

Ages and Stages Questionnaire at 3 Years for Predicting IQ at 5–6 Years

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abstract

OBJECTIVES: To assess the predictive value of the 36-month Ages & Stages Questionnaire (ASQ) score for IQ score at age 5 to 6 years in the general population and to identify factors associated with IQ <85 once the ASQ score is taken into account.

METHODS: Data were collected from 939 children enrolled in a population-based prospective cohort study. Developmental outcomes at 36 months were assessed via the ASQ and at 5 to 6 years via the Wechsler Preschool and Primary Scale of Intelligence. The ASQ threshold was identified via the receiver operating characteristic curve. Additional predictive factors to obtain an IQ <85 were investigated, and their interaction with ASQ score was studied.

RESULTS: Sixty-nine children (7.3%) had an IQ <85. A 36-month ASQ score threshold of 270 was optimal to identify children with an IQ <85 at 5 to 6 years, with a 0.77 ± 0.11 sensitivity and 0.68 ± 0.03 specificity. Maternal educational level and occupational activity at the time of ASQ completion were associated with the risk of an IQ <85 at a given ASQ level. In the multivariate model, no interaction between the studied factors and ASQ score reached significance.

CONCLUSIONS: In the general pediatric population, 36-month ASQ parental reports could be used to identify children at later risk of cognitive delay. Low maternal education level should also be considered as a major risk factor for lower IQ in preschool children regardless of ASQ score.



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Dr Charkaluk conceptualized and designed the study and drafted the initial manuscript; Ms Rousseau and Ms Forhan carried out the statistical analysis and reviewed and revised the manuscript; Ms Calderon and Mr Bernard contributed to the study design and critically reviewed and revised the manuscript; Ms Heude is principal investigator for the EDEN cohort and critically reviewed and revised the manuscript; Ms Kaminski contributed to the conceptualization and design of the study and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

All comparisons but for center are adjusted for center. *P* derived from analysis of covariance.

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WHAT'S KNOWN ON THIS SUBJECT: Ages & Stages Questionnaires (ASQ) is a parental report designed to identify children at risk for developmental delay who may need additional evaluation. Few data are available on the predictive value of the ASQ for later cognitive development.

WHAT THIS STUDY ADDS: A 36-month ASQ score could be used to predict IQ at age 5 to 6 years in the general population. Maternal educational level is a major predictor of cognitive outcomes, whatever the ASQ score.

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The identification of young children at risk for later suboptimal development is key to the design and implementation of early preventive or interventional strategies. Parental report instruments are designed to be used in primary care for first-line clinical screening of infant and preschool child development.¹ They are increasingly popular because they are easy to administer and score, have a short completion time, and lessen the burden of medical expenses.¹ The Ages & Stages Questionnaires (ASQ) are the most commonly used questionnaires to identify young children at risk for developmental delay.² Concurrent validity studies of the ASQ in comparison with in-person developmental assessments have been conducted in the general pediatric population³⁻⁶ and in several at-risk populations, including children born preterm^{4,7-10} and children who had neonatal hypoxic-ischemic encephalopathy.¹¹ The concurrent agreement rates and psychometric properties tend to improve with age at testing.^{4,5,9}

Previous evidence from a population of children born preterm showed that the 36-month ASQ predicted school difficulties at age 5.¹² A study using a community-based sample from the Netherlands also measured the predictive value of 48-month ASQ for schooling at age 5 years.¹³ They reported that it had 89% sensitivity (80% specificity) to predict special education use. However, there is a gap in knowledge about the predictive value of early ASQ scores for later cognitive functioning, such as IQ, in the general pediatric population.

The primary aim of this study was to investigate the predictive value of the 36-month ASQ score for IQ at age 5 to 6 years in a large population-based cohort study, the EDEN (Etude des Déterminants Pré- et Post-natals du Développement de l'Enfant) mother-child cohort study. The secondary

aim was to search for other child, maternal, and family-related factors associated with low IQ once the 36-month ASQ score is taken into account and to determine whether such factors could interact in the relationship between the 36-month ASQ score and later IQ.

