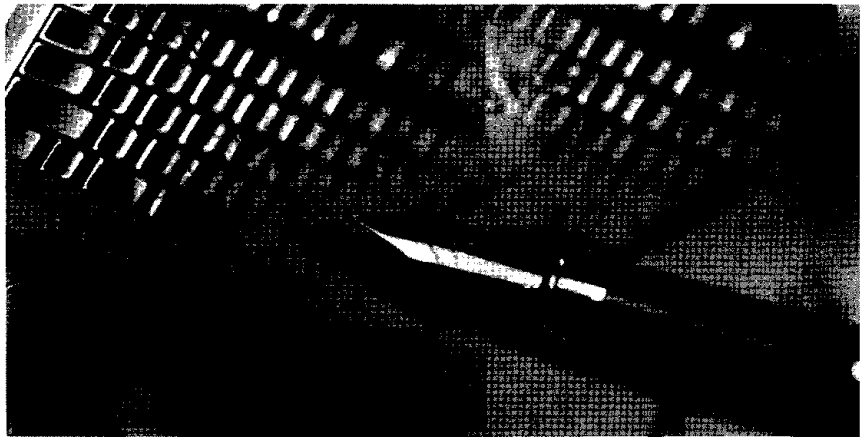
RESEARCH REPORT

MOLDY HOUSES:

WHY THEY ARE & WHY WE CARE

FINAL REPORT



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Morrison Hershfield Limited
Consulting Engineers

FINAL REPORT

Moldy Houses: Why They Are & Why We Care

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NOTE: **DISPONIBLE AUSSI EN FRANÇAIS SOUS LE TITRE:**

LES MOISISSURES DANS LES MAISONS : RAISONS DE LEUR PROLIFÉRATION ET RAISONS DE NOS PRÉOCCUPATIONS

DISCLAIMER

This study was conducted for Canada Mortgage and Housing Corporation under Part IX of the National Housing Act and with a contribution from the Panel for Energy Research and Development (PERD), through Health Canada. The analysis, interpretations and recommendations are those of the consultant and do not necessarily reflect the views of Canada Mortgage and Housing Corporation or those divisions of the Corporation that assisted in the study and its publication.

ABSTRACT

Fifty nine houses, selected on the basis of previous measurements of mold levels, were subjected to field inspection, testing and monitoring and the occupants subjected to health evaluation questionnaires and testing of blood and nasal secretions. Data on house performance, mold growth and health has been compiled in an electronic data base available for future researchers. The work showed correlations between measurements of mold growth and immunological reactions of occupants and that mold growth appeared to be more related to local moisture sources than ventilation levels.

EXECUTIVE SUMMARY

A previous study, carried out in the Town of Wallaceburg, Ontario measured biologically-active contaminants in houses and explored the health of occupants. This study found a great variation in the magnitude of biologically-active contamination and a correlation of these measures with subjective measures of health obtained through the health questionnaires. The Wallaceburg Phase II project reported here selected a group of houses with the worst levels of biological contamination and those with the least for more detailed study.

Thirty-nine houses with high measures of biologically active contamination and 20 with a low levels were subjected to detailed field inspections, testing to determine house operating parameters, monitoring of indoor environmental conditions, and simulation to predict condensation formation potential in winter conditions. Subjective measures of health were gained through questionnaires and brief physical exams of all occupants and objective measures of health were explored by the collection of samples of blood and nasal secretions from the Index Child in each house analysis for T-lymphocyte and B lymphocyte structure using a Fluorescence Activated Cell Sorter (FACS).

The protocols for inspection and testing were based on those developed in previous contracts by Canada Mortgage and Housing Corporation with some modifications to improve their field application. Protocols included the use of consistent data collection instruments for all phases of the work. Information collected was input into a relational database (Microsoft ACCESS) with ready manipulation and export capabilities for future users. This now contains in excess of 400 data fields.

Preliminary analysis undertaken for this project consisted of contrasting of house and health data of the "good" and "bad" house sample sets and determining correlations of measured and combined variables considered significant measures of house and health performance.

Preliminary data review indicates that there was a link between measurements of mold growth and objective measures of health and these could not be explained by the potentially confounding factors for which data was obtained including smoking, the level of Volatile Organic Compounds or CO_2 in the indoor air or possibly-related biologically contamination including dust mite and pet antigen levels in household dust.

The preliminary analysis indicates that the level of general ventilation in the houses was not a significant factor in the level of biological contamination. It would appear that the presence of local moisture sources is a much more significant factor.

The project scope was defined recognizing that much more detailed analysis of the data base was possible and necessary. Further analysis is recommended to confirm the relationships found in the preliminary analysis and to further examine the apparent relationships found between house performance, mold growth parameters and health impacts as well as relationships found that do not relate directly to mold growth. This analysis should include a more rigorous statistical examination and detailed examinations of some relationships made evident by the correlations determined in the preliminary review.

FOREWORD

This research report is the summary document that is one of the final deliverables of the study designed to collect and analyse the data on the differences between moldy houses and less moldy ones, as well as the differences in the some of the indicators of the health of one of the children in each of those houses. The data analysis performed to date is cursory and further work is underway to better understand the implications of the findings of this study. Readers are cautioned that much complex work is needed to gain a full understanding of the results obtained. As soon as further analysis is performed, it will be released in reports and/or research papers.

The Appendices to this report are available from the Project Manager, on the understanding that all analysis done on them will be joint property of those performing further analysis and Canada Mortgage and Housing Corporation. If you wish copies of any or all of the Appendices, less the confidential information which could identify the individual houses, please contact the Project Manager of the study, as identified below. You will be required to sign an agreement on both restrictions on further duplication of the data and on joint ownership of the analysis of that data.. CMHC retains full ownership of the data, in partnership with Health Canada and Agriculture Canada.

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1. INTRODUCTION

Health and Welfare Canada, Agricultural Canada and Canada Mortgage and Housing Corporation (CMHC) have jointly sponsored several research projects examining the health effects of mold and other biological contamination in houses. The main predecessor to the project reported here was a 1993/94 study of about 400 houses in Wallaceburg, Ontario[1]. In this project, which we will call *Wallaceburg Phase I*:

- levels of biological contamination were assessed by: air sampling and analysis for endotoxin and egosterols; swab samples of visible mold for species identification; a large dust sample was collected from the living area and analyzed for xerophilic and hydrophilic fungi, endotoxin, dust mite antigen, cat antigen and cell line cytotoxicity; dust from the "Index Child's" mattress was analyzed for dust mite antigen [2];
- health impacts were assessed by questionnaires administered to occupants and placing a tape recorder over night in the "Index Child's" bedroom to determine the frequency of coughs; and
- house characteristics were assessed by a survey carried out by project field staff.

The results of the Phase I study showed a very large variation in the levels and exposure to some types of biologically-active material in the sample houses and even large variation by location within the house. There appeared to be a correlation between the level of exposure and the subjective measures of health (questionnaire results). The data did not give clear indications of what factors lead to high levels of biologically-active contaminants and therefore what modifications to house construction practice and operation could lead to reduced exposures.

This project, which we will call *Wallaceburg Phase II*, was designed to address some of the unanswered questions. The project was awarded to Morrison Hershfield Limited (MH).

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1 HC Research Project, report not issued at time of writing

2 Miller J.David, Plant Research Centre, Agriculture Canada, *Quantification of Health Effects of Combined Exposures: A New Beginning*: 1994

The study design was based on selecting a subset of houses from the Phase I sample that displayed the either the highest burden of biological contaminants (referred to in this report as the "*Bad*" sample group) or the lowest loading (the "*Good*" sample group). In each of these houses data collection activities included:

- collection of house characterization data based on direct inspection and an interview with the occupant;
- house characterization testing including air tightness testing, one hour tracer gas testing, measurement of temperature and humidity, and testing to determine the potential for combustion product spillage from the furnace and hot water heater;
- detailed inspection of sites that had been wetted or exhibited mold growth;
- continuous monitoring of temperature, humidity and carbon dioxide levels in the "Index Child's" bedroom for approximately one week;
- dosimeter type sampling for Volatile Organic Compounds (VOC) in the living room for approximately one week;
- administration of a medical questionnaire and brief physical examination of the whole family by a nurse;
- collection and analysis of blood samples and nasal secretions (by nasal lavage) from the index child; and
- collection of lung function data of the index child by provision of a peak flow meter and occupant recording of morning and evening peak flows for a one week period.

These tasks were carried out in 39 "Bad" houses and 20 "Good" houses.

The collected data has been entered into a relational data base (Microsoft ACCESS). The preliminary data analysis carried out to date and reported here has been focused on determining the factors which affect winter condensation and mold growth, contrasting data from the "Good" and "Bad" sample sets and determining correlations between house characterization and medical testing data. Data analysis is not intended to be exhaustive at this stage.

2. OBJECTIVES

The primary objectives of the Wallaceburg Phase II Study were to determine:

1. why some houses/occupants produce so much biologically active material and why others produce so little;

2. exposure conditions that could confound or synergize a moisture/mold causality;

3. whether or not high exposure is reflected in measurable immunological response and/or disease in occupants; and

4. which obvious changes in house construction and operation could alleviate most problems.

It was also recognized that the information collected in this project, in conjunction with Phase I data, would constitute one of the most extensive and detailed data bases in the world on the interaction of house construction, house operation, biological contamination, indoor air contaminants and subjective and objective measures of health. A secondary objective of the project was to provide a validated data base that could be used by researchers for many purposes, some of which can only now be surmised.

3. BACKGROUND

3.1 Phase 1 Project

The following excerpt from the background of CMHC's Request for Research Proposals provides a summary of Phase I results and why they prompted this project.

Health Canada has conducted questionnaire surveys in 30 cities across 5 regions of the country, plus duplicate surveys in Wallaceburg Ontario, all of which have produced consistent correlations between reported moisture and mold problems and reported respiratory health symptoms. Moisture problems and mold exposure appear to lead to certain types of disease, above and beyond an obvious allergy effect, and the incidence rates are significant. If we could reduce the incidence of moisture and mold problems, could we reduce certain health problems - or is the correlation and opportunity only illusionary?

