Published by Oxford University Press on behalf of the International Epidemiological Association
© The Author 2007; all rights reserved. Advance Access publication 28 February 2007

International Journal of Epidemiology 2007;**36**:569–579
doi:10.1093/ije/dym007

Domestic violence is associated with adult and childhood asthma prevalence in India

SV Subramanian,[1]* Leland K Ackerson,[1] Malavika A Subramanyam[1] and Rosalind J Wright[2]

Accepted 12 January 2007

Background Little is known on the influence of stressful psychosocial circumstances in predicting asthma. We examine the link between asthma prevalence and domestic violence (DV) in a nationally representative sample of adults and children in India.

Methods Analyses were based on the 1998–99 cross-sectional nationally representative Indian National Family Health Survey administered in 92 486 households. Individual-level prevalence of asthma was the primary outcome for this study. Exposure to DV was based on women's self-report of DV.

Results In adjusted models, women who experienced DV either recently or in the past were at greater risk of being asthmatic [odds ratio (OR) range 1.26–1.37], compared with those who did not report any abuse. In households where women reported to have experienced DV, asthma risk was higher for all individuals in those households (OR range 1.15–1.19). The association between household DV and individual risk for asthma was also observed in gender-stratified analysis, and also in age-stratified analysis, with strong association observed in age groups of under-five, 5–14, 15–24 and 25–44 years.

Conclusions We find a consistent association between being exposed to, and having experienced, DV and asthma prevalence. Stress-induced mechanisms, partially captured through violence and social circumstances, may be a critical explanatory link in furthering our understanding of the social disparities in asthma.

Keywords Asthma, domestic violence (DV), stress, life stages, India

Introduction

Current understanding of the determinants of asthma has been largely informed through the role of environmental exposures, such as exposure to aeroallergens, indoor and outdoor air pollution, endotoxin, smoking and viral infections.[1,2] More recently, this knowledge base has been supplemented by considering genetic modifiers of environmental exposures on asthma expression.[3,4] Meanwhile, like most diseases, asthma also is socially patterned,[5] with lower socio-economic groups, on average, being more burdened. Some suggest that the observed social patterning in asthma may simply reflect the disproportionate exposure to adverse environmental factors among lower socio-economic groups.[6,7] Others have proposed the differential exposure to psychosocial stressors as a direct explanation to account for the social disparities in asthma.[5,8–11] Laboratory as well as prospective population-based studies have shown associations between stress experiences and asthma expression,[12,13] potentially mediated through physiologic pathways resulting in enhanced IgE expression, enhanced allergen-specific lymphocyte proliferation, and differential cytokine expression in children.[14–16] Using domestic violence (DV) as a marker of stressful pyschosocial circumstance for both those who directly experience the abuse,[17] as well as those who witness the violence,[18] we investigate the relationship between stress and asthma prevalence among adult women, men and children in India.

Methods

Data

The analyses are based on the nationally representative cross-sectional sample of 92 486 households from the 1998–99 Indian National Family Health Survey (INFHS).[19] The household head, or a knowledgeable adult in the household available at the

[1] Department of Society, Human Development and Health, Harvard School of Public Health, USA.

[2] Channing Laboratory, Brigham & Women's Hospital, Harvard Medical School; Department of Society, Human Development and Health, Harvard School of Public Health, USA.

* Corresponding author. 677 Huntington Avenue, KRESGE Bldg, 7th floor, Boston, MA 02115, USA. E-mail: svsubram@hsph.harvard.edu

time of the survey, reported for every household member. Each respondent was surveyed through a face-to-face interview in one of 18 Indian languages in the respondent's own home providing information on a range of health, demographic and socio-economic factors for each member of the household. The total sample of individuals residing in these households was 517 379. The survey response rate ranged from 89% to ~100% across the 26 Indian states.[19] A survey of women, restricted to households with ever married women from ages 15 to 49 years (since the original focus of the survey was on women's reproductive health), was also conducted in ~90% of the households. The outcome (whether a particular household member had asthma) was obtained from the household survey, while the exposure related to DV was self-reported by women on the woman-specific survey. All individuals and households were geo-coded to the primary sampling unit (i.e. villages or groups of villages in rural areas and wards or municipal localities in urban areas), district and state to which they belonged.

We created two analytical data sets. The first was on the ever-married women sample, and after restricting our sample to complete cases on the outcome and chosen predictors our final analytic sample for the ever-married women analysis was 88 513. The second analysis was based on all individuals, and after restricting the sample to complete cases on the outcome and chosen predictors we retained a final sample of 443 249 individuals. Table 1 provides the descriptive sample characteristics of the variables considered for the women-specific and the full sample of all individuals. We additionally conducted gender- and age-stratified analysis in the sample consisting of all individuals. The six age-strata considered for the analysis were <5, 5–14, 15–24, 25–44, 45–64, and >64 years.

Outcome

The outcome was ascertained based upon a single question: 'Does anyone listed as a usual resident of the household suffer from asthma?' Asthma prevalence was thus ascertained for each individual in the household and was considered as a binary outcome. In the final analytic samples, 2.23% of all ever-married women (15–49 years) and 2.25% of all individuals were reported as having asthma (Table 1).

Exposure

We conceptualize DV as one source of psychosocial stress for women as a result of being a victim, and additionally as a household stressor for those (e.g. children, adolescents and young adults) who live in DV-households. In the ever-married women analysis, DV was an individual exposure answering the research question: are women who personally experienced DV more likely to have asthma? In the analysis of all individuals, DV against women was a household variable answering the question: are individuals living in households where a woman experiences DV more likely to have asthma? In India, DV is highly prevalent,[20] ranging between 20% and 40%.[19,21]

Respondents to the ever-married women questionnaire were asked: 'Since you completed 15 years of age, have you been beaten or mistreated physically by any person?' Women who answered yes were then asked, 'How often have you been beaten or mistreated physically in the last 12 months: once / a few times / or not at all?' We combined the above two questions to create a DV measure with the following three categories: never abused / abused over a year ago but not in the past year / abused once or more in the past year (Table 1).