METHODS

Study Population

The EDEN mother-child cohort study aims to examine prenatal and postnatal determinants of child development, growth, and health.¹⁴ Participants were recruited between 2003 and 2006 among pregnant women followed in Poitiers and Nancy university maternities. Exclusion criteria were multiple pregnancies, a known history of diabetes, non-French speakers or readers, or plans to move out of the study region in the next 3 years. Complete birth data were obtained from 1889 mother-infant pairs. Maternal education in the cohort was somewhat higher than national estimates, with 53.6% of mothers in the EDEN cohort having attained a high school diploma, compared with 42.6% in the 2003 National Perinatal Survey.^{14,15} Several follow-up steps were planned, including questionnaires and clinical examinations and assessments that took place in both centers. When the children were 3 years old, mothers filled out a questionnaire reporting sociodemographic status for the family and specific data on current maternal health, together with the ASQ. When the children were 5 to 6 years old, a cognitive assessment was conducted by trained psychologists. In the overall cohort, mothers of children lost to follow-up were younger at delivery and less likely to have attained a high school diploma.¹⁴ For the current study, we excluded children with deafness or blindness ($n = 1$, deafness). Parental written informed consent

was obtained for all participants. The study was approved by the Ethics Committee of Kremlin Bicêtre Hospital and by the French Data Protection Authority.

Measures of Child Development

36-Month ASQ Score (French Second Edition)

The ASQ¹ is a brief parental questionnaire in which the child's current skills and development are rated. Parents answer 6 questions in each of 5 domains of development: communication, gross motor, fine motor, problem-solving skills, and adaptive skills. Parents are instructed to try activities with their child when necessary. Each question is given a 10 (yes), 5 (sometimes), or 0 (not yet) score according to the parents' answers. Raw scores for each domain are calculated as the sum of scores for the 6 questions. Missing answers are replaced by the mean of the answers to the other questions in the same domain, within the limit of 2 missing questions per domain.¹ US norms are available for each domain, and any domain screened <2 SDs below the mean is considered a positive screening. However, in accordance with other studies, we used the sum or the 5 domain scores, producing a score between 0 and 300.^{5,7,13,16} The ASQ was filled out by the mother. Questionnaires were retained for the study only if the children were aged 33 to 39 months.

IQ With the Weschler Preschool and Primary Scale of Intelligence-Third Edition at Age 5 to 6 Years

When the child was 5 to 6 years old, cognitive assessment was performed by trained psychologists using the French version of the Weschler Preschool and Primary Scale of Intelligence-Third Edition (WPPSI-III).¹⁷ The WPPSI-III includes 7 subtests used to compute a verbal IQ, a performance IQ, and a full-scale IQ. IQ was considered low if it was <85.

Factors Included in the Analysis

We selected child, maternal, and family factors that could be associated either with a potential maternal misreporting of the child's development milestones or with an actual change (improvement or worsening) of the child's performances between the ages of 3 and 5 to 6 years. Thus, these factors could be associated with IQ at 5 to 6 years once the 36-month ASQ score was taken into account. They could also interact in the relationship between ASQ score and IQ.

Child's characteristics included gender; whether the child was a first-born child; behavioral problems at age 3, rated via the Strengths and Difficulties Questionnaire (SDQ)^{18,19}; and whether the child had started preschool at age 3. Behavioral problems were defined as an SDQ total score ≥ 16 , a level considered high to very high (www.sdqinfo.com/py/sdqinfo/c0.py).

Maternal characteristics at the time of ASQ completion included maternal educational level, occupation, and depressive symptoms assessed with the Center for Epidemiologic Studies–Depression scale.²⁰ Maternal educational level was classified as below high school, high school level, or college level. Depressive symptoms were considered present when the Center for Epidemiologic Studies Depression Scale score was ≥ 16 .²⁰

Family characteristics included parents' occupation (highest occupational level for both parents) and financial difficulties reported by the parents when the child was 3. Parents' occupational level was classified according to the Institut National de la Statistique et des Etudes Economiques classification as manual labor, administrative employment, intermediate-level profession, or intellectual profession.

