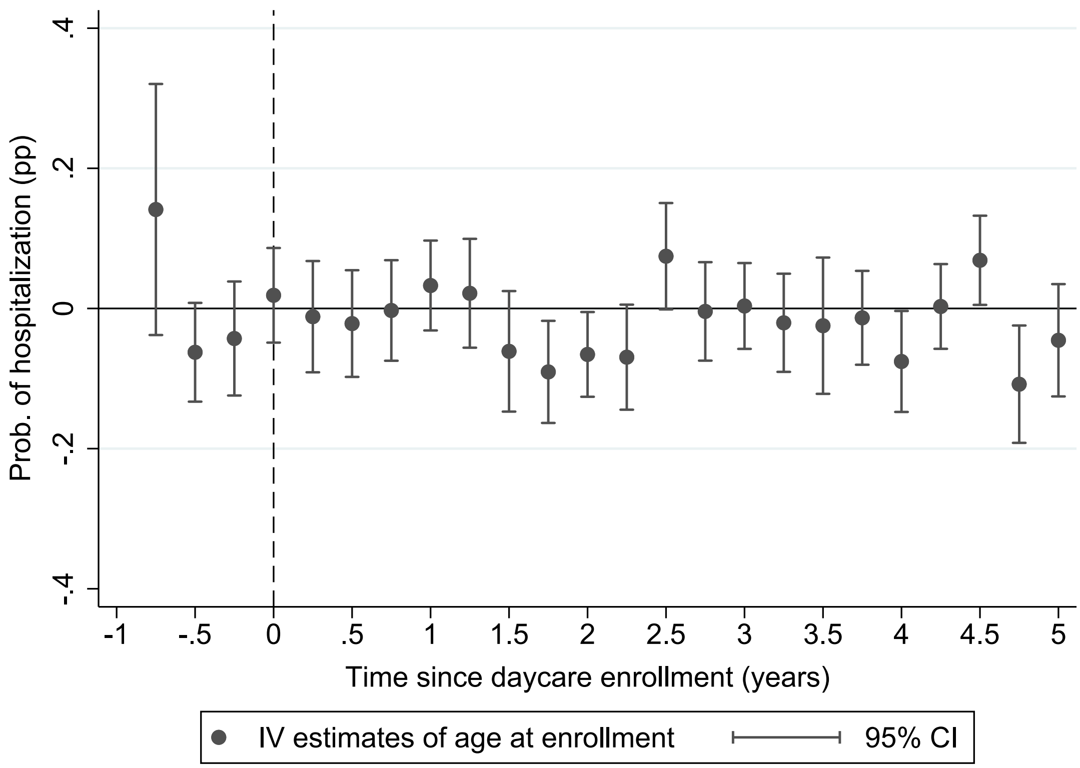
NOTE— The table shows the mean and standard deviations of the predetermined variables for all born in greater Copenhagen in column (1). Columns (2) and (3) show the mean and standard deviations for those excluded from and included in the sample, respectively. Column (4) shows the differences between columns (2) and (3). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure A1: Distribution of the differences between actual and preferred enrollment age