Test and questionnaire results from a joint Health Canada, Agriculture Canada and Canada Mortgage and Housing Corporation study of about 400 houses in Wallaceburg are coming in and are being correlated, but simple viewing of the data is enough to trigger this next phase of the research. We can see very large ranges of bacterial endotoxin (several decimal orders of magnitude), dust mite antigen (the same range), cat allergen (ditto) and mold mass (a smaller range, but still very large). Viable mold counts are being completed, as well as speculation. Swab tests on visible mold have indicated an unusually large fraction of mycotoxin-producing molds - not something we wanted to see but something that partly explains some of the reported health symptoms. As the correlations are completed, we should soon have a set of houses in which exposure to biologically-active material is unusually high (in several measures, or just a few) and others in which it is much, much lower. Why do some houses produce so much and others so little? Is it a simple matter of envelope performance or of occupant behavior, or is it a function of combined effects and conditions? If we can find out the answer to that question, even for a major subset of these houses, we could help prevent the construction of many new problem houses, and make strong recommendations for the renovation of existing problems units.

3.2 Phase II Study Design

The design of the phase II study was focused to the specific objectives identified in Section 2.0 and incorporated two primary elements: the houses were to be assessed to explain why some Wallaceburg houses produced significantly more biological contamination than other houses; and the health of people living in the houses were to be assessed using objective measures of health. Correlations between each element and with Phase I data could then be determined.

Sample houses were selected based on some of the Phase I test results to obtain the broadest range of data possible. A sample of the houses with the highest level of biological contamination was the prime study group and a sample of houses with low levels of contamination was established as a control set. With data from the ends of the spectrum of Phase I results, one would obtain the maximum contrast between the study and control groups and the broadest possible range of data for which to determine correlations between Phase I results, building factors, and measures of health. The size of sample for each group was based on statistical necessity and budget. The target was set at 40 "bad" houses and 20 "good" houses. Due to a last minute cancellation, the actual sample size was 39 "bad" houses and 20 "good" houses.

The building evaluation protocol that was designed for this study focused on factors related to mold growth, and specifically mold growth that could be related to condensation forming on surfaces chilled by winter weather.

Most molds generally require four things to grow rapidly: a suitable surface to grow on, suitable temperatures, nourishment and a relatively constant source of water. The first three requirements are met in virtually all environments which people would choose to live in. Therefore, it is to be expected that the only way that mold is controllable is to control the moisture source. Condensation on the building envelope is the one of many sources of water for mold growth which the test protocols focused on. All building inspection and medical testing carried out for Phase II was to be carried out in winter conditions. Most of the testing of the houses was directed towards obtaining data that would allow detailed analysis of the factors which affect condensation on cold surfaces in winter conditions (air leakage, air change, moisture sources and temperature of surfaces exposed to the interior environment).

Other sources of water were not ignored. The inspection protocols called for review and quantification of all mold growth sites regardless of source of water. Field personnel were asked to make an assessment of the probable source of moisture at each site.

The health testing component included both an occupant interview on the health of the whole family and objective medical testing on the Index Child carried out by nurses engaged for the project.

The questionnaire repeated many of the questions from the Phase I questionnaire and incorporated a well-tested questionnaire on occupant psychological outlook. This was administered to an adult interviewee.

The medical testing focused on the Index Child in each home (the same as used in Phase I). The nurse collected samples of blood and the nasal secretions of each index child. These samples were analyzed at the Department of Nephrology of University Hospital at the University of Western Ontario, under the direction of Dr. Andrew Lazorovitz. The intent of the testing was to determine if the immune system of the Indexed Children appeared to be reacting to something in the child's environment.

Recognizing that there could be confounding or synergistic reactions with other contaminants, the testing protocol also incorporated:

- continuous monitoring, for a period of approximately one week, of carbon dioxide levels (considered to be a measure of the level of ventilation per occupant in the room and house), temperature and humidity in the Index Child's bedroom;
- collection of a one week duration sample of Volatile Organic Compounds (VOCs) levels in the indoor air in the living room; and
- testing of the likelihood of spillage of combustion products from vented heating appliances.

Phase I data also included some potentially confounding or synergizing factors including cat antigen and two species of dust mite antigen.

Respiratory function was assessed by having an adult occupant measure peak flows of the Index Child in the morning and evening for a period of approximately one week. This coincided with the period that indoor environmental conditions were monitored.

Efforts were made to keep the study as "blind" as possible. Field inspection personnel, nurses and analysis laboratories were not notified whether the buildings or samples they were reviewing were from the "Good" or "Bad" sample sets. However, it must be recognized that the program relied very heavily on visual evidence and field personnel could very likely have guessed which sample group the house they were reviewing was drawn from shortly after entering each house.

4. METHODOLOGY

4.1 Final Study Design

Prior to contracting for the Phase II study, CMHC engaged separate consultants to produce a draft protocol for house inspection and testing, occupant questionnaires and a detailed analysis procedure for predicting the condensation performance of the houses being studied[3]. Health Canada researchers provided the base protocols for health questionnaire, lung function tests and immunological testing. These base protocols were modified in the design phase of this Phase II project to reflect expected site conditions, specific test procedures and the data handling methods to be employed. The modifications focused on improving the ability to code and analyze the collected data rather than extending the research scope.

One prime output of this task was the final definition of the data collection instruments used to record data collected in the field. Appendix C contains copies of the forms developed including:

- **Inspection Data** - used by field inspection personnel to record inspection and building test results;
- **House Performance Questionnaire** - completed by field inspection personnel based on an occupant interview and direct observation;
- **Mold Growth Site Report** - completed by field inspection personnel for each typical site where mold growth was evident or reported (even if evidence had been removed);
- **Medical Questionnaire** - completed by the nurse based on both the occupant interview and physical exam; and
- Logs of **Peak Flow Readings** and **Occupancy Index Child's Bedroom** - filled out by occupants.

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3 *Wallaceburg Phase II Field Testing Protocol, Draft Final Report and Appendices*, for CMHC by Appin and Associates, Sheltair Scientific Ltd., Scanada Consultants Ltd.

4.2 Sample Selection

The two sample groups ("Good" and "Bad") were selected for recruitment based on Phase I data as supplied and dictated by CMHC. The categories use for selection were as follows:

- High Biologicals (bad households)
- Low Biologicals (good households)

The following recruitment process was carried out.

- CMHC provided MH with a list of the 400 households which participated in Phase 1 of this project in 1994. A database was set up which contained all of the pertinent information regarding each household, including the household identification number, family name, address, telephone number, and the name of the Index Child.

- CMHC provided MH with lists of households in each of the above categories listed in order of recruitment priority. High ergosterols (and therefore high mold mass) in the Index Child's Bedroom was the first selection criteria. A high count of molds in the living room carpet dust was the second. A high ratio of xerophilic to phyloplane molds was the third criteria.

- A recruitment letter was sent to each household on the priority lists. This letter included a full explanation of the project emphasizing its importance to the future health of families throughout the world. The letter also described the tests that would be performed, and the commitment that each participant would have to make to ensure that the study was a success.

- A "town hall" meeting was held as part of a regular Wallaceburg town committee meeting to discuss the study and answer any questions the prospective participants might have. We obtained full media coverage from the local television, radio, and newspapers.

- Each of the prospective participants were contacted by telephone and we answered any questions or concerns that they had.

- When negative responses were initially received from high priority households, CMHC made contact directly in an attempt to recruit them. This was only successful in a few cases.

- A database was set-up for all of the households actively recruited listing the testing schedules together with all of the information listed in item 1.

4.3 Field Inspection and Interviews

Field data collection was carried out in a series of site visits undertaken during February and March of 1995. On the site visit, information was obtained by direct inspection, testing and from occupants via the administration of an occupant questionnaire. Data collection forms are included in Appendix C.

The questionnaire asked information about the age and history of renovations of the house, type and use of heating, supplementary heating systems and air conditioning, the nature of ventilation used and occupancy characteristics which could be used to assess internal moisture generation. The occupant was then asked about historical instances of wetting or mold growth, requesting information about the timing, duration and extent of these problems on a site-specific basis. The occupant was also asked about any remedial actions taken to resolve mold growth problems.

The inspection data recorded included general information about the construction of the house including dimensional data, type of building envelope elements, nature of basement interior finishes, presence of elements which could affect results (including unvented dryers or clothes dryers, sumps, humidifiers, wood burning appliances etc.) and an assessment of general levels of maintenance. The data sheets were also used to record results of the building tests described in Section 4.4.

For every mold growth site identified either by the occupant or by the inspector, a Mold Growth Site Report was completed. This categorized the nature and location of the problem and probable source of moisture and identified the area of mold growth

and the nature and condition of growing surfaces. Surface temperatures, indoor air temperature and outdoor air temperatures at the time of the test were recorded. The inspectors also sketched the assumed construction of those building elements which exhibited mold growth.

The instrumentation for environmental monitoring and VOC dosimeters were deployed during the site visit and picked up approximately one week later.

One element of the medical testing that was carried out at the time of the site visit was the provision and instruction on the use of the peak flow meters that were used to assess respiratory function. This was done in order to coordinate pick up of the results with the return visit in which monitoring instruments were recovered.

4.4 Field Testing

4.4.1 Air Tightness Testing

Air Tightness tests were carried out according to CGSB149.10 M86[4] but incorporating new procedures proposed by the CGSB committee for testing of occupied houses. These new procedures relate to how the building is prepared for the test. The details of house preparation are provided on page INSP-11 of the Inspection Data form included in Appendix C. In general, flues are not sealed and intentional openings are treated only if a built in damper is supplied. This preparation protocol is (arguably) a better simulation of the leakage area of the house in normal operating condition and is better suited for obtaining the type of data needed for this study (estimating air change rates). However, *we caution readers that the results obtained (ELA) will generally be higher than if the more traditional CGSB 149.10 M-86 building preparation procedures were applied.*

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4 Canadian General Standards Board, CAN/CGSB 149.10-M86, *Determination of the Air Tightness of Building Envelopes by the Fan Depressurization Method*, 1986

4.4.2 Tracer Gas Testing

A tracer gas decay test was carried out to validate and adjust estimates of air change rate determined from the AIM2 simulation program. The method employed was as per ASTM E741[5] using Sulfur Hexafloride (SF_6). The building was left in the same state as the Air Leakage Test but with the furnace circulating fan turned on to promote mixing. SF_6 was injected into the space and allowed to mix for a period of at least one hour. The concentration of SF_6 was measured at intervals of 10-15 minutes for a test period of one hour using a MIRAN 1B. The measured concentrations and sampling time were entered into a spread sheet program that carried out a least regression analysis of the decay rate and calculated Air Change Rate for the test period.