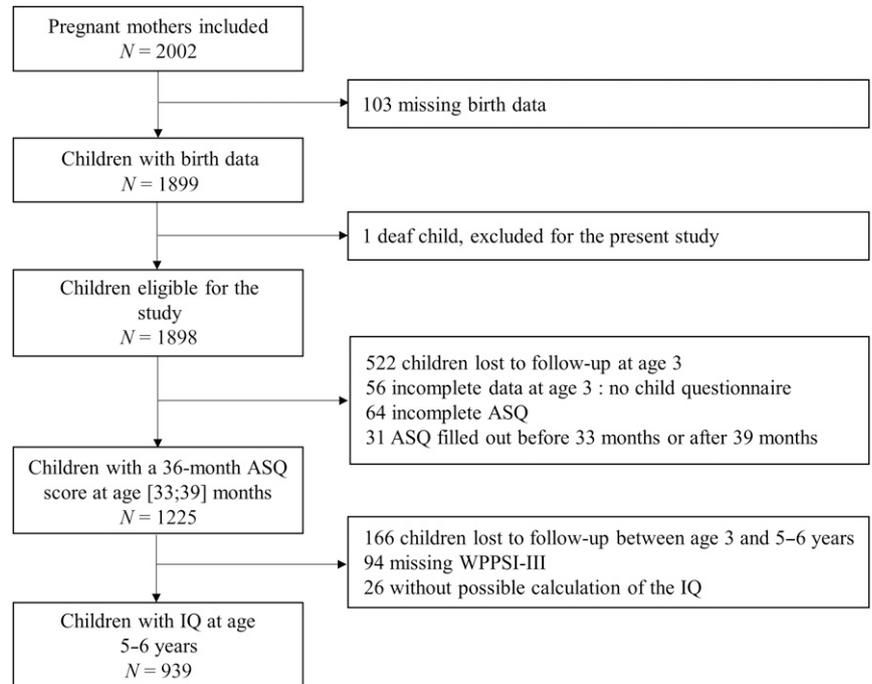


FIGURE 1
Flowchart of the study.

Statistical Analysis

Children included in the current analysis were first compared with the other children in the EDEN cohort who were not included. Results for the 36-month ASQ score and the 5- to 6-year WPPSI-III evaluation were described as means \pm SDs and median with interquartile ranges (IQRs), when appropriate. The receiver operating characteristic (ROC) curve linking low IQ (< 85) and ASQ score was used to determine the optimal cutoff value for the ASQ score, which maximized the Youden index both graphically and via a macro developed for SAS (SAS Institute, Inc, Cary, NC).

A 3-step analysis was then conducted, with logistic regression. First, potential associations between the child, maternal, and family factors defined above and low IQ were studied, adjusted only for center. Second, interaction terms for each of the factors and the 36-month ASQ score (less than or greater than or equal to cutoff) were separately studied for predicting low IQ, adjusted for center. Last, a multivariate model

with low IQ as the dependent variable was built. ASQ score and center were forced variables. Forward logistic regression was applied to determine the final model. Each variable or interaction term associated with low IQ with a P value $< .10$ was considered to enter the model. Because maternal educational level and parental occupational level were highly correlated, only maternal educational level was included in the multivariate model when both were significant in the first analysis. However, sensitivity analyses were performed with parental occupational level instead of maternal educational level.

Statistical analyses were performed in SAS software version 9.3.

RESULTS

Description of the Sample

The 36-month ASQ score was available for 1225 children (64.8% of the eligible population) (Fig 1). Among them, complete WPPSI-III IQ scores were available for 939 children (76.7%), representing 49.5% of the initial

sample. Table 1 presents the main characteristics of the 939 children with complete data. Children not included were more often from Nancy, were less often first-born, had mothers with lower educational levels, and had parents with lower occupational levels than children included.

ASQ scores were determined at a mean age of 37.3 ± 0.8 months. Supplemental Figure 4 displays the observed distribution of ASQ scores and IQs and shows the ceiling effect for the ASQ scores, whereas IQ follows a Gaussian distribution. The mean 36-month ASQ score was 270 ± 30 , with a median of 280 (IQR 260–290). IQ was measured at a mean age of 67.2 ± 1.8 months. The mean IQ was 103 ± 13 , and 69 children (7.3%) had an IQ <85. All child, maternal, and family factors studied, except gender and maternal depressive symptoms, were significantly associated with ASQ score (Supplemental Table 3).

IQ at Age 5 to 6 Years According to 36-Month ASQ Score

The ROC curve linking IQ <85 with ASQ score is shown in Fig 2. The area under the curve was 0.78 (95% confidence interval [CI], 0.72–0.84). The optimal cutoff value for predicting low IQ was 270, which provided a sensitivity of 0.77 (95% CI, 0.66–0.85) and a specificity of 0.68 (95% CI, 0.65–0.71). The positive predictive value was 0.16 (95% CI, 0.12–0.20), and the negative predictive value was 0.97 (95% CI, 0.96–0.98). The positive and negative likelihood ratios were 2.38 (95% CI, 2.02–2.80) and 0.34 (95% CI, 0.22–0.53), respectively.

