


Visible damp in a child's bedroom is associated with increased respiratory morbidity in early life: a multicentre cohort study

Tom Ruffles ^{1,2}, Sarah K Inglis,³ Anjum Memon,⁴ Paul Seddon,^{1,2} Kaninika Basu,^{1,5} Stephen A Bremner,⁴ Heike Rabe,^{1,2} Somnath Mukhopadhyay,^{1,2} Katy J Fidler^{1,2}

► Additional supplemental material is published online only. To view, please visit the journal online (<https://doi.org/10.1136/archdischild-2024-326944>).

¹Academic Department of Paediatrics, Royal Alexandra Children's Hospital, University Hospitals Sussex NHS Foundation Trust, Brighton, UK

²Brighton and Sussex Medical School, Brighton, UK

³Tayside Clinical Trials Unit, University of Dundee, Dundee, UK

⁴Department of Primary Care and Public Health, Brighton and Sussex Medical School, Brighton, UK

⁵Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK

Correspondence to

Tom Ruffles;
tomruffles@doctors.org.uk

Received 30 January 2024

Accepted 10 June 2024

Published Online First

26 June 2024



© Author(s) (or their employer(s)) 2024. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Ruffles T, Inglis SK, Memon A, et al. *Arch Dis Child* 2024;**109**:818–821.

ABSTRACT

Objective Household damp exposure is an important public health issue. We aimed to assess the impact of the location of household damp on respiratory outcomes during early life.

Methods Household damp exposure was ascertained in children recruited to the GO-CHILD multicentre birth cohort study. The frequency of respiratory symptoms, infections, healthcare utilisation and medication prescription for wheezing were collected by postal questionnaires at 12 and 24 months. Log binomial and ordered logistic regression models were fitted to the data.

Results Follow-up was obtained in 1344 children between August 2010 and January 2016. Visible damp was present in a quarter of households (25.3%) with 1 in 12 children's bedrooms affected (8.3%). Damp in the bathroom, kitchen or living room was not associated with any respiratory or infection-related outcomes. Damp in the child's bedroom was associated with an increased risk of dry cough (8.7% vs 5.7%) (adjusted relative risk 1.56, 95% CI 1.07 to 2.27; $p=0.021$) and odds of primary care attendance for cough and wheeze (7.6% vs 4.4%) (adjusted OR 1.37, 95% CI 1.07 to 1.76; $p=0.009$). There were also increased risk of inhaled corticosteroid (13.3% vs 5.9%) (adjusted RR 2.22, 95% CI 1.04 to 4.74; $p=0.038$) and reliever inhaler (8.3% vs 5.8%) (adjusted RR 2.01, 95% CI 1.21 to 2.79; $p=0.018$) prescription.

Conclusion Damp in the child's bedroom was associated with increased respiratory morbidity. In children presenting with recurrent respiratory symptoms, clinicians should enquire about both the existence and location of damp, the presence of which can help prioritise those families requiring urgent household damp assessment and remediation works.

INTRODUCTION

The burden of preschool wheeze and cough is a prominent public health issue that appears to be increasing in prevalence and is associated with significant morbidity, healthcare utilisation and cost.¹ The aetiology of preschool wheeze and cough, and childhood asthma is a complex interplay between host genetics and environmental factors that may be modifiable.²

There is compelling evidence from a series of meta-analyses and systematic reviews that early life exposure to household damp is associated with respiratory symptoms and subsequent diagnosis of

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Household damp is a major public health challenge with 1.6 million children in England estimated to be living in affected properties.
- ⇒ Damp exposure in early childhood is associated with increased respiratory symptoms and subsequent diagnosis of asthma.

WHAT THIS STUDY ADDS

- ⇒ Visible damp in a child's bedroom but not elsewhere in the household is associated with primary care attendance for cough and wheeze as well as inhaled steroid and reliever inhaler prescription.
- ⇒ The location of damp within the household may be an important determinant of the impact of mould on children's respiratory health.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Health professionals should enquire about both the presence and location of household damp in children presenting with recurrent respiratory symptoms.
- ⇒ The presence of visible damp in a child's bedroom could be used to help identify those families most urgently in need of targeted household damp treatment by the local government.

asthma.^{3 4} There has been a renewed focus on the harmful impact of damp in the UK after the tragic death of Awaab Ishak in 2020 following mould inhalation from extensive damp in the family's home. Awaab's law was introduced as part of the Social Housing (Regulation) Act 2023 and requires social housing landlords in England to investigate and treat damp issues.

Household damp is a substantial public health problem with an estimated 1.6 million children in England living in affected properties.⁵ Tackling this potentially preventable cause of significant respiratory morbidity in children is vitally important and identifying which household rooms affected by damp are most associated with respiratory outcomes could allow remediation work to be efficiently targeted. The aim of our study was to assess the impact of the location of household visible damp on respiratory symptoms, infections,

healthcare utilisation and medication prescription for wheezing during the first 2 years of life.

METHODS

Pregnant women were recruited to the GO-CHILD prospective birth cohort study between August 2009 and November 2013 from throughout England and Scotland to investigate the role of environmental and gene variation on respiratory outcomes in young children. Postal questionnaires were completed at 12 and 24 months to determine household damp exposure and respiratory symptoms and outcomes (see online supplemental file 1 for questionnaires). Carers provided informed consent.

Exposure and outcomes

Carers were asked whether there was visible damp within the house and whether damp was present in the bathroom, kitchen, living room or the child's bedroom. The frequency of respiratory symptoms (wheeze and cough), healthcare utilisation (primary care attendance, emergency department attendance and secondary care referral) and medication prescriptions (reliever inhaler, inhaled and oral corticosteroid) for wheeze were recorded. The frequency of respiratory infections (bronchiolitis, pneumonia, otitis media and cold or influenza) were also recorded.

