

PEDIATRIC ASTHMA

Early Daycare Attendance Increase the Risk for Respiratory Infections and Asthma of Children

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Objectives. To study the impact of daycare attendance on airways infections and “allergic” symptoms of children aged 1–8 years in Northeast Texas. **Methods:** Self-administrated questionnaires were distributed to parents through Women, Infants and Children offices, daycare centers, elementary schools, clinic centers, hospitals, and churches. The health outcomes consisted of “allergic” symptoms, and respiratory tract disorders. Questions on child care included; type of daycare settings (proxy for the number of children in daycare), time spent at daycare centers per week, and age of entry to a daycare center. **Results.** A total of 3766 children participated in this study, giving a response rate of 71%. Daycare attendance was associated with more frequent respiratory tract infections and “allergic” symptoms, compared to home care. A dose–response relationship between time spent at daycare centers and prevalence of respiratory tract disorders and asthma and allergies was observed. Earlier age exposure at daycare centers was a risk factor for rhinitis up to 7–8 years. **Conclusions.** Daycare attendance had a substantial negative influence on health status of children aged 1–8 years in Northeast Texas.

Keywords allergy, child, common cold, daycare attendance, eczema, rhinitis

INTRODUCTION

For the past decades, an increase in the prevalence of allergic rhinitis, eczema, and asthma has been documented especially in developed countries (1, 2). Data from the National Health Interview Survey in the United States show that the self-reported prevalence of asthma increased 75% between 1980 and 1994 (3). This increase has continued (4). The worldwide increase in these diseases cannot be due to genetic changes or to changed diagnostic criteria (5). Since World War II, the number of women entering the labor force has increased and the number of children cared for outside the home has increased proportionately. In 1995, about 65% of 4-year-old children were at a daycare or nursery school in the United States (6). As the exposure in daycares are different from homes, especially with regard to infectious agents, it is important to assess both the short- and long-term implications of daycare use on the health of children.

It is clear that children attending daycares are more likely to have respiratory tract infections than children in home care (7–9). However, the association between daycare attendance and allergic diseases later in life is a topic of discussion. There is scientific evidence on an inverse association with daycare attendance (i.e., daycare protective) (10, 11), on an association varying with age at

exposure and type of outcome (12–14), and on a positive association (i.e., daycare a risk factor) (15, 16). Major published studies have neither described daycare group size, nor time exposure in a daycare.

The aim of the present article is to analyze the impact of daycare attendance, in terms of the size of the daycare setting, time spent at a daycare center, and age of entry to a daycare center, on respiratory tract infections and “allergic” symptoms among children aged 1–8 years in Northeast Texas, USA.

MATERIALS AND METHODS

This study is part of a cross-sectional study on children’s health and home exposure in Northeast Texas. Children 1–8 years old were eligible participants. Surveys with 89 questions on, for example, health status, home environment and life styles of families, and index children were distributed to parents through Women, Infants and Children offices, daycare centers, elementary schools, clinical centers, hospitals, and churches. Participants were from 9 cities (Cayuga, Flint, Hawkins, Henderson, Larue, Lindale, Longview, Palestine, and Tyler), which covered 7 (Anderson, Gregg, Harrison, Henderson, Rusk, Smith, and Wood) out of 23 counties in Northeast Texas. The randomly selected study sample and the high response rate guarantee that participants are well representatives of children 1–8 years old in Northeast Texas. The questionnaire is the same as used in the Swedish DBH (17) and Bulgarian ALLHOME (18) studies, with small changes on housing characteristics. The same questionnaire has been used in Singapore (19),

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and is used in ongoing studies in Taiwan, Denmark, Korea, and China. The health outcomes were allergic symptoms ever and those in the previous 12 months, and respiratory tract disorders. Questions on children's care included type of daycare (home care; family care; daycare center; home-now-center-early), daycare center exposure time (<20 h/week; >20 h/week), and entry age at a daycare center (<1 year old; 1–2 years old; >2 years old). In our study, “home care” means that children are cared for at home always, while “home-now-center-earlier” means children that are at home right at the time of the study, but that had been at daycare centers before. Family care means that the child is in a private home together with other unrelated children. In United States, family care usually has less than six children.