Factors Associated With IQ <85 Once ASQ Is Taken into Account

All factors but gender, being a first-born child, and depressive symptoms in the mother were associated with low IQ, with a *P* value < .10 (Table 2). Only the interaction between ASQ score and maternal educational level had a *P* value < .10 (*P* = .09)

TABLE 1 Characteristics of the Study Population in Comparison With Children in the EDEN Cohort but Not Included in the Study Analysis

Characteristics at birth	Children Included in the Study Analysis, <i>N</i> = 939	Children Not Included in the Study Analysis, <i>N</i> = 959	<i>P</i>
	<i>n</i> (%)	<i>n</i> (%)	
Center			<.001
Poitiers	552 (58.8)	383 (39.9)	
Nancy	387 (41.2)	576 (60.1)	
Gender			.53
Male	500 (53.3)	497 (51.8)	
Female	439 (46.7)	462 (48.2)	
First child			.01
No	495 (52.8)	561 (58.6)	
Yes	442 (47.2)	397 (41.4)	
Gestational age, wks			.26
Median (IQR)	40 (39–40)	39 (39–40)	
Birth weight, g			.20
Median (IQR)	3320 (3020–3620)	3290 (2980–3620)	
Maternal educational level			<.001
Below high school	209 (22.5)	326 (34.7)	
High school	162 (17.5)	175 (18.7)	
College	556 (60.0)	437 (46.6)	
Parents' occupation			<.001
Manual labor	155 (16.6)	244 (25.9)	
Administrative employment	185 (19.8)	203 (21.5)	
Intermediate-level profession	330 (35.3)	271 (28.7)	
Intellectual profession	265 (28.3)	226 (23.9)	
Characteristics at age 3			
ASQ score			.06
ASQ \geq 270	605 (64.4)	167 (58.4)	
ASQ <270	334 (35.6)	119 (41.6)	
Median (IQR)	280 (257–290)	275 (255–290)	.06
Child attending preschool			.95
No	312 (33.4)	130 (33.6)	
Yes	622 (66.6)	257 (66.4)	
Behavioral problems			.42
No	813 (87.2)	320 (85.6)	
Yes	119 (12.8)	54 (14.4)	
Mother had an occupational activity			.24
No	241 (26.0)	114 (29.2)	
Yes	686 (74.0)	277 (70.8)	
Mother had depressive symptoms			.45
No	742 (81.9)	302 (80.1)	
Yes	164 (18.1)	75 (19.9)	
Family financial difficulties			.83
None	774 (83.1)	324 (82.7)	
Mild or severe	157 (16.9)	68 (17.3)	

P derived from χ^2 or Kruskal–Wallis test. Factors determined at age 3 are available for a maximum of 391 children in the “not included” group. Comparisons for ASQ scores are restricted to children having the ASQ between 33 and 39 mo.

(Table 2). Whereas children with an ASQ score <270 and a college maternal educational level or with an ASQ score \geq 270 and a maternal educational level at high school or below had similar risks of low IQ, the risk was significantly higher in children with an ASQ score <270 and a maternal educational level at

high school or below. Conversely, only 1 child in 396 with an ASQ score >270 whose mother had a college education had a low IQ (Fig 3).

In the forward regression model, low IQ was associated with ASQ score, maternal educational level, and occupation (Table 2). Interaction

between ASQ score and maternal educational level was no longer significant. Using parental occupational level instead of maternal educational level in the multivariate analysis produced similar results.

DISCUSSION

In this population-based cohort of children from the general population, we found that the 36-month ASQ score could be used to predict the risk of a low IQ (IQ <85) at age 5 to 6 years. An ASQ score <270 had fairly good sensitivity with an acceptable specificity. After the ASQ score was taken into account, the most powerful additional predictor of later low IQ was maternal educational level.