Statistical analysis

Data on children whose carers had completed at least one follow-up questionnaire were included in the analysis. The data was reshaped into a long format to enable analysis of repeated measures. A cluster variance estimator adjustment was made to the SEs to take account of repeated measures. Log binomial regression was used for binary outcomes. Ordinal logistic regression was used for ordered grouped counts. A regression analysis was performed for each of the 12 clinical outcomes. On the basis of existing knowledge and following discussion with the GO-CHILD study team, models were adjusted for: the mother's level of education; daycare attendance; breast feeding beyond 6 months; siblings at home; environmental tobacco smoke exposure; child's bedroom flooring (as a surrogate of house dust mite); animal exposure; road traffic density (traffic pollution) around child's home (little/moderate/dense); and solid fuel pollution

within the home (see online supplemental file 2 for confounder analyses). A two-sided p value of <0.05 was deemed statistically significant for all analyses. Stata (StataCorp 2019 Stata Statistical Software: Release 16 College Station, Texas: StataCorp) was used for all statistical analyses. Our study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology principles⁶ for reporting cohort studies.

RESULTS

Data were collected from August 2010 to January 2016. 1344 children were included in the analyses with at least 1 carer follow-up questionnaire completed (figure 1). Visible damp was present in over a quarter of homes (25.3%) and was most common in the living room (15.1%), bathroom (12.2%) and children's bedroom (8.3%). Visible damp was present in the bedroom only in 10.9% of the 340 homes affected by damp. Demographic information, damp exposure, environmental factors and follow-up are summarised in table 1.

Damp in the child's bedroom was associated with an increased risk of dry cough (adjusted relative risk (RR) 1.56, 95% CI 1.07 to 2.27; $p=0.021$) and increased odds of primary care attendance for cough and wheeze (adjusted OR 1.37, 95% CI 1.07 to 1.76; $p=0.009$) (table 2). It was also associated with an increased risk of reliever inhaler (adjusted RR 2.01, 95% CI 1.21 to 2.79; $p=0.018$) and a greater than twofold increased risk of inhaled corticosteroid (adjusted RR 2.22, 95% CI 1.04 to 4.74; $p=0.038$) prescription (table 2). There was no association between the presence of damp in the bathroom, kitchen or living room with any respiratory or infection-related outcomes (online supplemental file 3).

DISCUSSION

Visible damp in the child's bedroom was associated with an increased risk of cough and wheeze requiring primary care review as well as the requirement for a reliever and steroid controller inhaler prescription. The location of damp within the household may be an important determinant of the impact of mould on children's respiratory health. The association with the child's bedroom is logical as this is the location where the child is likely to spend the greatest period of time and thus have the greatest potential duration of mould exposure.

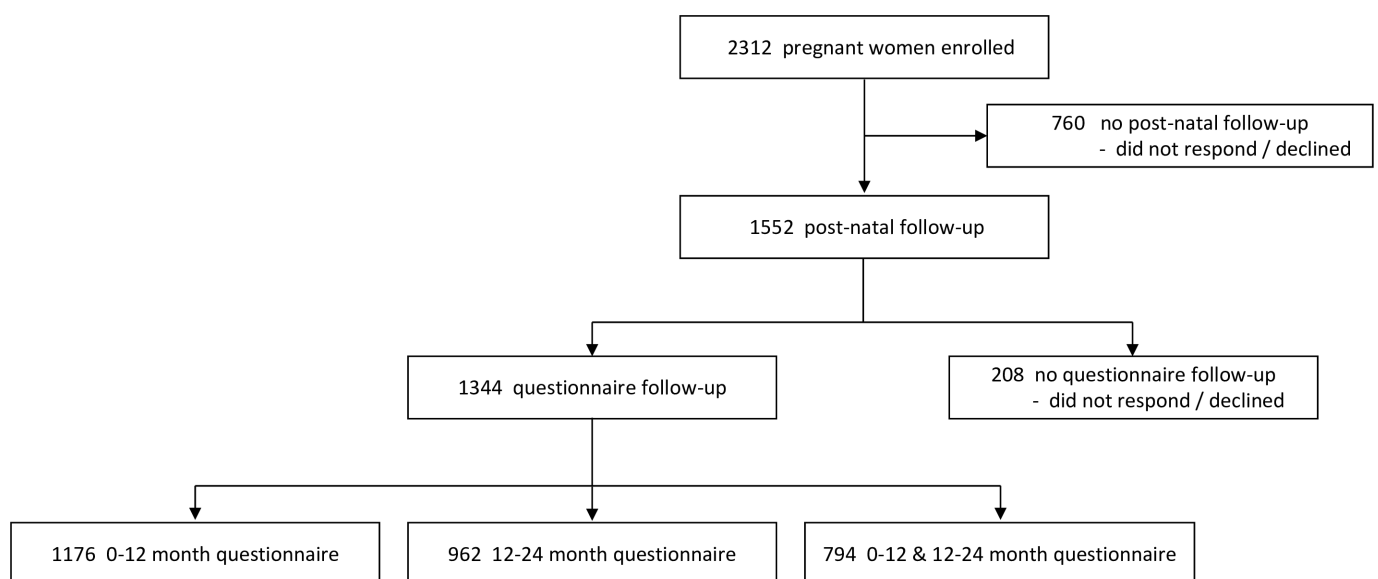


Figure 1 Study profile.