Statistical Analysis

Associations between daycare status, health outcomes, and other co-variables were analyzed by chi-square tests. Risks of daycare attendance for health outcomes were evaluated in logistic regression models with adjustment for gender, age, whether family members ever had asthma and allergies, number of siblings, months of breastfeeding, exposure to environmental tobacco smoke, and pets. Statistical analysis was performed by SPSS software. A *p*-value <.05 indicates a significant level.

The study was approved by the Institutional Review Board at University of Texas at Tyler. Consents have been obtained from older children and adolescents.

RESULTS

Parents of 3766 children responded the questionnaire, giving a response rate of 71%. After excluding data from children who did not meet the age criteria (i.e., 1–8 years old), 2819 surveys were included in the analysis, out of which 2094 children were preschool children (1–6 years old). The demographic information of children is shown in Table 1. Home cared children were breast-fed for

longer time and less frequently reported to have allergic family members.

The chi-square test on the associations between type of daycare and health outcomes are shown in Supplementary online (Table E-1). Family care and daycare centers were associated with an increased prevalence of allergic symptoms and respiratory tract disorders, compared to home care. Attending a daycare center was more strongly associated with health problems than family care.

The adjusted odds ratios of daycare attendance for health outcomes are shown in Table 2. Compared to home care, attending a daycare center was a significant risk factor for allergic symptoms and respiratory tract infections.

The time spent at daycare centers was categorized into <20 and >20 hours per week. The associations between time spent at daycare centers and health outcomes are shown in Table 3. With the increment of time spent at daycare centers, an increased risk for “allergic” symptoms and respiratory infections were observed among children 1–6 years old, especially for rhinitis, hay fever, and ear infection.

There was a dose–response relationship between the age of entry to a daycare center and health outcomes, as shown in Table 4. The earlier the entry to a daycare center, the more “allergic” symptoms and respiratory infections were reported. Attending daycare center before the first birthday was associated with a significant increment in prevalence of both allergic symptoms and respiratory infections.

First onset of wheeze, rhinitis, and eczema of children were reported by parents. The associations between starting age at a daycare center and consequent allergic symptoms are analyzed in Figure 1. Only those cases have been considered for which the daycare center attendance took place before health effects were seen. Daycare center attendance is a risk factor for “allergic” symptoms. Moreover, the strongest effect is observed when children enter a daycare center during their first year of life (*p* < .05).

TABLE 1.—Demographic information of children 1–8 years old in Northeast Texas, 2008–2009.

		Types of daycare (%)				P-value ^b	In school
		Home care	Family care	Daycare center	Center before home now ^a		
Total	<i>n</i>	607	428	760	159		725
Age	1–3 years	50.2	51.6	42.1	26.4		—
	4–6 years	49.8	48.4	57.9	73.6	.000	—
Gender	Male	52.1	50.9	50.3	47.5		50.7
	Female	47.9	49.1	49.7	52.5	.757	49.3
Allergic family ^c	Yes	47.5	50.8	57.3	56.1	.003	58.7
Siblings	≥1	74.6	72.1	69.1	74.5		83.5
	No	25.4	27.9	30.9	25.5	.128	16.5
Breastfeeding	<3 months	55.3	64.8	66.6	67.9		69.2
	≥3 months	44.7	35.2	33.4	32.1	.000	30.8
ETS ^d	Yes	24.5	24.5	24.1	32.3	.187	25.7
Pets	Yes	43.2	34.7	52.8	54.8	.000	50.6

Notes: ^aChild is cared at daycare center before but now cared at home.

^bP-value in chi-square test. Bold indicates significance.

^cWhether family members ever had asthma and allergy.

^dEnvironmental tobacco smoke.

TABLE 2.—Adjusted odds ratios of daycare attendance for health outcomes of children 1–6 years old in Northeast Texas, 2008–2009.

