# SIMPLIFIED MEASUREMENT TECHNIQUES FOR HEALTH VISITORS TO ASSESS INDOOR ENVIRONMENTS

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## ABSTRACT

There is research acknowledging that the home environment may be responsible for worsening respiratory conditions, especially for children. The indoor environment is a substantial source of exposure to pollutants e.g. environmental tobacco smoke. Apart from conducting specialised, costly and complex studies a method was needed to understand and assess indoor environments in the UK and how people could be encouraged to improve their indoor environment. In the UK, health visitors (HVs) have traditionally visited homes and from September 2003, the UK government will require HVs to take an even more preventative approach to their work. Potentially, HVs are the ideal candidates to perform simple checks and work with clients to improve their indoor environment. This paper highlights some of the initial work conducted as part of this research. Analysis of existing housing and health data revealed a number of indoor environmental variables that were the most influential on the indoor environment. Analysis showed that the number of variables could be reduced to around 17 out of an original 33 variables. A simplified tool kit will be more cost-effective and less time consuming than the original tool kit and will be suitable for use by HVs on routine home visits.

## KEYWORDS

Housing, health, health visitor, quantifying IAQ, indoor environment.

## INTRODUCTION

### Housing and Health

The drive for energy efficiency, originally brought about by the sharp increases in crude oil prices during the 1970s, resurfaced in the 1990s because of the requirement to reduce carbon dioxide ($CO_2$) emissions, created by the burning of fossil fuels (Richards, 1998). In the UK, nearly 50% of $CO_2$ emissions originate from the requirement to heat or cool houses and commercial buildings. Around 85% of houses in England have central heating systems and in theory, the majority of these houses should be warm in winter. However, this is not the case for many houses for the following reasons:

1. Occupants cannot afford the fuel needed to heat the houses to an acceptable level despite substantial Government support (for people aged 60+) and therefore are classed as fuel poor.
2. The poor thermal design of some houses make the cost of heating prohibitive, thereby exacerbating the problem for those who are fuel poor.
3. Occupants choose not to fully utilise heating facilities, preferring to use their expendable income elsewhere or they are often oblivious to the dangers of living in cold houses.

The second reason is possible to ameliorate by improving the energy efficiency of existing properties. The UK government is committed to spending £5.5 billion on housing through a system of grants to improve energy efficiency and reduce fuel poverty. By concentrating on the reduction of $CO_2$, the government is able to assist the private sector, whilst still modernising social housing. The private rented sector presently has the highest number of unfit houses in the UK, (BMA, 2003). The UK government is carrying out a massive housing modernisation programme unparalleled in any industrialised country, over a short period.

## Assessment of the indoor environment

The impact of housing modernisation programmes on the indoor environment and health is poorly understood in the UK. Whilst many studies have been conducted worldwide, the emerging scene in the UK is uncharted (Olsen, 2001). There is literature available worldwide which has assessed the impact of cold, damp houses and numerous indoor pollutants on human health. The indoor environment is continuously compromised by pollutants such as environmental tobacco smoke, nitrogen dioxide etc. Since the average person spends around 90% of their time indoors (mostly in their own home), the quality of the indoor environment is paramount. Research on the relationships between the indoor environment and health are ongoing in the UK, but need to include the impact of modernised houses.

## The current role of Health Visitors (HVs)

There is a need to promote a sustainable, cogent, well-financed and robust monitoring system to record, over a period of many years, the complex interaction between health outcomes and the indoor environment. An alternative is needed to conducting specialised, costly and complex epidemiological studies. Extensive studies usually cover a limited number of individuals, are relatively short term and do not record long-term health effects (BMA, 2003). Further to this, it is difficult to conduct housing studies because of UK legislation on privacy, which prevents any non-invited person or organisation from gaining access, irrespective of the ownership of the property. Health visitors (HVs) have traditionally been one of the few highly qualified health professionals that routinely monitor their clients over long periods (up to four years). They are most often able to enter any home in an official capacity (traditionally for postnatal care). Currently there are around 16,000 HVs in the UK (DOH, 2002). The HVs are managed by 303 local Primary Care Trusts (PCT) and therefore can call on assistance from other health professionals to keep abreast with new practices and regulations. In a move to expand the HVs role as nursing practitioners, the government wants more emphasis put on preventative measures in health care, shifting the emphasis from treatment to a more holistic health promotion (UKCC, 2001). The health of young children, who are especially vulnerable to their indoor environment, (Custovic, 1999) is routinely checked by HVs at present. HVs could therefore be the ideal professionals to perform basic checks of the indoor environment and to work with clients and required specialists to improve the client's indoor environment. As well as helping individual clients, there is an opportunity to close the knowledge gap about the current state of indoor environments in all types of houses in the UK. If 1 in 10 of the HVs visits included an assessment of the indoor environment, substantial information could be gained for little additional expenditure. This information could be used to understand occupants' use of their houses, enabling technicians and regulatory bodies to modify building regulations to better suit the occupants' evolving requirements. Following the modernisation of the housing stock in the UK, the continuous monitoring by HVs would provide a valuable up-to-date record on housing quality and health status.

