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Prenatal use of cleaning and scented products and its association with childhood asthma, asthma symptoms, and mental health and developmental comorbidities

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ABSTRACT

Introduction: Occupational use of cleaning chemicals has been related to asthma in adults. However, little information is available on the effect of non-occupational use of cleaning products during pregnancy on childhood asthma. This study examines the association between prenatal exposure to cleaning and scented products with childhood asthma, asthma symptoms, and mental and developmental comorbidities among low-income families in Karachi, Pakistan.

Methods: Four hundred children from the Koohi Goth Women's Hospital were included in the study. Parents' or guardians reported current asthma, asthma-related symptoms, mental health problems, and behavioral problems among the children. Multivariable logistic regression analysis was used to examine the association between the use of cleaning and scented products during pregnancy and seven different outcome variables.

Results: The odds of nocturnal cough were significantly elevated among children whose mothers reported the use of cleaning products (OR: 2.23, 95% CI: 1.15–4.31) or scented products (OR: 2.15, 95% CI: 1.22–3.77) during pregnancy. Mental health comorbidities were threefold elevated (OR: 3.05, 95% CI: 1.74–5.35) among children whose mothers reported using scented products during pregnancy. There was no statistically significant association of the prenatal use of cleaning or scented products with current asthma status or nocturnal symptoms of wheezing, shortness of breath, and chest tightness among children.

Conclusions: The study results indicate prenatal exposure to cleaning and scented products is associated with nocturnal cough among children. The study also suggests an association between prenatal use of scented products and mental health comorbidities among children.

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Introduction

Asthma, a leading non-communicable chronic disease, causes inflammation of the airways of the lungs and serious difficulty breathing (1). Globally, asthma affects approximately 358 million people (2) and results in an estimated 383 000 deaths each year (3). Furthermore, asthma is attributed to 15 million disability-adjusted life years lost, contributing significantly to the overall burden of disease (4). Asthma typically begins in childhood and may persist into adulthood (1). The International Study of Asthma and Allergies in Childhood (ISAAC) reported approximately 14% of children to suffer from asthma symptoms such as wheezing, coughing, and shortness of breathing (5). The childhood burden of asthma, as determined by disability and premature death, is greatest among children between 10 and 14 years old (6).

The prevalence of asthma is highest among children who live in developing countries (3,6).

Cleaning and scented products are regularly used in households for general-purpose cleaning, disinfection, and dirt removal. Commonly used household cleaning products such as bleach, soap powders or bars, laundry detergents, ammonia, and multipurpose cleaner have toxic properties, and many are volatile organic compounds (7). Several of these products have been linked to chronic diseases such as upper respiratory disorders, asthma, cardiac disease, and cancer (8–12). Two systematic reviews found that exposure to cleaning products increases the risk of asthma among the domestic and non-domestic cleaners (13,14). Individual components of cleaning products such as bleach have been linked to asthma and asthma symptoms (15). Accidental exposure to a

high concentration of bleach and ammonia can result in irritant-induced asthma called reactive airways dysfunction syndrome (16).

Prenatal period, especially the early trimester, plays a critical role for the healthy growth of the fetus. Prenatal exposure to both indoor and outdoor environmental factors is linked to childhood asthma in developing countries (17–20). The use of cleaning products during pregnancy has been linked to adverse respiratory and other health effects among children (21–24). The developing fetus is especially at risk of adverse respiratory health outcomes from exposure to household cleaning products. Prenatal exposure to chemicals such as phthalates has been related to mental and developmental impairment (25,26). However, little information is available on prenatal exposure to cleaning substances on a child's mental and developmental health. The majority of the studies are from developed countries, as opposed to developing countries where exposure profiles may be different. Furthermore, the adverse respiratory health effects of exposure to occupational cleaning related substances have been well documented. However, limited research has been done to explore the association between prenatal exposure to household cleaning products and the prevalence of childhood asthma, especially in developing countries.

The objective of the present study, therefore, was to investigate the association of household cleaning products with the prevalence of childhood asthma, asthma symptoms, and the presence of mental health and developmental comorbidities among low-income families in Pakistan. We hypothesize that prenatal exposure to cleaning and scented products increases the risk of asthma and asthma symptoms among children. Furthermore, we hypothesize that prenatal exposure to cleaning and scented products increases the risk of mental and developmental health comorbidities among children.