	Adjusted odds ratio ^a			
	Home care (reference)	Family care	Daycare center	Center before home now ^b
Allergic symptoms				
Wheeze ever	1.00	1.18 (0.88, 1.59)	1.64 (1.28, 2.11)	1.55 (1.12, 2.14)
Wheeze in the previous 12 months	1.00	1.10 (0.81, 1.51)	1.47 (1.13, 1.91)	1.23 (0.87, 1.74)
Dry cough in the previous 12 months	1.00	0.92 (0.64, 1.32)	1.63 (1.22, 2.18)	1.25 (0.86, 1.83)
Diagnosed asthma ever	1.00	1.17 (0.76, 1.79)	1.49 (1.04, 2.12)	1.91 (1.29, 2.84)
Rhinitis ever	1.00	1.12 (0.84, 1.48)	2.56 (1.99, 3.30)	1.53 (1.11, 2.11)
Rhinitis in the previous 12 months	1.00	1.08 (0.81, 1.43)	2.24 (1.75, 2.87)	1.52 (1.11, 2.08)
Diagnosed hay fever ever	1.00	1.09 (0.77, 1.54)	1.58 (1.19, 2.11)	1.37 (0.97, 1.93)
Eczema ever	1.00	1.22 (0.74, 2.00)	1.65 (1.11, 2.46)	1.17 (0.70, 1.95)
Eczema in the previous 12 months	1.00	1.05 (0.61, 1.80)	1.26 (0.82, 1.93)	1.38 (0.79, 2.42)
Respiratory tract infections				
Croup ever	1.00	1.03 (0.70, 1.51)	1.38 (1.01, 1.89)	1.27 (0.86, 1.86)
Pneumonia ever	1.00	1.03 (0.65, 1.63)	1.79 (1.24, 2.59)	1.94 (1.27, 2.95)
Ear infection ever	1.00	1.15 (0.87, 1.53)	2.34 (1.79, 3.07)	1.23 (0.88, 1.73)
Common cold ^c	1.00	1.60 (1.06, 2.42)	1.98 (1.38, 2.84)	1.21 (0.73, 2.01)

Notes: ^aOdds ratios were adjusted for gender, age, whether family member had asthma/allergy, siblings, breastfeeding (<3 vs. >3 months), environmental tobacco smoke and pet.

^bChild is cared at daycare center before but now cared at home.

^cCommon cold ≥6 times in the previous 12 months.

TABLE 3.—Adjusted odds ratios of time spending at daycare center for health outcomes of children 1–6 years old in Northeast Texas, 2008–2009^a.

	Home care (reference)		Center care <20 (h/week)		Center care >20 (h/week)		P-value ^b
	n (%)	AOR	n (%)	AOR	n (%)	AOR	
Allergic symptoms							
Wheeze ever	116 (42.3)	1.00	48 (48.0)	1.25 (0.85, 1.84)	179 (54.7)	1.80 (1.38, 2.35)	.002
Wheeze in the previous 12 months	96 (36.0)	1.00	38 (38.0)	1.15 (0.76, 1.74)	138 (42.7)	1.63 (1.23, 2.16)	.092
Dry cough in the previous 12 months	65 (23.5)	1.00	31 (31.0)	1.76 (1.15, 2.70)	102 (31.3)	1.62 (1.18, 2.21)	.035
Diagnosed asthma ever	46 (16.6)	1.00	27 (27.0)	1.62 (0.98, 2.66)	66 (20.1)	1.50 (1.03, 2.18)	.308
Rhinitis ever	178 (64.0)	1.00	78 (78.0)	2.72 (1.83, 4.06)	263 (80.2)	2.49 (1.90, 3.26)	.000
Rhinitis in the previous 12 months	158 (57.5)	1.00	71 (71.0)	2.11 (1.44, 3.09)	254 (77.7)	2.31 (1.77, 3.02)	.000
Diagnosed hay fever ever	81 (29.3)	1.00	44 (44.4)	1.53 (1.00, 2.35)	143 (43.9)	1.62 (1.19, 2.20)	.000
Eczema ever	28 (18.2)	1.00	15 (25.0)	0.97 (0.51, 1.84)	73 (35.3)	1.93 (1.26, 2.94)	.000
Eczema in the previous 12 months	25 (16.2)	1.00	11 (19.0)	0.94 (0.47, 1.87)	50 (24.2)	1.36 (0.86, 2.15)	.064
Respiratory tract infections							
Croup ever	58 (21.0)	1.00	23 (23.0)	1.36 (0.85, 2.18)	79 (24.1)	1.38 (0.98, 1.93)	.371
Pneumonia ever	26 (9.4)	1.00	20 (20.0)	1.69 (0.99, 2.89)	52 (15.9)	1.88 (1.27, 2.77)	.025
Ear infection ever	184 (66.9)	1.00	82 (82.0)	1.82 (1.20, 2.76)	289 (88.4)	2.57 (1.91, 3.45)	.000
Common cold ^c	39 (14.4)	1.00	22 (22.2)	1.63 (0.95, 2.79)	72 (22.1)	2.10 (1.44, 3.07)	.019

Notes: Time exposure was asked among children who attended daycare centers. Family care was not included in this analysis.