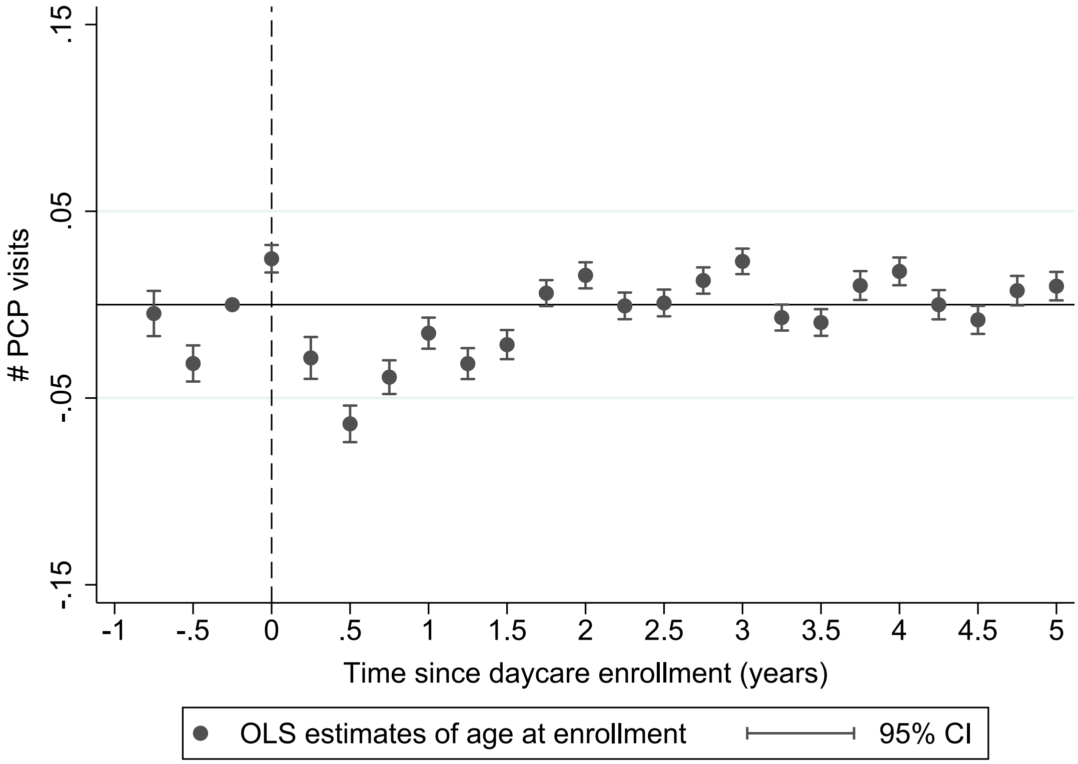
NOTE— The figure plot the difference between the actual enrollment age and the preferred enrollment age in intervals of weeks. Data on the left hand side of zero are from children who start before their preferred enrollment age, while data on the right hand side of zero indicate children who start after their preferred enrollment age.

Figure A2: The effects of daycare enrollment age on quarterly hospitalization



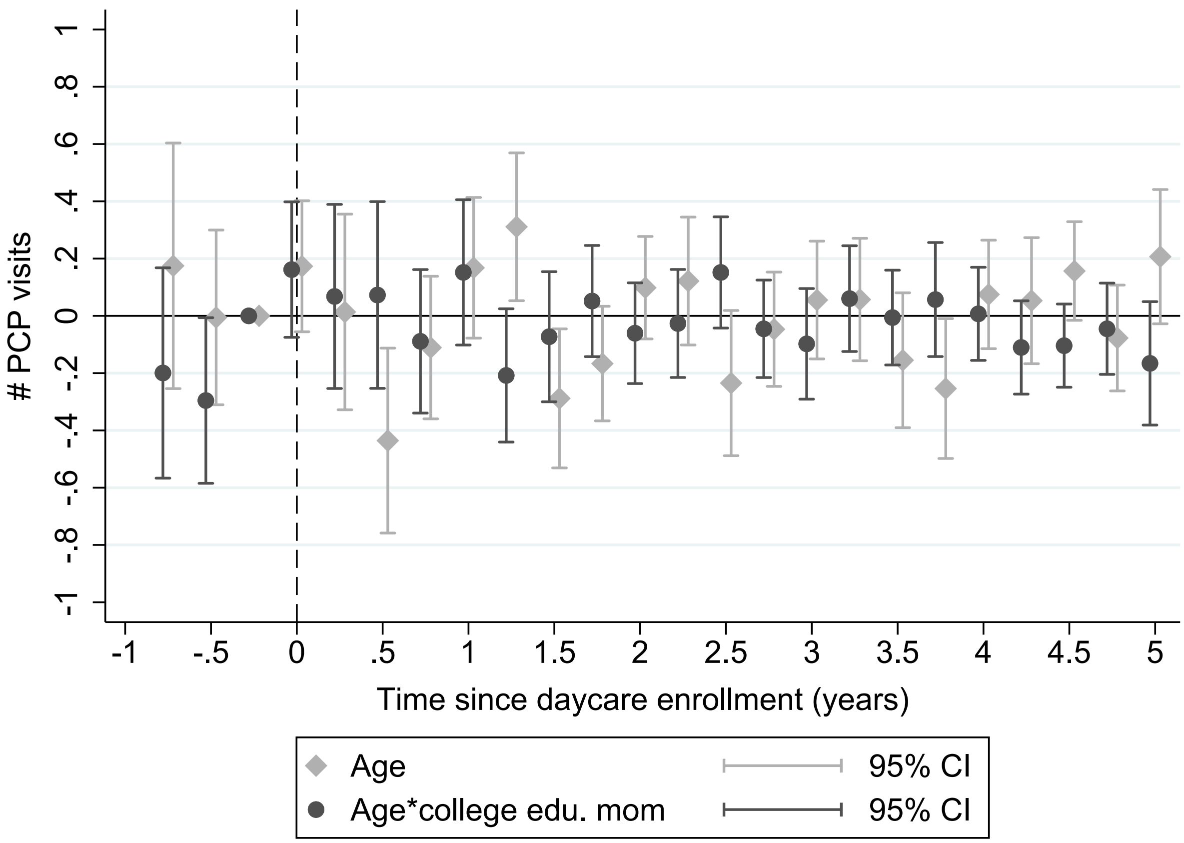
NOTE— The figure plots IV estimates of the age of enrollment on the probability of hospitalization. The vertical dotted line indicates the quarter of the year the child enrolls in daycare. Each dot is from a separate regression.