4.4.3 Chimney Spillage Testing

Chimney spillage tests were conducted as per CAN/CGSB 51.71-94 (seventh draft)[6]. This determines the degree of depressurization that can be created by installed exhaust equipment (including fireplaces with operation simulated with a propane burner) with the house prepared as for the airtightness test. This is compared to depressurization limits established for various types of heating appliances. In addition, site test personnel recorded the duration and severity of any spillage that occurred when the furnace started against the pressure created by installed exhaust equipment.

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5 American Society of Testing and Materials, Standard No. E 741-83, *Standard Test Method for Determining Air Leakage Rate by Tracer Dilution*, 1983 (Reapproved 1990)

6 Canadian General Standards Board, CAN/CGSB 51.71-94 Seventh Draft, Second Version, *Spillage Test - A Method to Determine the Potential for Pressure Induced Spillage from Vented, Fuel Fired Space Heating Appliances, Water Heaters and Fireplaces*, September, 1994.

4.4.4 Temperature, Humidity and CO2 Monitoring

CO_2, Temperature and Relative Humidity was continuously monitored in one location, the index child's bedroom, in each house for a period of approximately one week.. The instruments used were ACR 203s set to internally record digital data at approximately 10 minute intervals. The instruments were deployed during the site visit and picked up and down loaded by field inspection staff approximately one week later. The calibration of the CO_2 sensor was typically checked before re-deployment.

In addition, power psychrometer readings (wet bulb temperature, dry bulb temperature, calculated relative humidity) were recorded in the living room, child's bedroom and basement (if any) during the site visit.

4.4.5 VOC Sampling

The levels of Volatile Organic Compounds (VOCs) was determined using 3M passive dosimeters with analysis by GC/FID at Ortech International. The dosimeters were deployed in the living room of the test houses during the site visit and picked up approximately one week later by site inspection personnel.

4.5 Simulation of Moisture Performance

Analysis of the extent and duration of condensation on building envelope elements was carried using simulation tools developed for CMHC in a previous contract[3].

The simulation tool was a Microsoft Excel 5.0 based spreadsheet program called FPLAIMv5.xls which was developed by Shelter Scientific under a previous research contract. This program incorporated two models.

AIM2[7] predicts air change rates in buildings based on exposure, air leakage test results, building dimensions, estimated distribution of leakage area, outdoor temperature, wind speed and direction.

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7 Walker I.S. and Wilson, D.J., University of Alberta, *The Alberta Air Infiltration Model AIM-2*, 1990

FPLRH2 [8,9] is a simulation model developed by Anton TenWolde of the U.S. Forest Product Laboratory, which predicts humidity levels and duration of condensation formation based on estimated air change rate, estimated sources of moisture to the building, the thermal resistance of the building element being modeled and outdoor temperatures.

FPLAIMv5 uses hourly weather data to calculate the predicted air change rate using the AIM2 algorithms and periods of condensing conditions using the FPLRH2 algorithms. The primary output was the number of "mold growth periods" in the simulated heating season. The default mold growth period was defined as an interval of 168 hours during which average air temperatures is 15°C or greater and:

a) Surface condensation is occurring, or

b) Condensation or wetting occurs continuously for a period in excess of two hours followed by an R.H. of 70% or greater,

c) Surface moisture is present continuously from a source other than condensation.

FPLAIMv5 determines the number of growth periods from "a" and "b"

The research protocol incorporated modeling of three or four typical mold growth sites per house to determine a growth potential score for each type of growth site (area of mold growth addressed by the modeled site multiplied by duration of moisture conditions conducive to mold growth). The Growth Potential Scores for the house are determined by summing the GPS of each type of site including those not related to condensation.

The simulation work was carried out by the field personnel after the site visit. The input requirements are identified in Appendix E. One of the concerns that we had was that assumptions or judgment calls should not be hidden and this affected two types of input.

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8 TenWolde, Anton, *A Mathematical Model for Indoor Humidity In Homes During Winter,*

9 TenWolde, Anton, *Ventilation, Humidity, and Condensation in Manufactured Houses During Winter,* ASHRAE Transactions 1994 V100

The distribution of air leakage area was determined by envelope surface area. A total leakage area of the envelope was estimated by subtracting an allowance for flues from the ELA determined from air leakage test results. It was assumed that the remaining leakage area was evenly distributed over the envelope surface area. Leakage attributed to the basement area surfaces was assumed to be at floor level, the leakage attributed to ceiling area was assumed to be at ceiling level and the balance was attributed to the walls.

The assumed moisture source strength was determined solely on occupancy factors as identified on page TQ-6 of the House Performance Questionnaire (Appendix C).

FPLAIMv5 also had an adjustment factor of the simulated air change rate based on results of the one hour tracer gas test. This effectively multiplied each hour's estimated air change by the ratio of:

tracer gas test result / simulated air change rate for same hour

This required a separate AIM 2 run using weather conditions at the time of the test.

From the beginning of the test program it was recognized that one of the greatest areas of unknowns is the moisture sources in the houses, particularly since many researchers believe that occupant generated moisture may be only a fraction of the total moisture sources generated in the house. Part of the data analysis was an assessment of moisture source strength based on humidity and temperatures recorded during the one week monitoring period and outdoor weather conditions for the same period. This calculated moisture source strength was determined for the 47 of the test houses for which sufficient data were available.

4.6 Weather Data

Climatic information including temperature, dew point temperature, wind speed and wind direction are all required input for the AIM2 and FPLAIMv5 programs. These were used for predicting air change rates and/or moisture performance over three different periods; the one hour period to coincide and compare with tracer gas test, the one week period to coincide and compare with interior monitoring, and for a typical heating season. Outdoor temperature at the time of the site visit was also used to determine the Temperature Index of building envelope elements. The outdoor temperature and wind conditions on the day of each site test were obtained by calling

the local weather office. Weather data used for analyzing monitoring data was from the Atmospheric Environment Services (AES) 1995 hourly data for Windsor Ontario, the closest station from which hourly data could be obtained. Weather data used for predicting long term performance was also hourly data from Windsor. Based on conversations with local weather officers, winter data for 1988/89 was used as being a good representative year.

4.7 Medical Interview and Testing

The medical test protocol included the home administration of Health Questionnaires (provided in Appendix C) and drawing of samples of nasal secretions and blood from the index child for immunological testing. These tasks were carried out by nurses of the Victorian Order of Nurses who were engaged for the project.

For data on respiratory function of the Index Child, occupants were provided with a TruZone™ Peak Flow Meter at the time of the building site testing and asked to have the index child use them twice daily, record those results and maintain an occupancy log of the child's bedroom. This was done for a period of approximately one week to coordinate with monitoring of environmental conditions and air sampling for VOCs.

4.8 Medical Sample Analysis

Medical sample analysis was carried out at University Hospital, at the University of Western Ontario under the direction of Dr. Andrew Lazarovits. The analysis consisted of an evaluation of T lymphocyte and B lymphocyte structure using a Fluorescence Activated Cell Sorter (FACS).

4.9 Data Storage and Analysis Methods

Our approach to data handling for this project was to focus on providing all information for which there was a pre-envisioned use in a validated computerized data base available for analysis during this project and for future researchers. The data was assembled in a relational database, Microsoft ACCESS which operates in the WINDOWS environment. ACCESS provides very easy export capability to many other software packages including Microsoft EXCEL 5.0 which was used for most of the data analysis because the prime researchers were familiar with its use and capabilities. Appendix A contains a list of the data fields included in each of the data tables of the data base.

A complete "paper" record of all data collected for each house has also been created in the form of a binder for each house. This includes signed copies of permissions from households, completed data collection instruments, photos and computer discs with monitored data and simulation results.

This paper record may be important to future researcher because the completed forms contain information that is not currently in the electronic data base. For example, this would include.

- occupancy log for the Index Child's bedroom,
- daily peak flow readings (only average of morning and average of evening readings was input),
- intermediate results and regression correlations of air tightness and tracer gas testing,
- detailed history of wetting events from occupant interviews.

Graphical output of temperature, humidity and CO_2 concentrations recorded during the monitoring of each house is included in Appendix B and are also available separately on diskette. The mean and standard deviation of the monitored data for the total monitoring period were determined and input into the data base.

The preliminary data analysis carried out in this project focused on validating the data base, contrasting data from the "Good" and "Bad" sample sets and determining correlations between house characterization and the medical data. Correlation coefficients were determined using the Correlation function of EXCEL 5.0. This measures the relationship between two data sets by calculating the covariance of the two data sets divided by the product of their standard deviations[10].

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10 Microsoft Corporation, *Users Guide -Microsoft Excel Version 5.0*, 1993

$$P_{X,Y} = \frac{\mathrm{cov}(X,Y)}{\sigma_x \sigma_y}$$

where

$$\mathrm{cov}(X,Y) = \frac{1}{n}\sum(x_i - \mu_x)(y_i - \mu_y)$$

$$\sigma_x^2 = \frac{1}{n}\sum(X_i - \mu_x)^2$$

$$\sigma_y^2 = \frac{1}{n}\sum(Y_i - \mu_y)^2$$

μ_x and μ_y are means of x and y respectively

If there is a blank record in the data field it is ignored.

The statistical significance of the found correlations was tested using a Fisher transformation of the correlation coefficient,

$$Z = 1/2 \ln ((1 + \rho) / (1 - \rho))$$

The null hypothesis can be tested by the equation

$$z = (n-3)^{0.5} * Z$$

z can be compared with the t value for various levels of significance[11].

Most of the data fields contrasted or used to explore correlations were as recorded on field data collection instruments. Some fields were processed into summary variables or processed to reduce skew in the data. The processes worthy of special comment are described below.

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11 Miller, Irwin; Freund, John E; Johnson, Richard A; *Probability and Statistics for Engineers*, Fourth Edition, Prentice Hall, 1990

Phase I Data

The Phase I data imported for correlating with household and medical data was characterized as being highly skewed and with many zero values. The method used to accommodate this skew was to use a Rank Correlation. The data was inversely ranked (the lowest value assigned a rank of 1 and the highest the rank that matched sample size (59 for our sample)). Ties were assigned the mean value of the ranks for the tied set (if there were 4 zeros, their rank would each be 2.5). This rank data was used in all correlation tables provided in Section 5.

Age

Householders were asked the age of the house and this was categorized by decade of construction. To make correlations more understandable this was transformed into an age by assuming that the house was built in the middle year of the decade and this was subtracted from 1995. Houses built after 1986 were deemed to be 5 years old and houses built before 1939 were assigned an age of 60 years. Seven homeowners did not know the age of their house. After a review of photographs for construction methods, the researchers felt comfortable assigning ages to six of these houses (96, 134, 206, 226, 235 and 377) these houses for this analysis. The age field of house 276 was left blank.