^aOdds ratios were adjusted for gender, age, whether family members ever had asthma/allergy, siblings, breastfeeding (<3 vs. ≥3 months), environmental tobacco smoke and pets.

^bLinear-by-linear association.

^cCommon cold ≥6 times in the previous 12 months.

In order to find out whether there is selection bias between respondents and non-respondents, 527 parents who refused to fill out surveys were asked to answer several simple questions. It was found that there were no significant differences in children's gender, age, prevalence of wheeze in the previous 12 months, house type, and environmental tobacco smoke exposure among respondents and non-respondents.

DISCUSSION

A strong point of this study is that it is based on the general population, whereas most studies from the United States are about subgroups, notably children

from a family with a history of allergies, or children from a family with low socioeconomic status. The sample size of this study is reasonably large, and the response rate is good (71%). There is no significant difference in wheezing, house type, and environmental tobacco smoke between responders and non-responders. Therefore, selection bias should not affect the results of this study. The study should give a reasonable picture of the situation in Northeast Texas. Weak points which this study shares with other cross-sectional studies are the risks of recall bias. But with regard to the main issues discussed in this article (e.g., type of daycare, entry age of daycare, number of siblings, and health outcomes), recall bias should not be a problem. The questionnaire has been used in ISAAC (1), DBH (7), and ALLHOME (8) studies.

TABLE 4.—Associations between entry age at daycare center and health outcomes of children 1–8 years old in Northeast Texas, 2008–2009.

	Entry age at daycare center						P-value ^b
	Home care (reference)			> 2 years			
	n (%)	AOR ^a		n (%)	AOR		
Allergic symptoms							
Wheeze ever	241 (43.5)	1.00		116 (46.8)	1.26 (0.92, 1.73)		
Wheeze in the previous 12 months	199 (36.6)	1.00		81 (32.8)	1.05 (0.79, 1.39)		
Dry cough in the previous 12 months	121 (21.7)	1.00		57 (23.1)	1.27 (0.93, 1.74)		
Diagnosed asthma ever	108 (19.4)	1.00		62 (25.0)	1.27 (0.91, 1.77)		
Rhinitis ever	370 (66.2)	1.00		172 (69.9)	1.43 (1.10, 1.85)		
Rhinitis in the previous 12 months	328 (59.2)	1.00		164 (66.9)	1.45 (1.12, 1.87)		
Diagnosed hay fever ever	193 (34.8)	1.00		100 (40.5)	1.12 (0.84, 1.48)		
Eczema ever	61 (19.4)	1.00		35 (26.3)	1.33 (0.86, 2.06)		
Eczema in the previous 12 months	44 (14.0)	1.00		20 (15.0)	0.98 (0.58, 1.66)		
Respiratory tract infections							
Croup ever	107 (19.2)	1.00		49 (19.7)	1.16 (0.84, 1.61)		
Pneumonia ever	65 (11.7)	1.00		27 (10.9)	0.98 (0.66, 1.46)		
Ear infection ever	400 (72.3)	1.00		197 (79.8)	1.68 (1.25, 2.24)		
Common cold ^c	80 (14.6)	1.00		37 (15.2)	1.51 (1.05, 2.17)		
Entry age at daycare center							
				n (%)	AOR		P-value ^b
				254 (53.4)	1.40 (1.01, 1.95)		
				188 (40.1)	0.92 (0.67, 1.26)		
				140 (29.2)	1.66 (1.20, 2.29)		
				126 (26.4)	1.19 (0.80, 1.76)		
				369 (76.9)	1.88 (1.41, 2.52)		
				340 (71.4)	1.79 (1.34, 2.38)		
				204 (43.2)	1.44 (1.05, 1.96)		
				89 (31.1)	1.50 (0.95, 2.37)		
				76 (26.7)	1.23 (0.72, 2.10)		
				132 (27.5)	1.23 (0.86, 1.76)		
				88 (18.4)	1.56 (1.06, 2.30)		
				407 (85.7)	1.82 (1.32, 2.51)		
				93 (19.7)	1.52 (1.03, 2.26)		