Figure A3: OLS estimates of daycare enrollment age on quarterly PCP visits



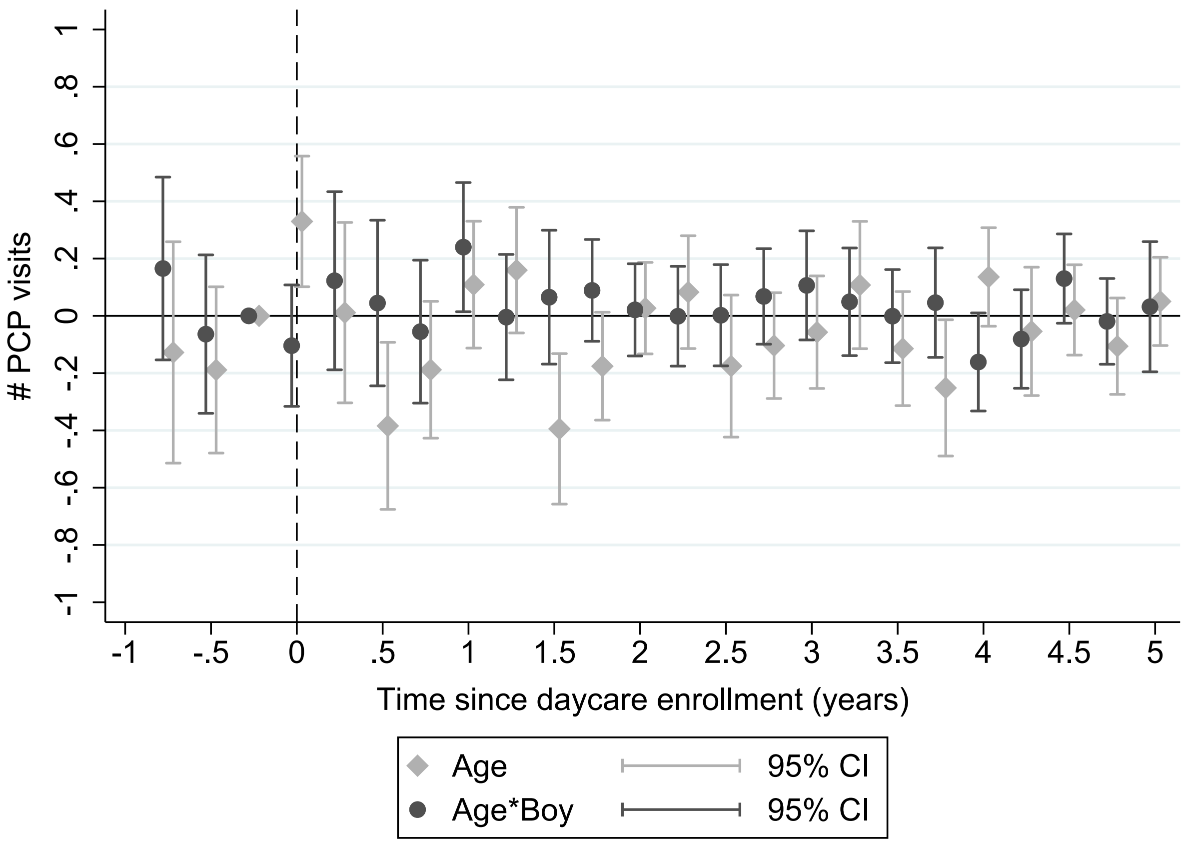
scNote— The figure plots the OLS estimates with fixed effects of the start age on the number of PCP visits. The vertical dotted line indicates the quarter of the year the child enrolls in daycare. Each dot is from a separate regression.