This population-based study has several strengths. The sample size is large, which made it possible to study numerous factors, and the ASQ score was studied in relation to the gold standard evaluation of cognitive ability at age 5 to 6 years. The psychologists performing the WPPSI-III were blinded to the ASQ score. Only 1 psychologist in each center performed the WPPSI-III, which guarantees the homogeneity of IQ measurements. Despite these strengths, our findings should be considered in light of several limitations. The IQ at 5 to 6 years itself also has limits and is not a perfect predictor of longer-term outcomes. Only 69 children had an IQ <85, leading to a lack of power for studying associated factors. Also, 959 children were lost to follow-up between birth and age 5 to 6 years. Furthermore, children not included had a lower socioeconomic background than children included. Accordingly, those who had ASQ assessed between 33 and 39 months had lower ASQ scores than the children studied. Additionally, mothers in the cohort had a higher educational level than those in the overall French population. For these reasons, the prevalence of low IQ was probably underestimated in the study. A prevalence of 16% could have been expected, considering the Gaussian

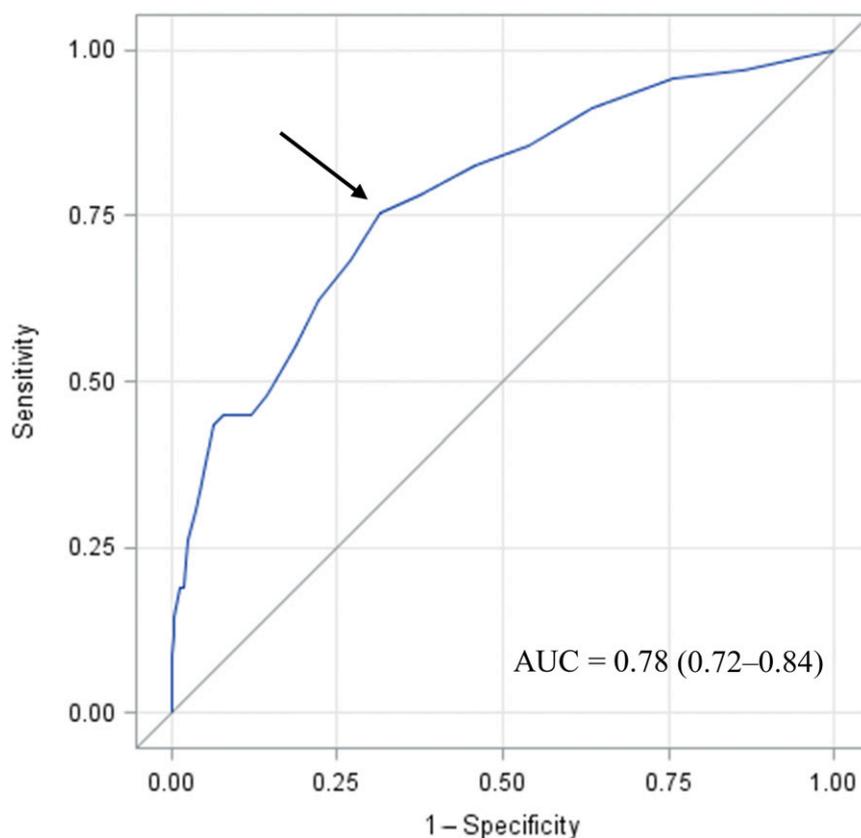


FIGURE 2

ROC curve linking the risk of IQ <85 and the 36-month ASQ score. The arrow denotes optimal predictive value (ASQ score of 270).

distribution of IQ (mean = 100, SD = 15). The prevalence we recorded was 7.3%, which was also in the lower range of the prevalence observed in the general pediatric population exhibiting some type of developmental delay or disability before entering school (5%–15%).^{13,21} This limitation probably did not affect sensitivity or specificity but might have altered the negative and positive predictive values. The true positive predictive value might be higher than found in the current study, and the true negative predictive value might be slightly lower.

Specific aspects of the child's development at age 5 to 6 were not studied, but IQ is an overall measure by itself, and the threshold of 85 can probably catch children with several types of difficulties. However, it is possible that "false negative" children, those with an ASQ score <270 but an IQ ≥85, had

poor outcomes in areas that are not covered by the WPPSI-III.

