Article:
Ward, L. (2026) Unlocking potential: investigating the prolonged impact of formal childcare intensity on non-cognitive skills. Journal of Population Economics, 39 (20). ISSN: 0933-1433

https://doi.org/10.1007/s00148-026-01162-2

Journal of Population Economics (2026) 39:20
https://doi.org/10.1007/s00148-026-01162-2

ORIGINAL PAPER

Unlocking potential: Investigating the prolonged impact of formal childcare intensity on non-cognitive skills

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Received: 21 March 2025 / Accepted: 3 February 2026

Abstract
Policymakers often cite positive outcomes from early childcare programmes, yet the evidence is mixed and largely based on enrolment effects for children aged 3–5. This study examines the intensity of childcare, measured in hours, for children under age 3, focusing on impacts on non-cognitive skills from ages 3 to 14. Despite policy focus on subsidised childcare hours, this question has received little attention. Using a nationally representative English birth cohort and an instrumental variables approach based on the probability of the mother working shift work and having unpredictable hours during pregnancy, this research finds that increasing hours in formal childcare has an initial positive impact on non-cognitive skills that persists over time. I also find that disadvantaged children appear to benefit more, suggesting that expanded access to longer childcare hours could reduce early inequalities. Findings are robust to sensitivity checks, including weak instrument testing and consideration of omitted variables.

Keywords Childcare · Child outcomes · Non-cognitive skills · Instrumental variables

JEL Classification J13 · I21 · C26

1 Introduction

This paper examines the causal relationship between hours spent in childcare by age 3 and non-cognitive development for children aged 3–14. Early years support systems are failing to bridge the gap for disadvantaged children. In the UK, while 72% of non-disadvantaged pupils reach the expected level of development by age

Responsible editor: Kompal Sinha

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Published online: 19 March 2026

5, only 55% of disadvantaged pupils achieve the same milestone (Andrews et al. 2017).[1] Gaps in early childhood skills are likely to drive inequalities later in life, affecting health (Case et al. 2005), education (Almond & Currie 2011), and employment (Black et al. 2007). The UK government's commitment to halve this gap by 2028 has created a conversation on how to achieve this goal. Early childhood has become a central focus in this discussion, particularly in relation to the development of human capital. There is a wide range of literature on the benefits of attending childcare, with specific focus on the benefits for disadvantaged children. Less research has focused on the intensity of this treatment. Using nationally representative data from the Millennium Cohort Study, I show that there are not only short-run gains but also long-run impacts of early access to childcare for more hours.

Despite the recognised importance of early childhood in human capital development, public investment in this stage remains limited in many countries. The UK, for instance, allocates just 0.1% of GDP to early childhood education and care, well below the OECD average of 0.8% (OECD 2023). This underinvestment contributes to high childcare costs, with 84% of childcare services provided by for-profit entities compared to just 3% in Germany and 4% in France. Similarly, the United States relies heavily on private provision, leading to significant financial burdens for families. In contrast, countries like Sweden and Denmark have long-established, affordable public childcare systems that ensure broader access (Menon 2023).

Childcare costs vary widely across countries, with families in Germany and Austria spending less than 5% of their income on childcare. Meanwhile, in the UK, childcare costs can amount to nearly 52% of median female earnings, making it one of the most expensive systems in the OECD.[2] High costs are not exclusive to the UK. Australia faces a similar crisis, where childcare expenses have contributed to a "cost-of-working" dilemma, particularly for women, as the financial strain of childcare often outweighs the economic benefits of employment (Dumas 2024). These global disparities highlight the need for a better understanding of optimal time spent in childcare.

Allocating resources to childcare could create numerous advantages, including the enhancement of children's development, the increase in family income, and a general improvement in productivity. This is because childcare likely has knock-on implications for parents' ability and incentive to work. In the short term, it boosts productivity by expanding labour force participation and hours of work. Additionally, there are medium-term benefits, as childcare prevents the deterioration of

[1] Disadvantaged is defined as being eligible for free school meals.

[2] The cost of childcare in the UK has been notoriously high, with the government first introducing childcare subsidies in the early 2000s. All 4-year-olds since 2000 and all 3-year-olds since 2004 have been entitled to free, part-time nursery education. Starting in 2000, the Department for Education funded childcare places for three-year-olds in 65 Local Education Authorities (LEAs). By 2001, this initiative was expanded nationwide, with the goal of achieving universal coverage for all three-year-olds by 2004. This was set at 12.5 h per week for 33 weeks per year until 2010, then 15 h per week for 38 weeks. Sure Start began in 1999 but did not offer childcare until 2004. In 2013, free part-time education was also extended to disadvantaged 2-year-olds. In 2017, this was increased to 30 h for working parents. In the 2023 budget, the government announced their plans to provide 30 h of free childcare for children over the age of nine months with working parents.

parents' skills during periods of non-employment. Over the long term, investing in childcare is expected to contribute to sustained productivity by improving children's development.

The first contribution of this research lies in its focus on non-cognitive skills, an area that has received limited attention in the literature. Non-cognitive skills are often overlooked within the education assessment system, where there is heavy reliance on written tests to screen and sort individuals, to evaluate pupils and schools, and to assess the performance of entire nations. This is despite the argument that non-cognitive skills predict a wide range of outcomes, including educational achievement, labour market outcomes, health, and criminality (Heckman & Kautz 2014; Almlund et al. 2011; Borghans et al. 2008; Roberts et al. 2007). Furthermore, the predictive power of non-cognitive skills has been shown to rival that of measures of cognitive ability. For example, conscientiousness predicts years of schooling with the same strength as measures of intelligence (Almlund et al. 2011). For the studies that have focused on non-cognitive skills, this evidence is mixed. Studies have found positive (Gupta & Simonsen 2010) but also zero (Kuehnle & Oberfichtner 2020; Hansen & Hawkes 2009) and negative (Fort et al. 2020; Baker et al. 2019; Magnuson & Duncan 2016; Burger 2010) effects of childcare. As the findings vary, it is challenging to provide clear policy guidance. Expanding the evidence base will help to strengthen the foundation for reliable conclusions.

A second contribution of this research is the focus on hours in childcare. This is the first research to shed light on the causal relationship between hours in childcare and non-cognitive skills both in short and long run. Much of the existing literature has examined the effects at the extensive margin (Berger et al. 2021; Fort et al. 2020; Kuehnle & Oberfichtner 2020; Felfe & Lalive 2018; Carta & Rizzica 2018; Del Boca et al. 2016, 2018; Caprera 2015; Blanden et al. 2016; Gregg et al. 2005). Those that have extended their analysis to the impact of hours (Gupta & Simonsen (2010) and Berger et al. (2021)) provide only descriptive evidence. In the UK, for example, the current childcare policy focus is on the number of hours which should be subsidised though the evidence base on this question is limited.

Identifying a causal relationship is a challenge due to formal childcare being determined by the parents' choices.[3] Parents' parenting skills and preferences for childcare are likely correlated with the amount of time spent in childcare and the child's non-cognitive skills. These factors are difficult to observe, potentially creating a spurious correlation between hours in childcare and non-cognitive development. To correct for endogeneity of hours in childcare, this research creates and uses instrumental variables.

Making use of the information on mother's occupation during pregnancy, I calculate the probability that the mother would work shifts or have uncertain working hours. The assumptions are that due to the structured nature of formal childcare, mothers working in sectors with more shift work, place their child in formal care

[3] This research focuses on 3-year-olds in 2003/2004, who were not eligible for the childcare policies of the time.

for fewer hours. On the other hand, if the mother has varying hours each week, the uncertainty causes them to place their child in formal care for more hours.