## OBJECTIVES

This research is designed to explore a new, technology supported expanded role for HVs to work with clients. The HVs will be encouraged to:

1. Use portable instruments to quantify indoor environmental variables and use questionnaires to record information about the occupants, their societal situation and surroundings.
2. Identify remedial or preventative actions that could be taken by occupants, landlords or grant authorities to address health risk factors highlighted by the assessment (1).
3. Follow and react to long-term effects from any interventions.

In addition, the research includes the assessment of:

1. A simplified tool kit (STK) with which HVs can assess the indoor environment, where the tool kit is based on an extensively tested set of measurement tools (Richardson et al. 2000).
2. The HVs' and occupants' acceptance of the STK, and remedial actions.
3. The feasibility of health visitors (given appropriate training) measuring environmental variables instead of environmental engineers.
4. Cost versus accuracy trade-off for the chosen indoor environmental variables

## METHOD

In previous IAQ and health studies (including unpublished work for the Breath of Fresh Air project in Cornwall, England), 33 indoor and outdoor variables have been recorded during a one-hour visit to over 190 properties by qualified environmental engineers. The assessment of IAQ consisted of using complex and expensive measuring instruments and perishable samples for off-site assays. The tool kit covering 33 variables, or $TK_{33}$, was designed to record indoor environmental risk factors previously associated with respiratory health; lifestyles, the structural quality of a house and local climatic conditions. The existing data from the $TK_{33}$ was analysed using principal component analysis (SPSS 11.5) to highlight variables, which could be removed from the $TK_{33}$ to provide a smaller tool kit. A limit was chosen so that the remaining variables would represent at least 80% of the information gathered when using the $TK_{33}$. Correlation and regression analysis were conducted to ascertain the relationships between the variables measured by the $TK_{33}$. These analyses were used to determine if groups of closely related variables could be reduced and whether the variables removed from the $TK_{33}$ could be calculated to replace missing measured data.

A preliminary study was made of HVs routines (e.g. time taken, weight of other equipment carried) through accompanying five different HVs on fifteen visits.

## RESULTS & DISCUSSION

### Statistical analysis of an existing tool kit

The principal component analysis highlighted 10 components, representing 80% of the information from the $TK_{33}$. The recording of the variables listed below will range from using simple measurements to complex and expensive monitoring equipment. For example, aspect and the number of pets are simply observations needing little effort or expense to record, however the recording of the number of fine and coarse particles would require a particle counter, which although can be compact is expensive £3000 – £10000. The measurements lost from the $TK_{33}$ were mainly complimentary measurements to those listed, in particular parallel outdoor measurements and weather conditions. The 10 main components given by the analysis were:

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| Relative humidity (%) indoors; | Temperature ($^{o}$C) indoors; |
| Wall damp (wood moisture equivalent WME%); | House dust mite allergen (*Der p* 1, μg $g^{-1}$); |
| Fine particulates (no. $litre^{-1}$ of air) indoors; | No. of tobacco smokers; |
| Coarse particulates (no. $litre^{-1}$ of air) indoors; | Bioaerosols in and outdoors (no. $cm^{-2}$ $h^{-1}$); |
| Number and type of furred and feathered pets; | Aspect ($^{o}$) of house front entrance. |

The 10 components did not represent a large reduction in the number of instrumentation needed to make an assessment. Relative humidity (RH) and temperature can be measured using simple hand held thermometer/ hygrometers and can be used to calculate absolute humidity (g $kg^{-1}$) and dew point ($^{o}$C), which would add more information to a database. There was a relationship between RH and dampness, however the WME% value could not be predicted through regression analysis. Dampness can be measured using a Protimeter or can be assessed by observing mould or damp on surfaces. A HV would need to enquire about damp and then visually confirm it. Self-reporting by clients has been shown to introduce bias. The measurement of the number of fine and coarse particles requires a particle counter. Although simple handheld laser counters are available, the cost of providing HVs with particle counters would negate their use. Coarse particles indoors are related to activities and the number of people and pets per living space and cannot be predicted from other variables. The removal of particle measurements would lead to a further 20% loss in information from the $TK_{33}$. However an assumption can be made that the presence of smokers and certain cooking practices in an under ventilated house would equate to a high fine particle load. House dust mite allergen requires complex measurement; the method used for the $TK_{33}$ requires offsite ELISA tests. A simplified measurement technique is available that can be used on site which gives an estimation of allergen levels (e.g. low, medium or high)- cost £20/ assay. House dust mite allergen could not be predicted from the other variables, however further analysis has shown that allergen levels are closely related to household management of soft furnishings, particularly bedding. Observations about cleaning routines, the presence of mite barriers on mattresses and the presence of carpets, soft toys etc can all be used to predict the presence of house dust mite allergen. Bioaerosol counts are inexpensive and can be collected on agar slides. The remaining variables in the list are observational (apart aspect which requires a compass). Observational and questionnaire based monitoring would compose the majority of the HVs records, reducing the number of instruments required. To be able to conduct the measurements described, the following instruments need to be carried by each HV: a combination hygrometer/ thermometer (£40) to measure indoors and outdoors; a compass (£3) and agar slides (£5 per sample) for indoors and outdoors. If further financing were available, it would be prudent to provide a Protimeter for dampness measurements (£120). The questionnaire/ observational part of the tool kit would also need to include the following:

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| Number of residents per $m^2$ of living area; | Presence of visible mould, damp, structural damage; |
| Type of cooking and heating appliances; | Routines effecting house dust mite proliferation; |

Available ventilation methods.
Obviously, the list of questions can be expanded to include many other variables. The final choice of variables has formed the basis for a reduced tool kit $TK_{17}$ to be used by HVs. The estimated capital cost per HV is £163. Cost of perishables and analysis would be around £15 per visit.

Accompanying visits with HVs to date have highlighted that the main indoor environmental problem is poor ventilation and occupant's difficulties in understanding why they should ventilate out heated indoor air. In pre-modernised houses, ventilation was often involuntarily provided through 'air leakage'. In a modernised house, this is reduced. The actual rate of ventilation can be estimated based on RH and temperature differences between in and outdoors. High RH indoors in comparison to lower values outdoors often indicates that a house is poorly ventilated or that there is water leakage in the house.

## Assessment of routines

Before each visit, preparatory work is required by the HV. Appointments have to be made and time allocated for travelling and writing records. Preliminary observations indicated that HVs spend approximately an equal amount of time with clients, as they do completing follow up work. Administration and travelling represents up to a third of all time allocated for each client. Each visit is around 30 – 45 minutes. HVs are used to carrying a bag of equipment with them. Increasing their burden to allow extra equipment was deemed feasible. At present, HVs carry their equipment in a bag in total weighing 2 - 4 kg with a volume of approximately 2700 $cm^{-3}$. Providing a $TK_{17}$ weighing no more than 2 kg has been suggested as a reasonable addition. All assessments will be conducted in the presence of clients within their own homes. Experience has verified that involving people openly and directly in assessments can add momentum to a situation. There will be a noticeable Hawthorne effect (The Burton Report, 2003) through the involvement of the clients in any project. The initial visits indicated that HVs have an understanding that the indoor environment can influence health and that they and their clients will benefit from having been shown quantified results, enabling accurately formulated reports when requesting remedial actions.

## Computerised records

It was noted that many of the HVs records are still recorded on paper. The results from the environmental assessments will be computerised to allow transmission of data. There is an existing framework for HVs report writing (Nelder, 2002) and the additional information will be adapted to fit the existing system. Computerisation of health records has already been highlighted as a way of enhancing health care (Darroch & Ellis 2003). Portable handheld computer equipment will be provided and software developed to allow quick and easy input of data from both the indoor environmental assessment and the HVs routine work. The software will enable the results of the indoor environmental assessment to be conveyed to public housing bodies, grant authorities or landlords for remedial action where required.

## Mapping IAQ in the UK

The government would be able to use the results from the HVs indoor environment assessments to monitor the state of both private and public houses across the UK. Ideally the format for the data collection would be compatible with the proposed ‘Housing Health and Safety Rating System’ (BMA, 2003) in the UK. The data could form the basis of a large longitudinal study following health and the indoor environment. Thomson et al., (2001) demonstrated the difficulty in collecting, organising and representing data from studies based on housing and health, therefore this research must consider Thomson’s recommendations. Inevitably, because HVs only regularly visit certain categories of people, the reporting that this study suggests will suffer from compositional effects. However, the people that the HVs visit are from the same cohort of people that cause compositional effects, in relation to winter deaths, housing problems etc. Because the UK has some of the most poorly thermally insulated houses in Europe (BMA, 2003), the suggested methodology will enable the beginning of a country wide record to quantify the relationship between health and housing. If every HV was given a STK costing £200 the total cost for the UK would be £200 x 16000 = £3.2 million. In addition, costs for computer software, training etc., a total of £10 million. Admittedly, these costs seem high in order to map the state of housing however, in comparison to potential benefits to the NHS and individual quality of life, the cost is small. From an expediency point of view, it might be prudent to quickly train one HV operating in each PCT. This would require less STKs and allow more money to be spent on each kit. The specialist HV from each PCT could then carry out a detailed analysis, on behalf of other HVs in a PCT area.

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