Maternal Socio-Economic and Race/Ethnic Characteristics Associated with Early Intervention Participation

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Abstract *Objectives* To evaluate whether Massachusetts Early Intervention (EI) serves children at risk of developmental delay due to social factors, we identified socio-demographic characteristics associated with program enrollment and examined predictors of participation at each stage from referral to enrollment. *Methods* The Pregnancy to Early Life Longitudinal (PELL) data system linked birth certificate, hospital discharge, and EI data for all Massachusetts births, 1998–2000. We identified predictors of enrollment among births and predictors of referral, eligibility evaluation among those referred, and enrollment among eligible children using multivariate modified Poisson models to adjust for medical risks. *Results* Overall, 29,950 children (13.7% of births) enrolled in EI. Most social risk indicators predicted enrollment, including maternal government insurance (RR = 1.32, 95% CI 1.29–1.36) and maternal education ≤10 years (RR = 1.36, 95% CI 1.30–1.42). Having a foreign-born (RR = 0.77, 95% CI 0.74–0.80), non-English speaking (RR = 0.93, 95% CI 0.89–0.97) or Asian (RR = 0.88, 95% CI 0.82–0.94) mother was negatively associated with enrollment. Of births, 18.6% were referred to EI. Similar socio-demographic variables predicted referral as predicted enrollment. Among referrals, 87.7% received an evaluation. Evaluation was negatively associated with young maternal age, black maternal race, and high poverty level. Of eligible children, 93.0% enrolled. Enrollment among eligible children was negatively associated with young maternal age and high poverty level. *Conclusion* In Massachusetts, children born with social risk factors have high EI participation. Nevertheless, children in immigrant communities may face barriers to initial contact with EI, while children from low socioeconomic environments may be at risk for not enrolling after EI referral.

Keywords Early Intervention · Early childhood development · Program evaluation · Race-ethnic disparities · Socio-economic disparities

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Background

Children living in impoverished socio-economic settings are at risk for developmental delay [1–4]. Substantial evidence suggests that these children benefit cognitively and socially from receiving early developmental intervention, perhaps even more so than those with established delays due to medical conditions [5–9]. Access to quality intervention programs for this group is therefore critical. State-coordinated Early Intervention (EI) services, mandated under part C of the Individuals with Disabilities Education Act (IDEA '97), cover services that enhance physical, cognitive, communication, social/emotional and/or adaptive development for children aged zero to 3 years with a developmental delay. In some states, including Massachusetts, children at risk for delay are also eligible for services.

Massachusetts defines "at-risk" as having four or more medical or social risk factors. The state recognizes eight risk factors relating to social environment: maternal age less than 17 years or three or more births before age 20 years; maternal education of 10 years or fewer; parental chronic illness/ disability affecting care giving; lack of social supports; inadequate food, shelter, clothing; open/confirmed Child Protective Services investigation; substance abuse in the home; and domestic violence in the home. Some of these risk factors, for example maternal education of 10 years or less and inadequate food, shelter, and clothing, are direct indicators of low socioeconomic status (SES) while others such as parental chronic illness are associated with low SES [10].

Massachusetts' EI program has an open referral process; any interested individual can make a referral. Many referrals come from physicians, parents, day care providers, and social service agencies. After referral, an evaluation is conducted within 45 days to determine whether the child meets eligibility criteria in one of 4 categories: (1) a disabling physical or mental condition referenced by one or more of 197 specific ICD-9 codes; (2) an established developmental delay; (3) clinician judgment of need for services; or (4) four or more child or family risk factors for delay (List of risk factors available from authors). Once a child is determined to be eligible, providers and parents develop an individualized family service plan (IFSP) and services are initiated.

While it has been demonstrated in Massachusetts that children at highest medical risk for developmental delay are referred to EI [11], there has been no assessment of EI participation among children born at social risk of delay. While previous reports have described the socio-demographic characteristics of EI populations [12, 13], population data that includes the socioeconomic characteristics of all state births are needed as a denominator to determine the percentage of socially at-risk children in the population who participate in EI and to determine whether any racial/ethnic and/or socio-demographic groups have lower participation than would be expected given their profile of medical and social risk factors.