Figure A4: The effects of enrollment age on quarterly PCP visits, by maternal education



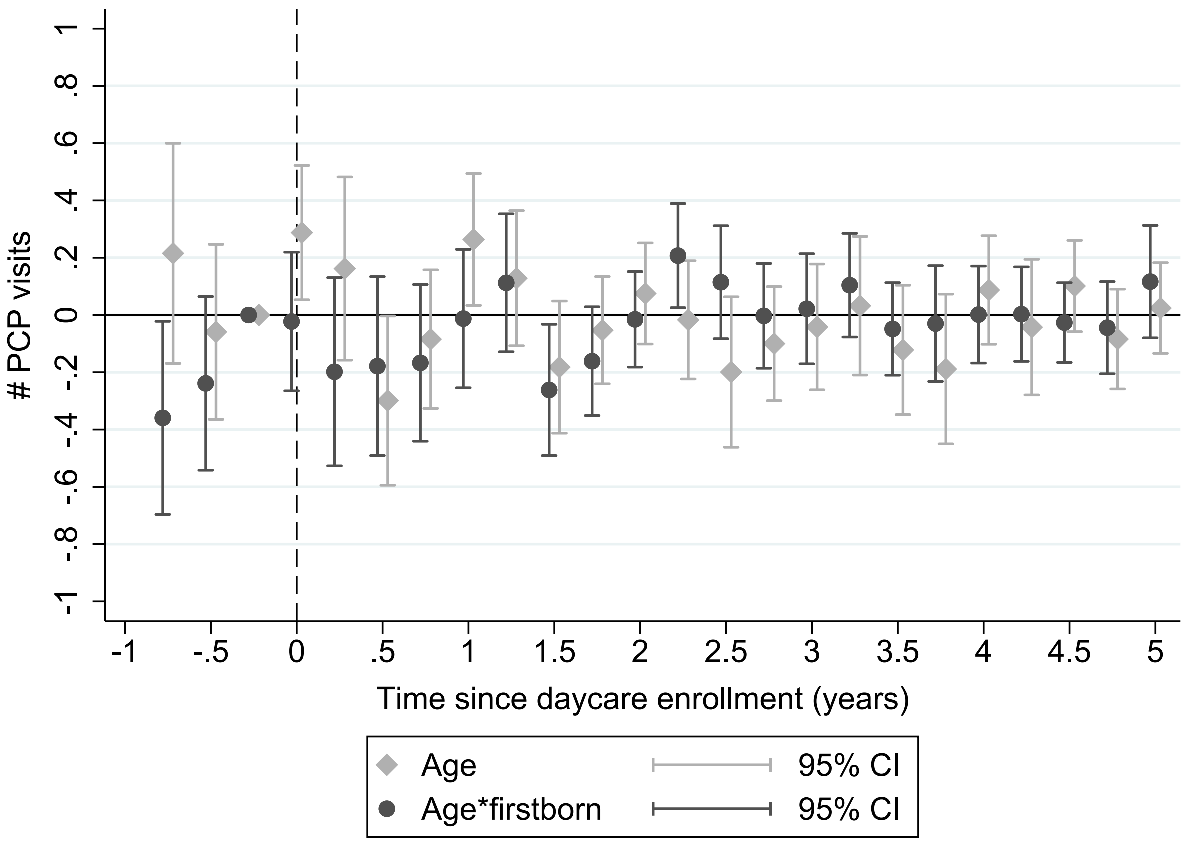
Note— The figure plots IV estimates of age at first enrollment on the number of PCP visits per quarter of a year. The dotted vertical line indicates the quarter in which children first enroll nonparental daycare. For each quarter of a year, we perform a regression with an interaction term between enrollment age and maternal education. The lighter gray dots are the main age effects, and the black dots are the results from the interaction terms.

