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Profiles and predictors of risk for developmental delay: Insights gained from a community-based universal screening program

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1. Introduction

The American Academy of Pediatrics (AAP) recommends universal screenings beginning in infancy to detect any potential developmental delays as early interventions can be more effective in terms of mitigating developmental problems and putting children back on track in their development [1,2]. The Ages and Stages Questionnaires (ASQ) [3,4] is one of the major screening tools recommended by AAP [5–8] and has been widely used to assess risks for developmental delays in five different domains [3,9–15]. A survey showed that the rate of pediatricians and other healthcare providers conducting standard, parent-completed developmental screenings including using the ASQ was 19.5% nationally, ranging from 10% to 47% across difference states in the US in a span of 12 months [16]. Although the rate of such developmental screenings performed by pediatricians has increased since the AAP's recommendation in 2006 [17], the goal of universal screening is still far from being achieved and some children with developmental disorders remain unidentified in early development [18].

Community-based universal screening programs outside of health professional settings can help fill in the gap left by pediatricians and increase the number of children being assessed. In addition, understanding the patterns and trajectories of changes revealed in the developmental screening data collected from community samples can assist the AAP's effort on early detections and intervention in the following two ways: First, it can demonstrate what a universal screening program is capable of capturing; Second, it can provide healthcare practitioners with information on who the most vulnerable groups of children are, what developmental areas are most likely to show risk for delay, and the possible patterns of changes over time. Both of them may lead to higher levels of interest and subsequentially a greater amount of participation in universal screening.

In the current study, we analyzed longitudinal ASQ scores collected from a large community-based sample in a universal screening program to achieve three goals: 1) to describe risk for developmental delay at 8-, 18-, and 24-months. These three time points closely correspond to the three AAP recommended screening points (9-, 18-, and 24- or 30-months); 2) to identify sub-groups of children with common profiles of risk for developmental delay and to examine longitudinal developmental trajectories; and 3) to determine how child (gender, gestational age, ethnicity) and maternal characteristics (age at birth of child, education level, family income) are related to child profile for risk of developmental delay at each time point and longitudinally between 8- and 24-months.

2. Method

Data for this study were drawn from archival infant developmental screening results collected by the Family Futures' Connections program [19]. Family Futures is a non-profit child and family support organization that through its Connections program universally offers free developmental screening opportunities until the age of five. County birth records are used to mail Connections recruitment information and offer the program to every family in multiple Michigan counties after the birth of a child. Participating families complete ASQ screenings and receive ASQ results and just-in-time educational information about their child's upcoming developmental milestones. Families with questions about development or a child showing risk for developmental delay are contacted by parent coaches who provide additional education and referrals for follow-up assessment. All screenings, materials and coaching are offered in both English and Spanish. Family Futures partners with the medical community and child care providers to enable parents to have the ASQ results automatically shared with their children's health care providers and/or their child care providers, creating shared understanding of developmental status.

2.1. Participants

Records for 2343 infants who participated in the Connections program between Jan. 1, 2006 and Dec. 31, 2016 were included in the analyses because they met three criteria: a) they had complete ASQ results for the three screening time points (8-, 18-, and 24-months); b) they were born between 34 and 41 weeks of gestational age, and c) they had complete demographic information for the covariates being considered in the analyses. See Table 1 for demographic information about

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Table 1
Demographic descriptors of infants and mothers in the sample and weighted population estimates.

		Full sample	Girls	Boys	Weighted population estimate[a]
Number of infants (%)		2343	1093 (46.65)	1250 (53.35)	
Child					
Race category (%)	African-American	44 (1.88)	23 (2.10)	21 (1.68)	
	Asian or Pacific Islander	16 (0.68)	4 (0.37)	12 (0.96)	
	Hispanic	90 (3.84)	49 (4.48)	41 (3.28)	
	Multi-Racial	167 (7.13)	78 (7.14)	89 (7.12)	
	Native American	4 (0.17)	2 (0.18)	2 (0.16)	
	White	2022 (86.30)	937 (85.73)	1085 (86.80)	(80.88)
Gestational age: mean (SD)		39.34 (1.24)	39.39 (1.24)	39.30 (1.24)	
% Late preterm birth (gestational age: 34–36 weeks)		3.97	4.32	3.57	7.23
Mother					
Age: mean (SD)		29.62 (4.59)	29.68 (4.62)	29.56 (4.57)	
Education level (%)	High school or less	309 (13.19)	153 (14.00)	156 (12.48)	(39.55)
	Some college/technical training	440 (18.78)	205 (18.76)	235 (18.8)	
	College degree	1020 (43.53)	461 (42.18)	559 (44.72)	
	Some post-college training	574 (24.50)	274 (25.07)	300 (24)	
Income: median		$62,500	$62,500	$62,500	$61,067.39