Methods

The study sample consisted of 400 parents or guardians of children visiting the outpatient clinic of Koochi Goth Women's Hospital (KGWH) (27,28). KGWH is a private nonprofit hospital which provides free primary care to women and children, as well as free tertiary care for women who come from low-income families. The KGWH physician enrolled children based on the clinical examination. Three KGWH nurses interviewed parents or guardians of children at the hospital or the residence of parents.

Several of the questionnaire items were adapted from the Pakistan Demographic and Health Survey 2006–07(29). Two bilingual individuals along with the primary care physician of KGWH translated the study questionnaire and informed consent in Urdu, the native language of Pakistan. For the present study, five different outcomes were defined based on self-reported current asthma and asthma-related symptoms such as nocturnal wheezing, nocturnal cough, nocturnal shortness of breath, and nocturnal chest tightness. Current asthma was defined based on affirmative responses to the following two items “Have you ever been told by a doctor, nurse or health professional that your child has asthma?” and “Does your child still have asthma?” The outcomes related to asthma symptoms were defined based on an affirmative response to the question “Has your child been awakened during the night by an attack of wheezing, cough, shortness of breath, and chest tightness in the last 12 months?” The secondary outcome of interest was the index of childhood mental health and developmental comorbidities (27). Briefly, factor analysis was used to group eight self-reported comorbidities into two constructs. The first construct, “mental health,” included anxiety, attention, and behavioral problems, and the second construct, “developmental problems,” including learning problems, hearing impairment, developmental delay, and speech problems.

Prenatal exposure to household cleaning supplies or scented products was the primary exposure of interest. A participant was considered exposed by an affirmative response to the survey questions, “While pregnant with this child how many times per week did you clean your house?” or, “How many days a week did you spray perfume or scented cleaning products at your house, while pregnant with this child?” Responses were categorized into two groups: never or rarely and at least once a week. Participants who used cleaning products only once a month were combined with those who never used cleaning products, to be considered unexposed. Relevant covariates included the child's age, gender, number of younger siblings, house water damage, smoking status of parents, and owning a cat, dog, goat, or poultry while pregnant with the child. Parents were asked about the child's weight at the time of birth. However, only 13 respondents were able to recall the weight their child, likely due to low education. Because of the missing responses, we decided to include the follow-up question “... At the time of birth, would you consider this child: very large, larger than average, average, smaller than average, very small, don't know.” This question was adapted from the Pakistan Demographic

and Health Survey 2006-07 (29). Response options very large ($n=7$) and larger than average ($n=9$) an average ($n=235$) were grouped and labeled as average and the response options smaller than average ($n=61$), and very small ($n=52$) were grouped together as smaller than average; there were 36 missing that were coded as a missing category.

Data were analyzed using descriptive summary statistics. To determine the association of household cleaning products used during pregnancy with current asthma, asthma symptoms, and mental health and developmental comorbidities, adjusted Odds Ratios (ORs) and corresponding 95% confidence intervals were computed using bivariate and multivariate logistic regression. Stata version 14.0 was used for the

analysis. The study was approved by the Institutional Review Board of the University of North Carolina at Charlotte.

Results

Of the study population, 52% of the children were male, and 48% were female, with an average age of 6 years (SD 2.9 years). Approximately, 28% of children were born small or very small. Half of the study population had one or more young siblings. Sixty-three percent of parents reported household water damage, and 6% of mothers reported smoking during pregnancy. About 20% owned a cat or a goat during pregnancy, and 16% reported owning a dog while pregnant with the child (Table 1).

Children of mothers who used cleaning products during pregnancy had twice the odds of nocturnal cough, an asthma symptom (adjusted OR: 2.23, 95% CI: 1.15, 4.31). Similarly, children of mothers who used scented products during pregnancy also had twice the odds of nocturnal cough (adjusted OR: 2.15, 95% CI: 1.22, 3.77) (Table 2). This study did not find any statistically significant association between the use of scented or unscented cleaning products during pregnancy and current asthma status or nocturnal symptoms of wheezing, shortness of breath, and chest tightness (Table 2).

The odds of mental health problems were threefold elevated among children whose mothers reported using scented products during pregnancy (adjusted OR: 3.05, 95% CI: 1.74–5.35) (Table 3). Of the three individual comorbidities included in the mental health construct, the ORs were significantly elevated for anxiety problems (adjusted OR: 2.91, 95% CI: 1.63, 5.20) and behavior problems (adjusted OR: 5.39, 95% CI: 2.70, 10.77). Prenatal exposure to cleaning products was associated with twice the odds of mental health problems in the unadjusted analysis only (Unadjusted OR: 1.97, 95% CI: 1.15–3.38) (Table 3). However, the

Table 1. Descriptive characteristics of the study sample, Karachi, Pakistan, 2012.