In Massachusetts, the Pregnancy through Early Life Longitudinal (PELL) data system contains population-based linked birth certificate data, death records, hospital discharge data, and EI program data, providing a unique opportunity to examine the association between maternal demographic characteristics documented at an infant's birth and subsequent EI participation. Although PELL does not contain specific information on all the characteristics identified as risk factors by MA, the data set does include information on several of the defined risk factors and several additional indicators of low socioeconomic status (SES).

The primary goal of these analyses was to evaluate Massachusetts EI program participation among socially at-risk children by assessing the percentage of all MA children with social risk characteristics who participate in EI and identifying maternal socio-demographic and race/ ethnic characteristics associated with enrollment in EI. The secondary goal was to better understand participation of socially at-risk children at each stage of the referral-evaluation-enrollment process by separately examining maternal characteristics associated with referral to EI, evaluation once referred, and program enrollment upon determination of eligibility.

Methods

Data Source and Sample

Data for these analyses were derived from the PELL data system. PELL is a public-private partnership between the Boston University School of Public Health, Massachusetts Department of Public Health, and the Centers for Disease Control and Prevention, the funding agency. The core PELL database consists of Massachusetts birth certificates, fetal and infant death records, and birth-related hospital discharge data on both mothers and infants. For these analyses, we used data from 219,037 in-state, resident live births from January 1, 1998 through September 30, 2000, excluding neonatal deaths. The sample represents 97% of all Massachusetts births during this time period. Birth certificate data from these infants were linked to 215,305 infant hospital discharge records (98.3% linkage). The records were then linked to program data from the 46,857 infants referred to the Early Intervention program that were born during this period. The data sets were linked using deterministic methods, with mother's name, mother's date of birth, infant's name and infant's date of birth as the linking variables. The linkage was performed with LinkPro software (InfoSoft, Inc., Winnipeg, Manitoba, Canada). Of the EI referral records, 40,705 (86.7%) linked back to a record in the core PELL data set. For analysis, records were stripped of name, address, and other identifying information, and a data use and confidentiality agreement was completed with the Massachusetts Department of Public Health to perform the current analyses.[1]

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[1] The authors linked birth, death, and hospital discharge data with Early Intervention (EI) program data in order to conduct this study on behalf of the Massachusetts Department of Public Health's Early Intervention Program. Personally identifiable information received by the EI program is protected under the provisions of the Individuals with Disabilities Education Act (IDEA) which adopts the privacy protections of the Family Educational Rights and Privacy Act (FERPA), 20 U.S.C. §1232g and 34 CFR Part 99. Under these laws, parental consent is not required to disclose identifiable data to an organization that is conducting a study for or on behalf of the EI program. The use of EI program data for this study was permissible under these laws since the authors conducted the study on behalf of the EI program and destroyed direct identifiers from the analytic file once the linkage was completed.

Variables

Several maternal socio-demographic characteristics were available from the birth certificate: Maternal age (<17 years, 18–19 years, 20–24 years, 25–29 years, 30+ years), race/ethnicity (White/Black/Hispanic/Asian/Other), place of birth (US born/foreign-born), and language preference (English/other). Education was categorized as followed: ≤10 years; 11–12 years; 1–3 years college; and 4+ years college. Of these variables, maternal age less than 17 and maternal education less than or equal to 10 years corresponded directly to two of the social risk factors defined by Massachusetts EI. Health insurance (commercial/government/none) was derived from method of payment on the infant's hospital discharge record following birth. Percentage of residents living below the federal poverty level in town or city of residence, obtained from the birth certificate, was classified according to the 2000 Census (<10%, 10–14.9%, 15%+ below federal poverty level).

Child characteristics associated with developmental delays were included in the analyses to adjust for a child's medical need for EI services: Sex, birthweight (less than 1200 g, 1200–1499 g, 1500–2499 g, 2500+ g), gestational age (<32, 32–36, and 37+ weeks), 5-min Apgar score (<5, 5+), and diagnosis of an EI-Eligible medical condition (yes/no), one of the 197 medical condition that qualifies a child for EI services, were used to control for medical indication for EI services (list of diagnoses available from authors).

We classified infants as *referred* to EI if they had one or more dates of referral in the EI data set. Among those referred to EI, a child was classified as *evaluated* if he or she had one or more dates for an eligibility evaluation in the EI database. Children were classified as *enrolled* if an IFSP was completed for the child.