[a] Population estimates were computed using county level 2010 US census [20,21] and public health data [22,23]. All estimates were weighted to reflect information from each county relative to the proportion of infants in the sample who resided in each county.

the sample. Population estimates based on 2010 Census [20,21] and public health data [22,23] on some key demographic characteristics are also included in Table 1. Compared to the population (all families and children in counties where our sample reside), our sample has similar family income, a higher proportion of children who are white, a higher proportion of mothers with post-secondary education, and a lower percentage of children who were born late preterm (i.e., 34–36 weeks of gestational age at birth).

2.2. Measures

Ages and Stages Questionnaires (ASQ).

2.2.1. ASQ administration

The ASQ is a standardized developmental screening and monitoring tool used to help identify potential developmental delays in five different areas: communication, gross-motor, fine-motor, problem solving, and personal-social. The psychometric properties of the ASQ have been investigated extensively and found to be excellent [3,4,24]. Validity studies comparing results from the ASQ to results from professionally administered standardized tests such as the Battelle Developmental Inventory have found that across test intervals, both the sensitivity and specificity of ASQs are high (85–92% and 78–92%, respectively), whereas over-identification and under-identification of delays tend to be low (6–13% and 1–13%, respectively) [3]. Test-retest reliability is also high [3]. The validity of ASQ scores has also been reported in non-English speaking community samples [10,25].

The ASQ screening tool contains 21 questionnaires administered at pre-specified age intervals ranging from 2 to 60 months. The questionnaires are designed to be completed by parents/primary caregivers [3,4]. Families involved in the Connections program choose the method (paper & pencil or on-line) and the language (English or Spanish) of the questionnaires that they complete. Parents were contacted about the appropriate ASQ 20 days before the age for which that ASQ was designed. For example, families receive the 18-month ASQ or an on-line invitation to the ASQ when their child turned 17-months and ten days of age and could return it any time within the ASQ defined window for that questionnaire.

2.2.2. ASQ scoring

Children are classified as in the *normal* or *low* range in each ASQ domain. A *low* score signifies that a child obtained a score ≥2SD lower than the mean score of other children tested. A *low* score indicates that a child should be further tested for the presence of a possible developmental delay, but is not itself a diagnosis of a developmental delay. Results from ASQ versions II and III were used in this study as the definition of a low score (≥2SD below the mean) was the same across both versions. Adjusted ages of administration were used for any infant born earlier than 37 weeks and under chronological age 2 as per the ASQ administration guidelines [3]. For example, infants born at 36 weeks received the first invitation for the 18-month ASQ at 8 days after they turned 18-months old rather than 20 days before.

2.3. Demographic and perinatal information

Infant Gestational age (GA) and ethnicity, maternal age at birth of child, maternal education level and family income level information was gathered via parent report on the demographics form submitted at entrance to the Connections program.

2.4. Statistical analyses

2.4.1. Identification of developmental risk profiles

Infant scores (low or typical) in the five ASQ domains at 8-, 18-, and 24-months were examined to identify groups of infants with similar patterns of risk for developmental delay using Latent Transition Analysis (LTA) estimated in SAS STAT, version 9.4 using the PROC LTA procedure, version 1.3.2, published by The Methodology Center, The Pennsylvania State University in 2014 [26].