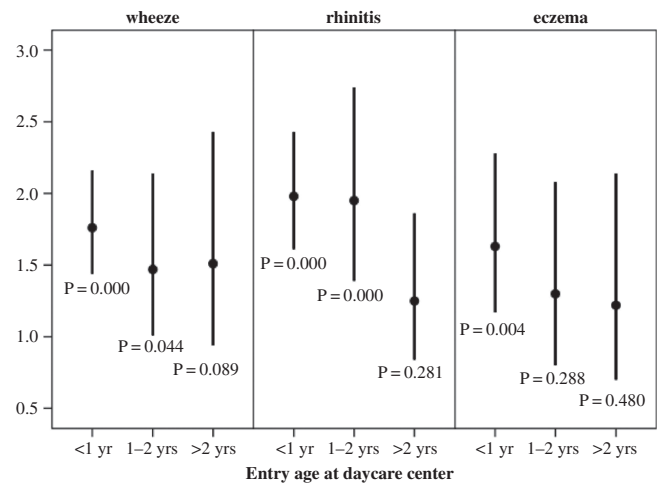
Notes: ^aOdds ratios were adjusted for gender, age, whether family members ever had asthma/allergy, siblings, breastfeeding (<3 vs. ≥3 months), environmental tobacco smoke and pets.^bLinear-by-linear association.^cCommon cold ≥ 6 times in the previous 12 months.

FIGURE 1.—Adjusted odds ratios for wheeze, rhinitis, and eczema depending on the entry age at daycare center (in years) and subsequently occurring symptoms. The odds ratios were adjusted for gender, age, whether family member had asthma and allergy, siblings, breastfeeding (<3 and >3 months), environmental tobacco smoke, and pets. Only those cases have been considered for which the daycare center exposure took place before first health effects were seen. Reference is home care.

We do not have objective data on atopy which is planned for a case-control study in Phase II.

The comparison of the demographic information of children with different caring types (Table 1) indicate that children cared for at homes had more “healthy” family members and less exposure to pets. In order to eliminate the influence of these confounding factors on the association between children’s asthma and daycare attendance, allergy history of family members and pet exposure were adjusted for in the analyses. Therefore, family allergy history and pet exposure does not account for the higher prevalence rates of asthma and allergy among children who attended daycare centers compared to their counterparts who were cared at home.

Our study shows that children cared for outside of home experienced more respiratory illnesses. This is consistent with Hurwitz et al.’s (8) study which showed that approximately 10% of respiratory illness in the United States in children younger than 5 years of age was attributable to daycare attendance. Our study reveals that daycare center attendance caused most health problems, followed by family care settings. This finding is supported by the NICHD study (9), which showed that for children aged 37–54 months, rates of upper respiratory tract illness, gastrointestinal tract illness, and ear infections were higher in those enrolled in child care arrangements with more than six children. However, the number of hours per week in child care in the NICHD study (9) was not a factor. In the present study, the time spent at daycare centers was categorized into <20 and >20 hours per week and it was found that there was a dose-response relationship between exposure time at daycare centers and respiratory illnesses, especially for pneumonia and common cold. These findings in our study indicate that

for preschool children, the likelihood of contracting a communicable illness is primarily a function of exposure to a sufficient number of other children and amount of time spent with them.