Data Analysis

To examine the association between maternal characteristics and enrollment, we fit both crude and multivariable modified Poisson regression models, including enrollment as the outcome variable and maternal characteristics as predictive variables. Multivariate models were adjusted for infant medical risk factors and maternal characteristics. Risk ratios and 95% confidence intervals were calculated. Similar models were fit to separately examine the association between maternal characteristics and referral to EI, evaluation once referred, and enrollment among eligible children. Since virtually all mothers <17 years of age had ≤10 years education, the estimate for maternal age <17 was entered into the multivariable model as an interaction term age <17 and education ≤10 years, and the risk ratio

estimates the association between maternal age and outcome among mothers with low education. Robust standard errors were calculated using general estimating equations to account for correlation between children born to the same mother [14]. Data were analyzed with SAS software (SAS institute, Cary, NC).

Results

Overall, from January 1998 through September 2000, 219,001 surviving infants were born in Massachusetts to resident mothers. Of these, 40,711 (18.6%) were referred to EI. Of the children referred, 35,707 (87.7%) received an evaluation to determine eligibility; of those eligible, 29,950 (90.3%) enrolled in EI. Table 1 presents the maternal socio-demographic characteristics of these births and the characteristics of the children referred to EI, evaluated for eligibility, and enrolled in EI. Altogether, seven percent of Massachusetts births were to teen mothers (less than 20 years of age), teen mothers comprised over 11% of EI referrals and over 9% of enrollees. While one-quarter of births were to non-white mothers, children born to minority mothers comprised 31% of referrals and 29% of enrollees. Nine percent of births, 15% of referrals and 14% of enrollees were to mothers with ten or fewer years of education.

In both the crude and adjusted analysis in Table 2, most indicators of low socioeconomic status were positively associated with enrollment. Adjusting for maternal and birth characteristics, the strongest maternal predictors of enrollment were 10 or fewer years of education compared to college or higher (RR = 1.36, 95%CI 1.30–1.42), government health insurance (RR = 1.32, 95% CI 1.29–1.36), and maternal Hispanic ethnicity (RR = 1.26, 95% CI 1.21–1.31). Some maternal characteristics were negatively associated with EI enrollment. Adjusting for birth and maternal characteristics, children of foreign-born women were less likely to be referred to EI (RR = 0.77, 95% CI = 0.74–0.80) than children of US born women. Referral was also negatively associated with maternal language preference other than English, Asian maternal race, and living in a town with a poverty level of 15% or higher.

All of the low SES indicators that were positively associated with enrollment were also associated with referral. In most cases the associations between these indicators and referral were stronger than for enrollment. Adjusting for maternal and birth characteristics, the strongest maternal predictors of referral were 10 or fewer years of education (RR = 1.37 95% CI 1.33–1.42), government health insurance (RR = 1.35, 95% CI 1.32–1.38), and Hispanic ethnicity (RR = 1.24, 95% CI 1.20–1.28). Nevertheless, similar to the findings related to enrollment,

Table 1 Maternal characteristics of MA infants, referral, evaluation, and enrollment in Early Intervention (EI)