2.4.1.1. Preliminary model considerations. Given the evidence of significant differences in some developmental outcomes for boys and girls in our sample, we first investigated whether to model all infants together or whether to group infants by gender and identify developmental risk profiles within each gender. When boys and girls were grouped together, developmental risk profile was significantly predicted by gender at every time point, and proportions of boys and girls in each profile were very unbalanced. When developmental risk profiles were identified within each gender, unique sets of profiles emerged for girls and boys. Given this pattern of results we decided all the subsequent analyses in the paper use the sets of unique developmental risk profiles that were identified within each gender. LTA analysis identifies latent classes in the population and then calculates the probability of each infant being in each subgroup at each time point. For each time point, an infant was assigned to the status group for which the probability of assignment was highest.

2.4.1.2. Final LTA model selection. We considered models with 2, 3, 4

and 5 latent classes estimated within each gender. Item response probabilities (Low or Normal) were constrained to be equal at all three time points. Scrutiny of the Akaike Information Criteria and Bayesian Information Criteria values for each model suggested that the optimal model would contain between 2 and 4 classes. The three class model was chosen based on interpretability and parsimony.

2.4.2. Assessing the relationship between developmental risk profiles and infant and maternal characteristics

A series of multiple cumulative logistic regression models were estimated in SAS 9.4 to determine if there was any relationship between infant developmental risk profile and infant (gestational age and race[1]) and maternal (age at birth of child, education level,[2] and income) characteristics.[3] This was modeled for each time point (8-, 18-, & 24-months) and for each gender separately. A separate series of logistic regressions were estimated to identify predictors of individual developmental trajectory types between 8 and 24 months and were modeled separately for girls and boys.[4]

The Benjamini & Hochberg False Discovery Rate procedure [27] was used to account for all instances of multiple comparisons in this paper.

3. Results

Across the three ASQ administrations (8-, 18-, & 24-months), 24% of infants showed at least one low domain score on at least one of the ASQ screenings and significantly more boys (27.9%) than girls (19.5%) ever had at least one low domain score ($\chi^2(1, N = 2343) = 22.7$, $p < 0.001$). Gender also predicted domain of low score with boys being more likely than girls to have at least one low score in the Communication domain ($\chi^2(1, N = 2343) = 25.6$, $p < 0.001$) and in the Personal-Social domain ($\chi^2(1, N = 2343) = 14.0$, $p < 0.001$) across three time points. See Table 2 for average number of low domain scores and the percentage of infants with at least one low domain score by gender at each time point and Fig. 1 for frequencies of low scores by domain and time point for girls and boys.

3.1. Profiles of risk for developmental delay

The three developmental profiles that emerged for girls were:

Single domain risk profile: girls in this profile typically showed a low score in only a single domain. The particular developmental domain that was low varied by child and was relatively equally distributed across the five ASQ domains.
Pervasive risk profile: girls in this profile had low scores in at least three of the five ASQ domains (and always in the Fine Motor domain) indicating high risk of developmental delay across multiple developmental domains.
On track profile: girls in this class typically had no low scores in any ASQ domain indicating very little risk of developmental delay.

[1] Race was collapsed into two categories (majority and minority).

[2] Maternal education was collapsed into two categories (education beyond high school, Yes or No).

[3] Because of the possibility of correlation between some of the predictors in these models, all models were checked for possible multicollinearity following the methods suggested by Allison (2003). None of the models showed significant multicollinearity. Preliminary analyses also showed no significant second or third order interactions in the models so interaction terms were left out of the final models.

[4] To determine if interaction terms should be included in the final models, all models were first estimated including all possible interaction terms and then again using a forward stepwise regression selection. Only one, four-way interaction was significant in one of the saturated models and no interaction terms were selected using a forward selection method. Thus, interaction terms were dropped from the final models.

Table 2
Mean (SD) number of low ASQ domain scores and proportion of infants with at least one low domain score by age and sex.

	8M	18M	24M*
Girls	0.17 (0.51)	0.07 (0.36)	0.08 (0.37)
	12.9%	4.94%	5.76%
Boys	0.20 (0.50)	0.10 (0.41)	0.15 (0.48)
	16.72%	6.88%	11.92%

* $p < 0.001$.