An additional contribution is that this study focuses on childcare taken at ages up to age 3, while the majority of the literature has examined the impact of childcare on children aged 3–5. The focus on this younger age group is important for two main reasons. Firstly, in the 2023 budget, the UK government announced their plans to provide 30 hours of free childcare for children over the age of nine months with working parents. The policy focus is therefore currently on this younger age group, for which the literature is unclear on the impact of childcare. Secondly, the Heckman Curve demonstrates that the highest economic returns are achieved through early investments in children (Heckman 2011).

Utilising the Millennium Cohort Study (MCS) for the UK, which provides detailed information about childcare and child outcomes, and employing the instrumental variables, the results here are summarised as follows: the amount of time spent in formal childcare has a positive and significant impact on non-cognitive skills at age 3 through to age 11. The impact on emotion, conduct and peer relationships is the most persistent over time, with larger effects for males and disadvantaged children.

The findings remain robust across multiple checks, including changes in the sample and controls for potential omitted variables, such as parental childcare preferences and distance to grandparents. Additionally, I carry out weak instrument robustness tests and further assess the strength of the instrumental variables by using additional survey data, including hours worked and job changes post-pregnancy.

This paper is organised as follows. Section 2 outlines the data while Section 3 discusses the methodology. Section 4 presents the estimated impact and tests the robustness, before concluding in Section 5.

2 Data

This research uses data from the Millennium Cohort Study (MCS). The MCS is a multidisciplinary cohort survey run by the Centre for Longitudinal Studies at the University College London.

The MCS is a valuable data source as it tracks the lives of a sample of about 19,000 babies born in the UK between 1 st September 2000 and 11th January 2002.[4] The sample was constructed to be representative of the total UK population. The data collectors selected electoral wards with the aim to recruit 100 per cent of the children born in the eligible period within them.[5] They also wanted to adequately represent disadvantaged and ethnic minority children. The population of wards was therefore stratified by ethnicity and the Child Poverty Index. This means that certain sub-groups of the population were intentionally over sampled.

[4] 1 September 2000 and 31 August 2001 (for England and Wales), and between 24 November 2000 and 11 January 2002 (for Scotland and Northern Ireland).

[5] They achieved a response rate of 72 per cent of all the families with eligible children living at nine months in the sampled wards.

The survey is conducted in several waves, the first occurred when children were aged nine months, gathering information from the parents of 18,818 children. Since then, families have been interviewed again six times at ages 3, 5, 7, 11, 14 and 17.[6] The survey was originally answered by just the parents. From wave 2 onwards, the child was also surveyed along with older siblings. Class teachers responded to a survey in waves 3–5. Topics covered include family composition, housing and local area, parental education, employment and income, parental and child health, parenting activities and attitudes, physical, social and cognitive development of the child, preschool experiences, schooling and leisure activities etc.

The main advantage of the MCS is the rich range of information regarding the experiences and outcomes of the MCS children and their families. This allows many individual and family characteristics to be controlled for. The main limitation of the survey is that the longitudinal pattern of response is complex, with attrition and re-entry. At each wave there has been non-response owing to refusal and non-contact.

2.1 Sample

This research uses data from the first six waves, which took place when the children were aged 9 months, 3, 5, 7, 11 and 14 years old.[7] I am interested in the impact of childcare at age 3, therefore the majority of the focus is on the information provided in wave 2. I use the data provided in wave 1, at 9 months, to construct the control variables and the information in waves 3–6 to measure non-cognitive skills at older ages.

I restrict the sample to children living in England, so that the childcare supply is similar for all children observed. The sample excludes twins and triplets since childcare arrangements, and their effects may be different when more children need to be looked after.

The Strength and Difficulties questionnaire, the outcome of interest, as well as reported hours in childcare, suffer from non-responses. I therefore keep cohort members who have responded at least once to the SDQ and report hours in childcare at age 3.[8] The initial sample is 7522 cohort members.[9]

2.2 Childcare measure

This research is interested in the impact of time spent in formal childcare at the age of 3. Formal childcare is defined as any type of childcare provided by someone who is not family or friend. This includes centre-based care for example nursery but

[6] Wave 8 at age 22, is currently being undertaken.

[7] This research stops at age 14 as this is the last year parents completed the Strengths and Difficulties Questionnaire, the main outcome of interest.

[8] I examine the determinants of non-response as well as examine the impact of a change in the sample and find no impact on the estimated results.

[9] Focusing on England reduces the sample to 11,680. Removing twins reduces the sample by 308. A further 814 observations are dropped due to the hours in children care questions not being responded to. There are 1211 non-responses to the Strength and Difficulties questionnaire.

also childminders. Nannies or au pairs are not included as this study is interested in the impact of being cared for in a group setting outside the home. Nurseries are likely to be more structured than childminders; however, both are required to have some level of childcare qualifications. The difference in structure is less important for non-cognitive skills than cognitive development. Cognitive skills benefit more from structured learning environments, while non-cognitive skills develop through stable, supportive social interactions found in any group setting (Heckman & Kautz 2013).

In the first three waves of the survey, the mother was asked about the childcare choices made. In wave 1, when the child was 9 months old, working mothers were asked to state the types of care being used at the time of the survey when they were at work. In wave 2, when the child was 3 years old, all mothers were asked details about the type of childcare that had been used since the first survey, including starting dates, stop dates, and the number of hours per week.[10][11]

There is potentially measurement error in the number of hours of care reported by the mother. While some parents will know exactly how many hours they enrol their child in childcare for, others may only know how many sessions a week they take them. This uncertainty could lead to mothers guessing how many hours this equates to. Whether the guessing or quick in head calculations would give under or overestimate is not clear.[12]

2.3 Measure of non-cognitive skill

The outcome of interest in this research is non-cognitive development. This study focuses on non-cognitive skills for two reasons. Firstly, in comparison to cognitive skills, the literature has found more varied results, meaning there is a lack of consensus on the impact of childcare on non-cognitive skills. Secondly, I am interested in both the short- and long-run effect of time in childcare and it has been argued that non-cognitive skills are more malleable as well as more predictive of long-term outcomes than are test scores (Heckman & Rubinstein 2001; Lindqvist & Vestman 2011; Mueller & Plug 2006).

I use the Strength and Difficulties Questionnaire (SDQ), proposed by Goodman (1997), to measure non-cognitive skills. The questionnaire consists of 25 questions over five separate dimensions: Conduct Problems, Hyperactivity, Emotional Symptoms, Peer Relationship Problems, and Prosocial behaviour. The questionnaire consists of statements to which the responses are: 'not true', 'somewhat true', and

[10] In the third wave, when the child is 5 years old, all mothers are asked about all childcare prior to starting school. This research focuses on children under the age of 3 and therefore, focuses on the first 2 waves of the survey.

[11] Some 3-year-olds were eligible for free childcare prior to 2004. In Table A.6 reduce the sample to children who paid for all their hours of childcare. In Table A.6 reduce the sample to those who had not used Sure Start. Our findings are robust to the change in the sample.

[12] Section 3 for how I try to control for this measurement error.