Figure A5: The effects of enrollment age on quarterly PCP visits, by child gender



Note— The figure plots IV estimates of age at first enrollment on the number of PCP visits per quarter of a year. The dotted vertical line indicates the quarter in which children first enroll nonparental daycare. For each quarter of a year, we perform a regression with an interaction term between enrollment age and child gender. The lighter gray dots are the main age effects, and the black dots are the results from the interaction terms.

Figure A6: The effects of enrollment age on quarterly PCP visits by firstborn and later-born children



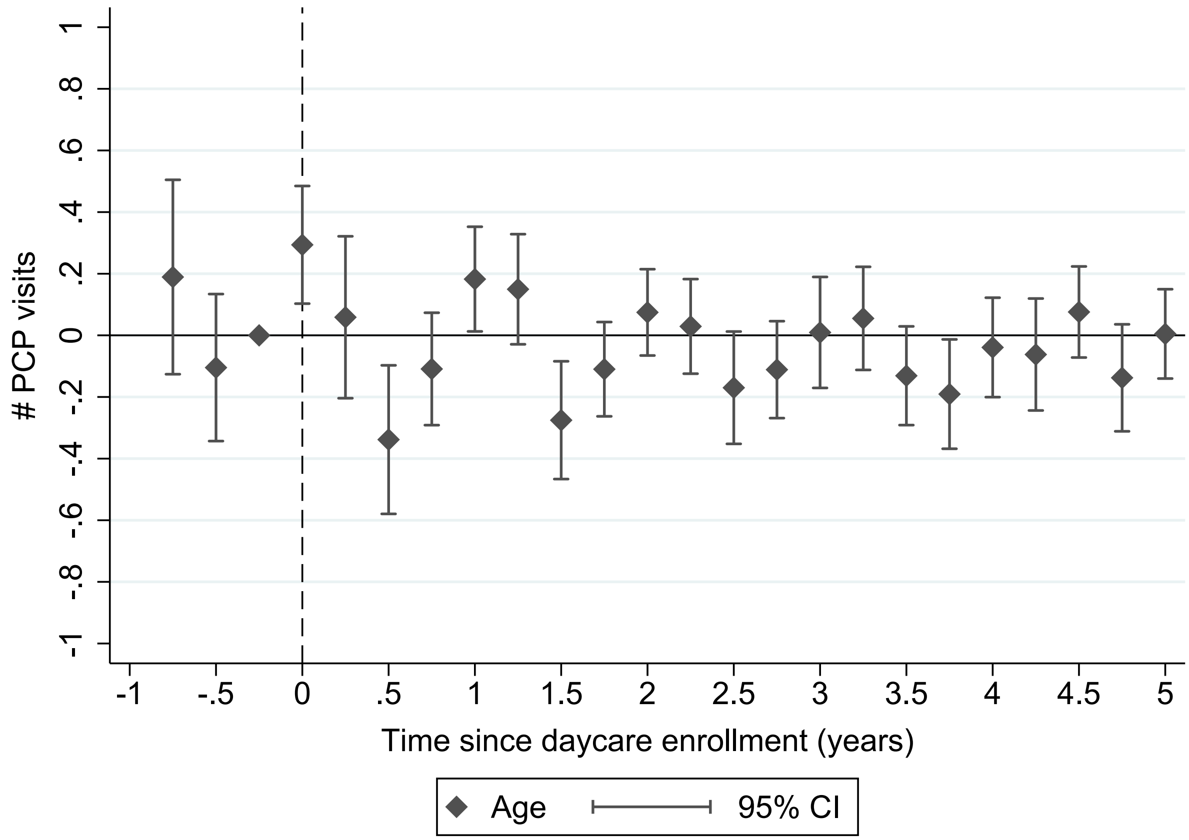
NOTE— The figure plots IV estimates of age at first enrollment on the number of PCP visits per quarter of a year. The dotted vertical line indicates the quarter in which children first enroll in nonparental daycare.

