

Continued Exposure to Maternal Distress in Early Life Is Associated with an Increased Risk of Childhood Asthma

Anita L. Kozyrskyj^{1,2,3}, Xiao-Mei Mai¹, Patrick McGrath⁴, Kent T. HayGlass⁵, Allan B. Becker³, and Brian MacNeil⁶

¹Faculty of Pharmacy, ²Department of Community Health Sciences, Manitoba Centre for Health Policy, and ³Department of Pediatrics and Child Health, Faculty of Medicine, University of Manitoba, Winnipeg, Manitoba, Canada; ⁴Department of Psychology, Faculty of Science, Dalhousie University, Halifax, Nova Scotia, Canada; and ⁵Department of Immunology, Faculty of Medicine, and ⁶School of Medical Rehabilitation, University of Manitoba, Winnipeg, Manitoba, Canada

Rationale: Evidence is emerging that exposure to maternal distress in early life plays a causal role in the development of childhood asthma. **Objectives:** Because much of the data are from high-risk cohorts, we undertook a birth cohort study in a complete population of children to test this association.

Methods: Using Manitoba, Canada's, health care and prescription databases, this longitudinal study assessed the association between maternal distress during the first year of life and onward, and asthma at age 7 in a 1995 birth cohort of 13,907 children.

Measurements and Main Results: Maternal distress was defined on the basis of health care or prescription medication use for depression or anxiety. Asthma status was derived from health care and prescription records for asthma, using a definition validated by comparison to pediatric allergist diagnosis. Multiple logistic regression was used to determine the likelihood of asthma (odds ratio [OR], 95% confidence interval [95% CI]). Independent of well-known asthma risk factors, our population-based study of a non-high-risk cohort demonstrated an increased risk of childhood asthma (OR, 1.25; 95% CI, 1.01–1.55) among children exposed to continued maternal distress from birth until age 7. Exposure to maternal depression and anxiety limited to the first year of life did not have a demonstrable association with subsequent asthma. Of interest, we observed that the risk of asthma associated with continued maternal distress was increased in children living in high- versus low-income households (OR, 1.44; 95% CI, 1.12–1.85). **Conclusions:** Maternal distress in early life plays a role in the development of childhood asthma, especially if it continues beyond the postpartum period.

Keywords: asthma; child; depression, postpartum

It is increasingly clear that traditional environmental risk factors do not fully explain the origins of childhood asthma and atopy. Growth in chronic stress of women has paralleled the rising prevalence of asthma in the Western world (1, 2). This is particularly true for inner-city low-income neighborhoods where family stress levels are high (3). Stress is a well-known precipitant for asthma exacerbations in children (4). However, recent epidemiologic evidence suggests that maternal stress in early life may lead to the development of childhood asthma. Caregiver stress has been associated with increased cord IgE levels and been shown to increase the frequency of wheeze in infants (5–8). In addition, parenting difficulties in the first year of life have been associated with asthma at ages 6–8 (9). Importantly, these studies controlled for known asthma risk factors such as

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Evidence is emerging from animal models and high-risk birth cohorts that exposure to maternal distress in early life plays a causal role in the development of childhood asthma.

What This Study Adds to the Field

In a population-based cohort of children born in 1995, maternal distress in early life was associated with an increased risk of childhood asthma, especially with distress that continued beyond the postpartum period.

birth weight, viral respiratory infections, and maternal smoking, thereby establishing stress as an independent risk factor for asthma.

The proposed mechanisms through which maternal stress may increase the risk of asthma in children are based on two well-characterized processes, as reviewed by von Hertzen (10). First, the neural and endocrine responses that result from stress drive immune responses in infants toward the development of atopy and asthma. Second, these stress responses are exaggerated in offspring if maternal stress was present during the developmental process. Consistent with this thesis, Wright and colleagues reported that caregiver stress in the first 6 months after birth was associated with an atopic immune profile in infants predisposed to asthma: increased production of tumor necrosis factor- α , reduced IFN- γ production, and an increased proliferative response to Der f 1 (8). Furthermore, others have identified that maternal distress disorders, namely depression, are the “toxic” components of caregiver stress that lead to asthma development (9). Meta-analysis evidence shows that postpartum depression has a large effect on mother–infant interactions and disrupts bonding between mother and child (11). Depressed mothers demonstrate less affection and fewer responses to infant cues. Their infants spend more time fussing and crying, and exhibit more stress behaviors compared with infants of mothers who are not depressed (12).