The three developmental profiles that emerged for boys were:

Communication risk profile: boys in this profile typically had a low score only in the communication domain.
Moderate risk profile: boys in this profile had low scores in one or two of the ASQ domains with the communication domain being the least likely.
On track profile: boys in this profile were unlikely to have a low score in any domain at any time point indicating very little risk for developmental delay.

See Fig. 2 and Table 3 for additional information about each profile.

3.2. Infant and maternal characteristics and developmental risk profile

For both girls and boys, all probabilities were modeled using the *On track* profile as the reference group. See Table 4 for odds ratios and confidence intervals.

3.2.1. Girls

Mother's age at birth was related to developmental risk profile at 8-months for girls ($\chi^2(2, N = 1093) = 9.66$, $p = 0.008$) such that advancing maternal age was associated with increased likelihood of a girl being in one of the risk profiles. Each additional year of maternal age was associated with a 4% increase in likelihood of being in the *Single domain risk profile* and a 20.7% increase in likelihood of being in the *Pervasive risk* profile as compared to being in the *On track* profile. No other factors were related to classification at 8-, 18-, or 24-months for girls.

3.2.2. Boys

Maternal age at birth was related to profile for boys at 8-months ($\chi^2(2, N = 1250) = 13.1$, $p = 0.0014$) such that a one year increase in mother's age at birth was associated with an 8% increase in likelihood of being in the *Moderate risk* profile. At 18-months, a one year increase in maternal age at birth was associated with a 9% increase in likelihood of being classified in the *Moderate risk* profile ($\chi^2(2, N = 1250) = 7.5$, $p = 0.0234$) as compared to the *On track profile*.

Gestational age was related to profile at 18-months ($\chi^2(2, N = 1250) = 6.4$, $p = 0.0407$) with each additional week of gestation after 34 weeks reducing the likelihood of classification in the *Communication risk* profile and the *Moderate risk* profile by 14.4% and 22.9%, respectively. Similarly, at 24-months, shorter gestation was associated with greater likelihood of being classified in one of the risk profiles ($\chi^2(2, N = 1250) = 8.61$, $p = 0.0135$) as compared to the *On track* profile. Each additional week of gestation after 34 weeks was associated with a 15.4% reduction in likelihood of being classified in the *Communication risk* profile and a 22.3% reduction in likelihood of being classified in the *Moderate risk* profile.

Family income was also a significant predictor of boys' profile status at 24-months ($\chi^2(2, N = 1250) = 9.54$, $p = 0.0085$) such that an increase of $1000 of family income was associated with a 1.2% decrease in the likelihood of a *Communication risk* profile and a 0.7% decrease in the likelihood of a *Moderate risk* profile classification as compared to a *On track* profile.

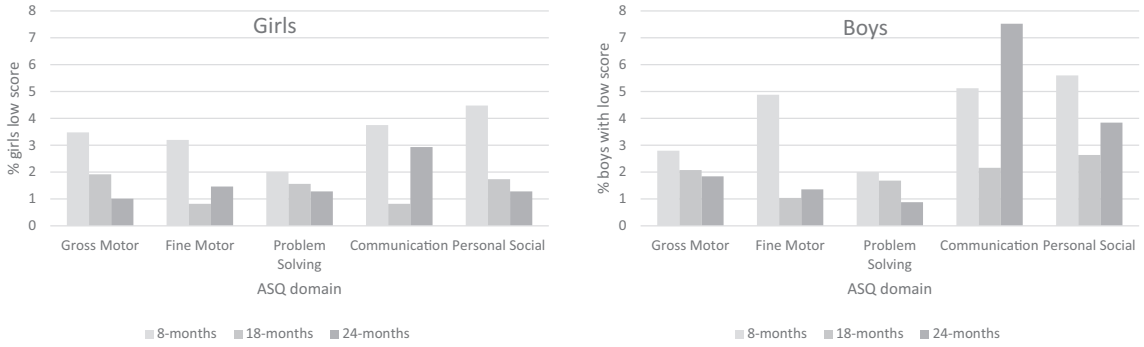

Fig. 1. Prevalence of low scores by domain and time point for girls and boys.