We chose to study the total ASQ score. As reported in several previous studies, total ASQ scores provide a global evaluation of a child's functioning, which seems relevant for predicting later global cognitive functioning.^{13,16,22} Norms by domain of the ASQ have been determined in the US context but not in France. The 36-month ASQ has been studied in children in the Paris area, where it was found that mean scores were significantly lower than reference US mean scores for 3 domains.²³ Of course, using the total score instead of the cutoff points by domain could miss less severe problems restricted to 1 domain. However, in a concurrent validity study comparing use of ASQ total score with the by-domain cutoff method for the 60-month ASQ, Hornman et al²² found that in the general population the use of ASQ total

TABLE 2 Factors Associated With the Risk of IQ <85 at Age 5 to 6 y: Univariate Logistic Regression and Multivariate Model (Forward Logistic Regression)

	Univariate Analysis, N = 939				Multivariate Model, N = 898	
	n = 69 With IQ <85				n = 63 With IQ <85	
	N	n (%)	Odds Ratio (95% CI)	P	Adjusted Odds Ratio (95% CI)	P
Child-related factors						
36-mo ASQ score				<.001		<.001
<270	334	53 (15.9)	6.7 (3.8–12.0)		5.4 (2.9–9.9)	
≥270	605	16 (2.6)	Reference		Reference	
Gender				.18		
Male	500	43 (8.6)	1.4 (0.9–2.4)			
Female	439	26 (5.9)	Reference			
First child				.05		
No	495	44 (8.9)	1.7 (1.0–2.8)			
Yes	442	25 (5.7)	Reference			
Child attending preschool at age 3				.05		
No	312	29 (9.3)	1.7 (1.0–2.8)			
Yes	622	40 (6.4)	Reference			
Behavioral problems at age 3				.004		
No	813	51 (6.3)	Reference			
Yes	119	17 (14.3)	2.4 (1.3–4.3)			
Maternal-related factors						
Maternal educational level				<.001		<.001
Below high school	209	30 (14.3)	5.3 (2.8–10.0)		4.0 (2.0–8.1)	
High school	162	21 (13.0)	4.7 (2.4–9.3)		4.0 (1.9–8.2)	
College	556	16 (2.9)	Reference		Reference	
Mother had occupational activity				.002		.02
No	241	29 (12.0)	2.3 (1.4–3.8)		1.9 (1.1–3.4)	
Yes	686	38 (5.5)	Reference		Reference	
Mother had depressive symptoms				.11		
No	742	50 (6.7)	Reference			
Yes	164	17 (10.4)	1.6 (0.9–2.9)			
Family-related factors						
Parents' occupation				<.001		
Manual labor	155	28 (18.1)	10.3 (3.8–27.6)			
Administrative employment	185	17 (9.2)	5.0 (1.8–13.8)			
Intermediate-level profession	330	18 (5.4)	2.9 (1.1–8.0)			
Intellectual profession	265	5 (1.9)	Reference			
Financial difficulties				.04		
None	774	49 (6.3)	Reference			
Mild or severe	157	18 (11.5)	1.8 (1.0–3.2)			
Center				.009		.09
Poitiers	552	51 (9.2)	2.1 (1.2–3.6)		1.7 (0.9–3.1)	
Nancy	387	18 (4.7)	Reference		Reference	

All analyses but center comparisons were adjusted for center.

score could be recommended because of the low prevalence of difficulties.

Our analysis of factors associated with IQ at age 5 to 6 years once ASQ score was taken into account was not designed to find factors associated with cognitive abilities at age 5 to 6 years. Rather, our objective was to identify the factors still having an impact between age 3 and 5 to 6 years, once abilities at age 3 were taken into account. Interventions conducted between age 3 and 5 to 6 years, such as speech therapy, were not studied,

because there is no evidence they have an impact on IQ at 5 to 6 years. An indication bias could also have occurred and could not be validly studied. Lower maternal educational level was associated with lower ASQ score. It was also associated with higher risk of low IQ at age 5 to 6 years, once the ASQ score was taken into account. This association underlines the fact that socioeconomic background plays a crucial role in child development throughout early childhood.^{24,25} Notably, our result that the risk of low IQ is higher with a low

maternal educational level at a given ASQ score was found despite the fact that the more deprived families were not included or dropped out. Had these families been included, the association could have been even stronger.