Table A2: The effects of enrollment age on test taking, language scores and being late for grade, by firstborn and later-born children

	(1) Age 5: Tested	(2) Age 5: Low score	(3) Late for grade
Age at first enrollment	0.076	0.053*	-0.004
	(0.053)	(0.027)	(0.019)
Age*Firstborn	-0.013	-0.026	0.001
	(0.047)	(0.023)	(0.017)
Firstborn	0.123	0.265	-0.009
	(0.503)	(0.253)	(0.185)
Observations	24961	24961	20015
Kleibergen-Paap F statistic	8.74	8.74	6.41

NOTE— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table shows IV estimates of the age at the first enrollment in cognitive outcomes of first-born siblings. Column (1) outcome is a dummy variable for child tested for language proficiency at age five, column (2) outcome is a dummy-variable for a low score on the test, column (3) outcome is a dummy for being late for grade. All regressions include a set of child and parent characteristics, a set of year-of-birth and month-of-birth dummies, and choice set fixed effects. Standard errors clustered in the choice set are shown in parentheses.

Figure A7: The effects of enrollment age in center-based daycare on quarterly PCP visits



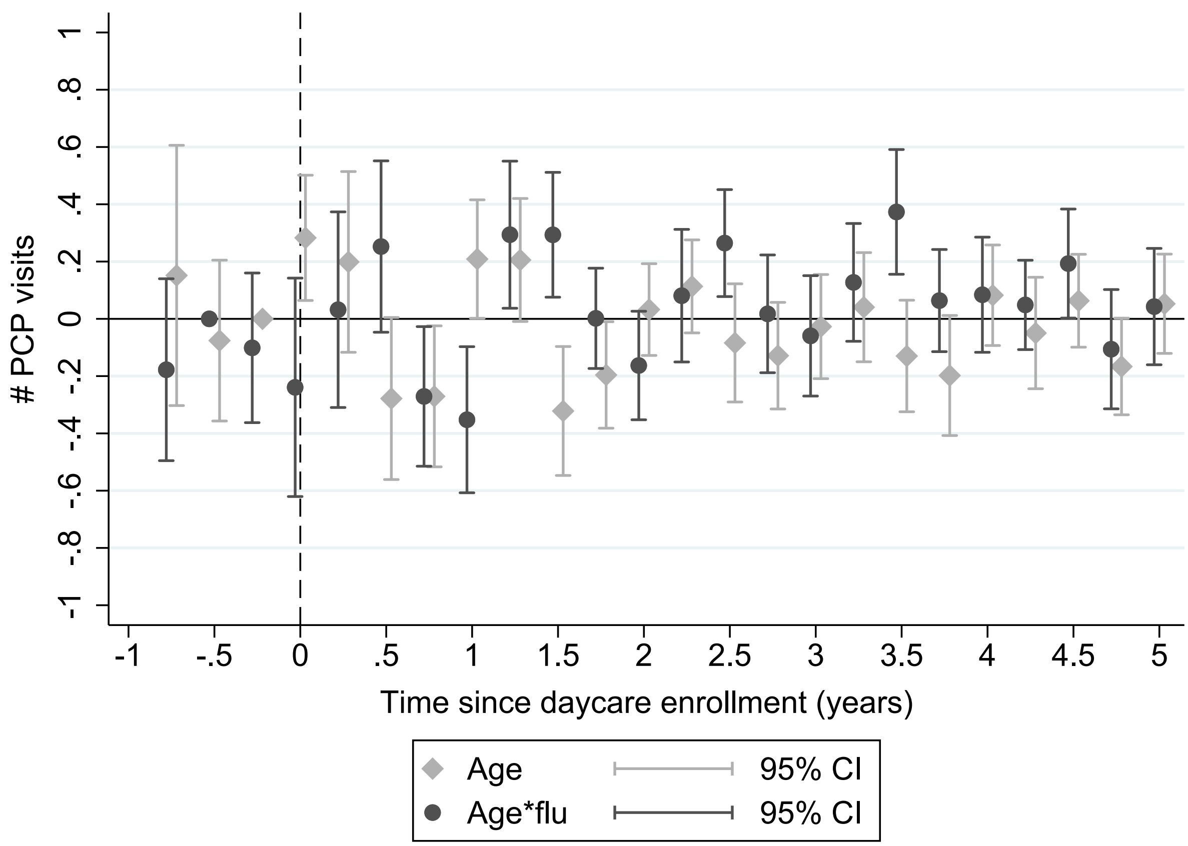
NOTE— The figure plots IV estimates of age at the first enrollment in the center-based daycare on the number of PCP visits per quarter of a year since the first daycare enrollment. The vertical dotted line indicates the quarter of the year in which the children first enroll in daycare.