Table 1 Demographic information, damp exposure, environmental factors and follow-up

Gender (n=1344)	
Male	681 (50.7%)
Female	663 (49.3%)
Ethnicity (n=1344)	
Caucasian	1216 (92.5%)
Asian	33 (2.5%)
Black	21 (1.6%)
Mixed race	27 (2.1%)
Other	7 (0.5%)
Not reported	40
Visible damp in the house (n=1344)	
Damp in child's bedroom	111 (8.3%)
Damp in bathroom	164 (12.2%)
Damp in kitchen	78 (5.8%)
Damp in living room	203 (15.1%)
Damp anywhere in house	340 (25.3%)
Environmental factors (n=1344)	
Daycare attendance	782 (58.2%)
Breast fed >6 months	685 (51.0%)
Siblings	812 (60.4%)
Tobacco smoke	181 (13.5%)
Carpet in bedroom	1069 (79.5%)
Animals	765 (56.9%)
Dense traffic	125 (9.3%)
Solid fuel	142 (10.6%)
Maternal education level (n=1285)	
Completed primary education	58 (4.5%)
Completed secondary education	345 (26.8%)
Further education	388 (30.2%)
Higher education	494 (38.4%)
Not reported	59
Follow-up	
0–12 months questionnaire	1176
12–24 months questionnaire	962
0–12 and 12–24 months questionnaires	794
Questionnaire follow-up/included in analysis	1344

Environmental factors for the demographic table were taken from the first survey in preference to the second. Gender and ethnicity data relate to the child.

Visible damp anywhere within the house in the GO-CHILD birth cohort has been reported previously.⁷ It was associated with an increased risk of dry cough, and increased odds of wheeze as well as primary care attendance for cough and wheeze. There was also an increased risk of reliever inhaler and inhaled corticosteroid prescription (online supplemental file 2).

Damp surfaces provide conditions favourable for the indoor growth of mould. *Penicillium* spp, *Cladosporium* spp, *Aspergillus* spp and *Alternaria* spp are common mould allergens found in houses with visible damp.⁸ It is hypothesised that these microscopic allergens can induce inflammation by releasing mycotoxins and by antigen-specific (IgE) mast cell activation.⁸ A series of meta-analyses and systematic reviews provide robust evidence that early life exposure to visible damp is associated with early asthma symptoms and later diagnosis of asthma.^{3–4} Early life damp exposure may have a long-term impact on respiratory health with an adverse impact on lung function growth in young people between aged 12 and 16 years identified⁹ as well as an increased risk of asthma at age 16.¹⁰

Table 2 Presence of damp in a child's bedroom and the occurrence of respiratory symptoms, healthcare utilisation, medication prescriptions and respiratory infections

		Damp in bedroom				0–24 months
		0–12 months		12–24 months		
		No	Yes	No	Yes	
Wheeze	Yes	246	22	192	14	RR 1.16 (0.61 to 1.57) p=0.319
	No	860	48	708	48	
Dry cough	Yes	169	17	134	12	RR 1.56 (1.07 to 2.27) p=0.021
	No	937	53	766	50	
Primary care attendance for cough and wheeze	0	517	29	494	22	OR 1.37 (1.07 to 1.76) p=0.009
	1	288	24	214	19	
	2–3	228	14	138	17	
	≥4	66	3	45	4	
Emergency department attendance for wheeze	Yes	63	3	61	5	RR 1.29 (0.73 to 2.31) p=0.376
	No	1043	67	839	57	
Secondary care attendance for cough and wheeze	Yes	37	2	28	2	RR 1.47 (0.46 to 4.68) p=0.511
	No	1069	68	872	60	
Reliever inhaler	Yes	152	13	156	15	RR 2.01 (1.21 to 2.79) p=0.018
	No	938	57	734	46	
Inhaled corticosteroid	Yes	20	3	33	5	RR 2.22 (1.04 to 4.74) p=0.038
	No	1058	65	847	54	
Oral corticosteroid	Yes	66	4	51	4	RR 1.39 (0.70 to 2.24) p=0.318
	No	1042	33	883	56	
Bronchiolitis	0	950	61	772	52	OR 1.29 (0.73 to 2.31) p=0.376
	1	105	7	97	7	
	≥2	43	2	23	2	
Pneumonia	0	1085	67	871	60	OR 2.10 (0.73 to 6.03) p=0.169
	≥1	15	3	25	1	
Cold or influenza	0	25	0	19	2	OR 1.04 (0.89 to 1.21) p=0.658
	1–3	539	35	501	30	
	4–9	391	26	291	21	
	≥10	147	9	85	8	
Otitis media	0	856	55	650	38	OR 1.26 (0.83 to 1.91) p=0.277
	1	193	12	167	17	
	≥2	52	2	67	5	

Adjusted relative risks (RR) and 95% CI were estimated for binary outcomes using log binomial regression. Adjusted OR and 95% CI were estimated for ordered grouped counts using ordinal logistic regression. Models were adjusted for: the mother's level of education; daycare attendance; breast feeding beyond 6 months; siblings at home; environmental tobacco smoke exposure; child's bedroom flooring (as a surrogate of house dust mite); animal exposure; road traffic density (traffic pollution) around child's home (little/moderate/dense); and solid fuel pollution within home.

The scale of the public health challenge of damp in UK housing is substantial with the regulator of Social Housing publishing a report in February 2023 estimating that up to 160 000 social homes in England (3–4%) were impacted by 'notable' damp and mould and an estimated 1.6 million children in England are living in affected properties.⁵

The government's ambition to address household damp is clear with the introduction of Awaab's law compelling landlords

to address damp and mould in social homes. Citizen's advice (www.citizensadvice.org.uk) and the charity Shelter (www.shelter.org.uk) provide comprehensive advice on dealing with damp and mould issues in private rented homes. Raising awareness among parents and health professionals of the health issues affecting children who live in damp environments is important. Our findings will be valuable in assisting health professionals in advocating for their vulnerable patients as well as helping local government prioritise action for families whose children's bedrooms are affected by visible mould.