Covariates

Our covariate set included variables that have been previously recognized as predictors of asthma including age, gender, marital status, religion, caste, education, standard of living index, occupation, urban-rural status, smoking status, environmental tobacco smoke exposure (ETS), type of cooking fuel, house type (including whether the house has a separate kitchen), source of energy for lighting, over-crowding and categories of body mass index (BMI) (see Note to Table 1 for a brief explanation of the covariate set). For the gender and age-stratified analysis in all individuals we could not consider BMI or occupation, as this information was only ascertained for the ever-married women sample.

Statistical analysis

Given the hierarchical structure of the sample and the binary outcome, a logistic multilevel modelling approach was adopted.[22–24] We specified a five-level model with a binary response (y, reported as having asthma or not) for individual i living in household j in local area k in district l in state m, of the form, $\pi_{ijklm} : y_{ijklm} \sim \text{Bernoulli}(1, \pi_{ijklm})$. The probability π_{ijklm} was related to a set of categorical predictors, X; and a random effect for each level, by a logit-link function as $\text{logit}(\pi_{ijklm}) = \log(\pi_{ijklm}/(1-\pi_{ijklm})) = \beta_0 + \beta X + u_{0jklm} + v_{0klm} + f_{0lm} + g_{0m}$. The linear predictor on the right-hand side of the equation consisted of a fixed part ($\beta_0 + \beta(X)$) estimating the conditional coefficients for the exposure variable (and covariates), and four random intercepts attributable to households (u_{0jklm}), local areas (v_{0klm}), districts (f_{0lm}) and states (g_{0m}) with each assumed to have an independent and identical distribution and variance estimated at each level. For the ever-married women sample we estimated four-level models (women, local areas, districts, and states). Models were estimated with the quasi likelihood approximation with first-order Taylor linearization procedure.[22]

Results

Social and environmental distribution of asthma risk in India

Table 2 presents the mutually adjusted effects of all predictor variables (including DV) from the analysis based on the 15–49 ever-married women, and the all-individual sample. We summarize the key patterns observed in both samples. Reported asthma was higher in older compared with younger ages. No gender differences were observed in asthma prevalence. Although, in the age-stratified analyses, we found, compared with males, females have a lower risk of asthma until age 14, but higher risk in the 15–44 years strata, with the relative odds lowering in the elderly age group (data not shown). There was an association between caste and asthma, with the 'worse-off' castes having lower risk of asthma. Both education and standard of living index (the two measures of socio-economic status) were inversely correlated with

Table 1 Sample description and prevalence of asthma across the different variables for the ever-married women subsample and the sample of all adult men, women, and children in the 1998–99 Indian National Family Health Survey (INFHS)

	Ever-married women aged 15–49 years		Full sample	
Variable	Subjects (%)	Asthma (%)	Subjects (%)	Asthma (%)
Domestic violence				
Never abused	71 427 (80.7)	1494 (2.1)	343 209 (77.4)	7418 (2.2)
Abused over 1 year ago	8322 (9.4)	241 (2.9)	46 460 (10.5)	1130 (2.4)
Abused in the last year	8764 (9.9)	246 (2.8)	53 580 (12.1)	1361 (2.5)
Location of the household				
Urban population ⩾1 million	9792 (11.1)	156 (1.6)	47 858 (10.8)	765 (1.6)
Urban population 100 000–1 million	5659 (6.4)	108 (1.9)	27 894 (6.3)	502 (1.8)
Urban population ⩽100 000	12 167 (13.8)	224 (1.8)	59 748 (13.5)	1066 (1.8)
Rural area	60 895 (68.8)	1493 (2.5)	307 749 (69.4)	7576 (2.5)
Religion				
Hindu	68 821 (77.8)	1486 (2.2)	337 176 (76.1)	7181 (2.1)
Muslim	10 506 (11.9)	217 (2.1)	58 651 (13.2)	1311 (2.2)
Christian	4927 (5.6)	166 (3.4)	25 450 (5.7)	907 (3.6)
Sikh	2065 (2.3)	27 (1.3)	10 435 (2.4)	135 (1.3)
Other/Missing Religion	2194 (2.5)	85 (3.9)	11 537 (2.6)	375 (3.3)
Caste				
General	36 959 (41.8)	798 (2.2)	186 107 (42.0)	3997 (2.2)
Scheduled caste	15 030 (17.0)	302 (2.0)	74 644 (16.8)	1593 (2.1)
Scheduled tribe	10 755 (12.2)	309 (2.9)	55 788 (12.6)	1562 (2.8)
Other backward class	25 769 (29.1)	572 (2.2)	126 710 (28.6)	2757 (2.2)
Marital status				
Married	83 216 (94.0)	1753 (2.1)	193 491 (43.7)	5933 (3.1)
Widowed	3558 (4.0)	166 (4.7)	17 757 (4.0)	1378 (7.8)
Divorced	367 (0.4)	10 (2.7)	659 (0.2)	36 (5.5)
Separated	1372 (1.6)	52 (3.8)	1722 (0.4)	64 (3.7)
Single			229 620 (51.8)	2498 (1.1)
Years of schooling				
13 or more (College and above)	4472 (5.1)	58 (1.3)	25 351 (5.7)	325 (1.3)
11–12 (High School)	3803 (4.3)	51 (1.3)	21 061 (4.8)	256 (1.2)
9–10 (Secondary School)	10 162 (11.5)	160 (1.6)	55 455 (12.5)	834 (1.5)
6–8 (Middle School)	10 993 (12.4)	212 (1.9)	57 074 (12.9)	1056 (1.9)
1–5 (Primary School)	14 574 (16.5)	334 (2.3)	76 976 (17.4)	2080 (2.7)
0 (No schooling)	44 509 (50.3)	1166 (2.6)	207 332 (46.8)	5358 (2.6)
Standard of living index				
Top quintile	21 458 (24.2)	367 (1.7)	108 094 (24.4)	1828 (1.7)
Fourth quintile	19 406 (21.9)	357 (1.8)	98 487 (22.2)	1935 (2.0)
Third quintile	18 114 (20.5)	463 (2.6)	92 246 (20.8)	2343 (2.5)
Second quintile	15 085 (17.0)	402 (2.7)	74 896 (16.9)	1922 (2.6)
Bottom quintile	14 450 (16.3)	392 (2.7)	69 526 (15.7)	1881 (2.7)
Ever smoked				
No	85 851 (97.0)	1841 (2.1)	225 488 (50.9)	5519 (2.5)
Yes	2662 (3.0)	140 (5.3)	51 440 (11.6)	2522 (4.9)
Not applicable			166 321 (37.5)	1868 (1.1)
ETS				
No	45 576 (51.5)	967 (2.1)	245 769 (55.5)	5593 (2.3)
Yes	42 937 (48.5)	1014 (2.4)	197 480 (44.6)	4316 (2.2)
Fuel				
Low polluting	19 458 (22.0)	333 (1.7)	94 205 (21.3)	1549 (1.6)
Moderate polluting	8184 (9.3)	145 (1.8)	38 669 (8.7)	619 (1.6)
High polluting	60 871 (68.8)	1503 (2.5)	310 375 (70.0)	7741 (2.5)