Although these hypothesized causal links between maternal distress and childhood asthma are intriguing, much of the epidemiologic evidence to date has been derived from small cohort studies of genetically high-risk children. Our primary research objective was to determine whether maternal distress in early life was associated with the development of childhood asthma in a complete population of children, including children who were or were not predisposed to asthma. To this end, we assessed the risk of asthma at age 7 years in a cohort of 13,980 born in Manitoba, Canada, in 1995 in relation to their exposure

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Correspondence and requests for reprints should be addressed to Anita Kozyrskyj, Ph.D., 210 Pharmacy Building, Winnipeg, MB, Canada, R3T 2N2. E-mail: kozyrsk@cc.umanitoba.ca

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to maternal distress in the first year of life and onward, controlling for early-life exposure to other asthma risk factors. Preliminary findings from this research have been published in an abstract (13).

METHODS

This was a longitudinal study (known as the Study of Asthma, Genes, and the Environment) of a cohort of 13,980 children born in Manitoba in 1995 and continuously registered with the Manitoba Health Services Insurance Plan (MHSIP) until 2003. The likelihood of asthma at age 7 according to maternal distress during the first year of life and afterward was determined. Data sources were the complete health care administrative records for the cohort, including all physician visits, hospitalizations, and prescription drugs collected by MHSIP in the provision of universal health insurance to Manitoba residents. MHSIP databases are reliable and valid data sources (14, 15). Database record linkages were achieved through anonymous personal identifiers. A family registration number permitted linkage of maternal and child records. Seventy-three children were excluded from the analysis (study $n = 13,907$) due to the inability to link to maternal health care records. This study was approved by the Health Research Ethics Board at the University of Manitoba and the Health Information Privacy Committee.

Current asthma at age 7 was defined as at least two physician visits for asthma, one asthma hospitalization, or two prescriptions for any asthma drug (β -agonists, inhaled corticosteroids, cromones, or leukotriene receptor antagonists) in the year after the child's 7th birthday. This definition was chosen from a validation study in a subset of 539 cohort children recruited for clinical assessment by an allergist (16, 17), on the basis of a high positive predictive value (94%, 95% confidence interval [CI], 82–99%) and high specificity (92%, 95% CI, 78–98%). Seventy-five percent of children in the study cohort received their first diagnosis of asthma after the postpartum period.

Maternal distress was determined on the basis of physician visits, hospitalizations, or prescription medications for depression or anxiety during the first year of life and afterward. Diagnoses included *International Classification of Diseases* (9th revision) codes (296, 300, 309, 311) for episodic mood disorders; anxiety, dissociative, and somatoform disorders; and adjustment reactions and depressive disorders. Prescription medications included selective serotonin reuptake inhibitor (SSRI) and non-SSRI antidepressants, anxiolytics, and hypnotics. These diagnoses and prescription medications encompass common depressive and anxiety disorders in the postpartum period, and have been operationalized into database definitions by others (18, 19). Our validation of this database definition against maternal report of postpartum distress in a subset of 454 women revealed it to be a specific (83%, 95% CI, 78–87%), but not sensitive (21%, 95% CI, 16–27%), measure for maternal distress in the first year of life (20). The sensitivity increased to 42% (95% CI, 21–66%) in mothers reporting depressive symptoms more often. Duration of maternal distress was incorporated to create a four-category variable: no postpartum distress, postpartum distress only, short-term maternal distress (at least one episode during the first year and the first to fifth year), and long-term maternal distress from the birth of the child to age 7 (at least one episode during the first year, the first to fifth year, and the fifth to seventh year). This classification also measured intensity of maternal distress. The mean number of health care visits for depression and anxiety increased successively with duration of distress, and dramatically so, in mothers with long-term distress (16 visits in comparison to 4.4 visits among mothers with short-term distress; Table 3). Similarly, the mean number of prescriptions for depression and percentage of mothers receiving one or more antidepressants rose with duration of distress. Of note, health care and antidepressant use was much higher during the postpartum period for the long-term distress group.

Risk and protective factors for asthma, derived from health care administrative records (16), included gender, urban (municipality population > 40,000) or rural location, neighborhood income, total number of siblings at age 7, number of health care visits during the first year of life, and maternal history of asthma (at least one physician visit or hospitalization for asthma during pregnancy and the prior 5-yr period, or one prescription for an asthma drug during pregnancy).

Additional confounding or pathway factors included the number of lower respiratory tract (bronchitis, bronchiolitis, pneumonia), upper respiratory tract (otitis media, pharyngitis, sinusitis), nonrespiratory tract infections (genitourinary infections, cellulitis, and impetigo), and the number of antibiotic prescriptions (categorical format).