There are notable limitations that should be considered when assessing our study findings. Recall bias is an important consideration given the retrospective questionnaires used to determine symptoms, diagnoses and treatments. Misclassification bias is another potential limitation given diagnoses were carer-reported and not always confirmed by a physician. Carer focus group feedback was obtained to ensure questionnaire definitions were unambiguous and to limit misclassification error with only 1.4% of carers reporting difficulty in understanding the study questionnaires. Guidance to clarify the definition of damp was not included within the questionnaires representing another potential cause of misclassification bias. Future studies could address this by using trained inspectors to visit homes to classify and assess the extent of damp. Alternatively, detection and quantification of mould in indoor air and settled dust is possible using Mould Specific Quantitative PCR.¹¹ This technology has been used to develop the Environmental Relative Moldiness Index (ERMI) scale which via dust sampling protocols can quantify the burden of mould within the home.¹² Children with high ERMI exposure in the first year of life have been shown to have a significantly increased risk of developing asthma at 7 years of age.¹³

Correction for multiple comparisons was not undertaken to avoid inflating type II error so reducing the risk of missing potentially important true associations.^{14 15}

CONCLUSION

Our study highlights the importance of identifying both the presence and location of household damp exposure in the history of a child presenting with recurrent respiratory symptoms. The presence of damp within a child's bedroom should be considered as an eligibility criterion to prioritise households requiring urgent damp assessment and remedial intervention.

Contributors TR: Writing—original draft; formal analysis; data curation; methodology; investigation; writing—review and editing; software; resources; guarantor. SKI: Data curation; writing—original draft; writing—review and editing; project administration. AM: Conceptualisation; funding acquisition; writing—review and editing; writing—original draft. PS: Conceptualisation; writing—original draft; funding acquisition; writing—review and editing. KB: Data curation; writing—original draft; writing—review and editing. SAB: Formal analysis; writing—original draft; writing—review and editing. HR: Conceptualisation; funding acquisition; writing—review and editing; writing—original draft. SM: Conceptualisation; visualisation; writing—original draft; writing—review and editing; supervision; investigation; methodology; validation; funding acquisition; resources. KJF: Conceptualisation; investigation; funding acquisition; writing—original draft; methodology; validation; visualisation; writing—review and editing; supervision; resources.

Funding The study was funded by the medical charity Sparks (grant number G0010) and Rockinghorse Children's Charity. We received additional funding from the Brighton and Sussex Medical School. The study was sponsored by Brighton and Sussex University Hospitals NHS Trust who provided grant funding for operational costs of the project. The sponsor did not participate in data collection, analysis, or decision to publish.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The study was approved by the Tayside Committee on Medical Research & Ethics (FB/08/S1401/130). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iD

Tom Ruffles <http://orcid.org/0000-0001-9925-5262>

REFERENCES

- Bloom CI, Franklin C, Bush A, *et al.* Burden of preschool wheeze and progression to asthma in the UK: population-based cohort 2007 to 2017. *J Allergy Clin Immunol* 2021;147:1949–58.
- Bonner K, Scotney E, Saglani S. Factors and mechanisms contributing to the development of preschool wheezing disorders. *Expert Rev Respir Med* 2021;15:745–60.
- Tischer CG, Hohmann C, Thiering E, *et al.* Meta-Analysis of mould and dampness exposure on asthma and allergy in eight European birth cohorts: an ENRIECO initiative. *Allergy* 2011;66:1570–9.
- Caillaud D, Leynaert B, Keirsbulck M, *et al.* Indoor mould exposure, asthma and rhinitis: findings from systematic reviews and recent longitudinal studies. *Eur Respir Rev* 2018;27:170137.
- Citizens Advice. More than one and a half million children in England live in cold, damp or mouldy private rented homes, citizens advice reveals. 2023.
- Vandenbroucke JP, von Elm E, Altman DG, *et al.* Strengthening the reporting of observational studies in epidemiology (STROBE): explanation and elaboration. *PLoS Med* 2007;4:e297.
- Ruffles T, Inglis SK, Memon A, *et al.* Environmental risk factors for respiratory infection and wheeze in young children: a multicentre birth cohort study. *Pediatr Pulmonol* 2024;59:19–30.
- Dai X, Dharmage SC, Lodge CJ. The relationship of early-life household air pollution with childhood asthma and lung function. *Eur Respir Rev* 2022;31:220020.
- Milanzi EB, Koppelman GH, Smit HA, *et al.* Timing of secondhand smoke, pet, dampness or mould exposure and lung function in adolescence. *Thorax* 2020;75:153–63.
- Thacher JD, Gruzieva O, Pershagen G, *et al.* Mold and dampness exposure and allergic outcomes from birth to adolescence: data from the BAMSE cohort. *Allergy* 2017;72:967–74.
- Norbäck D, Cai GH. Dampness, indoor mould, fungal DNA and respiratory health—molecular methods in indoor epidemiology. *Clin Exp Allergy* 2015;45:840–3.
- Vesper SJ. The development and application of the environmental relative Moldiness index (ERMI). *Crit Rev Microbiol* 2024;2024:1–11.
- Reponen T, Lockey J, Bernstein DI, *et al.* Infant origins of childhood asthma associated with specific molds. *J Allergy Clin Immunol* 2012;130:639–44.
- Rothman KJ. No adjustments are needed for multiple comparisons. *Epidemiology* 1990;1:43–6.
- Michels KB, Rosner BA. Data Trawling: to fish or not to fish. *Lancet* 1996;348:1152–3.