continued

Table 1 Continued

	Ever-married women aged 15–49 years		Full sample	
Variable	Subjects (%)	Asthma (%)	Subjects (%)	Asthma (%)
Separate kitchen				
No	38 145 (43.1)	914 (2.4)	188 971 (42.6)	4301 (2.3)
Yes	50 368 (56.9)	1067 (2.1)	254 278 (57.4)	5608 (2.2)
Housing type				
Pucca	31 264 (35.3)	605 (1.9)	154 375 (34.8)	2937 (1.9)
Semi-pucca	31 610 (35.7)	727 (2.3)	160 465 (36.2)	3527 (2.2)
Kachha	25 639 (29.0)	649 (2.5)	128 409 (29.0)	3445 (2.7)
Lighting				
Non-polluting	59 258 (67.0)	1233 (2.1)	296 017 (66.8)	6100 (2.1)
Polluting	29 255 (33.1)	748 (2.6)	147 232 (33.2)	3809 (2.6)
People per room				
<1	4994 (5.64)	128 (2.6)	19 246 (4.3)	463 (2.4)
1 to <3	48 102 (54.34)	1105 (2.3)	231 046 (52.1)	5356 (2.3)
3 to <5	21 686 (24.5)	443 (2.0)	113 672 (25.7)	2449 (2.2)
⩾5	13 731 (15.51)	305 (2.2)	79 285 (17.9)	1641 (2.1)
Gender				
Male			223 119 (50.3)	5170 (2.3)
Female			220 130 (49.7)	4739 (2.2)
Employment				
Not working	55 910 (63.2)	1182 (2.1)		
Unpaid non-manual	286 (0.3)	9 (3.2)		
Paid non-manual	4219 (4.8)	89 (2.1)		
Unpaid agricultural	8267 (9.3)	193 (2.3)		
Paid agricultural	11 787 (13.3)	302 (2.6)		
Unpaid manual	429 (0.5)	10 (2.3)		
Paid manual	7615 (8.6)	196 (2.6)		
Body mass index				
<16	4494 (5.1)	197 (4.4)		
16–17	6133 (6.9)	164 (2.7)		
17–18.5	14 930 (16.9)	322 (2.2)		
18.5–23	39 299 (44.4)	737 (1.9)		
23–25	7473 (8.4)	184 (2.5)		
25–30	7710 (8.7)	194 (2.5)		
⩾30	2116 (2.4)	58 (2.7)		
Missing BMI	6358 (7.2)	125 (2.0)		
Total	**88 513 (100.0)**	**1981 (2.2)**	**443 249 (100.0)**	**9990 (2.2)**

Note: The meaning of the variables are described elsewhere;[19,52–56] a brief description is provided here. *Caste*: Scheduled tribes and scheduled castes are the most socially disadvantaged groups and are identified by the government of India for affirmative action. Other backward class comprises a diverse collection of 'intermediate' castes that were considered low in the traditional caste hierarchy but above scheduled castes. General caste is a residual group (i.e. persons who do not belong to a scheduled caste, scheduled tribe or other backward class) that enjoys higher status in the caste hierarchy. *Standard of living index*: is linear index derived from combining household assets and material possessions. Asset ownership indices are commonly used as a reliable and valid surrogate measure for wealth and standard of living. *Fuel*: high-polluting fuels: wood, animal dung or crop residues; medium-polluting fuels: coal/coke/lignite/charcoal or kerosene; low-polluting fuels: electricity, petroleum gas or bio-gas. *Smoking*: individual currently smokes or has smoked regularly in the past. *Environmental exposure to tobacco smoke (ETS)*: one or more other household members smoke currently. *Household type*: 'pucca' houses are made from high-quality materials (such as bricks, tiles, cement and concrete) throughout, including roof, walls and floor; 'kachha' houses are made from mud, thatch or other low-quality materials; 'semi-pucca' houses are made from partly low-quality materials and partly high-quality materials. *Lighting*: non-polluting lighting is powered by electricity; polluting lighting is from any other source. *People per room*: is the ratio of the number of household members by the number of rooms in the house. *Women's current employment*: non-manual work (e.g. professional/managerial positions or clerical or sales or generally employed in the service sector); skilled or unskilled manual work (including paid household or domestic work); agricultural work either as an employee or as an owner; and those not currently participating in the labour force (including those not seeking work, such as home-makers). The employed groups were further classified as those in which a woman was paid, either in cash or kind, or not. *Years of schooling*: We assigned the head of household's years of schooling to children under age 15. Age was also included in the analysis. For the women sample, we used the following age categories: 15–19, 20–24, 25–29, 30–34, 35–39, 40–44 and 45–49. For the full sample, we used the following age categories: 0–4, 5–14, 15–24, 25–44, 45–64 and 65 and above.