Variables	<i>n</i> (%)
Age in years, mean (SD)	6.0 (2.9)
Gender of the child	
Male	191 (52.3)
Female	209 (47.8)
Number of younger siblings	
None	188 (47.0)
One	142 (35.5)
Two or more	64 (16.0)
Child's weight at birth ^a	
Average	251 (62.8)
Small/very small	113 (28.3)
Mother smoke cigarettes while pregnant with the child	
Yes	23 (5.8)
No	372 (93.0)
House water damage status	
Yes	253 (63.3)
No	141 (35.3)
Own a cat while pregnant with the child	
Yes	90 (22.5)
No	308 (77.0)
Own a dog while pregnant with the child	
Yes	64 (16.0)
No	332 (83.0)
Own a goat while pregnant with the child	
Yes	80 (20.0)
No	316 (79.0)
Own poultry while pregnant with the child	
Yes	37 (9.3)
No	359 (89.8)

^aMissing observations were coded and included as a missing category.

Table 2. Univariable and multivariable association between prenatal use of cleaning and scented products with asthma and asthmatic symptoms among low-income families, Karachi, Pakistan, 2012.

Outcomes	Prenatal use of cleaning products ^a		Prenatal use of scented products ^a	
	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)
Current asthma	1.23 (0.72–2.09)	1.08 (0.56–2.10)	1.09 (0.69–1.72)	0.96 (0.55–1.69)
Nocturnal wheezing	0.99 (0.59–1.69)	0.85 (0.44–1.66)	1.11 (0.70–1.75)	0.91 (0.52–1.61)
Nocturnal cough	1.99 (1.14–3.46)	2.23 (1.15–4.31)	2.06 (1.26–3.36)	2.15 (1.22–3.77)
Nocturnal shortness of breath	1.06 (0.62–1.79)	0.82 (0.42–1.61)	1.09 (0.69–1.72)	0.94 (0.54–1.65)
Nocturnal chest tightness	1.11 (0.65–1.88)	0.90 (0.47–1.74)	1.08 (0.69–1.71)	0.93 (0.54–1.63)

^aAt least once a week vs. never/rarely.

^bAdjusted for adjusted for child's age, weight at birth, gender, number of younger siblings, house water damage, and mother smoke cigarettes while pregnant with the child, owning a cat, dog, goat, or poultry while pregnant with the child.

Table 3. Unadjusted and adjusted ORs and 95% confidence intervals for the association of prenatal exposure to cleaning and scented products* with mental health and developmental indicators.

Outcomes	Prenatal use of cleaning products ^a		Prenatal use of scented products ^a	
	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)
Mental Health Construct	1.97 (1.15–3.38)	1.86 (0.96–3.60)	3.03 (1.89–4.87)	3.05 (1.74–5.35)
Anxiety problems	1.64 (0.96–2.82)	1.74 (0.88–3.42)	2.67 (1.66–4.31)	2.91 (1.63–5.20)
Attention problems	1.02 (0.55–1.88)	0.85 (0.41–1.77)	1.34 (0.77–2.32)	1.18 (0.63–2.23)
Behavioral problems	2.78 (1.43–5.40)	2.85 (1.33–6.12)	4.80 (2.60–8.86)	5.39 (2.70–10.77)
Developmental Construct	1.33 (0.78–2.28)	1.18 (0.60–2.32)	1.24 (0.78–1.96)	1.14 (0.65–2.00)
Learning problems	1.65 (0.86–3.17)	1.16 (0.53–2.54)	2.47 (1.37–4.46)	2.02 (1.00–4.09)
Developmental delay	0.75 (0.42–1.36)	0.74 (0.35–1.57)	0.84 (0.50–1.42)	0.76 (0.39–1.47)
Hearing impairment	0.94 (0.45–1.97)	0.72 (0.28–1.87)	2.06 (0.97–4.37)	1.59 (0.64–3.92)
Sleep disturbance	1.71 (0.95–3.07)	1.30 (0.65–2.58)	1.90 (1.15–3.12)	1.64 (0.92–2.95)
Speech problems	1.87 (0.96–3.66)	1.47 (0.66–3.27)	2.01 (1.15–3.51)	2.01 (1.02–3.97)

^aAt least once a week vs. never/rarely.