Compared to children cared for at home, more allergic symptoms were reported among children cared for in family care and daycare centers. With the increase of time spent at a daycare center, more “allergic” symptoms were reported, particularly wheeze, rhinitis, and hay fever. These findings are supported by previous studies that show daycare attendance is associated with the development of later asthma (7) and with a threefold risk of having recurrent wheezing illness (20). The effect is explained by the increased occurrence of infections among children attending daycare centers. On the contrary, in Celedon’s (21) study it was found that daycare-related exposure was protective for children without a maternal history of asthma, but was associated with an increased risk of wheezing of children with a maternal history of asthma. However, in their study, the number of children with a maternal history of asthma was small ($n = 111$) and most of the children attended family care with modest infectious exposure. Only 52 children attended daycare centers. In our study, 969 children were from non-allergic families and 1061 from allergic families, and daycare facilities were clearly categorized as family care and daycare centers. After stratification by family-member allergy history, attending a daycare center was a risk factor for children’s “allergic” symptoms consistently for both subgroups (Supplementary Table E-2). Ball et al. (12) reported a preventive effect of daycare on the development of asthma lasting up to the age of 13 years. In their study, daycare exposure was defined as daycare before the age of 6 months and information was collected retrospectively around the age of 7 years, introducing the possibility of recall bias (12). Furthermore, in their study a significant effect on asthma was only reported for the combined effects of older siblings and daycare. No prospective study has reproduced these findings. In our study, no evidence of a protective effect of daycare attendance was found up to school age (7–8 years old) (Supplementary Table E-3). Our finding is consistent with the Prevention and Incidence of Asthma and Mite Allergy birth cohort study carried out in the Netherlands (22).

In our study, “home-now-center-earlier” children had significantly higher prevalence of wheeze, asthma, and rhinitis (Table 2). This may partially explain the negative effects of home care observed in some previous studies where the bias from such misclassification was not eliminated (10). The effect could be the same as reported by Bornehag et al. (23) regarding pet exposure. If the family has knowledge about the risk for allergies of exposing a child to pets, the family more often decides not to have pets or get rid of pets, when the child is getting allergic symptoms. Consequently, pets may seem protective to asthma and allergy in cross-sectionals study.

It may be that parents of children with health problems are more likely to take their child out of daycare centers and take care for them at home.

Our study shows that, regardless of number of siblings, there was an increased risk (higher odds ratios) of entering daycare center earlier for respiratory tract infections and “allergic” symptoms. This is supported by the parallel Swedish study (16). In Northeast Texas, 57% children start daycare before their first birthday, among those 37% start daycare before 10 weeks, 36% between 10 weeks and 6 months. The early exposure to daycare center did not show any protective effect (Supplementary Table E-4). Entering daycare center before 1 year and/or between 1 and 2 years of age were significantly associated to subsequent onset of wheeze, rhinitis, and eczema, while these associations either disappeared or became less significant among children attending daycare after 2 years of age.

Our results are not consistent with the “hygiene hypothesis” (24), which states that early infections measured with proxy variables, such as the number of siblings and early daycare attendance, are protective against allergies. If correct, the hypothesis indicates that children today have fewer infections than earlier. However, there are no data supporting this. Instead, there are data showing that in the United States the mean incidence of acute respiratory illness for children 1–9 years old did not decrease from the 1960s to the 1980s (25, 26). The current updates on the hygiene hypothesis suggest that this hypothesis should be examined mainly in the light of exposure to other microbes than airborne virus (27, 28). Gastrointestinal infections are suggested to be more important in the context of the hygiene hypothesis than other infections (29–31). However, so far, in spite of impressive research efforts (32), nothing has been revealed to support this idea. This could be due to that the microflora of our intestines is so complex (1000 trillion microbes of 300–1000 different species), but studies so far have focused on only a small subset of microbes.

Studies showing number of siblings or daycare attendance are protective against allergies are all dealing with children born in the 1950s (24) or up to the 1990s. No study of children born later supports hygiene hypothesis. A recently published international study on wheezing in infants found that attending nursery school was among the most important independent risk factors for occasional wheezing (OR: 2.50; 95% CI: 2.04–3.08) and recurrent wheezing (OR: 3.09; 95% CI: 2.04–4.67) (33). Studies showing that daycare (or siblings) is not protective are from modern societies like the Nordic countries (7, 16, 34) and Holland (22). Perhaps what was protective earlier (e.g., early infections, daycare, or siblings) are not strong protective factors today. Today the main proposed risk factors for the increase in allergies are about new chemicals (35–37) making more or less infections less important.

Sophisticated and multidisciplinary studies on indoor air quality in child care centers are needed to uncover gaps in our knowledge.

CONCLUSIONS

Daycare attendance increases the risk for respiratory tract infections and “allergic” symptoms in children. Indoor environment quality of daycare facilities needs further studies.

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DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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