Table 2 Adjusted ORs and CIs for the risk of asthma in the women-specific and pooled sample

	Ever-married women		Full sample	
	OR	95% CI	OR	95% CI
Frequency of abuse				
Never abused (reference)	1		1	
Abused over 1 year ago	1.26	(1.09–1.46)	1.15	(1.08–1.23)
Abused in the past year	1.37	(1.19–1.58)	1.19	(1.11–1.27)
Location of the household				
Urban population ⩾1 million (reference)	1		1	
Urban population 100 000–1 million	1.18	(0.88–1.57)	1.00	(0.86–1.17)
Urban population ⩽100 000	1.10	(0.85–1.42)	0.94	(0.82–1.07)
Rural area	1.31	(1.02–1.69)	1.04	(0.91–1.18)
Religion				
Hindu (reference)	1		1	
Muslim	0.90	(0.77–1.07)	1.07	(0.99–1.16)
Christian	1.27	(1.01–1.59)	1.35	(1.19–1.54)
Sikh	1.02	(0.63–1.65)	0.95	(0.78–1.16)
Other/Missing religion	1.29	(0.99–1.68)	1.24	(1.07–1.45)
Caste				
General (reference)	1		1	
Scheduled caste	0.80	(0.69–0.93)	0.92	(0.86–0.98)
Scheduled tribe	0.91	(0.77–1.09)	0.81	(0.74–0.89)
Other backward class	0.89	(0.78–1.00)	0.94	(0.88–1.00)
Marital Status				
Married (reference)	1		1	
Widowed	1.56	(1.31–1.86)	1.12	(1.05–1.20)
Divorced	0.91	(0.48–1.73)	1.30	(0.89–1.88)
Separated	1.60	(1.19–2.14)	1.19	(0.92–1.53)
Single			0.89	(0.80–0.98)
Years of schooling				
13 or more (College and above) (reference)	1		1	
11–12 (High School)	1.02	(0.70–1.50)	0.97	(0.83–1.14)
9–10 (Secondary School)	1.11	(0.80–1.52)	1.06	(0.94–1.20)
6–8 (Middle School)	1.32	(0.96–1.82)	1.25	(1.11–1.42)
1–5 (Primary School)	1.34	(0.97–1.85)	1.46	(1.29–1.65)
0 (No schooling)	1.44	(1.04–1.99)	1.45	(1.28–1.63)
Standard of living index				
Top quintile (reference)	1		1	
Fourth quintile	0.90	(0.75–1.06)	1.01	(0.94–1.09)
Third quintile	1.18	(0.98–1.43)	1.23	(1.13–1.34)
Second quintile	1.28	(1.04–1.57)	1.30	(1.18–1.43)
Bottom quintile	1.36	(1.08–1.70)	1.46	(1.31–1.61)
Ever smoked				
No (reference)	1		1	
Yes	1.54	(1.27–1.87)	1.26	(1.20–1.34)
ETS				
No (reference)	1		1	
Yes	1.10	(1.00–1.22)	1.05	(1.00–1.10)
Fuel				
Low polluting (reference)	1		1	
Moderate polluting	0.95	(0.76–1.20)	0.93	(0.83–1.03)

continued

Table 2 Continued

	Ever-married women		Full sample	
	OR	95% CI	OR	95% CI
High polluting	1.00	(0.82–1.21)	0.99	(0.91–1.09)
Separate kitchen				
No (reference)	1		1	
Yes	0.89	(0.80–1.00)	0.94	(0.90–1.00)
Housing type				
Pucca (reference)	1		1	
Semi-pucca	1.15	(1.01–1.32)	1.09	(1.03–1.17)
Kachha	1.06	(0.91–1.24)	1.12	(1.03–1.20)
Lighting				
Non-polluting (reference)	1		1	
Polluting	0.95	(0.84–1.08)	0.96	(0.90–1.02)
People per room				
<1 (reference)	1		1	
1 to <3	0.91	(0.75–1.11)	0.98	(0.88–1.08)
3 to <5	0.77	(0.62–0.97)	0.89	(0.80–1.00)
⩾5	0.77	(0.61–0.99)	0.86	(0.76–0.97)
Gender				
Male (reference)			1	
Female			0.97	(0.92–1.01)
Employment				
Not working (reference)	1			
Unpaid non-manual	1.33	(0.68–2.62)		
Paid non-manual	0.86	(0.68–1.09)		
Unpaid agricultural	0.79	(0.67–0.94)		
Paid agricultural	0.76	(0.65–0.88)		
Unpaid manual	0.92	(0.48–1.73)		
Paid manual	0.89	(0.76–1.05)		
Body mass index (Kg/m^2)				
<16	2.14	(1.81–2.53)		
16–17	1.42	(1.19–1.69)		
17–18.5	1.16	(1.01–1.33)		
18.5–23 (reference)	1			
23–25	1.30	(1.10–1.54)		
25–30	1.35	(1.13–1.60)		
⩾30	1.54	(1.15–2.04)		
Missing BMI	1.07	(0.88–1.31)		

Note: Both models were additionally adjusted for age.

asthma, with lower socio-economic groups more greatly burdened. Smokers had a higher risk of reported asthma, but no substantial effects were observed for ETS in mutually adjusted models. We observed lower asthma risks in households that had a separate kitchen. However, the association between other environmental factors (e.g. use of high polluting cooking fuel, source of energy, and housing type) and risk of reported asthma was not substantial.

DV and asthma

In adjusted models, compared with those who have never experienced DV, women who experienced DV once or more in the past year had an increased risk of being asthmatic [odds ratio (OR) 1.37, 95% confidence interval (CI) 1.19–1.58]. Risk for asthma was also elevated among women who reported being abused since age 15 but not in the past year (OR 1.26, 95% CI 1.09–1.46).

Adjusting for a range of covariates, the probability of reported asthma was higher for all individuals in households that experienced DV against women once or more in the past year (OR 1.19, 95% CI 1.11–1.27). Households where women had experienced DV since age 15, but not in the past year, was also associated with higher asthma risk (OR 1.15, 95% CI 1.08–1.23).

Table 3 Adjusted ORs and 95% CIs associated with DV for the risk of asthma in different subsamples

	Ever-married women		Full sample		All females		All males	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Domestic violence								
Never abused (Reference)	1		1		1		1	
Abused over 1 year ago	1.26	(1.09–1.46)	1.15	(1.08–1.23)	1.10	(1.00–1.20)	1.17	(1.07–1.28)
Abused in the past year	1.37	(1.19–1.58)	1.19	(1.11–1.27)	1.24	(1.14–1.35)	1.14	(1.05–1.24)

Note: All models were adjusted for age, location of the household, religion, caste, marital status, years of schooling, standard of living index, smoking, ETS, type of fuel used in the household, availability of separate kitchen, housing type, source of lighting and overcrowding. Model based on the ever-married women sample, additionally adjusted for occupational status, and body mass index. Model based on the full sample, additionally adjusted for gender.