Table A3: Effects of enrollment age on cognitive outcomes for children in center-based care

	(1) Age 5: Tested	(2) Age 5: Low score	(3) Late for grade
Age at first enrollment	0.076**	0.036**	-0.011
	(0.038)	(0.018)	(0.015)
Observations	18752	18752	14561
Kleibergen-Paap F statistic	34.01	34.01	20.64

Note— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table shows IV estimates of age at first enrollment on cognitive outcomes for the children in the sample enrolling in center-based care. Column (1) outcome is a dummy-variable for child tested for language proficiency at age five, column (2) outcome is a dummy-variable for a low score on the test, column (3) outcome is a dummy for being late for grade. All regressions include a set of child and parent characteristics, a set of year of birth and month of birth dummies, and choice set fixed effects. Standard errors clustered at the choice set are shown in parentheses.

Figure A8: The effects of daycare starting age on quarterly PCP visits by flu outbreak



Note— The figure plots IV estimates of age at first enrollment on number of PCP visits per quarter of a year. The dotted vertical line indicates the quarter in which children enroll nonparental daycare for the first time.

Table A4: The effects enrollment age on cognitive outcomes by flu outbreak

	(1) Age 5: Tested	(2) Age 5: Low score	(3) Late for grade
Age at first enrollment	0.090*	0.054**	-0.005
	(0.048)	(0.024)	(0.018)
Age*Flu	-0.040	-0.043	0.009
	(0.056)	(0.028)	(0.019)
Flu	0.446	0.475	-0.091
	(0.614)	(0.306)	(0.210)
Observations	24961	24961	20015
Kleibergen-Paap F statistic	11.22	11.22	8.44

NOTE— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table shows IV estimates of age at first enrollment on cognitive outcomes by enrollment during flu outbreaks. Column (1) outcome is a dummy-variable for child tested for language proficiency at age five, column (2) outcome is a dummy-variable for a low score on the test, column (3) outcome is a dummy for being late for grade. All regressions include a set of child and parent characteristics, a set of year of birth and month of birth dummies, and choice set fixed effects. Standard errors clustered at the choice set are shown in parentheses.

Table A5: Robust to only including enrolled +/- 12 weeks of preferred enrollment age

	(1) Age 5: Tested	(2) Age 5: Low score	(3) Late for grade
Panel A: IV			
Age at first enrollment	0.1643**	0.0654**	-0.0093
	(0.0649)	(0.0319)	(0.0257)
Kleibergen-Paap F statistic	17.13	17.13	12.19
Montiel-Pflueger F statistic	18.28	18.28	12.33
Critical values	6.905	6.905	4.083
Panel B: OLS			
Age at first enrollment	0.007**	0.003**	-0.001
	(0.003)	(0.001)	(0.001)
Observations	22626	22626	18388

Note— * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table shows IV estimates (panel A) and OLS estimates (panel B) of age at first enrollment on cognitive outcomes using a sub sample of children enrolling within 12 weeks of their preferred enrollment date. Column (1) outcome is a dummy-variable for child tested for language proficiency at age five, column (2) outcome is a dummy-variable for a low score on the test, column (3) outcome is a dummy for being late for grade. All regressions include a set of child and parent characteristics, a set of year of birth and month of birth dummies, and choice set fixed effects. Standard errors clustered at the choice set are shown in parentheses.