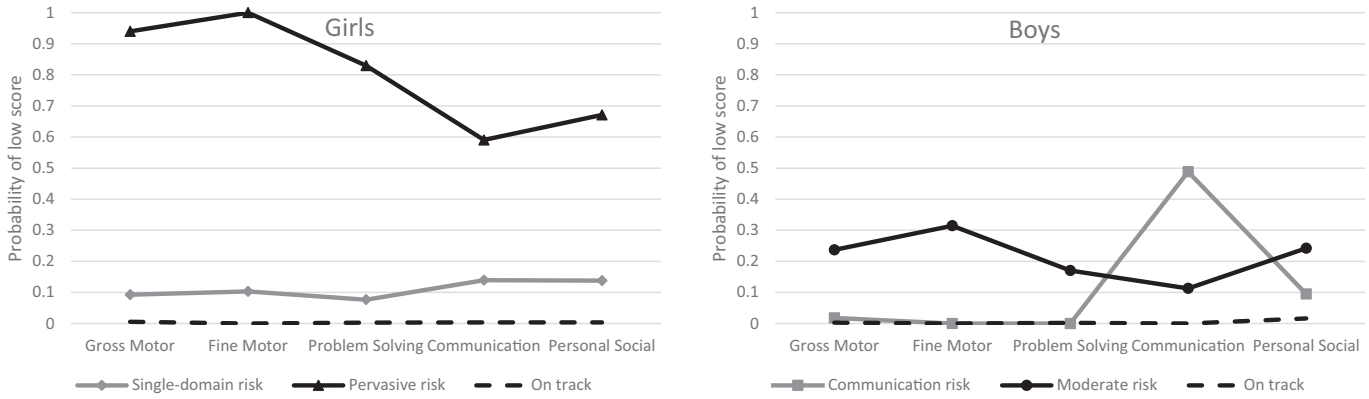

Fig. 2. Profiles of risk for developmental delay and probability of a low score in a particular domain at any time point for girls and boys.

Table 3
Percent of infants in each developmental risk profile at each time point.

Sex	Profile	8M	18M	24M
Girls	Single domain risk	13.27	3.48	6.68
	Pervasive risk	0.64	0.46	0.18
	On track	86.09	96.07	93.14
Boys	Communication risk	4.56	1.68	7.84
	Moderate risk	8.56	3.52	2.48
	On track	86.88	94.8	89.68

Table 4
Odds ratios and 95% confidence intervals for significant predictors of developmental risk profile for girls and boys at all ASQ time points.

Profile	Maternal age	Gestational age	Income
Single domain risk (Girls)	8M 1.04 (1.002–1.08)		
Pervasive risk (Girls)	8M 1.21 (1.04–1.4)		
Communication risk (Boys)		24M 0.84 (0.72–0.97)	24M 0.99 (0.98–0.996)
Moderate risk (Boys)	8M 1.08 (1.04–1.13) 18M 1.09 (1.02–1.16)	18M 0.77 (0.63–0.95) 24M 0.78 (0.61–0.998)	

3.3. Infant developmental trajectories

Most girls (86.28%) and boys (79.92%) remained in the same profile at all three time points. Boys were significantly more likely to shift profiles than were girls ($\chi^2(1, N = 2343) = 16.61, p < 0.0001$). 13.5% of girls and 17.3% of boys shifted profile status once while only 0.2% of girls and 2.8% of boys shifted twice.

Table 5
Proportion of infants showing various types of longitudinal transitions between time points.

Trajectory type	8M to 18M		18M to 24M		8M to 24M	
	Girls	Boys	Girls	Boys	Girls	Boys
Positive	9.97	10.72	0.27	1.36	10.25	9.84
Neutral	0.18	0.96	0.27	0.56	0.09	1.92
Negative	0	2.8	3.2	6.48	3.2	7.04
Stable	89.84	85.52	96.25	91.6	86.46	81.2

In order to examine longitudinal patterns of profile change or stability, the trajectory of risk for developmental delay was coded for each infant. Infants who were in the same profile from one time point to the next were coded as showing a *stable* trajectory. If an infant transitioned from one of the *risk* profile into the *On track* profile, the trajectory was coded as *positive* trajectory. If a child transitioned out of the *On track* profile, the trajectory was coded as *negative* trajectory. If a child switched from one of the *risk* profiles to another *risk* profile the trajectory was considered *neutral* trajectory. See Table 5 for proportions of infants showing various types of trajectories between time points.