Table 3, besides summarizing the results associated with DV and asthma for ever-married women and the full sample of individuals, present the adjusted ORs along with 95% CIs for the effect of DV across different subsamples. The positive association between DV at the household level and individual risk of asthma was also observed in gender-stratified analysis. Risk of reported asthma was higher for men (OR 1.14, 95% CI 1.05–1.24) and women (OR 1.24, 95% CI 1.14–1.35) living in households that experienced DV against women once or more in the past year. In households where women experienced DV over a year ago, the ORs for reporting asthma was 1.17 (95% CI 1.07–1.28) for men, and 1.10 (95% CI 1.00–1.20) for women. Interaction tests between gender and DV categories in a pooled analysis were not statistically significant however at conventional levels ($P = 0.15$).

A consistent association between exposure to DV at the household level and individual risk for reported asthma was observed across all age-strata, except in the 45–64 years age-strata (Figure 1). Interaction tests between the different age and DV categories in a pooled analysis was statistically significant at $P = 0.002$. Risk of asthma in children under 5 years was substantially higher in households where women reported DV once or more in the past year (OR 1.32, 95% CI 1.10–1.32). In households where women reported DV over a year ago there was again an increased asthma risk, but the relationship did not attain statistical precision (OR 1.15, 95% CI 0.93–1.43). In the 5–14 years age group, there was ~17% (95% CI 1.00–1.36) increased risk of reporting asthma in households where women had experienced violence, but not in the past year. In age-strata of 15–24 years, households where women reported DV once or more had an OR of 1.35 (95% CI 1.10–1.66). In the age-strata of 25–44 years, the OR associated with the risk of reported asthma was 1.27 (95% CI 1.14–1.42) in households that had experienced DV against women once or more in the past year, and similar effects were observed in households that had experienced DV against women more than a year ago (OR 1.30, 95% CI 1.15–1.46). The association between domestic violence and asthma in the age-strata of 45–64 years was not substantial and not statistically significant ($P = 0.55$). Asthma risk was higher among the elders aged >64 if they lived in households that had experienced DV against women once or more in the past year (OR 1.23, 95% CI 1.06–1.44).

Sensitivity analyses

We conducted additional analyses to confirm the consistency in the association between DV and asthma. For instance, the association between using DV as a household exposure and asthma among females in the household (Table 3, 'All Female' column) was re-estimated now excluding females who reported to have experienced any DV. We found that females living in a household where women had been beaten in the past year were 21% (95% CI 1.09–1.34) more likely to have asthma compared with women in households without reported DV. We also estimated an additional model for males, excluding those males who beat their wives, and the relationship between asthma prevalence among males was no longer statistically significantly related to whether they lived in households experiencing domestic violence or not ($P = 0.17$). Finally, restricting the analysis among the ever-married women to those observations where the woman was the respondent for both the household and women's questionnaire ($n = 40\,279$, 46% of the ever-married women sample), we find a strong association between living in a household where DV occurred and the probability of reporting asthma ($P < 0.0001$). Women who were abused over a year ago, and those abused in the past year were 48% (95% CI 1.17–1.74) and 43% (95% CI 1.17–1.74) more likely to report asthma, respectively, than those who reported never to having been abused. Meanwhile, restricting the sample of ever-married women to those observations where women reported questions related to DV but a different adult household member responded to whether the woman had asthma, we found the association to be substantial and statistically significant only for women who had been beaten in the past year (OR 1.30, 95% CI 1.05–1.60), and not for women who reported being beaten in the past (i.e. more than a year ago).

Discussion

Utilizing a large-scale nationally representative data set, our study finds a robust and consistent association between DV and asthma prevalence in India. Specifically, women who are victims of DV had a higher probability of being reported as having asthma. Furthermore, compared with DV-free households, living in households where women experience DV increased the risk of reported asthma for all individuals in the households, including children and adult men. Finally, the association between household exposure to DV and asthma was largely consistent across the different age-strata, with stronger effects observed in age groups under 5, 15–24 and 25–44 years. These findings are consistent with the few studies that have examined the links between violence and asthma in the US[5,25,26] and Australia[27]; we are not aware of any study that has examined the links between violence and asthma in India.

