Environment International 79 (2015) 115–129

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Fuel poverty increases risk of mould contamination, regardless of adult risk perception & ventilation in social housing properties

Richard A. Sharpe [a], Christopher R. Thornton [b], Vasilis Nikolaou [c], Nicholas J. Osborne [a,d,e,*]

[a] European Centre for Environment and Human Health, University of Exeter Medical School, Knowledge Spa, Royal Cornwall Hospital, Truro, Cornwall TR1 3HD, United Kingdom
[b] College of Life and Environmental Sciences, University of Exeter, Stocker Road, Exeter EX4 4QD, United Kingdom
[c] University of Exeter Medical School, The Veysey Building, Salmon Pool Lane, Exeter EX2 4SG, United Kingdom
[d] Department of Paediatrics, University of Melbourne, Flemington Road, Parkville, Melbourne, Australia
[e] Department of Clinical Pharmacology, Sydney Medical School, University of Sydney, Australia

ARTICLE INFO

Article history:
Received 20 July 2014
Received in revised form 27 February 2015
Accepted 6 March 2015
Available online 28 March 2015

Keywords:
Risk
Fuel poverty
Mould
Asthma
Ventilation
Health

ABSTRACT

Introduction: Fuel poverty affects 2.4 million UK homes leading to poor hygrothermal conditions and risk of mould and house dust mite contaminations, which in turn increases risk of asthma exacerbation. For the first time we assess how fuel poverty, occupants' risk perception and use of mechanical ventilation mediate the risk of mould contamination in social housing.

Methods: Postal questionnaires were sent to 3867 social housing properties to collect adult risk perception, and demographic and environmental information on occupants. Participant details were linked to data pertaining to the individual properties. Multiple logistic regression was used to calculate odds ratios and confidence intervals while allowing for clustering of individuals coming from the same housing estate. We used Structured Equation Modelling and Goodness of Fit analysis in mediation analyses to examine the role of fuel poverty, risk perception, use of ventilation and energy efficiency.

Results: Eighteen percent of our target social housing populations (671 households) were included into our study. High risk perception (score of 8–10) was associated with reduced risk of mould contamination in the bedrooms of children (OR 0.5 95% CI; 0.3–0.9) and adults (OR 0.4 95% CI; 0.3–0.7). High risk perception of living with inadequate heating and ventilation reduced the risk of mould contamination (OR 0.5 95% CI; 0.3–0.8 and OR 0.5 95% CI; 0.3–0.7, respectively). Participants living with inadequate heating and not heating due to the cost of fuel had an increased risk of mould contamination (OR 3.4 95% CI; 2.0–5.8 and OR 2.2 95% CI; 1.5–3.2, respectively). Increased risk perception and use of extractor fans did not mediate the association between fuel poverty behaviours and increased risk of mould contamination.

Discussion: Fuel poverty behaviours increased the risk of mould contamination, which corresponds with existing literature. For the first time we used mediation analysis to assess how this association maybe modified by occupant behaviours. Increased risk perception and use of extractor fans did not modify the association between fuel poverty and mould contamination. This suggests that fuel poor populations may not benefit from energy efficiency interventions due to ineffective heating and ventilation practices of those occupants residing participating households. Our findings may be modified by a complex interaction between occupant behaviours and the built environment. We found that participant age, occupancy, SES, pets, drying washing indoors, geographic location, architectural design/age of the property, levels of insulation and type of heating regulated risk of mould contamination.

Conclusion: Fuel poverty behaviours affected around a third of participating households and represent a risk factor for increased exposures to damp and mouldy conditions, regardless of adult risk perception, heating and ventilation practices. This requires multidisciplinary approach to assess the complex interaction between occupant behaviours, risk perception, the built environment and the effective use of heating and ventilation practices.

Study implications: Our findings have implications for housing policies and future housing interventions. Effective communication strategies focusing on awareness and perception of risk may help address indoor air quality issues. This must be supported by improved household energy efficiency with the provision of more effective heating and ventilation strategies, specifically to help alleviate those suffering from fuel poverty.

Abbreviations: ACH, air exchange rate; IAQ, indoor air quality; IMD, Index of Multiple Deprivation; LARES, The Large Analysis and Review of European housing and health Status; MSqPCR, mould specific quantitative polymerase chain reaction; OR, odds ratio; SEM, Structured Equation Modelling; SES, social economic status

* Corresponding author at: European Centre for Environment and Human Health, University of Exeter Medical School, Knowledge Spa, Royal Cornwall Hospital, Truro, Cornwall TR1 3HD, United Kingdom.
E-mail address: n.j.osborne@exeter.ac.uk (N.J. Osborne).

http://dx.doi.org/10.1016/j.envint.2015.03.009
0160-4120/

1. Introduction

Tailored housing improvements aimed at improving ventilation and heating offer a cost-effective approach for delivering healthcare to individuals suffering from moderate to severe asthma (Edwards et al., 2011). There is also compelling evidence supporting energy efficiency interventions aimed at vulnerable populations (Gibson et al., 2011), which can be adversely impacted by fuel poverty. Fuel poverty affects around 2.4 million UK households (Department of Energy and Climate Change, 2014a) and up to 34% of homes in some European countries (Liddell and Morris, 2010). Inadequate heating leads to poor hygrothermal conditions and increases risk of damp and mould contamination (Sharpe et al., 2015a), and the development of asthma (Quansah et al., 2012) and/or exacerbation of symptoms in asthmatic individuals (Sharpe et al., 2014a). Other potential health risks resulting from increased exposure to damp and mould contamination include dyspnea, wheeze, bronchitis, cough, respiratory infections (including otitis media), eczema, allergic rhinitis, and upper respiratory tract symptoms (including allergic rhinitis).