3.4. Infant and maternal characteristics and developmental trajectory from 8 to 24 months

We used the 8–24 month developmental trajectory type to examine the relationship between child and maternal characteristics and individual developmental trajectories. All reported probabilities were

Table 6
Odds ratios and 95% confidence intervals for significant predictors of longitudinal pattern between 8 and 24-months for girls and boys.[a]

Longitudinal trajectory 8-24M	Girls	Boys
Positive change	Income 1.01 (1.003–1.02)	Maternal age 1.06 (1.02–1.11)
Negative change		Gestational age 0.82 (0.70–0.96)

[a] Stable group used as reference class for girls and boys.

calculated using the group of infants with a *stable* trajectory as the reference group. Analyses were conducted separately for girls and boys and the very small number of infants showing a *neutral* trajectory were excluded from the model.[5] See Table 6 for odds ratios and confidence intervals.

3.4.1. Girls

Family income reliably predicted trajectory such that as family income increased girls were more likely to show a *positive* trajectory ($\chi^2(2, N = 1092) = 9.09$, $p = 0.0106$). An increase of $1000 of family income was associated with a 1% increase in likelihood of a *positive* trajectory (OR = 1.01 95% CI [1.003, 1.02]) as compared to remaining in the same profile.

3.4.2. Boys

Gestational age and maternal age significantly predicted individual trajectory for boys. As gestational age increased boys were less likely to show a *negative* trajectory ($\chi^2(2, N = 1226) = 6.36$, $p = 0.0415$) with each additional week of gestation after 34 weeks reducing the likelihood of a *negative* trajectory by 18% (OR = 0.82 95% CI [0.70, 0.96]) as compared to remaining in the same profile. As maternal age increased, boys became more likely to display a *positive* trajectory ($\chi^2(2, N = 1226) = 8.51$, $p = 0.0142$). A one year increase in maternal age at birth was associated with a 6% increase in likelihood of a transitioning from a *risk* profile at 9-months of age to the *On track* profile at 24-months (OR = 1.06 95% CI [1.02, 1.11]) as compared to staying in the same profile.

4. Discussion

Our results provided strong support for the AAP's recommendation for universal screening of children during early development on several fronts: First, low ASQ scores were fairly common across all three time points in the first two years. In our sample, 28% of boys and 20% of girls had at least one low score during these time points indicating risk for delay in at least one domain. Without conducting universal screening, we could have missed the opportunity to identify potential problems among a large number of children. Second, the risks profiles for both boys and girls revealed that the risks were commonly associated with only one or two domains and that very few children scored low on multiple domains at the same time. Most of the children in the *risk* profiles (other than *Pervasive*) are likely to appear fairly typical since they are on track in most areas of development. As a result, their potential problems can be easily overlooked. Thus, screening all children in multiple developmental areas as the AAP recommends is vital for identifying the majority of cases of potential developmental delays. Finally, our transition analyses showed that while some children exited from a *risk* profile and moved into the *On track* profile between 8- and 24-months, around 3% of girls and 7% of boys transitioned in an opposite direction during the same time period. This finding stresses the importance of continuous screening throughout early development even if no risk for delay is identified at a younger age.

Another important finding from our study is the gender differences in both overall performance on the ASQ and in the *risk* profiles. Low ASQ scores were more common in boys than in girls, especially in the communication and personal-social domains. Gender-specific risk profiles also emerged. That is, girls' *risk* profiles were not tied to specific ASQ domains whereas for boys, one of the two risk profiles identified was almost exclusively associated with the communication domain. The analysis of trajectory of change in risk profile also revealed that once a boy was in the *communication risk* profile, he was likely to remain there. Although girls have been found to perform better than boys on the ASQ in previous studies [10,12,28], our results clearly delineated more details of such gender differences regarding risks for delays in specific domains and patterns of changes over time. Such information can be important for designing evidence-based programs to reduce or prevent possible developmental problems in specific areas among boys and girls.