Crude odds ratios for asthma at age 7 years were first determined, followed by ratios adjusted for the above confounding factors. The latter values were achieved with multiple logistic regression analysis, using SAS software (SAS Institute, Cary, NC). Variables were retained in models at the 95% level of confidence. Separate models were tested for male and female children, for children living in urban and rural areas, for children with and without maternal history of asthma, for children living in high- and low-income households, and for children with few or many siblings. The stratified analyses were based on *a priori* questions we had previously pursued (16). To test for reverse causation (maternal distress appearing after asthma is diagnosed in the child), analyses were re-run after the exclusion of 167 children with diagnoses during the first year of life indicative of asthma (two or more asthma diagnoses and atopic dermatitis, or maternal history of asthma) using the Castro-Rodriguez asthma high-risk index (21).

RESULTS

Among the 13,907 children born in Manitoba in 1995, 18.9% were exposed to maternal distress during their first year of life, as indicated by health care use for depression and anxiety. The prevalence of current asthma at age 7 years in the population of children as a whole was 6.6%. Maternal asthma, urban location, low family income, total health care visits, lower respiratory tract infection, nonrespiratory infection, and the use of antibiotics were all positively associated with maternal distress during the child's first year of life (Table 1). Conversely, the number of siblings was inversely associated with maternal distress. In addition, all the mentioned variables were significantly associated with child asthma at age 7, except for family income (Table 1).

There was a highly significant association between maternal distress in early life and subsequent expression of asthma. 8.3% of the children who were exposed to maternal distress during the first year of life had asthma at 7 years of age compared with 6.2% of the children who were not exposed to maternal distress ($P < 0.001$). The crude odds ratio (OR) was 1.38 (95% CI, 1.18–1.62). Among children who had exposure to maternal distress during their first year of life, 5.7% of them had exposure to maternal distress only during the first year, 4.5% had subsequent exposure to short-term maternal distress, and 8.7% of the children had continued exposure to long-term maternal distress (Table 2). A dose-response relationship between maternal distress and childhood asthma was observed, with the highest prevalence of asthma in children who were exposed to long-term maternal distress ($P < 0.001$ by trend test). Overall, mothers of children with asthma had a greater intensity of health care use for depression/anxiety in early life than mothers without children with asthma, especially those with long-term distress (Table 3). However, mothers of children with asthma received a fewer number of antidepressants in the long-term distress category.

Long-term maternal distress was significantly associated with a 1.6 times increased risk of asthma at age 7 years (crude OR, 1.63; 95% CI, 1.33–2.00). However, the association between child asthma and short-term maternal distress or maternal distress only during the postpartum period was not statistically significant (Table 4). Maternal asthma, male gender, urban location, and total health care visits were also associated with an increased risk for asthma in children, and the number of siblings was associated with a decreased risk of asthma (Table 4). After adjustment for these factors, long-term maternal distress was

TABLE 1. PERCENTAGE DISTRIBUTION OF CONFOUNDING FACTORS IN RELATION TO MATERNAL DISTRESS DURING THE FIRST YEAR OF LIFE AND CHILD ASTHMA AT AGE 7

	No.	Maternal Distress during First Year of Life (n = 2,625)			Child Asthma at Age 7 (n = 917)		
		n	%	P	n	%	P
Maternal asthma							
Yes	766	214	27.9	<0.001	109	14.2	<0.001
No	13,214	2,411	18.4		808	6.1	
Child gender							
Male	7,116	1,349	19.0	0.62	593	8.3	<0.001
Female	6,864	1,276	18.7		324	4.7	
Residence Location							
Urban	7,973	1,619	20.3	<0.001	641	8.0	<0.001
Rural	6,007	1,006	16.9		276	4.6	
Family income							
Low	3,489	722	20.8	<0.001	248	7.1	0.13
High	10,491	1,903	18.2		669	6.4	
No. of health care visits							
>20 Visits	5,041	1,201	23.9	<0.001	477	9.5	<0.001
20 Visits or less	8,935	1,423	16.0		440	4.9	
No. of siblings at age 7							
>1 Sibling	7,014	1,251	17.9	0.004	380	5.4	<0.001
1/No sibling	6,966	1,374	19.8		537	7.7	
Lower RTIs during infancy							
Yes	4,956	1,076	21.8	<0.001	448	9.0	<0.001
No	9,024	1,549	17.3		469	5.2	
Non-RTIs during infancy							
Yes	5,766	1,219	21.3	<0.001	524	9.1	<0.001
No	8,214	1,406	17.2		393	4.8	
Antibiotic use during infancy							
Yes	9,289	1,890	20.5	<0.001	706	7.6	<0.001
No	4,691	735	15.7		211	4.5	