The Influence of genetic and environmental factors on childhood diseases

Postal questionnaire to assess asthma/allergy: Year 1

Thank you for agreeing to participate in our study one year ago. Please fill out this questionnaire and return it in the pre-paid envelope that has been supplied.

How to complete the questionnaire: Please tick the appropriate box

Example: Person completing questionnaire (tick box please):

Mother Father Other

Name of Child:

Bar Code Sticker

Date of Birth:

- Person completing questionnaire (tick box please):

Mother Father Other

- Date questionnaire completed:

day ____ month ____ year _____

(please fill in today's date)

1. In the last year, has your child had an **ITCHY** skin condition - by *itchy* we mean scratching or rubbing the skin)?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

IF YOU HAVE ANSWERED 'NO' PLEASE SKIP TO QUESTION 2

IF YOU HAVE ANSWERED 'YES' PLEASE ANSWER THE QUESTIONS IN THE SHADED BOX BELOW:

1b. Was this ITCHY skin condition coming and going for at least six months?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

1c. Has your child had this ITCHY skin condition in the last week?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

1d. How old was your child when this skin condition began? months old

1e. Has this skin condition ever affected the skin creases in the past – by skin creases we mean fronts of elbows, behind the knees, front of ankles, around the neck or around the eyes?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

2. In the last year, has your child suffered from a dry skin in general?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

3. In the last year, has your child suffered from any of the following skin complaints: (PLEASE TICK ALL THAT APPLY).

Eczema	<input type="checkbox"/>
Facial spots	<input type="checkbox"/>
Nappy rash	<input type="checkbox"/>

4. In the last year, has your child ever had wheezing or whistling in the chest? By "wheezing" we mean breathing that makes a high-pitched whistling or squeaking sound from the chest, not the throat

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

IF YOU HAVE ANSWERED 'NO' PLEASE SKIP TO QUESTION 12

IF YOU HAVE ANSWERED 'YES' PLEASE ANSWER THE QUESTIONS IN THE SHADED BOX BELOW:

4a. How old was your child when he/she first began to months wheeze?

5. In the last year, has your child had wheezing or whistling in the chest during or soon after a cold or flu? Yes
No

6. How many attacks of wheezing has your child had during the last 12 months? None
1 to 3
4 to 12
More than 12

7. Do these attacks cause him/her to be short of breath? Yes, always
Most of the time
Occasionally
No, never

8. Which of these two descriptions fits best your child's wheeze? (TICK ONE ONLY)

My child has only short attacks of wheeze, for example with colds. In between these attacks, he/she does not normally wheeze
My child wheezes always or a lot of the time. With colds he/she has attacks with more severe wheeze

9. In the last year, how often, on average, has your child's sleep been disturbed due to wheezing? never woken with wheezing
less than one night per week
one or more nights per week

10. In the last year, did any of the following things cause wheezing in your child? Feeding; playing? Yes
No
Don't know

laughing, crying or excitement?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
	Don't know	<input type="checkbox"/>
Contact with pets or other animals?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
	Don't know	<input type="checkbox"/>
Food or drinks?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
	Don't know	<input type="checkbox"/>
11. Looking back on the last year, do you think that your child had asthma?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>

12. Does your child usually have a cough with colds?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

13. Does your child have a cough even without having a cold?

Yes, always	<input type="checkbox"/>
Yes, sometimes	<input type="checkbox"/>
No, never	<input type="checkbox"/>

14. Do you think that your child coughs more than other children?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

15. In the last year, has your child had a dry cough at night, apart from a cough associated with a cold or a chest infection?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

16. In the last 12 months, did the following things cause coughing in your child?

	Yes	<input type="checkbox"/>
Feeding or playing?	No	<input type="checkbox"/>
	Don't know	<input type="checkbox"/>

	Yes	<input type="checkbox"/>
laughing, crying or excitement?	No	<input type="checkbox"/>
	Don't know	<input type="checkbox"/>

	Yes	<input type="checkbox"/>
contact with pets or other animals?	No	<input type="checkbox"/>
	Don't know	<input type="checkbox"/>

	Yes	<input type="checkbox"/>
food or drinks?	No	<input type="checkbox"/>
	Don't know	<input type="checkbox"/>

	Never	<input type="checkbox"/>
17. How often did your child see the GP for coughing or wheezing during the last 12 months?	Once	<input type="checkbox"/>
	2-3 times	<input type="checkbox"/>
	4-6 times	<input type="checkbox"/>
	7 or more times	<input type="checkbox"/>

18. In the last 12 months, has wheezing or asthma resulted in your child:

	Yes	<input type="checkbox"/>
being referred to a consultant in hospital	No	<input type="checkbox"/>

	Yes	<input type="checkbox"/>
being admitted to hospital	No	<input type="checkbox"/>

	Yes	<input type="checkbox"/>
attending the casualty (A and E) department	No	<input type="checkbox"/>

	Yes	<input type="checkbox"/>
attending (or calling) the GP in an emergency	No	<input type="checkbox"/>

19. Did your child take any of the following drugs during the last 12 months?

Salbutamol, Ventolin, Bricanyl or other blue inhaler

Yes
 No
 Don't know

Pulmicort, Flixotide, Becotide or other brown inhaler

Yes
 No
 Don't know

Steroid tablets (prednisolone) for asthma attacks

Yes
 No
 Don't know

20. In the last year, did your child suffer from rattly breathing (rattles)?

Never
 Only with a cold
 Sometimes even without a cold
 Almost always

21. In the last year, how many times has your child had a cold or flu?

Never
 1-3 times
 4-6 times
 7-10 times
 More than 10 times

22. How long does a cold usually last in your child?

Less than 1 week
 1 to 2 weeks
 2 to 4 weeks
 More than 4 weeks

23. In the past year, has your child had a problem with sneezing, or a runny, or blocked nose when he/she did NOT have a cold or the flu?