There could be a number of possible reasons underlying the gender-specific risk profiles for developmental delays in infancy. Imaging studies have reported structural differences in boys' and girls' brain during early development [29,30]. Sex hormones, which have been linked to gender differences in early language development [31,32], may also account for the gender differences in our risk profiles. Besides these possible biological differences, boys and girls could also be subjected to different environmental influences. For example, Johnson et al. [33] reported that mothers responded and talked more to girls than to boys even in the first months after birth. Studies of older children in natural settings found that how parents communicated with their children and the specific language used in communication differed between boys and girls [34,35]. These differential treatments in parent-child interactions may contribute to the higher rate of possible communication delays among boys.

We also found that boys' risk profile status and developmental trajectories were more sensitive to variations in demographic factors than those of girls. For girls, advancing maternal age increased the likelihood of being at risk for developmental delay at 8 months of age, and an increase in family income reliably predicted a girl's shift from a *risk* profile to the *On track* profile over time. None of the other infant and maternal factors predicted either the girls' profiles or their trajectory. Maternal age, gestational age, and family income all predicted a boy's developmental risk profile and longitudinal changes in their profile membership. More specifically, boys of older mothers were more likely to be in the two *risk* profiles but they were also more likely to shift from a *risk* profile into the *On track* profile between 8 and 24-months. Longer gestational age and higher family income lowered a boy's chance to be in a *risk* profile and increased stability in boys' profile membership. An increase in gestational age also reduced the likelihood of boys to switch from the *On track* profile to a *risk* profile between 8- and 24-months.

Our results provided support for the seemingly conflicting findings from earlier studies regarding the influence of maternal age on early development (for a review see, [36]). A number of studies have linked advanced maternal age to premature births and poor health outcomes including risks for disorders such as Down syndrome possibly due to reproductive aging [36,37]. However, studies on long-term developmental outcomes of children with older mothers revealed an opposite pattern. Large scale studies coming from Europe have demonstrated that increased maternal age was associated with positive health, cognitive, and social developmental outcomes from early childhood [38] to young adulthood [36]. These results may suggest that an increase in maternal age can offset the risks associated with perinatal problems resulting from older maternal age over time and that advanced maternal age can even bring about positive developmental outcomes. Our

[5] Because sparseness of data was causing our models not to converge, we dropped the very infrequent neutral category from the analyses. Similarly, we could not model direction of transitions between two adjacent time points by sex due to sparseness, so we modeled transitions only between 8M profile and 24M profile.

results provided concrete data to support this complicated relationship between maternal age and development outcomes. We found that this relationship was negative only at placing children in *risk* profiles during early infancy but not at the end of infancy. Our transition analyses, on the other hand, supported a positive relationship indicating that children with older mothers were more likely to show a *positive* trajectory by exiting from a *risk* profile. However, it was only significant for boys suggesting that the influence of maternal age over time might be gender-specific.

In our study, gestational age seemed only to predict boy's developmental risk patterns and developmental trajectories. 20% of the children in our sample were born late preterm (34–36 weeks of gestation) or early term (37–38 weeks of gestation). Recent studies have shown that late preterm infants may experience comprised brain development at term-equivalent age [39] and gender differences were also detected in their altered brain development resulted from prematurity [40,41]. Among a large number of behavioral studies that have reported that risks for developmental delays decrease with each additional week of gestation towards a full-term birth [42–45], some also found that preterm boys were at a higher risk for developmental delays [46–48]. Our results add to the literature by showing that longer gestation not only can result in better developmental outcome among boys, especially in the communication domain, but can also reduce the likelihood of a *negative* developmental trajectory as increasing gestational age was associated with reduced likelihood of shift from *On track* to one of the *risk* profiles.