'certainly true'.[13] Higher scores on the first four dimensions and lower scores on the pro-social subscale indicate greater problems. A total difficulties score is generated by adding the first four scales and excluding the prosocial scale, which can be used as a positive counter measure to the overall SDQ score. The total difficulties score ranges from 0 to 40, the subscales from 0 to 10. For the total difficulties score, 0–15 is defined as having low needs, 16–19 some needs and 20–40, high needs. The analysis uses the overall SDQ score as well as its dimensions to cover various aspects of a child's non-cognitive skills. The SDQ and all subscales are standardised to have a mean of zero and a standard deviation of one.

Figure 1 illustrates the distribution of the total difficulties at age 3. The distribution is normal, with a few children reported to have very low or very high difficulties.

2.4 Conditioning variables

Cohort members were first surveyed at 9 months old, before many of them started childcare, and I therefore use the information given at age 9 months to construct the control variables. Due to the large amount of information held on both the children and their families I am able to control for many variables.[14] I consider the child's characteristics (gender, ethnicity, age, birth-weight, birth-month, special educational need (SEN) and three indicators of child development[15]); household characteristics (number of siblings, presence of father, real weekly equivalent income[16] and region of residence); and the mother's characteristics (age, health, level of education[17] and economic activity status).

3 Method

The data allow this research to observe hours spent in childcare by the age of 3 as well as non-cognitive outcomes from age 3 to 14. This analysis aims to identify the causal effect of hours spent in childcare by the age of 3 on non-cognitive outcomes

[13] Statements include: Often has temper tantrums, generally obedient, often fights with other children, restless and overactive, easily distracted, thinks things out before acting, sees tasks through to the end, many worries, often unhappy, nervous or clingy in new situations, easily scared, rather solitary and tends to play alone, has at least one good friend, generally liked by other children, picked on or bullied by other children, considerate of other people's feelings, shares readily, helpful if someone is hurt. For negative statements 'Not true' is coded as zero, 'somewhat true' is given one point and 'Certainly true' two points. For positive statements, the opposite is true.

[14] See Table 2 in Section 4.

[15] I include three factors suggested by Del Boca et al. (2018). They are: "s/he waves bye-bye on her/his own when someone leaves", "s/he can pick up a small object using forefinger and thumb only", "s/he can sit up without being supported"; answers are "often", "once or twice", and "not yet".

[16] The equivalent income is the income of the household taking into account the number of people in the family and assigning weights. The ones provided in the MCS follows the OECD equivalence scale, which assign a value of 1 to the first household member, of 0.7 to each additional adult, and of 0.5 to each child.

[17] The level of education is controlled for by including a range of dummy variables relating to level of qualification.

both in the short run and the medium run. As previously discussed, establishing causality between hours spent in childcare and non-cognitive outcomes faces methodological challenges. There are two primary threats to causality: (i) omitted variable bias, and (ii) measurement error. This section will outline how this research will try to correct for the bias.

The analysis starts by estimating an ordinary least squares (OLS) regression in which I regress total difficulties reported in each year on hours spent in childcare at age 3 and the covariates.[18] The models take the following form:

$$TotalDifficulties_{it} = \beta_0 + \beta_1 Hours_i + \beta_2 Child_i + \beta_3 Family_i + \beta_4 Mother_i + \varepsilon_{it} \quad (1)$$

where $TotalDiffculties_{it}$ is the total number of difficulties reported by the mother in the strength and difficulties questionnaire for child i at age t. Hours is the number of reported hours spent in formal childcare at age 3. *Child* is a vector of individual characteristics including gender, ethnicity, age, birth-weight, birth-month, special educational need (SEN) and three indicators of child development. *Mother* is a vector of the mother's characteristics including age, health, level of education and economic status. *Family* is a vector of family characteristics including number of siblings, local government region and presence of the father. ϵ_{it} captures the unobservable determinants of non-cognitive skills.

The main interest of this research is the estimation of β_1, which is the effect of hours in formal childcare on non-cognitive skills. To interpret β_1 as the causal effect of an hour in formal childcare at age 3 on an individual's non-cognitive skills requires independent variation in hours in formal childcare, meaning the zero conditional mean assumption must hold, $E(\epsilon_{it}|Child_i, Family_i, Mother_i) = 0$. Due to the endogeneity of hours in formal childcare, it can be argued that this assumption may not hold.

Parents who enrol their children in formal childcare for more hours may differ in both observable and unobservable ways from those who opt for a few hours or none at all. These differences could be driven by child and parent factors. Parents of children with higher natural ability may place their child in formal childcare for more hours because they believe they will be able to cope with the separation from their parents better. On the other hand, they might enrol their child in formal childcare for fewer hours, due to a belief their child does not require early intervention. Parents with more time to devote to their child may have chosen fewer hours of childcare though having the time does not always lead to effective use. More "education-oriented" parents may choose to place their child in childcare for many hours at an early age. They may also believe that they can provide their child with a strong early education at home and therefore place them in formal childcare for fewer hours. Many of these factors may not be observable and may influence the child's non-cognitive development, biasing the estimates. The direction of the bias is not straightforward. Take a child's ability, for example. While this is likely to increase non-cognitive skills, it is not clear whether this would increase or decrease hours in formal childcare. The same can be said for a number of potential omitted variables. The number

[18] I make the assumption that hours in formal childcare depends linearly on total reported difficulties. This assumption is discussed in Section 4.

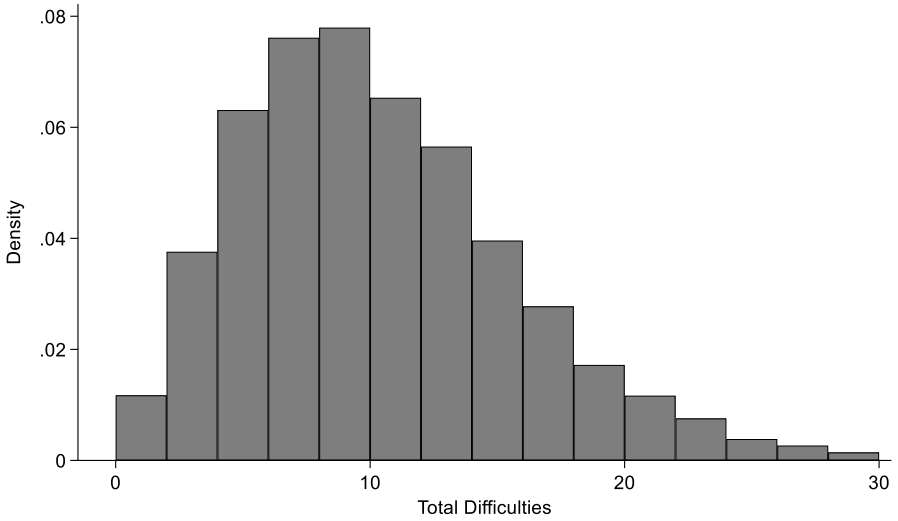


Fig. 1 Distribution of total difficulties at age 3

of recorded hours in childcare may also be subject to measurement error. Much of the literature to date has suggested a negative bias, so I interpret the OLS results as a lower bound of the association between hours in childcare and non-cognitive skills.

3.1 Instrumental variables

To identify the causal effect of hours in formal childcare on non-cognitive skills, I exploit endogenous variation in hours by using instrumental variables.