Definition of abbreviations: RTIs = respiratory tract infections.
Total n = 13,980.

independently associated with childhood asthma (adjusted OR, 1.34; 95% CI, 1.09–1.66). This increased risk for asthma remained after additional adjustment for lower respiratory tract infection, nonrespiratory infection, and the use of antibiotics (adjusted OR, 1.25; 95% CI, 1.01–1.55). After the exclusion of 167 children with diagnoses during the first year of life indicative of asthma, the association between exposure to maternal long-term distress and asthma at age 7 years remained statistically significant (adjusted OR, 1.25; 95% CI, 1.00–1.56; $P < 0.05$).

The risk of asthma was increased after exposure to long-term maternal distress in the following environments: among children living in high-income households and among children who had more than one sibling (Table 5). Conversely, no association with asthma was observed in children living in low-income families and in children with one or no sibling. The crude OR in children with one or no sibling was statistically significant, but fell to nonsignificance after adjustment for other factors.

DISCUSSION

Our population-based study of 13,907 children demonstrated an association between childhood asthma and exposure to continued maternal distress beginning at birth. This increased likelihood was 1.25 (95% CI, 1.01–1.55) and independent of many well-known risk factors for asthma. Exposure to maternal depression and anxiety that was limited to the first year of life did not have a demonstrable association with the subsequent development of asthma. Our findings are consistent with the epidemiologic literature in high-risk cohorts, which shows an association between maternal stress, infant wheeze, increased cord IgE, and childhood asthma (5, 6, 8, 9). This is the first study

of a non-high-risk cohort of children to report an association with childhood asthma (7).

An important original contribution of our study is the stratification of maternal distress by duration. At first glance, our findings indicate that the risk of childhood asthma was almost 1.5 times higher in the presence of maternal distress detected in the first year of life. However, this prevalent measure included mothers with distress in the first year of life only, as well as those who continued to experience distress 6 years later. Unlike existing studies that have measured maternal stress during the first few years only (5–9), the longitudinal nature of our health care database study enabled us to characterize maternal distress over time to identify whether it continued. When this was done, the association with asthma was clearly not significant in the situation of postpartum distress only (OR, 1.05; 95% CI, 0.79–1.41). In contrast, the association was highly significant for those children with continued exposure to maternal distress from birth.

Our findings are analogous to the work by Essex and colleagues, who demonstrated that elevated cortisol levels and

TABLE 2. PERCENTAGE OF CHILD ASTHMA AT AGE 7 ACCORDING TO DURATION OF MATERNAL DISTRESS

	Maternal Distress, n (%)	Child Asthma at Age 7, n (%)
No distress (reference group)	11,282 (81.1)	694 (6.2)
Only at first year	791 (5.7)	55 (7.0)
Short-term distress	623 (4.5)	46 (7.4)
Long-term distress	1,211 (8.7)	117 (9.7)*

Total n = 13,907.

* By chi-square test for trend, $P < 0.0001$.

TABLE 3. MATERNAL HEALTH CARE AND PRESCRIPTION MEDICATIONS FOR DEPRESSION AND/OR ANXIETY BY DISTRESS CATEGORY DURING THE CHILD'S FIRST YEAR OF LIFE AND THEREAFTER

Distress Category	Postpartum (n = 791)	Short-term (birth–5 yr) (n = 623)		Long-term (birth–7 yr) (n = 1,211)	
	First Year	First Year	First–Fifth Year	First Year	First–Seventh Year
Mean no. of health care visits (%*)					
Asthma	1.4 (78)	1.9 (89)	4.5 (91)	2.5 (80)	18.4 (98)
No asthma	1.2 (80)	1.7 (84)	4.4 (93)	2.6 (77)	15.7 (97)
Total	1.2 (80)	1.7 (84)	4.4 (93)	2.5 (77)	15.9 (97)
Mean no. of prescriptions (%†)					
Asthma	0.1 (6)	0.6 (20)	1.4 (41)	1.0 (33)	12.5 (85)
No asthma	0.2 (11)	0.5 (20)	2.1 (39)	1.2 (32)	13.6 (76)
Total	0.2 (11)	0.5 (20)	2.0 (39)	1.2 (32)	13.5 (77)

* Percentage in group with 1+ visits.