Characteristic	N (%) births	N (%) referred	N (%) evaluated	N (%) enrolled
Overall	219,001	40,711	35,707	29,950
Maternal age				
<17	2,475 (1.1)	982 (2.4)	784 (2.2)	565 (1.8)
17–19	12,855 (5.9)	3,678 (9.0)	2,922 (8.2)	2,207 (7.4)
20–24	32,133 (14.7)	6,916 (17.0)	5,814 (16.3)	4,762 (15.9)
25–29	55,007 (25.1)	9,211 (22.6)	8,121 (22.7)	6,863 (22.9)
30–34	71,332 (32.6)	11,795 (29.0)	10,645 (29.8)	9,099 (30.4)
35+	45,198 (20.6)	8,129 (20.0)	7,421 (20.8)	6,454 (21.6)
Maternal race				
White	163,537 (74.9)	28,192 (69.3)	25,223 (70.7)	21,331 (71.4)
Black	15,370 (7.0)	3,741 (9.2)	3,019 (8.5)	2,470 (8.3)
Hispanic	24,238 (11.1)	6,366 (15.7)	5,395 (15.1)	4,419 (14.8)
Asian	11,243 (5.2)	1,459 (3.6)	1,268 (3.6)	1,069 (3.6)
Other	4,074 (1.9)	887 (2.2)	743 (2.1)	610 (2.0)
Maternal education				
≤10 years[a]	20,574 (9.4)	6,160 (15.2)	4,395 (12.3)	4,116 (13.8)
11–12 years	62,391 (14.7)	12,776 (31.5)	11,690 (32.8)	9,167 (30.7)
1–3 years college	51,781 (13.0)	8,897 (21.9)	7,889 (22.1)	6,704 (22.4)
4+ years college	83,564 (11.8)	12,788 (31.5)	11,652 (32.7)	9,896 (33.1)
Insurance status				
Commercial	157,531 (73.6)	25,345 (63.4)	22,786 (65.0)	19,338 (65.8)
Government	51,679 (25.2)	13,683 (34.3)	11,491 (32.8)	9,409 (32.0)
None	4,726 (2.2)	932 (2.3)	764 (2.2)	633 (2.2)
Poverty in town/city				
≥15	39,161(17.9)	8,775 (21.6)	7,140 (20.0)	5,573 (19.3)
10–14.9	26,936 (12.3)	6,337 (15.5)	5,645 (15.8)	4,753 (15.9)
<10	152,779 (69.8)	25,585 (62.9)	22,909 (64.2)	19,413 (64.5)
Country of birth				
US	176,341 (80.5)	33,942 (83.4)	29,875 (83.7)	25,036 (83.6)
Outside US	42,621 (19.5)	6,764 (16.6)	5,827 (16.3)	4,909 (16.4)
Preferred language				
English	197,223 (90.3)	36,547 (89.9)	32,154 (90.2)	26,956 (90.2)
Other	21,311 (9.8)	4,104 (10.1)	3,497 (9.8)	2,944 (9.8)

[a] Among mothers ages 17 years and older

several socio-demographic characteristics were negatively associated with referral after adjusting for birth and maternal characteristics. Children of foreign-born women were less likely to be referred to EI (RR = 0.77, 95% CI = 0.74–0.79) than children of US born women. Referral was also negatively associated with maternal language preference other than English and Asian maternal race (Table 3).

Among children referred to EI, subsequent evaluation to determine eligibility was negatively associated with all maternal indicators of socioeconomic status, black maternal race, and Hispanic maternal ethnicity in the crude analysis. After adjusting for birth and maternal characteristics, children born to teenage mothers were slightly less likely to receive an evaluation compared to mothers over

age 35 (RR = 0.91, 95% CI 0.88–0.94 for maternal age <17; RR = 0.90, 95% CI 0.88–0.92 for maternal age 17–19). Evaluation also demonstrated a slight negative association with maternal age 20–29 years, black maternal race, lack of health insurance at time of delivery, and poverty level of 15% or higher (Table 4).

In the crude analysis, among those children eligible for services, subsequent enrollment was negatively associated with most maternal indicators of low socioeconomic status. After adjusting for birth and maternal characteristics, fewer predictors remained. Children with younger mothers were 3–9% less likely to enroll compared to children of mothers ages 35 years and older (RR = 0.91, 95% CI 0.88–0.95 for maternal age <17, RR = 0.93, 95% CI 0.91–0.95 for maternal age 17–19, RR = 0.97, 95% CI 0.96–0.98 for

Table 2 Crude and adjusted risk ratios and 95% confidence intervals for the association between maternal characteristics and EI enrollment, Massachusetts, 1998–2000