The job characteristics of the parents, specifically the mother, are likely to be large determinants of the amount of time children are enrolled in childcare. Using the Labour Force Survey, which is a nationally representative study of the employment circumstances of the UK population, covering approximately 40,000 responding UK households per quarter, I obtain information on some job characteristics. I focus on two characteristics. Firstly, shift work. I make the assumption that mothers who work shifts are likely to place their child in formal childcare for fewer hours per week. This is due to the structured opening hours in formal childcare not working for the unsocial working hours of shift workers. The second characteristic I focus on is having variation in working hours each week. I believe that the uncertainty of hours of working will drive parents to enrol their child in formal childcare for more hours per week, in order to cover all possible times when they might be working.[19]

To try to increase the validity of the instruments, I use the probability of shift work and uncertain hours calculated at the three-digit SOC code level. Using the Labour Force Survey, I calculate the percentage of individuals within a three-digit

[19] These assumptions are tested in Section 4.

SOC code that report working shift work/having varying hours, which I link to the MCS using the three-digit SOC code in which the mother was employed while she was pregnant.[20] I use the job the mother was in during pregnancy as this can be argued to be pre-determined and uncorrelated with child characteristics.[21] Further discussion on the quality of the instrument is provided in Section 4.

The average percentage of individuals within a three-digit SOC code that reported working shifts was 22.1%, which relates to SOC code 221, health professionals for humans and animals. The occupation that reported the highest percentage of shift work at 75.3% was transport associate professionals. Workers in this group command and navigate aircraft and vessels. The occupation reporting the lowest percentage of shift work at 1.1% was architects, town planners and surveyors.

For uncertain hours of work, the mean was 45.5% associated with SOC code 213, information technology and telecommunication professionals. The SOC code associated with the highest percentage of workers with uncertain hours (80.5%) was 121, managers and proprietors in agriculture-related services who plan, organise, direct, and control the activities and resources of agricultural, forestry, fishing and similar establishments and services. The SOC code associated with the lowest percentage of workers with uncertain hours (22.1%) was 923, elementary cleaning occupations.

I use a two-stage least-squares (2SLS) regression approach to first estimate the hours in formal childcare as a function of the probability of shift work and uncertain hours for the mother, net of child, household and mother characteristics. The predicted hours in formal childcare is then forwarded to a second-stage regression to predict the unbiased local average treatment effect (LATE) of hours in formal childcare on non-cognitive skills. The first stage equation takes the following form:

$$Hours_i = \lambda_0 + \lambda_1 Shift_i + \lambda_2 Uncertain_i + \lambda_3 Child_i + \lambda_4 Family_i + \lambda_5 Mother_i + \gamma_{it} \tag{2}$$

where $Shift_i$ is the percentage of individuals, working in the same three-digit SOC code as the mother at the time of pregnancy, who reported working shift work, and $Uncertain_i$ is the percentage of individuals working in the same three-digit SOC code as the mother at the time of pregnancy, who reported having variation in their weekly hours.

The second-stage equation takes the following form:

$$TotalDifficulties_{it} = \beta_0 + \beta_1 \widehat{Hours_i} + \beta_2 Child_i + \beta_3 Family_i + \beta_4 Mother_i + \varepsilon_{it} \tag{3}$$

where $\widehat{Hours_i}$ is the predicted hours of childcare based on the first stage.

The IV strategy requires that three assumptions be met. First, the instruments must be relevant, meaning that they are highly predictive of hours in formal childcare. Second, they must be exogenous, meaning they are not correlated with the error term in the explanatory (second-stage) equation. Finally, the instruments affect

[20] I also calculate the instrument at the one and two-digit SOC code levels. Results using these alternative instruments are shown in Table A4 and A5 in the Appendix.

[21] The current occupation of the mother could be a function of childcare use and so does not satisfy the requirements of an instrumental variable. If they are unemployed the instruments are coded as zero.

non-cognitive skills only through their effect on hours in formal childcare and not through any other pathway. I discuss the second and third assumptions together.

The first assumption is easily tested and, as shown in the first stage results (Table A1), holds true in all of the models.

The second assumption may be violated if, for example, mothers select into professions based on children's needs. Although I cannot fully rule out this possibility, I attempt to minimise it by arguing that mother's occupation at the time of pregnancy is predetermined and therefore uncorrelated with child characteristics. To reduce the possibility of there being correlation with mothers' characteristics, I also adjust for an extensive array of covariates. I control for characteristics of the mother including education level, age and health as well as household income, presence of the father and a first-born indicator. Adjusting for these factors should reduce the risk of bias.

In the robustness checks, I test this assumption further by examining why they left their previous job. I drop observations where mothers report leaving a job due to not having flexible hours or where mothers report having a change in hours in their new job. These mothers could have based this change on anticipating childcare needs. I also drop observations where the mother changes SOC code between pregnancy and the child being three years old. A change in the jobs or adjusting their hours could reflect a job switch that is motivated by factors linked to the child, which would create a correlation between the mother's job and the child's outcomes, violating the assumption that the instrument is not correlated with unobserved child characteristics. By dropping these observations, I ensure that the mother's occupation during pregnancy remains unrelated to the child's characteristics or needs.[22]

4 Results

4.1 Descriptive statistics

This research focuses on hours in formal childcare for children under the age of 3. I focus on an initial sample of 7522 individuals who record at least one year of non-cognitive skills as well as hours in childcare (see Section 2 for further discussion on construction of the sample.) Within the sample, 18% of children have attended formal childcare by the age of 3.83% have not yet attended formal childcare, of whom 87% have only been cared for by their parents, leaving 13% who have received informal childcare, mainly from the grandparents.

The main variable of interest within this research is non-cognitive development, measured by the parent's response to the strength and difficulties questionnaire as discussed above. Table 1 presents the average number of difficulties reported for ages 3, 5, 7, 11 and 14.[23] Children who receive formal childcare by age 3 have statistically significantly lower reported difficulties at every age compared to children who receive no formal childcare at age 3.

[22] Table 7 shows that the findings are robust to these changes.

[23] Standard deviation is in parentheses.

Table 1 Average number of reported difficulties

	Childcare	No childcare
Total difficulties age 3	8.45	10.12
	(4.78)	(5.39)
Total difficulties age 5	6.60	7.65
	(4.43)	(5.12)
Total difficulties age 7	6.76	7.86
	(4.97)	(5.54)
Total difficulties age 11	7.06	8.05
	(5.49)	(5.93)
Total difficulties age 14	7.17	8.57
	(5.65)	(6.05)

Descriptive statistics for the covariates, shown in Table 2, reinforce that there is likely systematic selection into childcare. Focusing on individual characteristics, children of white ethnicity, children born with a higher birth weight, having no learning difficulties and having fewer siblings are all associated with a greater likelihood of attending childcare by age 3. Differences are also evident for family and parental characteristics. For example, children of less-educated, lower-income and younger parents are less likely to attend formal childcare by the age of 3.[24] All covariates, apart from gender, are statistically significant. As discussed in Section 2, I use three indicators of child development measured at age 9 months to proxy ability, I find significant differences for development 2 (waves bye-bye) and development 3 (sits up).

This research is predominantly interested in the impact of the intensity of childcare measured by hours. Children who attend formal childcare by age 3 on average, spent 24.1 hours per week in that setting. To conclude the descriptive analysis, Fig. 2 documents the association between the average number of reported difficulties across all years surveyed and hours spent in formal childcare. As expected, the correlation is negative. Spending up to 8 h per week in childcare is associated with an average of 6.4 reported difficulties, spending 40 h a week in childcare is associated with an average of 5.9 reported difficulties.[25]

4.2 Regression results

Table 3 contains the OLS estimates for non-cognitive skills from age 3 to 14 from the production function specified in Eq. (1). The OLS results are positive (apart

[24] Mother's education is a dummy variable equal to one if the mother has a degree or equivalent. In the main estimations I include mother's education as a range of dummy variables.