Moisture Source Strength

One of the key factors in predicting humidity levels is the magnitude of the sum of moisture sources in the house. For the FPLAIMv5 simulations that were carried out for this project, the sources of moisture into the indoor house environment was estimated from occupancy data collected in the occupant interviews. When AES weather data for February and March became available, the moisture source strength was estimated from environmental data recorded in the one week monitoring. The hourly source strength was estimated by the equation:

$$S = ACH * V * 1.2 * (W_i - W_o)$$

where

S is moisture source strength (kg/hr)

ACH is the AIM2 simulated Air Change Rate for the house using the AES supplied wind and temperature data for the hour.

V is heated volume of the house (m^3)

1.2 is density of air (kg/m^3)

W_i is moisture ratio of indoor air calculated from monitored temperature and relative humidity in the particular hour (kg_{H20}/kg_{air})

W_o is moisture ratio of outdoor air calculated from AES supplied temperature and dew point temperature for the hour (kg_{H20}/kg_{air})

The average hourly moisture source strength was determined for the period over which monitoring results were available. This average was used for data correlation purposes.

It is recognized that the above estimating method assumes that the source strength in any one hour equals the removal rate. This does not account for phase change, storage effects or changes in R.H. over that hour. However, by using a weekly average value, these effects should cancel out.

The calculated moisture source strength was determined for a total of 47 houses. Of the 12 house for which results were not obtained:

3 (houses 30, 154, 276) were missing critical data (Indoor R.H or ELA) for the calculation

1 (house 177) required April weather data for reasonable analysis (this was not yet available at the time of analysis but could be obtained now).

2 (houses 134, 414) were missing indoor temperature data that could be reasonably well estimated.

6 (houses 132, 157, 109, 206, 232, 434) had data anomalies that could probably be "cleaned up" with additional effort.

Peak Flow (Respiratory Function)

Peak flow readings were normalized for the sex, age and height of the Index Child by the following equations which were supplied by Dr. Robert Dales, Health Canada's Scientific Authority on the project.

For Males

Predicted Peak Flow = 0.166 * Age + 0.078 * ht (cm) - 8.060

For Females

Predicted Peak Flow = 0.157 * Age + 0.049 * ht (cm) - 3.916

Behavioral Patterns

A standard psychological questionnaire, GHQ-12, was administered. This is shown on page MQ-5 of the Medical Questionnaire included in Appendix C. The response is one of four choices to twelve questions. The score for the survey was calculated by summing one point for each response in the first column, two points for the second, three points for the third and four points for the fourth.

5. SUMMARY OF FINDINGS

5.1 House Selection and Recruitment

Some difficulty was encountered in recruiting the high priority houses of the "bad" sample group. This is shown by looking at the outcome of the recruitment process

High Biologicals - Bad Houses

Category 1A,

A total of 50 households were provided by CMHC prioritized from H1 to H50 (with H1 being the highest priority and H50 the lowest). The 24 (48%) households recruited and subsequently tested from this group were H2, H11, H12, H15, H16, H18 to H23, H25, H27 to H31, H36 to H38, H40, H43, H47, and H48. The majority of tested households came from the middle third of the list, with the overall weighting towards the lower priority end.

Category 1B,

A total of further 28 candidate households were provided by CMHC in two groups, with the priorities rated P1 to P9 as the high priority group. A secondary priority group were numbered U1 to U19. The 10 (36%) households recruited and subsequently tested from these groups were P2, P7, U4, U5, U9, U12 to U15, and U18. Again the majority of the recruited households were from the lower half of the two groups combined.

Category 1C,

A further 12 households were provided by CMHC, prioritized E1 to E12. The 5 (42%)recruited households were E2, E4, E5, E9, and E11.

Low Biologicals - Good Houses

Category 2,

A total of 50 households were provided by CMHC, prioritized L1 to L50 . The 20 households recruited were L2, L4 to L8, L10, L12, L14, L16, L18, L19, L21, L23, L24, L28, L42, L44, and L47. The majority of these households are from the high priority half of the list.

The main reasons given for not participating in the study included (in no particular order of frequency) were: the Index Child or the parents did not want to undergo the medical tests (especially the blood test); too busy; in the process of house renovations; illness in the family, not happy about not having received any information regarding the Phase 1 study.

5.2 Data-Base Structure and Contents

Electronic format data is contained in a data-base compiled in Microsoft ACCESS 2.0. The current version of the data-base at the time of writing this report was entitled "WALLY5. MDB". Appendix F, under separate cover, provides a hard copy output of all data tables contained in WALLY5. A list of data tables and all data fields that they contain is included in Appendix A of this Volume of the report.

Appendix A also contains the data summary tables (in EXCEL 5.0 format) that were developed for the correlation analysis of household and medical test data that was performed in the preparation of this report.

5.3 Statistical Summary Tables

The statistical summary of the data in Tables 5.1 through 5.8 have been organized to reflect the logic of the preliminary analysis.

Tables 5.1 through 5.3 contrast results from "good" and "bad" house sample sets for building testing, medical questionnaires and immunological testing respectively.

Table 5.4 through 5.6 are tables of correlation coefficients as described in section 4.9. The output is in correlation coefficients that would be 1.000 if there were a perfect relationship between data and 0.000 if there were none. A negative number indicates that the apparent relationship is inverse (a high value of one variable is related to a low value of another variable). The nature or form of the relationship is not defined. To determine that would require a much more detailed multi-variant analysis that was beyond the funded scope of this stage of the project.

Table 5.4 shows the cross correlations using data from all of the houses in the sample set. The only data that are transformed are the Phase I results, which were imported as rank data as described in section 4.9.

Table 5.4a is provided to show a measure of the statistical significance of the correlations shown in table 5.4. It shows the z values calculated by the methods described in section 4.9 and compares them with t values for rejecting the null hypothesis at levels of significance (α) of 0.05 and 0.1. We would note that with the limited sample between 50 and 60 houses, rejecting the null hypothesis at $\alpha = 0.1$ requires a good correlation of the data.

Table 5.5 also uses data from all houses, but all data have been transformed to **rank data.** It should be noted that in this process, ties were not assigned the mean values (example: a data set of 0,1,1,2 would be ranked as 1,2,2,4) as was done for processing the Phase I data. Rank Correlation converts the data to a form with a precisely defined distribution curve. This minimizes the effect of highly skewed data or the impact of one or two records that are highly unusual compared to the rest of the data set. This can be very valuable in validating the apparent correlations provided in Table 5.4 In layman's terms, one is much more likely to believe that there is a real relationship between two data fields if a significant correlation coefficient is found for both the regular and rank correlation.

Table 5.6 is identical to 5.4 except that it is restricted to the data set of "bad houses".

Many of the data fields that were selected for this cross-correlation exercise are reasonably self explanatory. The following warrant further explanation:

- *AIM2 estimated air change rate* are results from the one hour simulated air change corresponding to the tracer gas test period.
- *Mn + SD.* is the mean RH over monitoring period plus one standard deviation of RH above the mean, over the monitoring period (typically one week) for each house. This variable was included to see if variability and range of indoor humidity was a correlating feature.
- *air change* is the average air change rate estimated by AIM2 for the monitoring period.
- *source* is the calculated moisture source strength as described in Section 4.9.
- *complicating factors* is an artificial variable created by adding 1 for each of: unvented dryer, interior clothes drying, operating humidifier or open sump.
- *Wood Burners*: 0 if none, 1 if either a fireplace or wood stove.
- *Mold Area* is as estimated by site inspection.
- *Endotoxins* through *CFU Glys* - Phase I data in rank listing as described in Section 4.9.
- *G-Index* is a combination variable calculated in Phase I as the ratio of the counts of the three most common (as found in the whole study) xerophilic mold species to the counts of the three most common phyloplane mold species.
- *Behavioral patterns* score of behavioral survey as described in Section 4.9.
- *am peak flow* is the average of the morning peak flow readings taken for each index child normalized by estimated value as described in Section 4.9.
- *am - pm average peak flow.* The difference between the average morning reading and the average evening reading for each index child normalized by the estimated value as per Section 4.9.
- *CD4CD8CT* and *CD4503CT* - Two immunological testing data fields suggested by Dr. Lazarovits as showing a strong contrast between good and bad houses. CD4CD8CT is defined as "Count: CD4:CD8 Ratio" and CD4503CT was defined as a count of CD3 + cells expressing CD45RO.

Table 5.7 provides a preliminary summary of location and probable moisture sources of mold growth sites as reported by the site inspectors.

Since the test program design was focused strongly on looking at mold growth attributed to winter condensation on building elements, Table 7 was developed to show location information similar to Table 5.7 but restricted to sites are the inspectors attributed the moisture source to condensation on building envelope elements.

5.4 Unusual Houses

When reviewing the statistical data it must be recognized that the sample is made up of individual houses, some which were found to be unusual. The following list of special cases identified by field personnel all address houses from the "bad " sample set. The inspectors did not know this when the list was developed.

Notes Made Concerning Houses from Bad House Sample Set

028 The front porch of this house has been converted into an aviary for a pet parrot. The porch has been closed off with loose fitting Plexiglas panels. The window that opens from inside onto this porch has been covered with chicken wire and access to the porch is through a screen door.

This house also has a cold storage room on the ground floor which experienced significant mold growth.

048 The two pet dogs are kept inside the house in the bedroom adjacent to the index child's bedroom and there was a strong odor of urine in this room.

There was extensive mold growth on the floor sheeting below the linoleum in the bathroom due to wetting from showers.

055 There was extensive mold growth on the ceiling of the bathroom.

There was a large but empty aquarium in the childs bedroom. The bedroom had more extensive mold growth than other bedrooms. Past operation of the aquarium could have played a role in Phase I results as well as found conditions.

086 The double hung window in the upstairs bedroom was missing the upper sash. The opening was covered with plastic shrink wrap.

100 Ventilation is supplied by a fresh air duct to the return air duct.

111 The basement walls were insulated with fibre glass insulation with no interior finish or covering. The was an extremely large area of mold growth on surfaces on the cold side of the insulation.

134 This house has a central gas wall furnace as it main source of heating.

This house has a cold storage room on the ground floor which experienced significant mold growth.

197 This house has a gas stove as its main source of heating.

250 This house has a HRV unit. It also has a electrostatic precipitator, however the unit is not connected to an electrical source.

276 This house is divided into two apartments. The apartment that was tested was at the rear and the only access was by a sliding door. It was not possible to perform a fan door test due to the width of this sliding door.