The interaction between ASQ score and maternal educational level did not reach significance in the multivariate model. However, considering the lack of power of interaction tests, a real interaction cannot be formally ruled out. It could be hypothesized that children with an

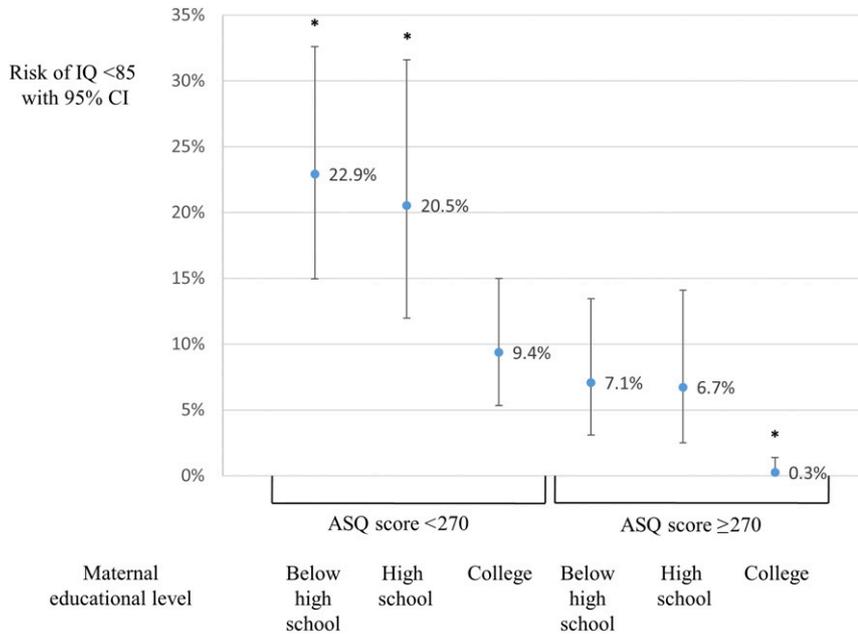


FIGURE 3 Risk of IQ <85 according to 36-month ASQ score and maternal educational level. * $P < .05$ for comparison with children with ASQ score ≥ 270 and high school maternal educational level, adjusted for center and maternal occupational activity.

ASQ score ≥ 270 whose mothers had an educational level at high school or below have not reached their full potential between 3 years and 5 to 6 years because of a less enriched environment. Their later risk of low IQ was similar to what was observed in children with an ASQ score < 270 and a college maternal educational level. These children might have other intrinsic characteristics that adversely affected their development and for which a favorable socioeducational environment may not have been enough to compensate.

Children whose mothers had no occupational activity had a greater risk of low IQ once ASQ score was taken into account and after adjustment for their mothers' educational level. It is possible that maternal occupational activity serves as a proxy for various aspects of sociocultural and economic background. It may also reflect different kinds of earlier day care known to affect a child's developmental trajectory. There is evidence in the literature that high-quality early child care promotes better school achievement in low-income children.²⁶

The other studied factors were not found to be associated with the risk of low IQ at a given ASQ level. This finding highlights the validity of the ASQ assessment because the score's predictive value does not appear to be influenced by these different factors (ie, gender, being a first-born child, maternal depressive symptoms, and family financial difficulties).

Using the ASQ at age 3 could lead to decisions to perform more detailed developmental assessments for children with lower scores. The goal would be to set up early interventions designed to help the child achieve his or her full developmental potential. By itself, ASQ scoring has a very small financial cost, but the real cost would include expenditures necessary for subsequent professional assessments conducted in these children and for interventions themselves. Other "costs" would be the worries that a low 36-month ASQ score would create for families, an issue that warrants more attention and evaluation.

CONCLUSIONS

Our results suggest that the 36-month ASQ score could be useful in predicting the risk of having an IQ <85 at age 5 to 6 years. The score's sensitivity is 0.77 ± 0.11 , with 0.68 ± 0.03 specificity for a cutoff value of 270. At a given ASQ level, socioeconomic background affects children's development between age 3 years and age 5 to 6 years and should be taken into account when interpreting the ASQ score as a predictive tool.

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ABBREVIATIONS

ASQ: Ages & Stages Questionnaires
 CI: confidence interval
 EDEN: Etude des Déterminants Pré- et Post-natals du Développement de l'Enfant
 IQR: interquartile range
 ROC: receiver operating characteristic
 SDQ: Strengths and Difficulties Questionnaire
 WPPSI-III: Wechsler Preschool and Primary Scale of Intelligence-Third Edition

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