[25] Appendix Figs. A1–A5 show the correlation by each surveyed year. Reported difficulties reduce over time and the correlation gets weaker.

Table 2 Summary statistics for covariates

Variable	Childcare	No childcare
Female	47.6%	49.7%
	(0.50)	(0.50)
White	87.5%	80.4%
	(0.33)	(0.40)
SEN	14.4%	19.2%
	(0.34)	(0.39)
Birth Weight	3.39	3.34
	(0.54)	(0.58)
Development 1	1.14	1.14
	(0.45)	(0.44)
Development 2	1.99	1.94
	(0.83)	(0.84)
Development 3	1.03	1.06
	(0.20)	(0.30)
Number of Siblings	0.64	0.96
	(0.80)	(1.05)
Year of mother's birth	1969	1972
	(5.20)	(5.94)
Mother degree	41.68%	16.86%
	(0.49)	(0.37)
Mother employed	78.53%	51.19%
	(0.41)	(0.50)
Equivalised household income	448.61	286.81
	(226.44)	(187.30)

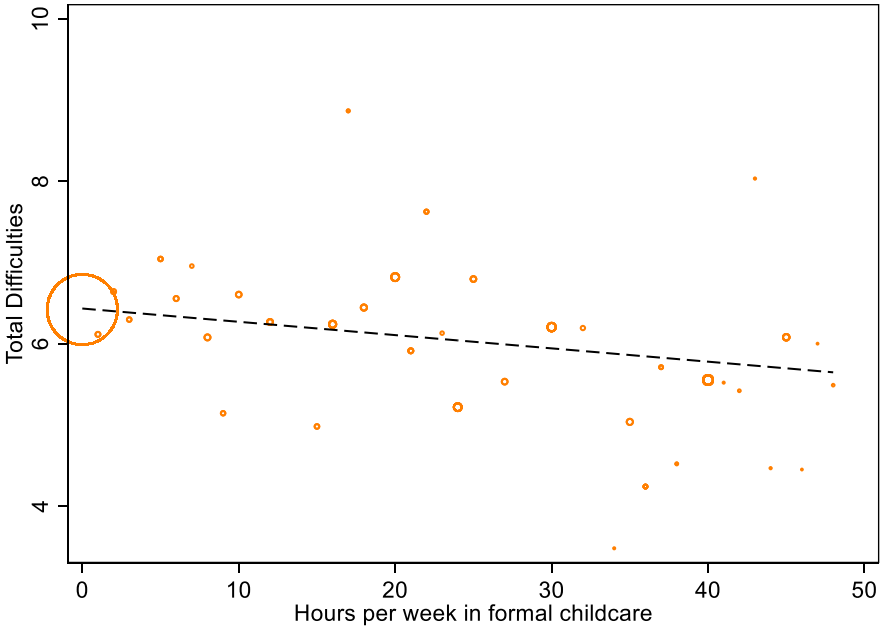
from at age 3) and small in magnitude. As previously discussed, these estimates are likely biased. Previous childcare research has found their unbiased estimates larger than OLS, suggesting a downwards bias Gupta & Simonsen (2016).

Turning to the IV results, the instruments perform well. The first-stage *F* statistics (Cragg-Donald Wald *F* statistic) range from 39.1 to 35.1. Tests for both under- and over-identification are satisfied in each model. The weak instrument (Anderson-Rubin) robustness test of the joint significance of the instruments in the reduced form model is satisfied for non-cognitive skills at ages 3–11 but not age 14.

The second-stage IV results, shown in Table 4,[26] are larger in magnitude than the OLS estimates.[27] The IV results indicate that on average, increasing hours in formal childcare at age 3 by 1, reduces reported difficulties at age 3 by 4.4% of a standard deviation. This reduces to 2.3% of a standard deviation by age 5, followed

[26] Full model second stage results are shown in Table A2 in the Appendix.

[27] I calculate low values of the coefficient of proportionality, as suggested by Ciacci (2021), which offer supportive evidence that IV estimates are not too large with respect to OLS.



Notes: Correlation between hours per week in formal childcare at age 3 and average reported difficulties from age 3-14. Reported difficulties are collapsed on the integer of hours in childcare. The size of the marker indicates the relative number of observations in the hours cell. The fitted line is taken from a simple linear regression of reported difficulties on weekly hours in childcare.

Fig. 2 Descriptive relationship between hours in childcare and non-cognitive skills between age 3 and 14

by 3.1% at age 7[28] and 2.5% at age 11, followed by 2.3% at age 14. When looking at the robust confidence intervals, I find significant impacts for children aged 3 to 11. However, the impact declines over time and slips into insignificance at age 14. I therefore argue that hours in childcare have a significant impact on initial non-cognitive skills that persists in the medium term. However, the findings for the long run are less clear.

By mapping the standardised results back to the original outcomes, I can estimate how many additional hours of childcare at age 3 would be required to reduce total difficulties by 1.[29] A reduction of one total difficulty would require roughly 4

[28] The reduction in the impact at age 5 followed by an increase in the estimates impact at age 7 is consistent with some of the literature. Peter et al. (2016), who also use data from the Millennium Cohort Study, report similar findings. Later day care entry significantly increases children's socio-emotional problems (SDQ) in the medium run (at age 7) but not in the short run (at age 5). As children enter school at age 5, there is a suggestion that such a big event in a child's life makes it difficult for the parent to correctly rank their difficulties.

[29] Mapping the standardised results back to the original outcomes gives the following coefficients: Non-cog 3: − 0.2314, Non-cog 5: − 0.1130, Non-cog 7: − 0.1684, Non-cog 11: − 0.1464, Non-cog 14: − 0.1316.

Table 3 OLS results

	Non-cog 3	Non-cog 5	Non-cog 7	Non-cog 11	Non-cog 14
Hours	0.001	0.001	0.001	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
N	7,522	7,702	7,116	6,904	6,223
R^2	0.18	0.18	0.16	0.14	0.14

Notes: The dependent variable is the total number of reported difficulties at each age surveyed. The dependent variable is standardised with a mean of zero and a standard deviation of one. Hours is the number of hours in formal childcare at age 3. Controls include gender, ethnicity, month of birth, SEN, birth weight, development at 9 months old, location, mother's age at birth, presence of the father number of siblings, mother's education, mother's economic status, mother's health and household income. All controls are measured at age 9 months. Standard errors are in parentheses. I assume iid errors; I also estimated all models with non-iid errors and obtained similar results. The change in sample size is due to non-response and attrition. The impacts of the change in the sample size are examined in the robustness-checks.* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

additional hours per week of formal childcare at age 3 for outcomes measured at age 3, 9 extra hours for outcomes at ages 5 and 6 extra hours for outcomes measured at age 7. At ages 11 and 14, approximately 7 and 8 additional hours of childcare per week at age 3 is required, respectively, to reduce total difficulties by one. The estimate at age 5 deviates from the otherwise consistent trajectory. This is consistent with the literature which suggests that developmental transitions associated with school entry make it difficult for the parent to correctly rank their difficulties (Peter et al. 2016). The broader pattern indicates that progressively greater hours of childcare at age 3 are required to offset later difficulties.