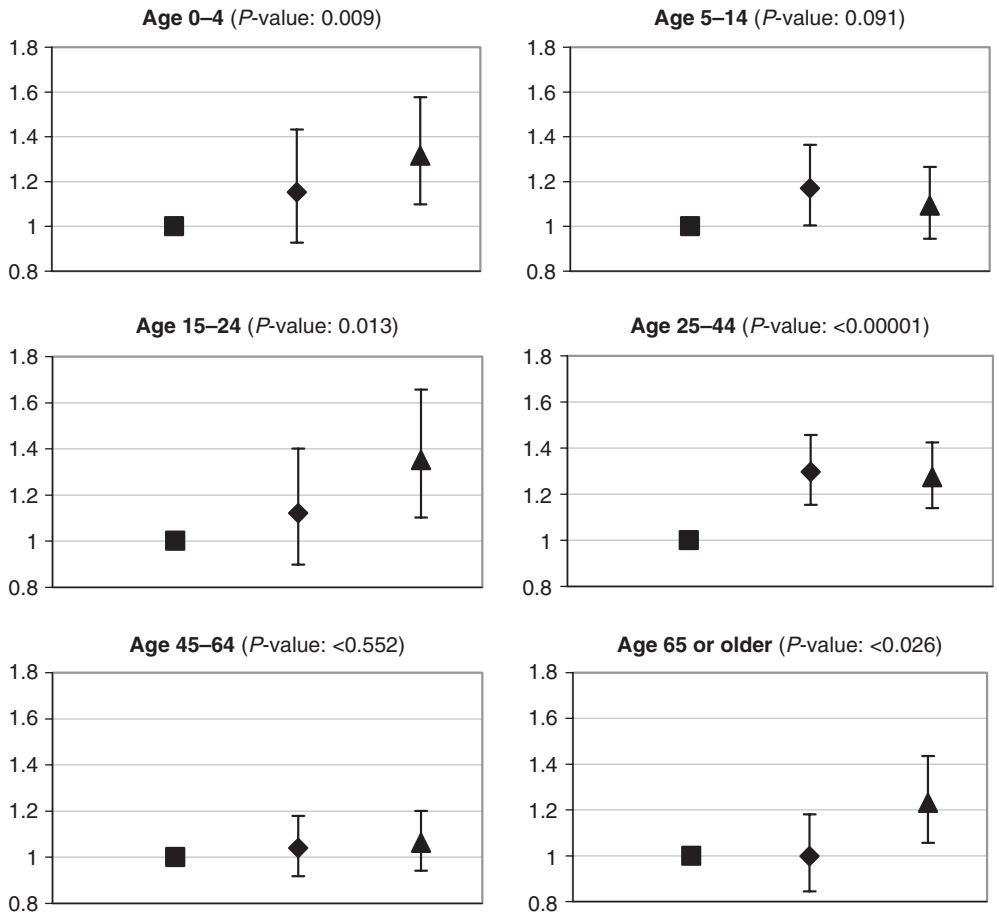

Figure 1 Adjusted ORs and CIs associated with DV for the risk of asthma in different age strata. Filled square, Never abused (reference); filled diamond, abused 1 year ago; filled triangle, abused in the past year

Why should violence be related to asthma expression? Psychosocial factors that can be linked to asthma mortality, morbidity and medication compliance have been well articulated.[28] Exposure to violence—viewed as a major psychosocial stressor—may impact the pathogenesis of asthma and/or contribute to asthma morbidity by triggering exacerbations through neuroimmunological mechanisms.[16] It is well known that persistent stress experiences augment parasympathetic response,[29,30] which produces increased smooth muscle tone in the lung and may mediate emotionally induced bronchoconstriction in asthma.[31] Psychosocial stressors can also moderate both humoral and cellular immune function, with such alterations predisposing the individual to respiratory tract infections,[32,33] which may in turn trigger acute asthma episodes. Thus, stress hormones through their influence on immune expression may increase a genetically predisposed individual's risk of developing asthma or perpetuate an existing condition. Violence as a psychosocial stressor, therefore, may be an 'adjuvant' to the asthmatic inflammatory response.[34] Current knowledge supports the notion that environmental factors that include viral infection, air pollutants, maternal smoking, breast-feeding and allergen exposure modulate the expression of the asthmatic phenotype, as related to the immune response. Stress may also accentuate the response to allergens by increasing the release of inflammatory mediators and the subsequent cascade of inflammatory events characteristic of chronic asthma. While the impact of stress and emotional distress are more apparent in their role in aggravating asthma symptoms in asthmatics, they may also play a role in the genesis of the disease.

Other indirect mechanisms through which exposures to violence (and perhaps other characteristics of stressful social circumstances) may operate is by adopting coping behaviours such as smoking, thus increasing the exposure to a known environmental asthma trigger. It has also been suggested that violence at a macro level (such as in the community) may influence asthma through limiting outdoor activities and thereby increasing the exposure to known indoor environmental risk factors for asthma,[34] including, in the Indian context, high polluting cooking fuel.[35,36] We examined this hypothesis by predicting whether the percentage of women reporting DV in an area (a marker for community violence) was associated with asthma, and did not find support for this hypothesis. The most probable explanation for the lack of association between a community-level measure of DV and individual asthma is that aggregate measures of DV are probably unrelated to the overall levels of crime and violence in the broader residential context.

In our study, with the exception of the relationship between smoking and asthma, we did not find support for the hypothesis that implicates ETS or use of high pollution

cooking fuel, that have been shown in other studies from India.[35–37] One possible reason for the difference may be the variation in the way adjustments for socio-economic factors were made. Our measures for socio-economic status (through caste, education and standard of living) are considerably stronger than those used in the other studies. Indeed, in unadjusted models we too find support for a positive association between high pollution cooking fuel, and ETS, and asthma, with the effect size and precision considerably weaker in adjusted models.

Notwithstanding the general challenges of measuring asthma in population-based studies,[38] the measurement of asthma in the INFHS has clear limitations. The INFHS measure of asthma prevalence was based on a single question, as opposed to a hierarchy of asthma/wheeze outcomes based on responses to standardized respiratory questionnaires.[39,40] No effort was made to clinically test for asthma or inquire whether the response was based on a physician-diagnosis. Indeed, given the marked variation in the recognition and presentation to a doctor by an individual with recurrent wheezing or asthma episodes, as well as considerable differences in diagnostic labelling and treatment by doctors between populations,[41] and suboptimal levels of access to health care, physician-diagnosed asthma prevalence or use of asthma medication is equally problematic in the Indian context. In general, the INFHS seem to underestimate asthma prevalence compared with other studies in India,[42–45] including those from the International Study of Asthma and Allergies in Childhood (ISAAC).[41] One local study that measured both a history of wheezing and a history of asthma diagnosis found that those who report a history of asthma symptoms tended not to report that they actually have asthma.[46] This under-reporting might have occurred in the INFHS too. A multi-centric study of asthma prevalence among adults in India found that while the prevalence of wheezing in the past 12 months ranged from 2.1% to 4.8% in rural centres and 2.1–4.3% in urban centres, the corresponding proportion of persons 'ever diagnosed with asthma' was 0.8–3.9% and 1.4–3.8%;[42] figures that correspond to INFHS estimates as well. Furthermore, ascertainment of asthma was not based on self-reports. Rather, the respondent to the household questionnaire, answered on behalf of all the household members. It is difficult to quantify the extent and direction of misreporting that this may have caused. Notably, however, the fact that the same individual need not have responded to questions on the exposure (DV) and asthma could be a potential strength as it avoids the bias related to victimized women having a greater propensity to report morbidities. These limitations related to asthma measurement inhibit the use of INFHS to derive the burden of asthma prevalence. At the same time, the INFHS, by way of collecting extensive social and demographic data (including on violence), and being nationally representative, provides a unique, if not the only, opportunity to draw descriptive inference on the social distribution and patterning of asthma risk in India.