† Percentage in group with 1+ antidepressants.

behavioral problems were more common in children whose mothers had postpartum and later-life depression (22). Thus, although current literature shows that maternal depression during the postnatal period increases cortisol levels in offspring in later life, and that maternal stress in early life promotes an enhanced allergy-specific proliferative response in infants (8, 22), isolated postpartum distress was not related with asthma in later life in our birth cohort of 13,907 children. Rather, our data indicate that continued exposure to maternal distress is important for this to happen. Depressed mothers are less likely to interact with their infants (23). Animal models suggest that poor mother–infant interactions cause epigenetic modification of DNA, which increases the expression of the glucocorticoid receptor gene and alters hypothalamic-pituitary-adrenal (HPA) responses to stress in the infant (24). This epigenetic modification can be reversed, but perhaps not when the child continues to be exposed to a noninteractive mother.

We observed that the risk of asthma subsequent to continued maternal distress was increased under specific home environments. Continued maternal distress was associated with asthma in children living in high-income households and in children who had more than one sibling. Consistent with the literature, maternal distress was more common in low-income households in our study (25). Given these findings, lack of an association between maternal distress and asthma in low-income households was unexpected. However, children in low-income households may be exposed to additional risk factors for asthma, such

as frequent respiratory tract infections, which cannot be disentangled from maternal distress, or protective factors, such as higher endotoxin levels, which counterbalance the effect of maternal distress (26). Of interest, our high-income finding is reminiscent of early literature, which reported that asthma was more common in children with overprotective mothers living in high-income households (27). We also observed more frequent maternal distress in one- or two-child families, which is consistent with the enhanced stress response reported among infants with few siblings (28). However, in the small-family context, the association with asthma disappeared after adjustment for other risk factors. The fact that the association remained for children with multiple siblings suggests that maternal distress is an independent risk factor for asthma only in large families.

The major strength of our study is that it was not limited to a birth cohort at high risk for asthma but studied a broad range of maternal stressors in an entire population of children, with representation from urban and rural areas. We used health care database definitions for school-age asthma and postpartum distress, which were found to be highly specific in our validation studies (17, 20). High specificity of measurement is required for epidemiologic research (29). Using longitudinal data over a 7-year period, maternal distress was characterized according to duration and intensity of distress. Our research identified a group of mothers with long-term distress who had a substantially higher intensity of health care utilization during the first year of life than mothers with postpartum distress. As

TABLE 4. RISK OF ASTHMA AT AGE 7 SUBSEQUENT TO EXPOSURE TO MATERNAL DISTRESS AND OTHER ENVIRONMENTAL FACTORS

	Crude OR (95% CI)	Adjusted OR* (95% CI)	Additional Adjustment†
Maternal distress only at first year versus none (reference)	1.14 (0.86–1.52)	1.08 (0.81–1.44)	1.05 (0.79–1.41)
Short-term maternal distress versus none	1.22 (0.89–1.66)	1.07 (0.78–1.47)	1.00 (0.72–1.37)
Long-term maternal distress versus none	1.63 (1.33–2.00)	1.34 (1.09–1.66)	1.25 (1.01–1.55)
Maternal asthma versus none		2.22 (1.78–2.77)	2.06 (1.64–2.57)
Male versus female gender		1.82 (1.58–2.10)	1.74 (1.51–2.01)
Urban versus rural location		1.54 (1.33–1.80)	1.64 (1.41–1.92)
Low versus high family income		1.14 (0.98–1.34)	1.02 (0.87–1.19)
No. of health care visits		1.02 (1.02–1.03)	1.01 (1.00–1.02)
No. of siblings		0.89 (0.84–0.94)	0.86 (0.81–0.91)
No. of lower respiratory tract infections			1.06 (1.04–1.08)
No. of nonrespiratory tract infections			1.15 (1.11–1.19)
1–2 Courses of antibiotics versus none			1.26 (1.05–1.51)
3–4 Courses of antibiotics versus none			1.32 (1.06–1.64)
>4 Courses of antibiotics versus none			1.45 (1.15–1.82)

Definition of abbreviations: CI = confidence interval; OR = odds ratio.

Total n = 13,907.

* Adjusted for maternal asthma, gender, urban/rural location, family income, number of health care visits, and number of siblings.

† Additional adjustment for number of lower respiratory tract infections, number of nonrespiratory tract infections, and course of antibiotic prescriptions.