395 This house has a gas stove as its main source of heating. The stove is located at the bottom of the stairs. The attic access hatch happens to be located in the side wall of this stairway and there was extensive mold growth on the roof sheeting.

Notes Made Concerning Houses from Good House Sample Set.

352 Ventilation is supplied by a fresh air duct to the return air duct.

Table 5.1 Contrast between "Good" and "Bad" Houses - House Data

		good		bad		Group Data			
Variable	Category or Units	% or Mean	std. dev.	% or Mean	std. dev.	max	min	n good	n bad
House Characteristics									
Deemed Age	Yrs	32	20	32	18	60+	5	20	38
Floor area	m^2	214	67	199	62	361	85	20	39
Heated Volume	m^3	517	143	464	141	876	220	20	39
Below grade space	% slab on grade	0		2				20	39
	% Above grade	10		8					
	% below grade	25		44					
	% Basement	65		46					
Below grade wall area	m^2	46	27	42	26	118	0	20	39
Eave height	m	4.23	1.36	3.96	1.34	7	2.5	20	39
Window Glazing Layers	% double glazed	100		100				20	39
Window Coverings	% none or sheers	30		54				20	39
	% drapes	70		46					
Primary Heating Fuel	% gas	95		82				20	39
	% oil	0		5					
	% elect	5		13					
Forced air distribution	% yes	90		77				20	39
Air Conditioning	% with Central AC	85		56				20	39
	% with Room AC	5		21					
Special Air Cleaners	% none	65		75				20	39
	% electronic	35		20					
	% special filters			5					
Woodstove	% yes	0		18				20	39
Fireplace	% yes	25		38				20	39
Occupancy and Moisture Source Factors									
Number of Occupants	No. of People	4.26	0.72	4.46	0.79	7	3	20	39
Occupant Density	People/1000m3	8.90	3.35	10.40	2.95	19.60	5.00	20	39
Interior clothes drying	% yes	30		21				20	39
Operating Humidifier	% yes	30		38				20	39
Open Sump	% yes	55		33				20	39
Inspection Findings									
Window Moisture Damage	% yes	50		77				20	39
Basement Wall Moisture Damage	% yes	17		34				18	35
On Grade Floor Moisture Damage	% yes	15		36				20	39
Attic Moisture Damage	% yes	15		19				13	21
Ceiling Moisture Damage (with no attic moisture damage)	% yes	0		5				20	39
Reported Mold Area	m^2	0.427	0.964	1.173	3.04	18.546	0	20	39

		good		bad		Group Data			
Variable	Category or Units	% or Mean	std. dev.	% or Mean	std. dev.	max	min	n good	n bad
Testing and Monitoring Data									
Equivalent Leakage Area	m^2	0.143	0.074	0.175	0.112	0.592	0.048	20	38
Tracer Gas Test (1 hr)	ACH	0.51	0.293	0.95	0.927	4.09	0.066	20	39
AIM 2 Estimate for test hour	ACH	0.66	0.45	0.99	0.80	3.6	0.09	20	38
Tracer/Aim 2	ratio	0.99	0.546	1.13	0.787	3.84	0.26	20	38
As found Living Room Temp	°C	20.6	1.57	20.4	1.55	23.3	17.0	20	39
As found Basement Temp	°C	17.4	3.42	16.5	3.09	22.5	9.0	18	36
As found Living Room R.H	%R.H.	42	7.2	41	8.0	56	28	20	39
As found Basement R.H	%R.H.	48	7.6	48	12	78	27	18	36
Failed CSA Spillage Test	%yes	20		26				20	39
Mean ACR Monitored Temp	oC	20.6	1.53	21.0	1.69	25.9	17.3	19	36
Mean ACR Monitored R.H.	%R.H.	38	10.3	34	9.5	71	18	20	37
Standard Deviation R.H.	%R.H.	3.2	3.3	2.1	1.1	16.5	0.9	20	37
ACR Monitored CO_2 Concentration	ppm	899	391	814	241	2317	422	20	39
Standard Deviation CO_2	ppm	298	218	237	156	1078	61	20	38
TVOC Concentration	mg/m^3	0.243	0.172	0.313	0.249	0.933	0.037	20	39
Ph I Bedroom Endotoxins		0.0063	0.013	0.021	0.047	0.2553	0	20	39
	Rank	24.9	17.1	33.1	16.5	59	3.5	20	39
Ph I Bedroom Egosterols		0	0	0.0404	0.126	0.5996	0	20	39
	Rank	13	0	38.7	13.6	59	13	20	39
Ph I Dust Mite Antigen F		654	687	6176	15300	78399	0	20	39
	Rank	25.7	14.3	32.2	18.2	59	5.5	20	39
Ph I Dust Mite Antigen P		4113	11700	2581	3580	47329	0	20	39
	Rank	24	16.5	32.2	17.3	59	5.5	20	39
Ph I Cat Antigen		1704	7620	1260	6660	40989	0	20	39
	Rank	30	6.6	30	6.6				
Ph I G Index		1.62	1.67	9.61	22.2	99.99	0.08	20	39
Ph I CFU (gly)	CFUs/1000	55	32.4	1410	3160	17311	4	20	39
	Rank	18.9	8.86	35.7	17.6	59	1	20	39
AIM 2 ACH over monitoring Period	ACH	0.49	0.307	0.79	0.568	2.24	0.110	16	32
Calculated Moisture Source Strength	kg/hr	0.377	0.273	0.794	0.424	1.860	0.110	16	31

Table 5.2 Contrast between "Good" and "Bad" Houses -Medical Questionaire Results

Variable	UNIT	% or MEAN GROUP				NUMBERS IN GROUPS							
						GOOD				BAD			
		Good		Bad		true	false	DNA or DNK	total	true	false	DNA or DNK	total
		% or mean	st. dev.	% or mean	st. dev.								
Age	mean	9.6	2.5	11.5	2.4				20				39
Sex	%male	40.		48.7		8	12	0	20	19	20	0	39
Average number of people smoking in home		0.6	1.	0.7	1.2				20				39
smoking house (YN)	%yes	30.		38.5		6	14	0	20	15	24	0	39
MQ2_01: chest illness	%yes	35.		51.3		7	13	0	20	20	19	0	39
MQ2_04: cough	%yes	35.		26.3		7	13	0	20	10	28	1	39
MQ2_N5: wheezy or whistling chest	%yes	61.1		43.3		11	7	2	20	13	17	9	39
MQ2_2: behavior patterns sum 1-12	mean	20.2	2.8	19.8	2.5				20				39
MQ2_3_01: carpets in bedroom	%yes	95.		89.7		19	1	0	20	35	4	0	39
MQ2_3_02: waterbed	%yes	5.		20.5		1	19	0	20	8	31	0	39
MQ2_3_04: plastic matress cover	%yes	25.		20.5		5	15	0	20	8	31	0	39
MQ2_3_05: portable air conditioner in bedroom	%yes	5.		0.		1	19	0	20	0	39	0	39
MQ2_3_06: bedroom water damage or mold	%yes	15.		23.1		3	17	0	20	9	30	0	39
MQ2_3_07: basement bedroom	%yes	5.		7.7		1	19	0	20	3	36	0	39
MQ2_3_08: humidifier in bedroom	%yes	5.		17.9		1	19	0	20	7	32	0	39
MQ2_3_09: changes made due to respiratory problems	%yes	15.		13.2		3	17	0	20	5	33	1	39
MQ3_04_1: education level person 1	% >hs	65.		48.7		13	7	0	20	19	20	0	39
MQ3_04_2: education level person 2	% >hs	40.		50.		8	12	0	20	18	18	3	39
MQ3_05_1: family income	% <$50	47.4		29.		9	10	1	20	9	22	8	39
am average peak flow	mean	251.7	94.8	307.2	113.				20				39
am peak flow estimate	mean	265.7	71.4	324.3	81.3				20			1	39
am peak flow (% of predicted)	mean	96.6	33.7	94.3	22.6				20			1	39
am-pm average peak flow (difference)/predicted peak flow	mean	-5.91	16.2	-5.70	11.4				20				39
Furry Pets	%yes	55.		65.8		11	9	0	20	25	13	1	39
MQ2_2a-d: allergic response to dust, pollen, mold, or animals in past 12 months	%yes	35.		20.5		7	13	0	20	8	31	0	39
MQ2_3_abcdf: chest tightness or wheezing from dusting, vacuuming, beating carpets, fluffing pillows, or when exposed to dust	%yes	20.		7.7		4	16	0	20	3	36	0	39
MQ2_6ace: itchy eyes, nose irritation, throat irritation in last month	%yes	60.		61.5		12	8	0	20	24	15	0	39
MQ2_6f-l: headaches, muscle aches, fever and chills, nausea, diarrhea, difficulty concentration, or irratibility in past month	%yes	80.		76.9		16	4	0	20	30	9	0	39
MQ2_7: medication - past 72 hours	%yes	40.		20.5		8	12	0	20	8	31	0	39
MQ2_9: health problems or illnesses	%yes	25.		23.1		5	15	0	20	9	30	0	39
MQ3_06A_1: dust allergy person 1	%yes	25.		17.9		5			20	7			39
MQ3_06A_2: dust allergy person 2	%yes	30.		15.4		6			20	6			39
MQ3_06A_3: dust allergy person 3	%yes	35.		23.1		7			20	9			39