^bAdjusted for adjusted for child's age, weight at birth, gender, number of younger siblings, house water damage, and mother smoke cigarettes while pregnant with the child owning a cat, dog, goat, or poultry while pregnant with the child.

OR was significantly elevated for behavioral problem comorbidity (adjusted OR: 2.85, 95% CI 1.33, 6.12).

Prenatal use of scented products was not associated with developmental problems construct. However, two of the individual comorbidities, learning problems (adjusted OR: 2.02, 95% CI 1.00, 4.09), and speech problems (adjusted OR: 2.01, 95% CI 1.02, 3.97), were significantly elevated among children whose mothers were exposed to scented products during pregnancy (Table 3).

Discussion

This study indicates an association between prenatal exposure to scented and cleaning products with nocturnal cough among children. Furthermore, this study indicates an association between prenatal exposure to scented products during pregnancy and elevated odds of mental health comorbidities among children. However, no association with current asthma status and other asthma-related symptoms was present.

Contrary to our findings, previous studies indicate an association between prenatal exposure to cleaning products and childhood asthma (21–23). A study by Casas et al. examined the use of household cleaning products during pregnancy and infant wheezing and lower respiratory tract infection (LRTI). This study found an association between the use of cleaning spray during pregnancy and an elevated risk of wheezing and LRTI during the first year of infancy (21). Similarly, Sherriff and colleagues reported that prenatal domestic use of cleaning products is associated with persistent wheezing in early childhood (23). Bedard et al. found that the use of household cleaning sprays for at least once a week is significantly associated with the prevalence of asthma (11). Discrepancies between these studies and the present study could

partly be attributed to differences in study populations, research settings, and the use of different cleaning products. The current study was conducted among parents of children from a very low-income neighborhood in a developing country where houses are usually not airtight, and emissions from cleaning products may easily be ventilated. The overwhelming majority of participants reported using Surf, a common cleaning detergent in Pakistan. The ingredients of Surf include nonionic surfactants, enzymes, sodium carbonate, and sodium aluminosilicate. The respiratory health effects of these substances are not known.

The present study also found a significantly elevated odds of nocturnal cough and mental health comorbidities, which includes anxiety, attention disorders, and behavioral problems, among children whose mothers used scented products during pregnancy. Scented products generally come in spray cans, which can increase exposure to harmful chemicals as they cover a greater area when sprayed. Previous research has identified the association between cleaning products in spray forms and the prevalence of asthma or asthmatic symptoms among children and women (8,11). The nighttime cough might be indicative of undiagnosed asthma (30) in this population as about 34% ($n = 98$) of children without current asthma complained of nocturnal cough.

Several studies have reported that prenatal exposure to phthalates, a commonly used consumer product in perfumes and colognes, is related to poor mental health and behavioral outcomes (25,26,31), consistent with our results. Kim et al. (25) in a prospective study reported prenatal exposure to phthalate metabolites was inversely related to mental and developmental indices among children at six months old (25). Furthermore, Whyatt et al. found phthalate metabolite concentrations during pregnancy was related to adverse

mental and behavioral health outcomes among preschool-aged children (26). Our results are consistent with previous study findings. To our knowledge, our findings are the first ones to report the association between the use of scented products and mental comorbidities among low-income families in a developing country. Further studies with better measurements of exposures are needed to understand these findings and explore potential interventions.

Despite these findings, some limitations exist. The use of cleaning and scented products was self-reported and subject to misclassification bias. However, the presence of misclassification bias is likely to be non-differential, resulting in an underestimation of the true OR. The presence of recall bias is minimized by the fact that parents were unaware of the study purpose, and there is no reason to believe that parents of children with asthma or asthma symptoms were more or less likely to recall exposure to fragrances and perfumes during pregnancy as compared to parents of children without asthma or asthma symptoms. While we included many potential confounders, residual and unmeasured confounding could still be present.

Children from low-middle-income countries bears a disproportionately higher burden of asthma morbidity and mortality (32). In countries like Pakistan, which spend less than 1% of its budget on health (33), childhood asthma and accompanying comorbidities can have significant long-term personal and societal cost. Health-care providers should be aware of the emerging risk factors and educate patients about prevention to improve quality of life of children with asthma and comorbidities.

In conclusion, this study found a significant association between prenatal exposure to cleaning products and development of nocturnal cough and the use of scented products during pregnancy and mental health problems among children later in life. Future studies using quantitative measures of cleaning-related chemicals are needed to evaluate the adverse respiratory and mental health effects among children

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