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

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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.

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.

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 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 principles[6] 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.

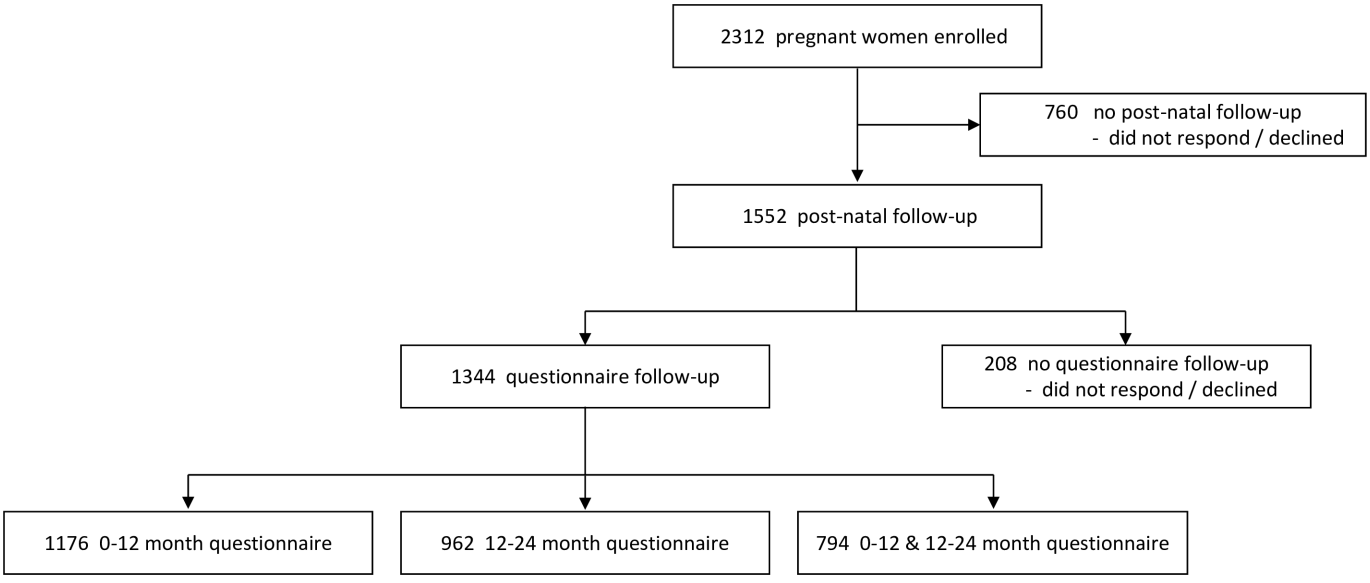

Figure 1 Study profile.

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.

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				
		0–12 months		12–24 months		
		No	Yes	No	Yes	0–24 months
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.

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 identified[9] as well as an increased risk of asthma at age 16.[10]

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 effecting 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.

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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.

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