Variable	UNIT	% or MEAN GROUP				NUMBERS IN GROUPS							
						GOOD				BAD			
		Good		Bad		true	false	DNA or DNK	total	true	false	DNA or DNK	total
		% or mean	st. dev.	% or mean	st. dev.								
MQ3_06A_4: dust allergy person 4	%yes	10.		2.6		2			18	1			36
MQ3_06A_5: dust allergy person 5	%yes	15.		0.		3			6	0			18
MQ3_06A_6: dust allergy person 6	%yes	0.		0.		0			1	0			2
MQ3_06B_1: pollen allergy person 1	%yes	30.		20.5		6			20	8			39
MQ3_06B_2: pollen allergy person 2	%yes	30.		25.6		6			20	10			39
MQ3_06B_3: pollen allergy person 3	%yes	25.		17.9		5			20	7			39
MQ3_06B_4: pollen allergy person 4	%yes	15.		5.1		3			18	2			36
MQ3_06B_5: pollen allergy person 5	%yes	10.		5.1		2			6	2			18
MQ3_06B_6: pollen allergy person 6	%yes	0.		0.		0			1	0			2
MQ3_06C_1: mold allergy person 1	%yes	20.		15.4		4			20	6			39
MQ3_06C_2: mold allergy person 2	%yes	15.		15.4		3			20	6			39
MQ3_06C_3: mold allergy person 3	%yes	25.		17.9		5			20	7			39
MQ3_06C_4: mold allergy person 4	%yes	5.		0.		1			18	0			36
MQ3_06C_5: mold allergy person 5	%yes	15.		2.6		3			6	1			18
MQ3_06C_6: mold allergy person 6	%yes	0.		0.		0			1	0			2
MQ3_06D_1: animal allergy person 1	%yes	15.		15.4		3			20	6			39
MQ3_06D_2: animal allergy person 2	%yes	25.		7.7		5			20	3			39
MQ3_06D_3: animal allergy person 3	%yes	35.		12.8		7			20	5			39
MQ3_06D_4: animal allergy person 4	%yes	10.		0.		2			18	0			36
MQ3_06D_5: animal allergy person 5	%yes	15.		5.1		3			6	2			18
MQ3_06D_6: animal allergy person 6	%yes	0.		0.		0			1	0			2
MQ3_07_1: cough? person 1	%yes	20.		17.9		4			20	7			39
MQ3_07_2: cough? person 2	%yes	15.		12.8		3			20	5			39
MQ3_07_3: cough? person 3	%yes	35.		20.5		7			20	8			39
MQ3_07_4: cough? person 4	%yes	20.		2.6		4			18	1			36
MQ3_07_5: cough? person 5	%yes	5.		7.7		1			6	3			18
MQ3_07_6: cough? person 6	%yes	0.		0.		0			1	0			2
MQ3_08_1: wheezy or whistling chest? per. 1	%yes	20.		10.3		4			20	4			39
MQ3_08_2: wheezy or whistling chest? per. 2	%yes	20.		5.1		4			20	2			39
MQ3_08_3: wheezy or whistling chest? per. 3	%yes	40.		17.9		8			20	7			39
MQ3_08_4: wheezy or whistling chest? per. 4	%yes	30.		10.3		6			18	4			36
MQ3_08_5: wheezy or whistling chest? per. 5	%yes	15.		7.9		3			6	3			18
MQ3_08_6: wheezy or whistling chest? per. 6	%yes	0.		2.6		0			1	1			2
MQ3_09_1: asthma? person 1	%yes	10.5		7.9		2			20	3			39
MQ3_09_2: asthma? person 2	%yes	10.5		0.		2			20	0			39
MQ3_09_3: asthma? person 3	%yes	31.6		34.2		6			20	13			39
MQ3_09_4: asthma? person 4	%yes	15.8		21.1		3			18	8			36
MQ3_09_5: asthma? person 5	%yes	15.8		7.9		3			6	3			18
MQ3_09_6: asthma? person 6	%yes	0.		2.8		0			1	1			2
MQ3_10_1: asthma attack? per. 1	%yes	10.		2.6		2			20	1			39
MQ3_10_2: asthma attack? per. 2	%yes	10.		0.		2			20	0			39
MQ3_10_3: asthma attack? per. 3	%yes	30.		15.4		6			20	6			39
MQ3_10_4: asthma attack? per. 4	%yes	20.		0.		4			18	0			36

		% or MEAN GROUP				NUMBERS IN GROUPS							
						GOOD				BAD			
Variable	UNIT	Good		Bad		true	false	DNA or DNK	total	true	false	DNA or DNK	total
		% or mean	st. dev.	% or mean	st. dev.								
MQ3_10_5: asthma attack? per. 5	%yes	10.5		0.		2			6	0			18
MQ3_10_6: asthma attack? per. 6	%yes	0.		0.		0			1	0			2
MQ3_11_1: cigarettes ever? per. 1	%yes	30.		61.5		6			20	24			39
MQ3_11_2: cigarettes ever? per. 2	%yes	30.		41.		6			20	16			39
MQ3_11_3: cigarettes ever? per. 3	%yes	0.		5.1		0			20	2			39
MQ3_11_4: cigarettes ever? per. 4	%yes	0.		2.6		0			18	1			36
MQ3_11_5: cigarettes ever? per. 5	%yes	0.		0.		0			6	0			18
MQ3_11_6: cigarettes ever? per. 6	%yes	0.		0.		0			1	0			2
MQ3_12_1: cigarettes now? per. 1	%yes	25.		25.6		5			20	10			39
MQ3_12_2: cigarettes now? per. 2	%yes	15.		17.9		3			20	7			39
MQ3_12_3: cigarettes now? per. 3	%yes	0.		5.1		0			20	2			39
MQ3_12_4: cigarettes now? per. 4	%yes	0.		2.6		0			18	1			36
MQ3_12_5: cigarettes now? per. 5	%yes	0.		0.		0			6	0			18
MQ3_12_6: cigarettes now? per. 6	%yes	0.		0.		0			1	0			2
MQ3_13_1: current cold? person 1	%yes	10.		12.8		2			20	5			39
MQ3_13_2: current cold? person 2	%yes	5.		20.5		1			20	8			39
MQ3_13_3: current cold? person 3	%yes	30.		12.8		6			20	5			39
MQ3_13_4: current cold? person 4	%yes	15.		12.8		3			18	5			36
MQ3_13_5: current cold? person 5	%yes	10.		7.7		2			6	3			18
MQ3_13_6: current cold? person 6	%yes	0.		0.		0			1	0			2

DNA or DNK = did not answer or did not know

Table 5.3 Contrast between Good and Bad Houses - FACS Test Results

	Good house Data			Bad House Data					
Description	n	Mean	STD	n	Mean	STD	Δmean/ SDev	Δmean/ mean	TTEST
WBC (10^9/L)	20	6.680	1.422	37	7.054	1.421	0.263	0.054	0.175
% Lymphocytes	20	47.400	11.482	36	44.889	9.786	-0.242	-0.055	0.207
Nasal Eosinophils Present (% yes)	16	0.000		32	0.054				
%CD20+	18	19.000	4.311	37	19.676	5.000	0.142	0.035	0.304
%CD20+ Cells Expressing CD5	18	53.556	10.042	37	57.703	8.212	0.462	0.074	0.070
%CD20+ Cells Expressing CD45RA	18	96.444	2.770	35	95.000	2.712	-0.517	-0.015	0.040
%CD20+ Cells Expressing CD45RO	18	19.222	7.337	37	21.946	8.031	0.347	0.129	0.109
%CD3+	20	81.700	6.530	37	82.378	5.983	0.111	0.008	0.351
%CD3+T Cells Expressing CD4	20	61.350	8.780	37	57.162	6.331	-0.560	-0.071	0.035
%CD3+T Cells Expressing CD8	20	35.700	6.650	37	37.892	5.844	0.355	0.059	0.112
%CD3+T Cells Expressing CD45RA	20	67.550	16.149	37	66.784	10.781	-0.060	-0.011	0.425
%CD3+T Cells Expressing CD45RO	20	43.550	16.411	37	55.946	14.772	0.758	0.240	0.004
%CD3+T Cells Expressing RA+RO-	20	43.350	10.199	37	39.000	9.715	-0.434	-0.107	0.063
%CD3+T Cells Expressing RA+RO+	20	15.230	9.294	37	18.514	6.858	0.417	0.189	0.087
%CD3+T Cells Expressing RA-RO+	20	15.850	8.437	37	20.189	7.283	0.548	0.232	0.030
%CD3+T Cells Expressing CD29 negative	20	0.900	1.586	37	0.378	0.639	-0.480	-0.929	0.086
%CD3+T Cells Expressing CD29 low	20	70.900	7.615	37	67.649	6.709	-0.455	-0.047	0.059
%CD3+T Cells Expressing CD29 high	20	28.150	8.512	37	32.000	6.856	0.505	0.126	0.046
%CD3+Quadrant 1 - CD45RA-CD29 high	20	16.250	7.643	37	19.000	6.155	0.406	0.152	0.088
%CD3+Quadrant 2 - CD45RA+CD29 high	20	9.400	4.260	37	10.135	4.967	0.156	0.074	0.280
%CD3+Quadrant 3 - CD45RA-CD29 low	20	17.800	13.946	37	15.514	5.258	-0.248	-0.140	0.244
%CD3+Quadrant 4 - CD45RA+CD29 low	20	56.550	12.215	37	55.351	8.985	-0.118	-0.021	0.351
%CD4:CD8 ratio	20	1.813	0.566	37	1.557	0.360	-0.562	-0.155	0.039
Lymphocyte count (10^9/L)	20	3.145	0.913	36	3.135	0.871	-0.012	-0.003	0.484
CD20+count	18	0.594	0.252	36	0.624	0.236	0.124	0.048	0.340
Count of CD20+ Cells Expressing CD5	18	0.326	0.167	36	0.364	0.152	0.238	0.106	0.216
Count of CD20+ Cells Expressing CD45RA	18	0.574	0.250	34	0.582	0.228	0.035	0.014	0.454
Count of CD20+ Cells Expressing CD45RO	18	0.111	0.048	36	0.138	0.070	0.430	0.215	0.048
Count of CD3+	20	2.570	0.753	36	2.594	0.796	0.031	0.009	0.456
Count of CD3+T Cells Expressing CD4	20	1.558	0.476	36	1.488	0.514	-0.141	-0.046	0.305
Count of CD3+T Cells Expressing CD8	20	0.937	0.357	36	0.979	0.309	0.132	0.045	0.327
* Count of CD4:CD8 Ratio (Same as CD4CD8)	20	1.813	0.566	36	1.556	0.366	-0.559	-0.156	0.039
Count of CD3+T Cells Expressing CD45RA	20	1.731	0.718	36	1.735	0.646	0.005	0.002	0.493
* Count of CD3+T Cells Expressing CD45RO	20	1.140	0.635	36	1.472	0.553	0.554	0.245	0.029
Count of CD3+T Cells Expressing RA+RO-	20	1.094	0.378	36	0.998	0.387	-0.249	-0.092	0.187
Count of CD3+T Cells Expressing RA+RO+	20	0.413	0.351	36	0.503	0.273	0.299	0.192	0.163
Count of CD3+T Cells Expressing RA-RO+	20	0.408	0.268	36	0.529	0.230	0.485	0.249	0.049
Count of CD3+T Cells Expressing CD29 negative	20	0.027	0.051	36	0.010	0.018	-0.506	-1.089	0.078
Count of CD3+T Cells Expressing CD29 low	20	1.836	0.611	36	1.742	0.569	-0.162	-0.053	0.288
Count of CD3+T Cells Expressing CD29 high	20	0.707	0.278	36	0.843	0.310	0.449	0.172	0.049
Count of CD3+Quadrant 1 - CD45RA-CD29 high	20	0.408	0.228	36	0.494	0.195	0.412	0.186	0.081
Count of CD3+Quadrant 2 - CD45RA+CD29 high	20	0.235	0.132	36	0.274	0.181	0.233	0.148	0.183
Count of CD3+Quadrant 3 - CD45RA-CD29 low	20	0.478	0.468	36	0.401	0.163	-0.252	-0.180	0.242
Count of CD3+Quadrant 4 - CD45RA+CD29 low	20	1.449	0.560	36	1.425	0.524	-0.045	-0.045	0.438