Occupant awareness of the potential health effects of air pollution may have a direct and indirect impact on people's awareness (Hunter et al., 2003) and mental health (Shenassa et al., 2007). Perceptions of risk may be modified by variations in occupant awareness and the adoption of different coping strategies to minimise exposures thought to be a health risk (Crosland et al., 2009). This is likely to be complicated by fuel poverty behaviours when occupants make financial trade-offs (Anderson et al., 2012; O'Sullivan et al., 2011), ration heating (Lomax and Wedderburn, 2009) and ventilation to save heat and energy. The impact of occupant awareness and resultant impact on indoor dampness, mould and indoor air quality (IAQ) will be regulated by a complex interaction between behavioural factors and the build environment (Sharpe et al., 2015a).

The best available evidence to date suggests that homes must be of an appropriate size for the household and affordable to heat (Thomson et al., 2013). Addressing occupant behavioural and built environment risk factors using multidisciplinary interventions involving home-based education, cleaning and mould abatement can decrease asthma triggers and improve quality of life (Sweet et al., 2014; Wu and Takaro, 2007), although not all educational programmes are successful (Wu and Takaro, 2007) and mould growth can return following its removal (Burr et al., 2007) or within 12 months of energy efficiency upgrades (Richardson et al., 2005). This may be because few intervention studies identify the dynamics of how people perceive and use the environment (Berke and Vernez-Moudon, 2014), or how occupant awareness contributes to the provision of adequate heating and ventilation (Dimitroulopoulou, 2012). Other potential causes of elevated dampness and mould growth include a number of factors such as the location/orientation of a property, changes in temperature/humidity, and property design/levels of maintenance/structural problems leading to rising damp or water leaks for example (Sharpe et al., 2015a).

Addressing occupant behaviours resulting from low risk perception offers an opportunity for health interventions to help alleviate dampness and mould contamination, and associated risk of asthma symptoms (Hunter et al., 2003). It is also important to consider recent trends in increased household energy efficiency, consequent of a policy to reduce the UK carbon footprint and alleviate fuel poverty. Increasing household energy efficiency is achieved by upgrading heating systems, insulation and reducing ventilation rates to prevent heat loss. Reduced ventilation rate increases risk of damp and mould contamination (Sharpe et al., 2015a), and has been shown to be a risk factor for asthma (Sharpe et al., 2015b) and allergic diseases (Bornehag et al., 2005) when air changes per hour (ACH) fall below the European standard of 0.5 ACH (Dimitroulopoulou, 2012). Assessing occupant behaviours and ventilation practices is needed to understand variations in indoor dampness/mould contamination and how it interacts with the built environment (Meadow et al., 2013) and asthma outcomes (Sharpe et al., 2014a).

To our knowledge, no study has assessed how fuel poverty and energy efficiency interact to modify the risk of mould contamination, and how the association is mediated by risk perception and use of mechanical ventilation. In the following paper, we focus on housing managed by a UK social housing association, a not-for-profit organisation responsible for the provision of affordable housing (Department for Communities and Local Government, 2013). Social housing associations are responsible for managing 17% of the UK housing stock (Department for Communities and Local Government, 2013). This provides an opportunity for area-level interventions targeting populations living in lower socio-economic status in order to help reduce indoor exposures to physical, chemical and biological agents and disease initiation and/or exacerbation. Our aims are to determine whether 1) risk perception and fuel poverty behaviour modify the risk of visible mould growth, 2) fuel poverty behaviour and mould contamination are mediated by occupant's risk perception, 3) fuel poverty behaviours and mould contamination are mediated by occupant's use of extractor fans, and 4) household energy efficiency and risk of mould contamination are mediated by fuel poverty behaviours.

2. Methods

2.1. Postal questionnaire

Ethical approval for this cross sectional study was granted by the University of Exeter Medical School, application number 13/02/013. We sent out 3867 postal questionnaires to tenancy holders residing in social housing in the South West of England, UK (Fig. A.1), during the months of August 2012, October 2013, November 2013 and January 2014. Questionnaires were designed using a closed questioning technique to collect demographic and behavioural data on all occupants in each household. Written consent was obtained using a form containing a series of scripted questions concerning participant involvement in various elements of the study.

The questionnaire collected information about all of the household occupants and indoor behaviours thought to modify the risk of indoor mould contamination. Behavioural questions were designed to obtain demographic characteristics such as smoking status, the amount of time participants spent indoors on an average day, employment, frequency of vacuuming, presence of pets, extent of carpeting, clothes drying methods, heating and ventilation patterns. We asked participants about their current awareness of the potential health risks resulting from exposure to damp and mould, efforts to alleviate dampness related exposures, and fuel poverty behaviours. We asked participants about their perception of risk associated with the presence of mould (a score of 0–10) and considered a low risk perception when participants scored between 0 and 4, and then a high risk perception for scores between 8 and 10. Our risk perception and fuel poverty exposures were defined by asking participants the following questions.

1. Perception of risk was assessed by asking "on a scale of 1 to 10 (10 being the highest risk), what do you perceive the risk to adults and children's health if" (Latent variable L1 — excluding inadequate heating and ventilation):

- ○ Adult living with mould greater > postcard in your lounge?
- ○ Adult living with mould greater > postcard in your bathroom?
- ○ Adult living with mould greater > postcard in your bedroom?
- ○ Child living with mould greater > postcard in your lounge?
- ○ Child living with mould greater > postcard in your bathroom?
- ○ Child living with mould greater > postcard in your bedroom?
- ○ You have inadequate heating in your home?
- ○ You have inadequate ventilation in your home?

2. Fuel poverty behaviours were assessed by asking three dichotomous questions (Latent variable L2);

- ○ Do you not ventilate your home to save heat/energy?
- ○ Do you think your home is adequately heated?