Consistent with studies that have demonstrated the protective nature of financial security for more optimal developmental outcomes (for a review see, [49]), our results also showed that higher family income was associated with better developmental outcomes for both boys and girls in different ways. There are numerous studies that have revealed detrimental effects of economic disadvantage on children's physical and mental development [50]. Neurological studies have even linked social-economic status (SES) to structural differences in specific brain regions [51]. A recent French study of children aged 2 to 6 found the low SES was associated with poor language abilities and boys were more susceptible to the negative impacts of low SES than girls [31]. Most of these studies investigating SES impacts on development have focused on older children [52]. Our study, on the other hand, suggested low income or poverty may begin to have its influence on the risk for developmental delays during infancy and that how income affects developmental risks over time is gender-specific.

Our findings have several implications for real world practices. First, the results regarding how the gestational age, maternal age, and family income predicted the possibility of a boy or a girl's status on a risk profile and developmental trajectory between 8 and 24 months of age can be considered in the policy-making process. By making evidence-based social policies and recommendations, we can potentially turn these demographic predictors into more modifiable ones to maximize a child's chance to be “on track” in development. The most recent example is the American College of Obstetricians and Gynecologists' (ACOG) decision to narrow “term pregnancy” to 39–41 weeks from 37 to 42 weeks based on the latest research indicating that aversive developmental outcomes associated with gestational ages shorter than 39 weeks are greater than previously realized [53]. This new definition of “term pregnancy” could influence doctors' practice and personal decisions made on elective early deliveries in the absence of medical necessity and impact a child's development outcomes. Additionally, the gender-specific developmental risk patterns revealed in our study suggest that boys could potentially benefit more than girls from these evidence-based practices given that boys are more sensitive to variations in these infant and maternal characteristics.

Another implication of our results involves pediatricians' practices. Our findings on the prevalence of risk for developmental delays may increase pediatricians' motivation to comply with the AAP's recommendations on universal screening of early development. In addition to screening, pediatric practices need to establish proper referral channels for further diagnosis and early interventions once a risk for delay is detected. Earlier studies have reported difficulties in placing referrals even after pediatricians encounter failed screens [54]. Community-based universal screening program like the *Connections* may serve as a model of how pediatricians and communities can work together to reach more children and connect them to resources on early intervention. Finally, our results on the predictors of developmental risk profiles and trajectories may help pediatricians identify more vulnerable groups of children and pay closer attention to their development until the goal of universal screening has been reached.

5. Limitations of this study

The most significant limitation of our study was our measure of development. The ASQ is meant as a screening tool and not a diagnostic tool. A low score in an ASQ domain can be interpreted as a delay *relative* to other infants of the same age, but is not the same as a diagnosis of a specific developmental delay. This is why all of our results were framed in terms of “risk” of developmental delay. Another limitation was that all infant and maternal characteristics (e.g. infant gestational age) were parent-reported, which can be a source of error, and incomplete demographic information caused the sample size to be smaller than it could have been. Finally, the generalizability of our findings may be affected by the use of a sample from a community-based screening program. Participation in the Connections program is voluntary. Parents who had concerns about their child's development might have been more inclined to stay in the program than parents who found their children to be on track. This could have inflated our estimates of the prevalence of risk for developmental delay. However, comparison of the proportions of low ASQ scores between our longitudinal sample and all children who had completed either an 8-, 18-, or 24-month ASQ through the Connections program does not substantiate this concern. That is, our sample has relatively similar proportions of infants with risk for developmental delay as the broader group of participants. Also, some of the infant and maternal characteristics of our sample (e.g. longer gestational age and higher maternal education level than the general population) have been found to be associated with reduced risk for developmental delay in other studies [42,55]. For these reasons, it is unlikely that our sample overestimates the risk for developmental delay in the general population.

6. General conclusions

Our study of this community-based sample from a universal screening program outside of the medical setting demonstrated that developmental screening is important because many children showed risks for delays at some points in the first two years but only in one or two domains. Without universal screening, these cases can be easily missed. We also found that the patterns of risks for delays were gender-specific. Boys were more likely to show problems in the communication domain whereas in girls, risks for delays were not tied to specific domains. Analyses of the predictors of developmental risk profiles and developmental trajectories pointed out that special attention should be paid to boys' communication development, boys who are born early, and all children born to older mothers or to families with low income.

Conflict of interest statement

None of the authors have any conflicts of interest to disclose and no external funding was obtained.

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