* Data field transfered to correlation tables

Table 5.4 Correlation Coefficients for Total Data Set

	Units	Age	Occupants	Occ. Density	Heated Volume	Eave Height	ELA	Tracer gas test est. air change	AIM2 estimated air change rate	Mean Temp	Mean RH	Std Dev RH
Units		yrs	#	#/m3	m3	m	m2	ACH	ACH	deg. C	%R.H.	%R.H.
Age	yrs	1.000										
Occupants	#	-0.148	1.000									
Occ. Density	#/m3	0.170	0.502	1.000								
Heated Volume	m3	-0.278	-0.030	-0.814	1.000							
Eave Height	m	0.368	0.024	-0.204	0.247	1.000						
ELA	m2	0.623	0.161	-0.042	0.117	0.384	1.000					
Tracer gas test est. air change	ACH	0.351	0.332	0.267	-0.155	0.200	0.585	1.000				
AIM2 estimated air change rate	ACH	0.620	0.228	0.292	-0.226	0.391	0.762	0.650	1.000			
Mean Temp	deg. C	-0.060	-0.115	-0.081	-0.079	-0.134	-0.178	-0.152	-0.153	1.000		
Mean RH	%R.H.	-0.043	0.086	0.245	-0.096	-0.051	-0.205	-0.094	-0.204	-0.496	1.000	
Std Dev RH	%R.H.	-0.084	-0.028	0.081	-0.063	0.125	-0.075	-0.014	-0.061	-0.266	0.420	1.000
Mn + SD	%R.H.	-0.056	0.072	0.237	-0.099	-0.021	-0.199	-0.087	-0.195	-0.504	0.983	0.578
Mean CO2	ppm	-0.320	0.096	0.103	-0.014	-0.224	-0.424	-0.343	-0.351	0.095	0.301	0.017
air change rate	ACH	0.703	0.220	0.267	-0.226	0.484	0.799	0.630	0.876	-0.085	-0.357	-0.078
moisture source	kg/hr	0.450	0.179	0.177	-0.046	0.162	0.481	0.191	0.420	-0.229	0.093	-0.181
complicating factors		-0.255	0.111	-0.066	0.108	-0.239	-0.098	-0.203	-0.253	0.153	0.114	0.011
Wood Burners		-0.189	0.290	-0.129	0.380	-0.063	0.058	0.011	-0.151	-0.168	0.096	-0.237
Mold Area	m2	-0.078	-0.068	-0.126	0.122	-0.067	-0.093	-0.033	-0.049	-0.083	-0.032	-0.097
Endotoxin	rank	0.122	0.068	0.108	-0.157	0.162	0.198	0.275	0.262	0.001	-0.031	0.090
Ergosterols	rank	-0.002	0.149	0.141	-0.064	-0.115	0.176	0.214	0.200	0.088	-0.181	-0.182
Mite F	rank	0.039	0.079	0.147	-0.110	0.123	-0.012	-0.013	0.110	-0.092	0.107	-0.093
Mite P	rank	0.164	0.045	0.363	-0.312	-0.101	-0.028	-0.019	0.087	-0.281	0.462	0.166
CFU Glys	rank	0.248	-0.051	0.157	-0.193	0.154	0.131	0.042	0.151	-0.021	0.202	-0.112
G-index		0.059	0.165	0.055	0.045	0.037	0.278	0.145	0.206	-0.101	-0.090	0.000
VOCs	mg/m3	-0.352	-0.139	-0.080	-0.026	-0.189	-0.303	-0.166	-0.174	0.035	-0.034	-0.118
Number of cigarettes smoked	#	0.067	0.025	0.196	-0.188	0.097	-0.077	-0.018	0.061	-0.041	-0.005	0.112
Behavioral patterns sum 1-12		-0.040	-0.179	-0.061	-0.003	0.030	-0.063	0.031	-0.132	0.244	-0.027	0.094
am peak flow (% of estimated)		0.181	-0.105	0.139	-0.205	0.051	-0.034	0.028	0.051	0.064	-0.125	-0.063
am-pm average peak flow/predicted		-0.048	0.090	0.076	-0.007	-0.102	0.009	-0.039	-0.082	-0.047	0.001	-0.182
CD4CD8CT		-0.097	-0.124	-0.040	0.021	-0.126	-0.192	-0.265	-0.216	-0.256	0.216	0.095
CD45O3CT		-0.010	0.067	0.188	-0.106	-0.064	-0.089	-0.034	-0.057	0.012	0.266	-0.131

	Mn + SD	Mean CO2	air change rate -week	Moisture source	complicating factors	Wood Burners	Mold Area	Endotoxin	Ergosterols	Mite F	Mite P	CFU Glys
Units	%R.H.	ppm	ACH	kg/hr			m2	rank	rank	rank	rank	rank
Age												
Occupants												
Occ. Density												
Heated Volume												
Eave Height												
ELA												
Tracer gas test est. air change												
AIM2 estimated air change rate												
Mean Temp												
Mean RH												
Std Dev RH												
Mn + SD	1.000											
Mean CO2	0.274	1.000										
air change rate	-0.334	-0.417	1.000									
moisture source	0.033	-0.112	0.630	1.000								
complicating factors	0.105	0.232	-0.235	-0.101	1.000							
Wood Burners	0.039	-0.025	-0.077	0.186	-0.042	1.000						
Mold Area	-0.048	0.074	-0.101	-0.095	-0.019	0.156	1.000					
Endotoxin	-0.010	-0.167	0.265	-0.009	0.097	0.033	-0.068	1.000				
Ergosterols	-0.199	-0.047	0.261	0.318	-0.126	0.287	0.117	0.030	1.000			
Mite F	0.077	0.149	0.188	0.257	-0.064	0.254	0.175	-0.097	0.262	1.000		
Mite P	0.449	0.140	0.192	0.400	-0.097	0.062	-0.062	-0.009	0.178	0.622	1.000	
CFU Glys	0.159	-0.123	0.246	0.387	-0.158	0.062	0.071	0.158	0.268	0.299	0.403	1.000
G-index	-0.080	-0.036	0.129	0.158	-0.092	-0.065	-0.046	0.178	-0.049	-0.144	-0.094	0.141
VOCs	-0.054	0.163	-0.400	-0.131	0.083	-0.119	0.144	0.049	0.000	-0.144	-0.229	-0.044
Number of cigarettes smoked	0.018	0.158	0.064	-0.012	-0.237	-0.048	-0.037	0.010	0.098	0.265	0.092	-0.020
Behavioral patterns sum 1-12	-0.006	-0.199	-0.082	-0.302	-0.050	-0.082	-0.018	-0.077	-0.154	0.028	-0.174	-0.012
am peak flow (% of estimated)	-0.125	-0.215	0.020	-0.034	0.006	-0.080	-0.020	0.129	-0.189	0.191	0.022	0.134
am-pm average peak flow/pred	-0.035	0.018	0.087	0.193	0.215	0.063	0.105	-0.193	0.055	0.007	-0.071	0.036
CD4CD8CT	0.215	0.285	-0.110	0.074	-0.185	-0.076	-0.082	-0.254	-0.165	-0.007	0.214	-0.180
CD45O3CT	0.209	-0.070	0.009	-0.047	0.021	0.325	0.051	0.161	0.138	0.047	0.063	0.230

	G-index	VOCs	Number cigarettes smoked	Behavioral patterns sum 1-12	am peak flow (% of estimated)	am-pm average peak flow/ predicted	CD4CD8CT	CD45O3CT
Units		mg/m3	#					
Age								
Occupants								
Occ. Density								
Heated Volume								
Eave Height								
ELA								
Tracer gas test est. air change								
AIM2 estimated air change rate								
Mean Temp								
Mean RH								
Std Dev RH								
Mn + SD								
Mean CO2								
air change rate								
moisture source								
complicating factors								
Wood Burners								
Mold Area								
Endotoxin								
Ergosterols								
Mite F								
Mite P								
CFU Glys								
G-index	1.000							
VOCs	0.113	1.000						
Number of cigarettes smoked	-0.110	-0.005	1.000					
Behavioral patterns sum 1-12	-0.159	-0.093	-0.107	1.000				
am peak flow (% of estimated)	-0.145	-0.138	0.073	0.327	1.000			
am-pm average peak flow/pred	-0.198	-0.099	0.058	0.002	0.002	1.000		
CD4CD8CT	-0.002	-0.126	0.074	-0.279	-0.359	0.103	1.000	
CD45O3CT	-0.028	-0.039	-0.067	0.151	0.043	0.227	-0.204	1.000

Table 5.4a Statistical Significance (z =Fisher(r) * (n-3)^0.5)