Another limitation is the global measure of DV used in this study. While we are not aware of any validated instrument to ascertain DV, it is clear that single-question measure of DV, as used in INFHS, has been found to be less accurate than measures which ask multiple behaviourally specific questions about what types of abuse the respondent has experienced.[47] This may account for why the prevalence of abuse reported in this study is markedly smaller than that reported in previous research of Indian women.[48] Furthermore, the inability to determine the severity of this exposure is also a limitation. The lack of precise and detailed measures on the severity, type and frequency of DV is likely to make our findings conservative.

The lack of a clear 'dose-response' in the relationship between the recency of DV and asthma, is likely to be an indication of, in this instance, the crude nature of the exposure assessment, which we discussed earlier. Furthermore, since no ascertainment was made on the severity of asthma or the frequency of asthmatic attacks, the 'threshold effect' could be reflecting the restricted nature of the outcome measure. Given these limitations these data most strongly suggest a relationship between experiencing DV and being more likely to have asthma, particularly among women.

The public health relevance of asthma, at the global level, is increasingly being recognized.[41,49,50] According to the World Health Organization,[51] India is estimated to have 15–20 million asthmatics, with the all-India asthma prevalence estimated to be ~3% for adults,[42] and between 4% and 20% for children,[41] and projected to increase in the coming decades. While physical environmental factors, supplemented with evidence from gene–environment interaction studies, have advanced our mechanistic understanding of this complex disease, they do not fully account for the substantial social patterning of asthma. Our study is the first to demonstrate an association between DV and asthma prevalence in India; a country with relatively high levels of DV. We find a consistent association between being exposed to, and having experienced, DV and asthma, even after controlling for known environmental triggers of asthma. Stress-induced mechanisms, partially captured through violence and psychosocial circumstances, may be a critical explanatory link in furthering our understanding of the social disparities in asthma.

Acknowledgements

S.V.S. is supported by the National Institutes of Health Career Development Award (NHLBI 1 K25 HL081275); L.A. is supported by the Harvard Education Program in Cancer Prevention and Control (NIH/NCI 5 R25 CA057711-12R). R.J.W. is supported by R01 HL080674 and R01 HL64108. No direct financial support was available for this study. We acknowledge the support of Macro International (www.measuredhs.com) for providing us access to the 1998–99 Indian National Family Health Survey data.

Conflict of interest: None declared.

References

[1] Maddox L, Schwartz DA. The pathophysiology of asthma. *Annu Rev Med* 2002;**53**:477–98.

[2] Walker BJ, Stokes LD, Warren R. Environmental factors associated with asthma. *J Natl Med Assoc* 2003;**95**:152–66.

[3] Kleeberger SR, Peden D. Gene-environment interactions in asthma and other respiratory diseases. *Annu Rev Med* 2005;**56**:383–400.

[4] Weiss ST. Gene by environment interactions and asthma. *Clin Exp Allergy* 1999;**29**(suppl 2):96–99.

[5] Wright RJ, Fisher EB. Putting asthma into context: community influences on risk, behavior, and intervention. In: Kawachi I, Berkman LF (eds). *Neighborhoods and Health*. New York: Oxford University Press, 2003.

[6] O'Neill MS, Jerrett M, Kawachi I *et al*. Health, wealth and air pollution: advancing theory and methods. *Environ Health Perspect* 2003;**111**:1861–70.

[7] Weiss KB, Wagener DK. Changing patterns of asthma mortality: identifying target populations at high risk. *J Am Med Assoc* 1990;**264**:1683–87.

[8] Adler N, Boyce T, Chesney M *et al*. Socioeconomic status and health: the challenge of the gradient. *Am Psychol* 1994;**49**:15–24.

[9] Busse WJ, Kiecolt-Glaser J, Coe C, Martin R, Weiss S, Parker S. Stress and asthma: NHLBI Workshop Summary. *Am J Respir Crit Care Med* 1994;**151**:249–52.

[10] Evans G. Environmental stress and health. In: Baum A, Revenson T, Singer J (eds). *Handbook of Health Psychology*. Mahwah, NJ: Lawrence Erlbaum Associates Inc., 2001. pp. 365–85.

[11] Wright R, Rodriguez M, Cohen S. Review of psychosocial stress and asthma: an integrated biopsychosocial approach. *Thorax* 1998;**53**:1066–74.

[12] Sandberg S, Paton JY, McCann DC, McGuiness D, Hillary CR, Oja H. The role of acute and chronic stress in asthma attacks in children. *Lancet* 2000;**356**:982–87.

[13] Wright RJ, Cohen S, Carey S, Weiss ST, Gold DR. Parental Stress as a Predictor of Wheezing in Infancy. A Prospective Birth-Cohort Study. *Am J Respir Crit Care Med* 2002;**165**:358–65.

[14] Chen E, Fisher EB, Bacharier LB, Strunk RC. Socioeconomic status, stress, and immune markers in adolescents with asthma. *Psychosom Med* 2003;**65**:984–92.

[15] Wright RJ, Wright RO, Finn P *et al*. Chronic caregiver stress and IgE expression, allergen-induced proliferation, and cytokine profiles in a birth cohort predisposed to atopy. *Am J Allergy Clinl Immunol* 2004;**113**:1051–57.

[16] Wright RJ, Cohen RT, Cohen S. The impact of stress on the development and expression of atopy. *Curr Opin Allergy Clin Immunol* 2005;**5**:23–9.

[17] Briere J, Jordan CE. Violence against women: outcome complexity and implications for assessment and treatment. *J Interpers Violence* 2004;**19**:1252–76.

[18] Kitzmann KM, Gaylord NK, Holt AR, Kenny ED. Child witnesses to domestic violence: a meta-analytic review. *J Consult Clin Psychol* 2003;**71**:339–52.

[19] IIPS. *National Family Health Survey 1998-99*. Mumbai: International Institute of Population Sciences, 2000.

[20] Krishnan S. Do structural inequalities contribute to marital violence? Ethnographic evidence from rural South India. *Violence against women* 2005;**11**:759–75.

[21] Kumar S, Jeyaseelan L. Domestic violence and its mental health correlates in Indian women. *Br J Psychiatry* 2005;**187**:62–7.

[22] Goldstein H. edn. *Multilevel Statistical Models*. 3rd edn., London: Arnold, 2003.

[23] Subramanian SV. The relevance of multilevel statistical models for identifying causal neighborhood effects. *Soc Sci Med* 2004; **58**:1961–67.