Yes
 No

24. In the past year, how much did this nose problem interfere with your child's feeding, playing and other activities?

Not at all	<input type="checkbox"/>
A little	<input type="checkbox"/>
A moderate amount	<input type="checkbox"/>
A lot	<input type="checkbox"/>

25. Over the past 12 months, has your child snored at night?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

IF YOU HAVE ANSWERED 'NO' PLEASE SKIP TO QUESTION 26

IF YOU HAVE ANSWERED 'YES' PLEASE ANSWER THE QUESTIONS IN THE SHADED BOX BELOW:

25.a. If yes, has he/she snored:	Only with a cold	<input type="checkbox"/>
	Sometimes even without a cold	<input type="checkbox"/>
	Almost always	<input type="checkbox"/>
25.b Did the snoring disturb your child's sleep?	Not at all	<input type="checkbox"/>
	A little	<input type="checkbox"/>
	A moderate amount	<input type="checkbox"/>
	A lot	<input type="checkbox"/>

26. In the past 12 months, has your child had any ear infections?

No, never	<input type="checkbox"/>
Yes, once	<input type="checkbox"/>
Yes, more than once	<input type="checkbox"/>

27. Has your child ever suffered from any of the following conditions?

pneumonia?	No, never	<input type="checkbox"/>
	Yes, once	<input type="checkbox"/>
	Yes, more than once	<input type="checkbox"/>

whooping cough?	No, never	<input type="checkbox"/>
	Yes, once	<input type="checkbox"/>
	Yes, more than once	<input type="checkbox"/>
bronchiolitis?	No, never	<input type="checkbox"/>
	Yes, once	<input type="checkbox"/>
	Yes, more than once	<input type="checkbox"/>
croup?	No, never	<input type="checkbox"/>
	Yes, once	<input type="checkbox"/>
	Yes, more than once	<input type="checkbox"/>
28. Does your child attend day care, childminder, nursery school or play school?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
29. Was your child breastfed?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
If yes, how long:	less than a month	<input type="checkbox"/>
	1-3 months	<input type="checkbox"/>
	4-6 months	<input type="checkbox"/>
	more than 6 months	<input type="checkbox"/>
30. During the first year of life, did your child posit or vomit?	Not at all	<input type="checkbox"/>
	A little	<input type="checkbox"/>
	A lot	<input type="checkbox"/>

31. Do you think your child has a reaction to any food items?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

IF YOU HAVE ANSWERED 'NO' PLEASE SKIP TO QUESTION 32

IF YOU HAVE ANSWERED 'YES' PLEASE ANSWER THE QUESTIONS IN THE SHADED BOX BELOW:

<p>31a. Does your child have a reaction to any of these foods? (PLEASE TICK ALL THAT APPLY)</p> <p>If you have ticked 'other', please describe the type of food that causes the reaction:.....</p>	<p>Peanuts <input type="checkbox"/></p> <p>Cows milk <input type="checkbox"/></p> <p>Egg <input type="checkbox"/></p> <p>Gluten (eg wheat, oats) <input type="checkbox"/></p> <p>Fruit <input type="checkbox"/></p> <p>Other (please describe) <input type="checkbox"/></p>
<p>31b. What type of reaction does the food cause? (PLEASE TICK ALL THAT APPLY)</p> <p>If you have ticked 'other', please describe the type of reaction:.....</p>	<p>Breathing problems <input type="checkbox"/></p> <p>Vomit <input type="checkbox"/></p> <p>Diarrhea <input type="checkbox"/></p> <p>Stomach pain <input type="checkbox"/></p> <p>Rashes <input type="checkbox"/></p> <p>Irritability <input type="checkbox"/></p> <p>Other (please describe) <input type="checkbox"/></p>
<p>31c. Has your child been treated by a doctor for allergies to any of these foods? (PLEASE TICK ALL THAT APPLY)</p> <p>If you have ticked 'other', please describe the type of food allergy that has been treated:.....</p>	<p>Peanuts <input type="checkbox"/></p> <p>Cows milk <input type="checkbox"/></p> <p>Egg <input type="checkbox"/></p> <p>Gluten (eg wheat, oats) <input type="checkbox"/></p> <p>Fruit <input type="checkbox"/></p> <p>Other (please describe) <input type="checkbox"/></p>

32. Does your child have brothers and sisters who have the same mother and father as him/her? Yes
No

If yes, how many? (please fill in number)

If yes, how many have: -

Asthma or wheezing? (please fill in number)

Hay fever? (please fill in number)

Eczema? (please fill in number)

33. How many children under 16 live in your household?
(PLEASE FILL IN NUMBER)

34. How many adults over 16 usually live in your household?
(PLEASE FILL IN NUMBER)

35. How many rooms are there in your house, not counting kitchens, bathrooms and toilets? (PLEASE FILL IN NUMBER)

36. At what age did the child's mother finish full-time education? (PLEASE FILL IN AGE)

37. Which fuel is mainly used for cooking in your home? Electricity
Gas
Other fuel

38. How do you heat your home?
(PLEASE TICK AS MANY AS APPLY)

- Electric central heating
- Gas central heating
- Central heating with other fuel, e.g. oil
- Heaters in rooms
- Coal or wood fire

39. Is there visible damp within the house ?

- Yes
- No

If there is visible damp, which rooms is it in?
(PLEASE TICK ALL THAT APPLY)

- Kitchen
- Bathroom
- Child's bedroom
- Other living areas

40. What type of flooring does your child have in his/her bedroom?

- Carpet
- Laminate
- Laminate with rug
- Other hard flooring
- Other

41. Is your child exposed to animals?
(By exposed we mean do they come into close contact with any animals on a regular basis)

- Yes
- No

If yes, which of the following animals?
(PLEASE TICK ALL THAT APPLY)

If your child is exposed to other animals that are not on the list, please write which kind of animals in the space below:

.....

