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Associations between home characteristics and mould levels in UK

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Abstract

Mould growth is governed by a complex set of factors, including among others physical characteristics of a given indoor environment, as well as how that space is used, i.e. heating, cleaning and ventilation habits, however how and to what extent these define propensity to grow mould is unclear. This study uses data from a testing scheme on 84 rooms in 18 properties to shed further light on these questions through elastic net regression analysis. The testing data includes the air and surface mould readings quantified based on the activity of β-N-acetylhexosaminidase (EC 3.2.1.52; NAHA), and particle intensity in each room.
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Keywords: Elastic net regression*;* Linear model; Mould testing; Passive sampling; Active sampling

Nomenclature

N	normal probability distribution function
Y	response variable: i.e., Air, Active_Particle, Passive_Particle, Clean_Surface, Dirty_Surface
$\ln(Y)$	natural logarithm of the response variable, Y
X	vector or explanatory variables: $[X_1, X_2,\ldots, X_n]$
a	vector of regression coefficients: $[a_1, a_2,\ldots, a_n]$
b	regression coefficient expressing the intercept of the fitted curve
σ	standard deviation of the normal distribution function

1. Introduction/Background

This study aims to identify which property or room characteristic affects the mould levels in the air or surfaces, or the particle counts in a room. This aim is addressed here empirically using information from tests conducted in rooms located in different sets of properties in the UK. The database adopted here includes information from 86 rooms in homes of those who volunteered to take part in the Mould Testing and Benchmarking project ran by the UKCMB between 2016-2017.

The data used here were obtained from properties of various sizes scattered across England with diverse age and construction characteristics. In particular, it includes information from 84 rooms of single use in 18 properties. The data include actively measured air mould concentrations quantified on the basis of activity of β-N-acetylhexosaminidase (EC 3.2.1.52; NAHA) (termed 'Air'), the average mould concentrations on visually dirty/dusty or visually clean surfaces (termed 'Dirty Surface' and 'Clean Surface', respectively) and the actively and passively measured particle count (termed 'Active Particle' and 'Passive Particle'). The terms "active" (activated) and "passive" (non-activated) are used to indicate measurements taken after actively mixing the air, and from still air, respectively (For more details see [1-3]).

During the testing programme, a number of house and room characteristics were also recorded through questionnaires and survey sheets. The statistical analysis aims to identify which are the characteristics of the dwelling, the room or the patterns of the resident behaviour which seem to affect the measurements of mould in the air and on surfaces as well as the particle counts.

2. Methodology

Despite the relatively high number of tested rooms in the database, the large percentage of missing data in the response and most of the explanatory variables, as well as the complex missing pattern, poses a major challenge in analyzing the data. Given this difficulty, the analysis of the database is based on the simplifying assumptions that the data are missing completely at random and only the explanatory variables with missing data less than 20% are considered. The statistical analysis is conducted here in two stages:

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- In Stage 1, the statistically significant explanatory variables which can predict trends in each response variable are identified among the explanatory variables by fitting linear models to the data. This case, however, tests the impact of individual explanatory variables a single response variable.
- In Stage 2, a multiple regression aims to account for all explanatory variables and identify the subset of the most significant explanatory variables for each response variable:

$$\ln(Y) \sim \mathrm{N}(a^T X + b,\ \sigma^2)$$

A variable selection method, termed ‘elastic net’, is adopted. It should be noted that the variables are standardised in order to reduce the impact of the scale to the determination of the penalty parameter, which means that the coefficients of regression are directly comparable. It should be noted that for coefficient values less than 0.10, the associated explanatory variable is considered insignificant.

3. Results

The final results of the second stage are summarized in Table 1. Room Function, which in this study determined whether the room has running water or not, is found to be insignificant for all 5 response variables. Similarly, the presence of curtains, carpets or rugs as well as the size of the surveyed room are also found to be negligible in predicting each of the 5 response variables. By contrast, the presence of visible mould, the degree of cleanliness of the room or the age of the house the levels are found to affect in varying degrees the measurements of the mould in the air or surfaces and/or the particle counts. In particular, increased mould levels in the air are expected in rooms with visible mould, and to a much smaller degree in rooms which are not clean, while the age plays a much lesser role. Increased mould levels on the clean surfaces are expected in less clean rooms. Increased mould levels on dirty surfaces are expected in less clean rooms with visible mould. Increased (active and passive) particular counts are found in room with visible mould and to a lesser degree in older less clean rooms.

Table 1. Values of *a* estimated by the elastic-net regression analysis.

Characteristic of the	**Variable**		ln(*Air*)	ln(*Clean Surface*)	ln(*Dirty Surface*)	ln(*Active Particle*)	ln(*Passive Particle*)
	Sample Size		***54***	***52***	***52***	***50***	***50***
House	Age	0= Pre1945 1= 1945-1964 2= 1965-1980 3= Post1980	-0.08	-0.03	-0.02	-0.37	-0.36
Room	Size	(2.1 -31.8) m^2	-0.03	0.00	0.00	0.00	0.00
	Function	0= Other 1= Kitchen or Bathroom	0.00	0.00	0.00	0.00	0.00
	Carpet or Rugs	0= Absent 1= Present	0.00	0.00	0.00	0.00	-0.04
	Curtains	0= Absent 1= Present	-0.03	0.00	-0.04	0.00	0.00
	Visible Mould	0= Absent 1= Present	0.35	0.05	0.18	0.68	0.79
	Cleanliness	0= Clean or Spotless 1= Normal 2= Dirty	0.11	0.19	0.11	0.22	0.40

4. Conclusions

In broad terms, the presence of visible mould and to a lesser degree the cleanliness in a room or the age of the dwelling appear to be the variables which affect most importantly the measurements of mould in the air and on dirty surfaces as well as the particle counts. By contrast, the function of the room, its size or the presence of carpets or curtains appear to have a negligible impact in the mould or particle counts in a room.

Acknowledgements

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