Characteristic	N	% Births enrolled in EI	Crude RR	Adjusted RR[a]
Overall	219,001	13.7		
Age				
<17	2,475	22.8	1.60 (1.48–1.73)	0.92 (0.85–1.01)
17–19	12,855	17.2	1.20 (1.15–1.26)	0.84 (0.80–0.88)
20–24	32,133	14.8	1.04 (1.00–1.08)	0.84 (0.80–0.87)
25–29	55,007	12.5	0.87 (0.84–0.90)	0.84 (0.82–0.87)
30–34	71,332	12.8	0.89 (0.87–0.92)	0.92 (0.89–0.95)
35+	45,198	14.3	1.0	1.0
Race				
White	163,537	13.0	1.0	
Black	15,370	16.1	1.23 (1.18–1.28)	1.09 (1.05–1.14)
Hispanic	24,238	18.2	1.40 (1.35–1.44)	1.26 (1.21–1.31)
Asian	11,243	9.5	0.73 (0.69–0.78)	0.88 (0.82–0.94)
Other	4,074	15.0	1.15 (1.06–1.24)	1.09 (1.01–1.18)
Education				
≤10 years HS[b]	20,574	20.0	1.69 (1.63–1.75)	1.36 (1.30–1.42)
11–12 years HS	62,391	14.7	1.24 (1.21–1.28)	1.11 (1.08–1.14)
1–3 years college	51,781	13.0	1.09 (1.06–1.13)	1.03 (1.00–1.06)
4+ years college	83,564	11.8	1.00	1.0
Insurance status				
Commercial	157,531	12.3	1.00	1.00
Government	51,679	18.2	1.48 (1.45–1.52)	1.32 (1.29–1.36)
None	4,726	13.4	1.09 (1.01–1.18)	1.07 (1.00–1.16)
Poverty in town/city				
≥15	39,161	14.7	1.16 (1.13–1.19)	0.94 (0.90–0.97)
10–14.9	26,936	17.7	1.39 (1.35–1.43)	1.19 (0.15–1.23)
<10	152,779	12.7	1.00	1.0
Country of birth				
US	176,341	14.2	1.0	1.0
Outside US	42,621	11.5	0.81 (0.79–0.84)	0.77 (0.74–0.80)
Preferred language				
English	197,223	13.7	1.0	1.0
Other	21,311	13.8	1.01 (0.97–1.05)	0.93 (0.89–0.97)

[a] Adjusted for infant sex, birthweight, gestational age, plurality, medical conditions present at birth, Apgar score, length of hospital stay, and maternal age, race, education, insurance, poverty rate, country of birth, and language preference

[b] Among mothers ages 17 years and older

maternal age 20–24). Enrollment was also inversely associated, though slightly, with high poverty level (Table 5).

Discussion

In Massachusetts, children at risk for developmental delay due to environmental circumstances are eligible for EI. It is therefore expected that program participation will be higher among children at social risk, including those from low SES environments. Using population-based linked data, we were able to characterize the entire population with regard to SES characteristics at birth and subsequent EI participation. A substantial percentage of children with indicators of low SES enrolled in EI. Moreover, most

indicators of low SES had a moderately positive association with EI enrollment after adjusting for medical risk factors for delay. Black maternal race and Hispanic ethnicity, associated with lower SES in Massachusetts, were also positively associated with EI enrollment. Although the percentage of children with low SES indicators who are eligible for services is not known, the over-representation of these groups in EI suggest that Massachusetts is disproportionately serving the population at risk of developmental delay due to living in impoverished socioeconomic environments.

While participation in EI was elevated among most socially at-risk children, enrollment was lower than expected in some groups, particularly children born to foreign-born mothers, non-English speaking mothers, and

Table 3 Crude and adjusted risk ratios and 95% confidence intervals for the association between maternal characteristics and EI referral, Massachusetts, 1998–2000