TABLE 5. RISK FOR ASTHMA AT AGE 7 SUBSEQUENT TO LONG-TERM MATERNAL DISTRESS FROM BIRTH, STRATIFIED BY CHILD GENDER, MATERNAL ASTHMA, RESIDENCE LOCATION, FAMILY INCOME, OR NUMBER OF SIBLINGS

	Crude OR	Adjusted OR*	Additional Adjustment†
Gender			
Male	1.66 (1.29–2.15)	1.35 (1.04–1.75)	1.27 (0.97–1.65)
Female	1.58 (1.11–2.24)	1.33 (0.93–1.90)	1.27 (0.97–1.65)
Maternal asthma			
Yes	1.42 (0.85–2.37)	1.34 (0.78–2.29)	1.31 (0.76–2.25)
No	1.55 (1.24–1.94)	1.34 (1.06–1.69)	1.24 (0.98–1.56)
Location			
Urban	1.53 (1.20–1.94)	1.34 (1.05–1.71)	1.25 (0.97–1.61)
Rural	1.67 (1.13–2.49)	1.34 (0.89–2.02)	1.25 (0.97–1.61)
Family income			
Low	1.31 (0.88–1.94)	0.97 (0.65–1.45)	0.88 (0.58–1.32)
High	1.77 (1.39–2.26)	1.54 (1.20–1.97)	1.44 (1.12–1.85)
Number of siblings			
>1	2.01 (1.48–2.73)	1.56 (1.13–2.14)	1.45 (1.05–2.00)
1 or none	1.37 (1.04–1.81)	1.19 (0.89–1.58)	1.11 (0.83–1.49)

* Adjusted for maternal asthma, gender, urban/rural location, family income, number of health care visits, and number of siblings. Stratification variable excluded where appropriate.

† Additional adjustment for number of lower respiratory tract infections, number of nonrespiratory tract infections, and course of antibiotic prescriptions.

reported in the literature, this level of severity of maternal psychopathology disrupts mother–infant bonding (30, 31). We adjusted for important confounding factors, such as health care utilization bias. Maternal distress and childhood asthma were more common in urban families, in families with maternal asthma, and in families that use the health care system, indicating the need to adjust for such confounding factors. Indeed, they explained some of the increased risk of childhood asthma. Finally, within the limitations of using health care contact as a proxy for disease onset, our findings were unchanged in analyses that excluded children diagnosed with the asthma in the first year of life, suggesting that reverse causation was not a significant bias. Asthma was diagnosed after the postpartum period in the majority of study children, which further increased our confidence that findings were not due to reverse causation.

Despite these strengths, our study was limited in the following ways. Although the database definition for postpartum distress was specific, it had low sensitivity in comparison to maternal report. Postpartum distress is multifactorial and hard to diagnose (18, 32), and we are unsure that maternal recall is the best gold standard. At the very least, our health care database definition included more severe depression or anxiety that resulted in a health care visit by the mother (19). Reluctance to obtain health care for depression and anxiety is greater among low-income women (33). This may have resulted in greater misclassification of depression or anxiety among low-income households in our study, and the subsequent lack of an association between maternal distress and asthma in this income group. We were also unable to adjust for maternal behaviors that are influenced by maternal depression, such as maternal smoking and breastfeeding. However, the association between maternal stress and depression has been shown to be independent of these factors (9). Finally, we did not test for the effects of distress during pregnancy.

Our observation of an increased risk for asthma was independent of the presence of infections in early life, as measured by the use of antibiotics and by health care for lower respiratory or nonrespiratory infections. Although these measures may be considered markers for the early signs of asthma (34), they may also be in the pathway between maternal distress

and child asthma. It is known that respiratory tract infections are much more likely in the children of parents experiencing stress (35). If childhood infections are indeed in the pathway between maternal distress and asthma, our analyses would be overadjusted, and the risk of asthma may be closer to the partially adjusted OR of 1.34.

In summary, our population-based study of 13,907 children found an increased risk of childhood asthma among children exposed to maternal distress after birth and onward. No association with childhood asthma was observed when the exposure to maternal depression or anxiety was limited to the postpartum period only. Although our findings are hypothesis generating, they are corroborated with animal and human studies that show an association between poor mother–infant interactions and later asthma (36, 37). They are consistent with emerging evidence that maternal care alters stress responses in the offspring through an epigenetic mechanism of inheritance (24, 38). Our population-based findings hint at obvious social, clinical, and public policy indications, particularly for new parents (39), but further study is required before recommendations for the early intervention of maternal distress can be made to prevent the development of asthma.

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