[24] Subramanian SV, Jones K, Duncan C. Multilevel methods for public health research. In: Kawachi I, Berkman LF (eds). *Neighborhoods and Health*. New York: Oxford University Press, 2003. pp. 65–111.

[25] Wright R, Hanrahan J, Tager I, Speizer F. Effect of the exposure to violence on the occurrence and severity of childhood asthma in an inner-city population. *Am J Respir Crit Care Med* 1997;**155**:972.

[26] Wright RJ, Mitchell H, Visness CM *et al*. Community violence and asthma morbidity. *Am J Public Health* 2004;**94**:625–32.

[27] Loxton D, Schofield M, Hussain R, Mishra G. History of domestic violence and physical health in midlife. *Violence against women* 2006;**12**:715–31.

[28] Harrison BD. Psychosocial aspects of asthma in adults. *Thorax* 1998;**53**:519–25.

[29] Gelhorn E. The neurophysiological basis of anxiety: a hypothesis. *Perspect Biol Med* 1965;**8**:488–505.

[30] Vingerhoets AJM. The role of the parasympathetic division of the autonomic nervous system in stress and the emotions. *Int J Psychosom* 1985;**32**:28–34.

[31] Nadel JA, Barnes PJ. Autonomic regulation of the airways. *Ann Rev Med* 1984;**35**:451–67.

[32] Cohen S, Line S, Manuck SB, Rabin BS, Heise ER, Kaplan JR. Chronic social stress, social status, and susceptibility to upper respiratory infections in non-human primates. *Psychosom Med* 1997;**59**:213–21.

[33] Graham NMH, Douglas RB, Ryan P. Stress and acute respiratory infection. *Am J Epidemiol* 1986;**124**:389–401.

[34] Wright R, Steinbach S. Violence: an unrecognized environmental exposure that may contribute to greater asthma morbidity in high risk inner-city populations. *Environ Health Perspect* 2001;**109**:1085–89.

[35] Behera D, Chakrabarti T, Khanduja KL. Effect of exposure to domestic cooking fuels on bronchial asthma. *Indian J Chest Dis Allied Sci* 2001;**43**:27–31.

[36] Mishra V. Effect of indoor air pollution from biomass combustion on prevalence of asthma in the elderly. *Environ Health Perspect* 2003;**111**:71–8.

[37] Gupta D, Aggarwal AN, Kumar R, Jindal SK. Prevalence of bronchial asthma and association with environmental tobacco smoke exposure in adolescent school children in Chandigarh, North India. *J Asthma* 2001;**38**:501–07.

[38] Pearce N, Beasley R, Burgess C, Crane J. *Asthma Epidemiology: Principles and Methods*. New York: Oxford University Press, 1998.

[39] Beasley RE, Asher I. International patterns of prevalence in pediatric asthma: the ISAAC program. *Pediatr Clin North Am* 2003;**50**:539–53.

[40] Ferris BJ. Epidemiology standardization project. *Am Rev Respir Dis* 1978;**118**:1–88.

[41] Committee TISoAaAiCIS. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. *Lancet* 1998;**351**:1225–32.

[42] Aggarwal AN, Chaudhry K, Chhabra SK *et al*. Prevalence and risk factors for bronchial asthma in Indian adults: a multicentre study. *Indian J Chest Dis Allied Sci* 2006;**48**:13–22.

[43] Awasthi S, Kalra E, Roy S, Awasthi S. Prevalence and risk factors of asthma and wheeze in school-going children in Lucknow, North India. *Indian Pediatr* 2004;**41**:1205–10.

[44] Chakravarthy S, Singh RB, Swaminathan S, Venkatesan P. Prevalence of asthma in urban and rural children in Tamil Nadu. *Natl Med J India* 2002;**15**:260–63.

[45] Chowgule RV, Shetye VM, Parmar JR *et al*. Prevalence of respiratory symptoms, bronchial hyperreactivity, and asthma in a megacity, results of the European Community Respiratory Health Survey in Mumbai (Bombay). *Am J Respir Crit Care Med* 1998;**158**:547–54.

[46] Khan S, Roy A, Christopher DJ, Cherian AM. Prevalence of bronchial asthma among bank employees of Vellore using questionnaire-based data. *J Indian Med Assoc* 2002;**100**:643–44, 55.

[47] Ellsberg M, Heise L, Pena R, Agurto S, Winkvist A. Researching domestic violence against women: methodological and ethical considerations. *Stud Fam Plann* 2001;**32**:1–16.

[48] Kumar S, Jeyaseelan L, Suresh S, Ahuja RC. Domestic violence and its mental health correlates in Indian women. *Br J Psychiatry* 2005;**187**:62–67.

[49] Bousquet J, Bousquet PJ, Godard P, Davers JP. The public health implications of asthma. *Bull World Health Organ* 2005;**83**:548–54.

[50] Gold DR, Wright R. Population disparities in asthma. *Annu Rev Public Health* 2005;**26**:89–113.

[51] http://www.who.int/mediacentre/factsheets/fs206/en/.

[52] Subramanian SV, Nandy S, Irving M, Gordon D, Davey Smith G. Role of socioeconomic markers and state prohibition policy in predicting alcohol consumption amongst men and women in India: a multilevel analysis of the 1998-99 National Family Health Survey. *Bull World Health Organ* 2005;**83**:829–36.

[53] Subramanian SV, Nandy S, Kelly M, Gordon D, Davey Smith G. Patterns and distribution of tobacco consumption in India: cross-sectional multilevel evidence from the 1998–99 National Family Health Survey. *Br Med J* 2004;**328**:801–06.

[54] Subramanian SV, Nandy S, Irving M, Gordon D, Lambert H, Davey Smith G. The mortality divide in India: the differential contribution of gender, caste and standard of living across the life course. *Am J Public Health* 2006;**96**:826–33.

[55] Subramanian SV, Smith GD. Patterns, distribution, and determinants of under- and overnutrition: a population-based study of women in India. *Am J Clin Nutr* 2006;**84**:633–40.

[56] Subramanian SV, Smith GD, Subramanyam M. Indigenous health and socioeconomic status in India. *PLoS Med* 2006;**3(10) e421**.