Characteristic	N	% births referred to EI	Crude RR	Adjusted RR[a]
Overall	219,001	18.7		
Age				
<17	2,475	39.7	2.21 (2.09–2.33)	1.22 (1.14–1.29)
17–19	12,855	28.6	1.59 (1.54–1.65)	1.08 (1.04–1.12)
20–24	32,133	21.5	1.20 (1.16–1.23)	0.94 (0.91–0.97)
25–29	55,007	16.8	0.93 (0.90–0.96)	0.89 (0.87–0.92)
30–34	71,332	16.5	0.92 (0.89–0.94)	0.94 (0.92–0.97)
35+	45,198	18.0	1.0	1.0
Race				
White	163,537	17.2	1.0	1.0
Black	15,370	24.3	1.41 (1.37–1.46)	1.18 (1.14–1.22)
Hispanic	24,238	26.3	1.52 (1.49–1.56)	1.24 (1.20–1.28)
Asian	11,243	13.0	0.75 (0.71–0.79)	0.90 (0.85–0.95)
Other	4,074	21.8	1.26 (1.19–1.34)	1.14 (1.07–1.21)
Education				
≤10 years HS[b]	20,574	29.9	1.96 (1.90–2.01)	1.37 (1.33–1.42)
11–12 years HS	62,391	20.5	1.34 (1.31–1.37)	1.11 (1.08–1.13)
1–3 years college	51,781	17.2	1.12 (1.09–1.15)	1.03 (1.00–1.05)
4+ years college	83,564	15.3	1.0	1.0
Insurance status				
Commercial	157,531	16.1	1.0	1.0
Government	51,679	26.5	1.65 (1.61–1.68)	1.35 (1.32–1.38)
None	4,726	19.7	1.23 (1.15–1.30)	1.12 (1.05–1.18)
Poverty in town/city				
≥15	39,161	22.4	1.34 (1.31–1.37)	1.02 (1.00–1.05)
10–14.9	26,936	23.5	1.40 (1.37–1.44)	1.14 (1.11–1.17)
<10	152,779	16.7	1.0	1.0
Country of birth				
US	176,341	19.2	1.0	1.0
Outside US	42,621	15.9	0.82 (0.80–0.85)	0.77 (0.74–0.79)
Preferred language				
English	197,223	18.5	1.0	1.0
Other	21,311	19.3	0.96 (0.93–0.99)	0.92 (0.88–0.95)

[a] Adjusted for infant sex, birthweight, gestational age, plurality, medical conditions present at birth, Apgar score, length of hospital stay, and maternal age, race, education, insurance, poverty rate, country of birth, and language preference

[b] Among mothers ages 17 years and older

Asian mothers. These results are consistent with previous studies finding lower health care utilization among children born to non-English speaking and/or foreign born mothers [15–19]. These results suggest that, despite existing efforts in these areas, EI may need to develop additional strategies to engage these populations.

We separately examined socio-demographic characteristics associated with each step in the referral-evaluation-enrollment process and found different associations between socio-demographic characteristics and participation at each stage. Low SES indicators that were positively associated with enrollment were more strongly associated with referral, indicating that MA is identifying children who may be in need of services due to their social risk. In contrast, referral was negatively associated with several

maternal characteristics, including being born outside the US, preferring a language other than English, and Asian race. These findings suggest that the reason for the lower enrollment in these groups may be inadequate identification of children in need of services in these communities. Non-English speaking families may be experiencing language barriers. Some immigrant families may be avoiding contact with the medical community due to documentation concerns. Alternatively, infants born in any of these groups may be in less need of EI or the families perceive less need for EI, even after taking into account their profile of birth risks.

Among those referred, the association between SES and race/ethnic characteristics and receipt of evaluation and enrollment was different than the association between these factors and initial referral. While many indicators of low

Table 4 Crude and adjusted risk ratios and 95% confidence intervals for the association between maternal characteristics and EI Evaluation among children referred, Massachusetts, 1998–2000

Characteristic	N referred	% evaluated	Crude RR	Adjusted RR[a]
Overall	40,711	87.7		
Age				
<17	982	79.8	0.87 (0.85–0.90)	0.91 (0.88–0.94)
17–19	3,678	79.4	0.87 (0.85–0.89)	0.90 (0.88–0.92)
20–24	6,916	84.1	0.92 (0.91–0.93)	0.94 (0.93–0.96)
25–29	9,211	88.2	0.97 (096–0.98)	0.98 (0.96–0.99)
30–34	11,795	90.2	0.99 (0.98–1.00)	0.99 (0.98–1.00)
35+	8,129	91.3	1.0	1.0
Race				
White	28,192	89.5	1.0	1.0
Black	3,741	80.7	0.90 (0.89–0.92)	0.95 (0.93–0.97)
Hispanic	6,366	84.7	0.89 (0.89–0.90)	1.01 (1.00–1.03)
Asian	1,460	86.9	0.97 (0.95–0.99)	0.98 (0.96–1.00)
Other	887	83.7	0.95 (0.94–0.96)	0.98 (0.95–1.01)
Education				
≤10 years HS[b]	6,160	83.0	0.91 (0.90–0.92)	0.98 (0.97–1.00)
11–12 years HS	12,776	85.9	0.94 (0.93–0.95)	0.99 (0.98–1.00)
1–3 years college	8,897	88.7	0.97 (0.96–0.98)	0.99 (0.98–1.00)
4+ years college	12,788	91.1	1.0	1.0
Insurance status				
Commercial	25,345	89.9	1.0	1.0
Government	13,683	84.0	0.93 (0.93–0.94)	0.98 (0.97–1.00)
None	932	82.0	0.91 (0.88–0.94)	0.96 (0.93–0.99)
Poverty in town/city				
≥15%	8,775	81.4	0.91 (0.90–0.92)	0.95 (0.94–0.96)
10–14.9%	6,337	89.1	0.99 (0.99–1.00)	1.03 (1.02–1.05)
<10%	25,585	89.5	1.0	1.0
Country of birth				
US	33,942	88.0	1.0	1.0
Outside US	6,764	86.1	0.98 (0.97–0.99)	0.99 (0.98–1.01)
Preferred language				
English	36,547	85.2	1.0	1.0
Other	4,104	88.0	0.97 (0.96–0.98)	1.00 (0.98–1.02)