Cat	<input type="checkbox"/>
Dog	<input type="checkbox"/>
Bird	<input type="checkbox"/>
Fish	<input type="checkbox"/>
Rat	<input type="checkbox"/>
Gerbil	<input type="checkbox"/>
Rabbit	<input type="checkbox"/>
Hamster	<input type="checkbox"/>
Guinea pig	<input type="checkbox"/>
Sheep	<input type="checkbox"/>
Pigs	<input type="checkbox"/>
Cows	<input type="checkbox"/>
Horses	<input type="checkbox"/>

42. Does the child's mother smoke cigarettes?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

If yes, how many per day?

1 to 10	<input type="checkbox"/>
11 to 20	<input type="checkbox"/>
More than 20	<input type="checkbox"/>

43. Do any other household members smoke cigarettes?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

If yes, how many per day (total cigarettes smoked by household members other than mother)?

1 to 10	<input type="checkbox"/>
11 to 20	<input type="checkbox"/>
More than 20	<input type="checkbox"/>

44. How would you best describe the location of your house? (PLEASE TICK THE ONE THAT BEST APPLIES)

- In a street with very dense traffic (main road)
- In a street with moderate traffic (residential road)
- In a quiet street with little or no traffic

<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>

45. Did you have any problems understanding this questionnaire?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

Please write any comments you have about your child’s health or about the questionnaire in the space below:

.....

.....

.....

.....

.....

Thank you for completing the questionnaire. It will cost you nothing to return it if you use the pre-paid envelope provided.

For any queries please do not hesitate to contact us:

Dr Konnie Basu, Mrs Maureen Quin
Tel: 01273 696955; ext 2404, 2396

E-mail:
k.basu@bsms.ac.uk; Maureen.Quin@bsuh.nhs.uk

DATA SUPPLEMENT 2

Supplementary Table 1 – Confounder analyses

	Bronchiolitis	Pneumonia	Otitis media	Cold or flu	Wheeze	Dry cough	Reliever inhaler	Inhaled corticosteroid	Primary care cough & wheeze	Emergency department for wheeze	Secondary care for wheeze
	0-24 months OR (95% CI) p-value	0-24 months OR (95% CI) p-value	0-24 months OR (95% CI) p-value	0-24 months OR (95% CI) p-value	0-24 months OR (95% CI) p-value	0-24 months RR (95% CI) p-value	0-24 months RR (95% CI) p-value	0-24 months RR (95% CI) p-value	0-24 months OR (95% CI) p-value	0-24 months RR (95% CI) p-value	0-24 months RR (95% CI) p-value
Breastfed >6 months	0.55 (0.39-0.77) p<0.001	1.05 (0.45-2.42) p=0.917	0.75 (0.59-0.99) p=0.040	1.07 (0.86-1.34) p=0.523	0.52 (0.39-0.75) p<0.001	0.85 (0.61-1.17) p=0.314	0.78 (0.57-1.07) p=0.122	0.68 (0.37-1.24) p=0.212	0.69 (0.55-0.86) p=0.001	0.81 (0.52-1.27) p=0.360	1.08 (0.59-2.00) p=0.740
Daycare	1.40 (1.02-1.90) p=0.035	2.39 (1.04-5.49) p=0.040	1.68 (1.32-2.14) p<0.001	1.72 (1.41-2.09) p<0.001	2.16 (1.62-2.87) p<0.001	2.01 (1.47-2.21) p<0.001	1.75 (1.33-2.31) p<0.001	1.46 (0.84-2.52) p=0.180	1.47 (1.21-1.78) p<0.001	1.81 (1.17-2.80) p=0.007	2.08 (1.15-3.73) p=0.015
Siblings	1.65 (1.18-2.32) p=0.004	2.25 (0.95-5.33) p=0.066	1.05 (0.82-1.35) p=0.689	1.03 (0.84-1.26) p=0.800	1.31 (0.97-1.77) p=0.082	1.04 (0.77-1.39) p=0.812	1.37 (1.02-1.85) p=0.037	1.57 (0.86-2.87) p=0.140	1.25 (1.02-1.53) p=0.030	1.32 (0.84-2.06) p=0.224	1.57 (0.73-3.35) p=0.245
Damp in house	1.47 (0.80-2.71) p=0.219	2.16 (0.58-8.12) p=0.254	1.21 (0.77-1.90) p=0.408	1.15 (0.77-1.70) p=0.499	1.85 (1.11-3.19) p=0.028	1.76 (1.02-3.04) p=0.042	1.73 (1.04-2.89) p=0.036	2.61 (1.03-6.59) p=0.043	1.68 (1.17-2.42) p=0.005	1.00 (0.43-2.39) p=0.982	1.14 (0.41-3.21) p=0.797
Tobacco smoke	0.94 (0.55-1.57) p=0.801	0.77 (0.23-2.65) p=0.684	1.08 (0.86-1.80) p=0.621	0.83 (0.59-1.12) p=0.208	1.15 (0.73-1.79) p=0.549	1.26 (0.79-2.00) p=0.329	1.30 (0.82-2.05) p=0.268	1.03 (0.42-2.49) p=0.953	1.52 (1.11-2.08) p=0.009	1.05 (0.54-2.03) p=0.885	1.59 (0.75-3.39) p=0.229
Carpet in bedroom	1.00 (0.68-1.47) p=0.988	0.82 (0.39-1.77) p=0.611	1.07 (0.80-1.42) p=0.654	1.19 (0.93-1.52) p=0.158	1.01(0.72-1.42) p=0.972	1.38 (0.942.03) p=0.101	1.32 (0.93-1.90) p=0.124	1.08 (0.52-2.29) p=0.842	1.01 (0.80-1.28) p=0.910	0.81 (0.51-1.30) p=0.383	0.99 (0.51-1.92) p=0.976
Animal	0.93 (0.67-1.30) p=0.683	0.81 (0.35-1.90) p=0.634	0.99 (0.77-1.26) p=0.910	0.84 (0.69-1.01) p=0.077	1.15 (0.86-1.55) p=0.343	0.99 (0.72-1.34) p=0.926	1.08 (0.81-1.44) p=0.598	1.10 (0.63-1.92) p=0.544	0.94 (0.77-1.15) p=0.547	0.90 (0.59-1.39) p=0.642	1.06 (0.62-1.82) p=0.832
Dense traffic	1.32 (1.08-2.29) p=0.011	0.69 (1.55-2.86) p=0.588	1.37 (0.92-2.04) p=0.121	1.01 (0.81-1.21) p=0.893	1.15 (0.88-1.50) p=0.927	0.96 (0.71-1.40) p=0.889	0.97 (0.59-1.58) p=0.891	0.41 (0.10-1.72) p=0.222	0.97 (0.68-1.38) p=0.869	0.70 (0.43-1.38) p=0.320	0.78 (0.28-2.19) p=0.632
Solid fuel	0.62 (0.32-1.18) p=0.145	1.23 (0.43-3.55) p=0.702	0.91 (0.60-1.39) p=0.667	1.10 (0.49-1.01) p=0.572	1.01 (0.74-1.98) p=0.889	0.87 (0.58-1.39) p=0.601	0.82 (0.47-1.42) p=0.476	0.79 (0.27-2.32) p=0.671	0.90 (0.66-1.23) p=0.501	0.59 (0.31-1.3-1) p=0.210	0.58 (0.17-1.71) p=0.285