The findings reduce over time, which is related to other literature on early education. Research on Head Start, a US programme that provides early childhood education, health, nutrition, and parent involvement services to low-income children and families, find an initial (5–6 years old) test score gain of about 0.15 standard deviations that fades out to less than half that amount by ages 11–14 (Deming 2009). Gibbs et al. (2013), Bitler et al. (2014), and Kline & Walters (2016) also find that the initial impact fades by the first grade (6–7 years old). However, there is some evidence that, despite the fadeout, impacts can re-emerge in adulthood. Carneiro & Ginja (2014) found long-run benefits to Head Start and Chetty et al. (2011) found similar findings for the Tennessee STAR experiment. Felfe et al. (2015) found positive effects at age 15. Bailey et al. (2017) highlight the importance of skill-building environments throughout childhood to sustain early gains. If children transition into less supportive educational or home environments as they age, initial benefits from formal care may disappear.

The difference between the OLS and IV results suggests that any bias induced by the endogeneity of hours in formal childcare likely results in underestimation of the effect of hours in formal childcare on non-cognitive skills. One explanation for the smaller OLS estimates is measurement error in reported childcare hours. Parental self-reports are likely noisy, and classical measurement error in the explanatory variable attenuates OLS coefficients toward zero. A second factor is omitted variable bias. Families who use more childcare may differ in unobserved ways that improve

Table 4 Over-identified IV model

	Non-cog 3	Non-cog 5	Non-cog 7	Non-cog 11	Non-cog 14
Hours	−0.044***	−0.023**	−0.031***	−0.025**	−0.023*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
First Stage *F*	39.14	38.89	39.78	37.28	35.13
A-R Wald (*P* value)	0.00	0.03	0.01	0.04	0.11
Hansen J Stat (*P* value)	0.08	0.13	0.42	0.32	0.47
A-R CI	[−0.067, −0.027]	[−0.046, −0.003]	[−0.059, −0.008]	[−0.0535, −0.0011]	[−0.0521, 0.0039]
N	7522	7702	7116	6904	6223

Notes: The dependent variable is the total number of reported difficulties ateach surveyed age. It is standardized with a mean of zero and a standard deviation of one. "Hours" refers to the number ofhours in formal childcare at age 3. The Cragg-Donald Wald F statistic, p-values for the Hansen J over-identification test, andAnderson-Rubin robustness test are reported, along with 95% confidence intervals. Standard errors are in parentheses.Controls include gender, ethnicity, month of birth, SEN, birth weight, development at 9 months old, location, mother's ageat birth, presence of the father, number of siblings, mother's education, economic status, health, and household income,all measured at age 9 months. The sample size variation is due to non-response and attrition. The results are robust toonly including the 4,390 individuals who responded in every wave.* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

child outcomes, such as parental motivation, home learning environment, parental mental health, or social support networks, again biasing OLS toward zero.[30]

While the IV estimate technically identifies a LATE, capturing the impact of childcare hours for children whose usage is influenced by maternal shift work or uncertain hours, there is little reason to believe that the developmental impact of childcare would differ meaningfully for this group compared to others. If formal childcare affects non-cognitive development through things such as exposure to structured routines or peer interaction, then theses are features of the care environment itself and do not vary by parental motivation for enrolment. Once in formal care, children are likely to experience similar settings regardless of the reason their parents use childcare.

The simplifying assumption made in the baseline model is that there are neither diminishing nor increasing benefits to hours in childcare. While there might be increasing or decreasing returns, I am unable to examine the non-linear impact as I was unsuccessful in finding an instrument for the quadratic of hours in childcare at age 3 that satisfies weak instrument testing.[31]

4.3 Heterogeneity

On average, increasing the amount of time spent in formal childcare has a positive impact on non-cognitive development both in the short and medium term. The next stage of this analysis explores the extent to which the effect of hours in formal childcare differs across observable characteristics. Understanding heterogeneous impacts is important for policy development as it can identify groups which may benefit the most from the intervention.

The Strength and Difficulties questionnaire asks about 25 attributes, some positive and others negative. These 25 items are divided between 5 scales: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems and prosocial behaviour. For the baseline estimates I use total difficulties as the dependent variable. I start examining the heterogeneous impact by estimating the impact of hours in childcare across the 5 scales, Table 5.[32]

I find no significant impact of childcare attendance on prosocial behaviour. This measure, which reflects positive non-cognitive skills, is not included in the total difficulties score. The results therefore suggest that time in childcare at age three improves negative non-cognitive outcomes (i.e., reduces difficulties) but has no effect on positive non-cognitive outcomes.

[30] To test for the potential of omitted variables, I run the model on a smaller sample who report preferences for childcare (mothers were asked if working before your child enters school had negative impacts on the child) and the distance lived from grandparents. I find similar estimated coefficients.

[31] I conduct a descriptive analysis using a spline specification where bands are created to reflect the number of days attended. I find evidence of a cubic relationship where there is an initial benefit from attending childcare, which does not get larger as you spend more hours in childcare, until you start hitting fulltime childcare. These are descriptive findings so we should be cautious in our interpretation.

[32] First stage *F* statistics range from 37.2 to 30.9 and over-identification checks are valid for all models.

Table 5 Impact of hours in formal care on type of non-cognitive skill estimated by an over- identified IV model

	Emotion	Conduct	Hyper	Peer	Pro-social
Impact at age 3	−0.018*	−0.029**	−0.033**	−0.033**	0.003
	(0.010)	(0.010)	(0.010)	(0.010)	(0.008)
Impact at age 5	−0.003	−0.022**	−0.017*	−0.021**	0.004
	(0.011)	(0.011)	(0.010)	(0.011)	(0.008)
Impact at age 7	−0.022**	−0.030***	−0.013	−0.029***	−0.011
	(0.011)	(0.011)	(0.010)	(0.011)	(0.008)
Impact at age 11	−0.029**	−0.013	−0.008	−0.029**	−0.016
	(0.012)	(0.011)	(0.011)	(0.012)	(0.011)
Impact at age 14	−0.026**	−0.015	−0.010	−0.013	−0.002
	(0.012)	(0.011)	(0.011)	(0.011)	(0.009)

Notes: The dependent variable is the total number of reported difficulties in each sub-section at each age. The dependent variables are standardised with a mean of zero and a standard deviation of one. Hours is the number of hours in formal childcare at age 3. Standard errors in parentheses. Controls include gender, ethnicity, month of birth, SEN, birth weight, development at 9 months old, location, mother's age at birth, presence of the father number of siblings, mother's education, mother's economic status, mother's health and household income. All controls are measured at age 9 months. * $p<0.10$; ** $p<0.05$; *** $p<0.01$

To interpret these findings, I draw on the psychology literature. Social learning theory (Bandura & Walters 1977) proposes that children model behaviours by observing and imitating others. In many formal childcare environments, negative behaviours are more immediately managed and corrected and are therefore more observable to children than prosocial acts. Additionally, early childhood education curriculum often emphasises school readiness. As a result, educators may devote more time to managing problem behaviour than to explicitly promoting prosocial skills, which may be assumed to develop naturally or be fostered at home.

Theories of executive function development suggest that prosocial behaviour requires more than suppressing negative impulses; it depends on empathy, perspective-taking, and moral reasoning, abilities that develop gradually through rich, individualised adult–child interactions (Eisenberg et al. 2006). Research on moral development and emotional scaffolding (Kohlberg et al. 1984) highlights the importance of intentional guidance in helping children internalise prosocial values. In settings with high child-to-staff ratios or predominantly group-based, rule-oriented activities, such complex, internally motivated behaviours may be harder to develop.