[a] Adjusted for infant sex, birthweight, gestational age, plurality, medical conditions present at birth, Apgar score, length of hospital stay, and maternal age, race, education, insurance, poverty rate, country of birth, and language preference

[b] Among mothers ages 17 years and older

SES had a positive association with referral, some of the same indicators had a small negative association with having an evaluation after referral. Among those referred, young maternal age was associated with not receiving an evaluation, and, among eligible participants, not enrolling in the program. Having non-commercial insurance at the time of birth also predicted not receiving an evaluation or enrolling.

Although the associations we found were small, even small decreases in evaluation and enrollment in high risk groups translates into sizable numbers of children lost to follow-up. For example, a 7% decrease in enrollment among eligible children born to mothers 17–19 years of age translates to 258 children in a cohort born over a 2.5 year period. Consequently, while the population of EI participants is comprised of children from lower socioeconomic status than the population of Massachusetts births overall, EI may be serving a smaller proportion of socially at-risk children than are in need of services due to their disproportionate loss during the enrollment process.

Our findings are consistent with other reports of lower compliance with prescribed pediatric medical care in low-income populations and among children born to teenage mothers [20–22]. Lower follow-up among younger women and women with less education may reflect a lack of knowledge of the benefit of EI. Teen mothers may also be involved in other programs, for example teen parentings programs, and not recognize the added value of EI. Children with government or no health insurance in Massachusetts are able to receive EI services at no cost. Nevertheless, indirect costs such as time away from work may still be a financial barrier to EI participation among

Table 5 Crude and adjusted risk ratios and 95% confidence intervals for the association between maternal characteristics and EI enrollment among eligible participants, Massachusetts, 1998–2000

Characteristic	N Eligible	% Enrolled, of children eligible for EI	Crude RR	Adjusted RR[a]
Overall	31,299	93.1		
Age				
<17	650	84.0	0.88 (0.86–0.92)	0.91 (0.88–0.95)
17–19	2,454	87.1	0.92 (0.90–0.93)	0.93 (0.91–0.95)
20–24	5,081	91.4	0.96 (0.95–0.97)	0.97 (0.96–0.98)
25–29	7,125	93.6	0.99 (0.98–0.99)	0.99 (0.98–1.00)
30–34	9,378	94.4	0.99 (0.99–1.00)	0.99 (0.99–1.00)
35+	6,595	95.0		
Race				
White	22,092	93.8	1.0	
Black	2,605	91.3	0.97 (0.96–0.98)	1.00 (0.98–1.01)
Hispanic	4,756	90.9	0.97 (0.96–0.98)	1.01 (0.99–1.02)
Asian	1,122	92.1	0.98 (0.96–1.00)	0.99 (0.97–1.01)
Other	654	90.8	0.97 (0.94–0.99)	0.99 (0.97–1.02)
Education				
≤10 years HS[b]	4,482	89.5	0.94 (0.93–0.95)	0.99 (0.98–1.00)
11–12 years HS	9,674	92.4	0.97 (0.97–0.98)	1.00 (0.99–1.01)
1–3 years college	6,945	93.8	0.99 (0.98–1.00)	1.00 (0.99–1.01)
4+ years college	10,109	94.8	1.00	1.00
Insurance status				
Commercial	19,905	94.3	1.00	1.00
Government	10,093	90.9	0.96 (0.96–0.97)	0.99 (0.98–1.00)
None	690	90.0	0.96 (0.93–0.98)	0.98 (0.95–1.00)
Poverty in town/city				
≥15	6,196	90.3	0.96 (0.95–0.97)	0.98 (0.97–0.99)
10–14.9	5,034	92.2	0.98 (0.97–0.99)	1.00 (0.99–1.01)
<10	20,041	94.1	1.0	1.00
Country of birth				
US	26,116	93.2	1.0	1.0
Outside US	5,162	92.4	0.99 (0.97–1.00)	1.0 (0.99–1.01)
Preferred language				
English	3,125	93.2	1.0	1.0
Other	28,106	91.8	0.98 (0.97–1.00)	1.00 (0.99–1.02)