Adjusted relative risks (RR) and 95% confidence intervals (95%CI) were estimated for binary outcomes using log binomial regression. Adjusted odds ratios (OR) and 95% confidence intervals (95%CI) were estimated for ordered grouped counts using ordinal logistic regression. A single multivariable regression analysis was performed for each of the 11 clinical outcomes. All environmental risk factors were included in each analysis and data was adjusted for mother's level of education.

DATA SUPPLEMENT 3

Supplementary Table 2 - Presence of damp in kitchen, bathroom and living room, and, the occurrence of respiratory symptoms, healthcare utilisation, medication prescriptions and respiratory infections.

	Damp in kitchen 0-24 months	Damp in bathroom 0-24 months	Damp in living room 0-24 months
Wheeze	RR 1.18 (0.81-1.61) p=0.510	RR 1.14 (0.90-1.54) p=0.212	RR 1.14 (0.91-1.47) p=0.227
Dry cough	RR 0.80 (0.46-1.46) p=0.468	RR 1.01 (0.72-1.40) p=0.887	RR 1.21 (0.92-1.61) p=0.193
Primary care for cough and wheeze	OR 1.10 (0.76-1.62) p=0.580	OR 1.20 (0.89-1.60) p=0.267	OR 1.22 (0.93-1.77) p=0.133
Emergency department attendance wheeze	RR 0.73 (0.40-2.01) p=0.499	RR 1.40 (0.87-2.32) p=0.152	RR 1.20 (0.71-1.97) p=0.512
Secondary care for cough and wheeze	RR 1.12 (0.49-3.50) p=0.770	RR 0.98 (0.42-2.23) p=0.969	RR 1.01 (0.50-2.09) p=0.998
Reliever inhaler	RR 0.82 (0.51-1.44) p=0.510	RR 0.92 (0.69-1.35) p=0.770	RR 1.03 (0.77-1.38) p=0.852
Inhaled corticosteroid	RR 1.31 (0.52-4.10) p=0.501	RR 1.49 (0.74-3.11) p=0.299	RR 1.42 (0.74-2.76) p=0.301
Oral corticosteroid	RR 0.88 (0.22-2.30) p=0.643	RR 1.51 (0.84-2.90) p=0.180	RR 1.22 (0.69-2.22) p=0.489
Bronchiolitis	OR 1.02 (0.62-1.99) p=0.851	OR 1.30 (0.84-2.17) p=0.250	OR 1.04 (0.70-1.58) p=0.886
Pneumonia	OR 1.07 (0.27-4.60) p=0.911	OR 1.43 (0.50-3.10) p=0.493	OR 0.99 (0.35-2.91) p=0.987
Cold or flu	OR 1.13 (0.80-1.61) p=0.480	OR 1.12 (0.74-1.50) p=0.412	OR 1.32 (0.94-1.87) p=0.088
Otitis media	OR 1.03 (0.64-1.65) p=0.904	OR 0.96 (0.66-1.30) p=0.790	OR 1.30 (0.93-1.78) p=0.133

Adjusted relative risks (RR) and 95% confidence intervals (95%CI) were estimated for binary outcomes using log binomial regression. Adjusted odds ratios (OR) and 95% confidence intervals (95%CI) were estimated for ordered grouped counts using ordinal logistic regression. Models were adjusted for: the mother's level of education; daycare attendance; breast feeding beyond 6-months; siblings at home; environmental tobacco smoke exposure; child's bedroom flooring (as a surrogate of house dust mite); animal exposure; road traffic density (traffic pollution) around child's home (little/moderate/dense); and solid fuel pollution within home.