Significant improvements are observed across all other Strengths and Difficulties Questionnaire (SDQ) subscales at age three, and in all except hyperactivity at age seven. The most persistent effects over time are found for emotional symptoms, conduct problems, and peer relationship difficulties. Emotional difficulties include being nervous or easily scared; conduct problems involve behaviours such as fighting, anger and defiance; and peer relationship difficulties include social isolation and stronger relationships with adults than with peers. A plausible explanation is that early exposure to structured childcare increases independence, encourages

children to step outside their comfort zones, promotes interaction with peers and provides an environment where trained staff help children regulate their emotions.

I also conduct a series of subgroup analyses based on individual and family characteristics; the results are shown below.[33]

Table 6 presents the estimated impact of formal childcare hours at age 3 on children's total difficulties, disaggregated by key subgroups including gender, birth order, maternal education, and household income. These analyses provide valuable insights into the heterogeneity of effects and contribute to understanding for whom early childcare is most beneficial.

The effect of formal childcare hours at age three is statistically significant for both males and females, but the difference between the two is not statistically significant. However, the persistence of effects differs. Among males, reductions in total difficulties remain statistically significant at ages 11 and 14. For females, in contrast, impacts are more significant at younger ages and the effects diminish more quickly and are no longer significant beyond age 7. This pattern is consistent with previous findings suggesting that males, who often exhibit higher baseline behavioural difficulties, may derive more sustained benefit from the structured routines and socialisation opportunities provided by formal childcare (Cornelissen & Dustmann 2019).

I also explore differential effects by birth order, comparing first-born children with those who have older siblings. While firstborns might be expected to be more affected by time in childcare, perhaps due to parents' lack of prior experience, it is equally plausible that children with older siblings could benefit more, given that parental time and attention must be divided among multiple children. Initially, children with older siblings show larger reductions in total difficulties, suggesting that non-first-born children may benefit more from early exposure to formal childcare. However, at ages 5 and 7, first-born children experience larger estimated improvements, indicating that the developmental gains for first-borns may emerge somewhat later. This evolving pattern may reflect differences in family dynamics and early home environments. Firstborns typically receive undivided parental attention in the earliest years, which could delay the observable advantages of formal childcare. Non-firstborns, in contrast, may gain more immediate social and emotional stimulation from childcare due to reduced one-on-one parental time. The differences are not statistically significant, precluding firm conclusions.

To examine heterogeneity by socioeconomic background, I disaggregate the sample by maternal education and household income. The literature typically suggests that children from more disadvantaged backgrounds benefit more from access to formal childcare. Consistent with this, I estimate larger initial coefficients (not significantly different) for children of mothers without a university degree. This may reflect differences in the home learning environment, whereby children of more educated mothers already receive developmental stimulation at home, reducing the marginal benefit of additional childcare hours.

[33] I estimate all subgroup analysis using the over-identified IV model. The first stage F statistics remain above 10 for all subgroups, except individuals with below average income. Overidentification tests are satisfied.

Table 6 The impact of hours in childcare at age 3 on total difficulties, by subgroup (Estimated by an over-identified IV model)

	Gender		First-born status		Mother's education		Household income	
	Female	Male	First-born	Older siblings	Degree or higher	No degree	Above average	Below average
Impact at age 3	−0.033***	−0.049***	−0.031**	−0.051***	−0.029***	−0.066***	−0.028***	−0.040
	(0.017)	(0.014)	(0.013)	(0.017)	(0.011)	(0.019)	(0.007)	(0.085)
Impact at age 5	−0.037***	−0.012	−0.026*	−0.015	−0.026**	−0.028	−0.022***	0.085
	(0.019)	(0.013)	(0.014)	(0.014)	(0.011)	(0.018)	(0.007)	(0.113)
Impact at age 7	−0.045**	−0.016	−0.029**	−0.028*	−0.026**	−0.044**	−0.017**	−0.161
	(0.019)	(0.012)	(0.014)	(0.014)	(0.011)	(0.019)	(0.007)	(0.136)
Impact at age 11	−0.028	−0.023*	−0.020	−0.027*	−0.021*	−0.029	−0.019**	−0.073
	(0.018)	(0.014)	(0.015)	(0.015)	(0.011)	(0.020)	(0.008)	(0.084)
Impact at age 14	−0.003	−0.037**	−0.012	−0.034*	−0.027**	−0.020	−0.009	−0.145
	(0.017)	(0.015)	(0.014)	(0.018)	(0.011)	(0.020)	(0.008)	(0.113)

Notes: See Table 5

Differences by household income are even more pronounced. Children from households with below-average income exhibit the largest estimated benefits, suggesting that early childcare may serve as a compensatory mechanism for socio-emotional development. However, it is important to interpret these results with caution. The instruments used in the IV estimation are relatively weak within this subgroup, which may lead to bias. Since the expected bias is negative, these estimates can be interpreted as lower bounds. Nonetheless, the magnitude of the estimated effects reinforces the conclusion that formal childcare may play an important role in mitigating early disadvantages linked to income. Taken together, the subgroup analysis suggests that while the benefits of formal childcare are widespread, they may be particularly relevant and durable for certain groups. These findings not only support the overall conclusions of the paper that time spent in early formal education is important but also point to potential avenues for targeted policy design.

In particular, ensuring access to affordable and high-quality formal childcare for disadvantaged families may yield disproportionately large developmental returns, helping to reduce inequalities in early childhood outcomes, as demonstrated by research on Sure Start (Carneiro et al. 2025). Around the world, policies such as subsidised childcare places, early intervention programmes like Early Head Start (US), and integrated family support services have focused primarily on disadvantaged groups. However, comparatively less attention has been paid to targeting children by gender or birth order. However, many care settings incorporate practices such as active learning environments, behavioural support strategies and early peer socialisation opportunities that may especially benefit males and first-borns, highlighting scope for more deliberate policy tailoring to these groups. For example, play-based curriculum and physical activity programmes can better engage boys' developmental needs, while parent–child group activities and transition support programmes can help first-born children develop social skills typically gained through siblings.

4.4 Robustness checks

All specifications control for individual and parental characteristics when the individual was 9 months old. Despite arguably controlling for a good amount of selection into childcare, there is still potential for selection on unobservables. One of the main potential unobservable factors is parental preferences for childcare. While many studies use household income and education measurements as a proxy, Bernal & Keane (2010) argue that the ability to provide does not always lead to provision, and that differences are potentially driven by preferences.

When the child is 9 months old, the mother is asked whether she believes working before the child enters school is detrimental to the child. The responses are recorded in a categorical variable ranging from strongly agree to strongly disagree. I use this categorical variable as a proxy for preferences. Column 2 of Table 7 presents the IV estimates with this additional control. The results are very robust to this controlling for preferences.