[a] Adjusted for infant sex, birthweight, gestational age, plurality, medical conditions present at birth, Apgar score, length of hospital stay, and maternal age, race, education, insurance, poverty rate, country of birth, and language preference

[b] Among mothers ages 17 years and older

lower-income mothers. Families living in poverty may be vulnerable to loss to follow-up due to being overwhelmed by the difficulty of daily life. Children ages 0–3 years from low-income families are also almost twice as likely as those from higher income families to have moved in the past year [23]. Residential instability has been shown to adversely affect participation in social and medical interventions aimed at high-risk groups [24]. Lack of transportation, an often-cited reason for low compliance in low SES populations [25], may not be a big factor in our data, as EI evaluations and services are largely provided in the client's home or the child's day care setting and transportation is provided for children as needed.

While referral was negatively associated with having a foreign-born mother, a non-English speaking mother, and maternal Asian race, children in these groups were no less likely to be evaluated or enrolled after referral. This indicates that the primary barrier is the initial contact with service providers and not loss to follow-up once connected with the system.

The results from these analyses provide program planners with targeted areas to focus efforts at improving access at each stage of the referral-evaluation-enrollment process. Examination of the referral process in health care facilities serving Asian, immigrant, and non-English speaking populations may help identify whether language and cultural barriers contribute to lower referral in these groups. In communication with Massachusetts hospitals, we found variation in the referral process for newborns. Some hospitals made the initial phone call to the program,

while others gave the phone number to the family for them to call. Such variations could have particular impact on rates of referral in families with linguistic and cultural barriers.

Retaining children in the program after referral is an ongoing effort among EI programs, with staff using all available resources to retain individual clients in the system. Nevertheless, our finding that children of teen mothers and those with government insurance are particularly vulnerable to discontinuing EI services before enrollment suggests possibilities for improved service coordination and staff education in programs such as WIC and teen parenting programs that are frequently used in the same populations.

Our results are subject to several limitations. While it is encouraging that a relatively high percentage of children with each of the SES indicators were referred to and enrolled in EI, we did not have information on all of the specific risk factors used by Massachusetts in determining eligibility. We were, therefore, unable to calculate the actual percentage of children eligible for EI due to the state's definition of social risk that were served by the EI program. Although linkage was high, not all EI records could be linked to a birth record. Most unlinked EI records were due to missing identifying data on the EI referral record. If having missing EI data was related to socio-economic characteristics, the results presented here may be biased. In examining the unlinked records, however, we found no evidence that non-linkage was related to socio-economic variables available in the EI data set. Records from infants born out of state or adopted could not be linked to a birth record, as these infants had no record in the Massachusetts births data set. Since information on place of birth and adoption status was not available on the EI records, we were unable to exclude them when linking the births and EI records. Our estimate of 88% linkage for in-state births to resident mothers is therefore an underestimate of the true linkage of infants in the study population.

These findings demonstrate the value to states of linking population and program data for the purpose of evaluating whether EI is reaching the children in need of services and identifying subsets of the MA population who may face barriers to EI participation. Although other states may find different characteristics associated with EI participation, this analysis is an example of how identifying the characteristics associated with each stage of the referral-evaluation-enrollment procedure can provide valuable information to help states target interventions to identify and retain children in EI at each stage. In Massachusetts, this information is being utilized by perinatal and EI programs to improve referral, evaluation, and enrollment, to ensure vulnerable populations receive services to optimize children's development.

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