Table 7 Robustness checks: over-identified IV models

	Baseline	+ Mother's Pref	+ Parenting style	+ Grandparents	+ Hours Worked	Drop Job Chg	Drop SOC Chg
Hours	0.044***	− 0.044***	− 0.040***	− 0.043***	− 0.045***	− 0.054***	− 0.048***
	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)	(0.013)	(0.013)
N	7522	7522	7302	5792	7522	6433	5591

Notes: The dependent variable is the total number of reported difficulties at each surveyed age. The dependent variable is standardized with a mean of zero and a standard deviation of one. Hours is the number of hours in formal childcare at age 3. Each column represents a different robustness check: including mother's preferences for childcare, distance to grandparents, hours worked, dropping mothers who changed jobs due to hours worked, and dropping mothers who changed SOC between pregnancy and the child being aged 3. Standard errors are in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$The dependent variable is the total number of reported difficulties at each surveyed age. The dependent variable is standardized with a mean of zero and a standard deviation of one. Hours is the number of hours in formal childcare at age 3. Each column represents a different robustness check: including mother's preferences for childcare, distance to grandparents, hours worked, dropping mothers who changed jobs due to hours worked, and dropping mothers who changed SOC between pregnancy and the child being aged 3. Standard errors are in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

To address concerns about omitted variable bias related to parenting values, I implement a robustness check that adds further controls intended as proxies for parental style. These include the self-described parenting approach (firm rules and discipline, lots of fun, firm discipline plus lots of fun, doing my best for the children, unsure, or other) and the stated priority for the most important quality they wants her child to develop (to be well liked or popular, to think for themselves, to work hard, to help others, to obey their parents, or to learn religious values). I also include responses on how the parent reacts to a crying child (pick them up immediately, let them cry for a while, never pick them up), as well as other indicators such as the frequency of reading to the child and whether they have taken them to a playground. Compared to the baseline coefficient of − 0.044, the magnitude slightly reduces to − 0.040 when these controls are included, showing that the main relationship remains robust and is not solely driven by omitted parenting values.

Another potential omitted variable is distance from grandparents. Being cared for by the maternal grandmother is the most common type of informal childcare; therefore, the distance from grandparents is likely to be a large determinant of the amount of hours children spend in formal childcare. Studies including Hansen & Hawkes (2009) also show grandparent care to have an influence on child development.

Column 4 of Table 7 presents the IV estimates with this additional control. The results are again very robust to controlling for distance lived from grandparents.

The validity of the instruments assumes that while the probability of working shifts and having uncertain hours are correlated with the number of hours the mother enrols her child in formal childcare for, they are uncorrelated with their non-cognitive developments. To try to reduce the concern that mothers select into jobs based on their child's non-cognitive skills, I use the characteristics of the job mothers had during pregnancy as the instrument due to it being pre-determined. As a robustness check, I conduct a series of robustness checks designed to reduce concerns about potential endogeneity or violations of the exclusion restriction.

First, I include a control for maternal hours worked (column 5), to separate the effect of childcare hours from broader labour supply decisions. Controlling for hours worked helps ensure that the estimated effect of childcare exposure is not impacted by changes in maternal time availability, which could independently influence child outcomes. This helps clarify that the instrument affects child development primarily through changes in childcare use, not other employment-related channels.

Second, I address the possibility that mothers may have changed jobs before or during pregnancy in anticipation of childcare needs. The data include self-reported reasons for job changes and characteristics of new jobs. I exclude observations where mothers report leaving a job due to inflexible hours, or where they report changes in working hours in their new job (column 6). These cases are likely to reflect forward-looking behaviour directly related to childcare planning and thus could violate the instrument's exogeneity.

Finally, I drop observations where mothers change their SOC code between pregnancy and the child's third birthday (column 7). Occupational switches may reflect broader unobserved changes in career path, work-life preferences or family circumstances, which could directly affect child development outcomes. Excluding these

cases helps ensure that the instruments are not picking up variation related to deeper unobserved characteristics.

Compared to the baseline coefficient of − 0.044, the magnitude modestly increases to − 0.045 when controlling for hours worked and to − 0.048 and − 0.054 when excluding mothers who changed SOC categories or jobs, respectively. These changes represent a change in the magnitude of approximately 2–23%. These are modest increases in magnitude but not a sign of instability. Crucially, the direction, size, and statistical significance of the estimates are preserved. Together, these checks indicate that the observed relationship between childcare hours and non-cognitive skill development is not being driven by unobserved changes in maternal employment and remains stable across different specifications.

5 Conclusion

This research provides the first attempt at identifying the causal relationship between hours in childcare prior to the age of 3 and non-cognitive skills reported at ages 3–14. I aim to shed light on the causal relationship by adopting an instrumental variables strategy that leverages exogenous variation in both the probability that the mother works shift work and has uncertain working hours. The IV results suggest that the relationship between hours in childcare and non-cognitive skills is likely causal and that the more naive OLS estimates likely underestimate the causal effect.

Using the Millennium Cohort Study, which focuses on children born in the UK in the year 2000, I find that increasing hours in formal childcare at age 3 by one hour reduces reported difficulties at age 3 by 4.4% of a standard deviation. This reduces to 2.3% of a standard deviation by age 5, followed by 3.1% at age 7. By age 11, the estimated impact is 2.5% and 2.3% at age 14. These findings show that time spent in childcare at age 3 has initial impacts on non-cognitive skills that persist into the medium run. In respect to the long run, a cautious interpretation is warranted as the impacts slip into insignificance when performing weak instrument robust testing. The fact that these effects do persist underlines the importance of early childhood education.

The findings here, especially for the medium run impact, deliver very robust results across different samples of individuals and measures of non-cognitive skills. The robustness checks consistently suggest that the existence of weak instruments or omitted variable bias is rather unlikely.

How do the findings fit within the literature? I estimate positive effects of increased time in childcare on non-cognitive skills, whereas Gupta & Simonsen (2010) and Berger et al. (2021), who provide descriptive evidence on the impact of time spent in childcare, both estimate negative effects.[34] Firstly, the estimates here

[34] There is a large literature which examines the impact of attending childcare which also find mixed evidence.

represent LATEs rather than average treatment effects. As such, they are less readily comparable to estimates from prior work. Secondly, the literature on the impact of hours spent in childcare is very small and for the most part descriptive, making it impossible to draw any general conclusions.

This research has useful policy implications. Firstly, consistent with the broader literature on childcare enrolment, I estimate positive effects of childcare. There is a current interest in the optimal number of hours in childcare in England due to changes in childcare subsidies. The subsidised hours in childcare for working parents have increased from 30 h for 3- and 4-year-olds to cover all under 5-year-olds. While this policy was driven by the impact on female labour supply, my findings provide evidence to show that the policy change also has benefits for the child.

Secondly, results from sub-group analysis suggest that there is heterogeneity in the magnitude and persistence of impacts across population subgroups. Most notably, less advantaged children appear to benefit most from hours spent in childcare. These findings are consistent with a large proportion of the literature that focuses on childcare for disadvantaged children. These findings support the argument that facilitating access to more time in childcare for disadvantaged children may hold potential for decreasing early socioeconomic disparities in child development.

This research has contributed to the literature by investigating the causal relationship between hours in childcare and non-cognitive skills. This study estimates positive findings, which I argue suggests that an expansion of subsided hours in childcare will be beneficial for all, especially children from disadvantaged backgrounds, which may have potential to contribute to decreasing early gaps in child development.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00148-026-01162-2.

Acknowledgements I would like to thank editor Kompal Sinha and the two anonymous referees for their extremely valuable suggestions. I am also grateful to Steven McIntosh, Bert Van Landeghem, Panos Nanos, and Jo Blanden for helpful comments.

The author would like to thank the anonymous referees for helpful comments and suggestions.

Funding No funding was received for conducting this study.

Data availability This study uses data from the Millennium Cohort Study which is available from the UK Data Service.

Declarations

Conflict of interest The author declares no competing interests.

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