	Age	Occupants	Occ. Density	Heated Volume	Eave Height	ELA	Tracer gas test est. air change	AIM2 est. air change rate	Mean Temp	Mean RH	Std Dev RH
Age	XXX										
Occupants	-1.11	XXX									
Occ. Density	1.27	***4.13***	XXX								
Heated Volume	***-2.12***	-0.22	***-8.52***	XXX							
Eave Height	***2.86***	0.18	-1.55	1.89	XXX						
ELA	***5.41***	1.21	-0.31	0.88	***3.03***	XXX					
Tracer gas test estimated air change	***2.72***	***2.56***	***2.03***	-1.16	1.50	***4.97***	XXX				
AIM2 estimated air change rate	***5.38***	**1.72**	***2.23***	**-1.71**	***3.06***	***7.41***	***5.74***	XXX			
Mean Temp	-0.43	-0.83	-0.58	-0.57	-0.97	-1.29	-1.10	-1.10	XXX		
Mean RH	-0.32	0.63	**1.84**	-0.71	-0.38	-1.51	-0.69	-1.50	***-3.92***	XXX	
Std Dev RH	-0.61	-0.21	0.60	-0.46	0.92	-0.55	-0.10	-0.45	***-1.97***	***3.29***	XXX
Mn + SD	-0.41	0.53	**1.77**	-0.73	-0.16	-1.47	-0.64	-1.44	***-4.00***	***17.55***	***4.85***
Mean CO2	***-2.46***	0.72	0.77	-0.10	**-1.71**	***-3.36***	***-2.67***	***-2.72***	0.69	***2.28***	0.12
air change rate	***5.86***	1.50	**1.83**	-1.54	***3.54***	***7.35***	***4.98***	***9.11***	-0.57	***-2.50***	-0.53
source	***3.22***	1.20	1.19	-0.30	1.09	***3.48***	1.28	***2.97***	-1.55	0.62	-1.21
complicating factors	**-1.93**	0.84	-0.49	0.81	**-1.82**	-0.73	-1.54	**-1.92**	1.11	0.84	0.08
Wood Burners	-1.42	***2.23***	-0.97	***2.99***	-0.47	0.43	0.08	-1.13	-1.22	0.71	**-1.77**
Mold Area	-0.58	-0.51	-0.95	0.92	-0.50	-0.69	-0.25	-0.36	-0.60	-0.23	-0.71
Endotoxin	0.91	0.51	0.81	-1.18	1.22	1.49	***2.11***	***1.99***	0.00	-0.23	0.66
Ergosterols	-0.01	1.12	1.06	-0.48	-0.86	1.32	1.63	1.51	0.63	-1.35	-1.35
Mite F	0.29	0.60	1.11	-0.83	0.92	-0.09	-0.09	0.82	-0.67	0.79	-0.68
Mite P	1.23	0.33	***2.84***	***-2.41***	-0.76	-0.21	-0.14	0.65	***-2.09***	***3.67***	1.23
CFU Glys	**1.88**	-0.38	1.19	-1.46	1.16	0.97	0.31	1.13	-0.15	1.50	-0.82
G-index	0.44	1.24	0.41	0.33	0.28	***2.12***	1.09	1.55	-0.73	-0.66	0.00
VOCs	***-2.73***	-1.05	-0.60	-0.19	-1.43	***-2.32***	-1.26	-1.30	0.25	-0.25	-0.87
Number of cigarettes smoked	0.50	0.19	1.49	-1.42	0.73	-0.57	-0.13	0.45	-0.30	-0.04	0.82
Behavioral patterns sum 1-12	-0.30	-1.35	-0.46	-0.02	0.23	-0.47	0.23	-0.98	**1.80**	-0.20	0.69
am peak flow (% of estimated)	1.34	-0.78	1.04	-1.54	0.38	-0.25	0.20	0.37	0.46	-0.92	-0.46
am-pm average peak flow/predicted	-0.35	0.67	0.56	-0.05	-0.76	0.07	-0.29	-0.60	-0.33	0.01	-1.34
CD4CD8CT	-0.70	-0.91	-0.29	0.15	-0.92	-1.41	**-1.98**	-1.58	**-1.83**	1.57	0.68
CD45O3CT	-0.07	0.49	1.39	-0.77	-0.46	-0.65	-0.25	-0.41	0.08	**1.94**	-0.94

Values formated as ***1.96*** reject null hypothosis at 0.05 level of significance
Values formated as **1.64** reject null hypothosis at 0.1 level of significance
based on two tailed student T distribution

Prepared by Morrison Hershfield Ltd. 9/7/95

	Mn + SD	Mean CO2	Air change - week	Moisture Source	comp factors	Wood Burners	Mold Area	Endotoxin	Ergosterols	Mite F	Mite P
Age											
Occupants											
Occ. Density											
Heated Volume											
Eave Height											
ELA											
Tracer gas test estimated air change											
AIM2 estimated air change rate											
Mean Temp											
Mean RH											
Std Dev RH											
Mn + SD	XXX										
Mean CO2	***2.07***	XXX									
air change rate	***-2.33***	***-2.98***	XXX								
source	0.22	-0.74	***4.91***	XXX							
complicating factors	0.77	**1.77**	-1.61	-0.67	XXX						
Wood Burners	0.29	-0.18	-0.52	1.25	-0.32	XXX					
Mold Area	-0.35	0.55	-0.68	-0.63	-0.14	1.18	XXX				
Endotoxin	-0.07	-1.26	**1.82**	-0.06	0.73	0.25	-0.51	XXX			
Ergosterols	-1.49	-0.35	**1.79**	***2.18***	-0.95	***2.21***	0.88	0.22	XXX		
Mite F	0.57	1.12	1.28	**1.74**	-0.48	**1.95**	1.32	-0.73	***2.00***	XXX	
Mite P	***3.55***	1.06	1.31	***2.81***	-0.73	0.47	-0.46	-0.07	1.35	***5.45***	XXX
CFU Glys	1.18	-0.92	**1.69**	***2.71***	-1.19	0.46	0.53	1.19	***2.06***	***2.30***	***3.20***
G-index	-0.59	-0.27	0.87	1.06	-0.69	-0.49	-0.34	1.34	-0.37	-1.08	-0.71
VOCs	-0.40	1.23	***-2.84***	-0.87	0.62	-0.89	1.09	0.37	0.00	-1.09	**-1.74**
Number of cigarettes smoked	0.13	1.19	0.43	-0.08	**-1.81**	-0.36	-0.28	0.08	0.74	***2.04***	0.69
Behavioral patterns sum 1-12	-0.04	-1.51	-0.55	***-2.07***	-0.37	-0.62	-0.14	-0.58	-1.16	0.21	-1.32
am peak flow (% of estimated)	-0.92	-1.62	0.14	-0.23	0.05	-0.60	-0.15	0.96	-1.42	1.44	0.16
am-pm average peak flow/predicted	-0.26	0.13	0.58	1.28	1.62	0.46	0.78	-1.45	0.41	0.05	-0.53
CD4CD8CT	1.56	***2.13***	-0.72	0.48	-1.36	-0.56	-0.60	**-1.89**	-1.21	-0.05	1.58
CD45O3CT	1.51	-0.51	0.06	-0.30	0.15	***2.45***	0.37	1.19	1.01	0.35	0.46

	CFU Glys	G-index	VOCs	Number of cigarettes smoked	Behavior patterns sum 1-12	flow (% of estimated)	am-pm average peak flow/ predicted	CD4CD8CT	CD45O3CT
Age									
Occupants									
Occ. Density									
Heated Volume									
Eave Height									
ELA									
Tracer gas test estimated air change									
AIM2 estimated air change rate									
Mean Temp									
Mean RH									
Std Dev RH									
Mn + SD									
Mean CO2									
air change rate									
source									
complicating factors									
Wood Burners									
Mold Area									
Endotoxin									
Ergosterols									
Mite F									
Mite P									
CFU Glys	XXX								
G-index	1.06	XXX							
VOCs	-0.33	0.85	XXX						
Number of cigarettes smoked	-0.15	-0.83	-0.04	XXX					
Behavioral patterns sum 1-12	-0.09	-1.20	-0.70	-0.81	XXX				
am peak flow (% of estimated)	1.00	-1.08	-1.03	0.54	***2.51***	XXX			
am-pm average peak flow/predicted	0.27	-1.49	-0.73	0.43	0.01	0.02	XXX		
CD4CD8CT	-1.33	-0.01	-0.93	0.54	***-2.09***	***-2.71***	0.75	XXX	
CD45O3CT	1.71	-0.20	-0.29	-0.49	1.11	0.31	1.67	-1.51	XXX

Table 5.5 Rank Correlation

	Units	Age	Occupants	Occ. Density	Heated Volume	Eave Height	ELA	Tracer gas test est. air change	AIM2 estimated air change rate	Mean Temp	Mean RH	Std Dev RH
Units		rank	rank	rank	rank	rank	rank	rank	rank	rank	rank	rank
Age	rank	1.000										
Occupants	rank	-0.191	1.000									
Occ. Density	rank	0.180	0.512	1.000								
Heated Volume	rank	-0.288	-0.047	-0.864	1.000							
Eave Height	rank	0.296	0.049	-0.182	0.209	1.000						
ELA	rank	0.705	0.029	0.002	-0.006	0.328	1.000					
Tracer gas test est. air change	rank	0.482	0.191	0.293	-0.232	0.066	0.575	1.000				
AIM2 estimated air change rate	rank	0.619	0.148	0.312	-0.294	0.251	0.736	0.717	1.000			
Mean Temp	rank	-0.036	-0.174	-0.062	-0.064	-0.141	-0.080	-0.133	-0.145	1.000		
Mean RH	rank	-0.020	0.068	0.199	-0.159	-0.187	-0.188	-0.161	-0.185	-0.450	1.000	
Std Dev RH	rank	0.117	0.069	0.233	-0.231	-0.002	0.203	0.127	0.189	0.049	0.234	1.000
Mn + SD	rank	0.005	0.066	0.226	-0.189	-0.192	-0.162	-0.148	-0.168	-0.426	0.987	0.341
Mean CO2	rank	-0.426	0.180	0.179	-0.130	-0.202	-0.573	-0.534	-0.433	0.111	0.363	-0.018
air change rate	rank	0.755	0.151	0.323	-0.329	0.361	0.865	0.713	0.821	-0.064	-0.255	0.128
source	rank	0.414	0.177	0.233	-0.219	0.064	0.547	0.225	0.447	-0.272	0.105	-0.040
complicating factors	rank	-0.257	0.130	-0.043	0.141	-0.179	-0.142	-0.214	-0.183	0.197	0.054	0.116
Wood Burners	rank	-0.206	0.290	-0.135	0.332	-0.101	-0.012	0.064	-0.134	-0.258	0.168	-0.275
Mold Area	rank	0.132	-0.051	0.014	-0.069	-0.106	0.194	-0.076	0.102	0.060	0.144	-0.032
Endotoxin	rank	0.108	0.068	0.078	-0.092	0.144	0.242	0.375	0.262	0.066	-0.032	0.043
Ergosterols	rank	-0.005	0.149	0.156	-0.120	-0.080	0.135	0.145	0.142	0.001	-0.178	-0.168
Mite F	rank	0.054	0.079	0.195	-0.142	0.089	-0.026	0.021	0.018	-0.148	0.201	-0.040
Mite P	rank	0.181	0.045	0.359	-0.359	-0.154	-0.006	0.017	-0.003	-0.270	0.530	0.197
CFU Glys	rank	0.254	-0.051	0.131	-0.190	0.160	0.133	0.101	0.078	-0.042	0.184	-0.254
G-index	rank	-0.081	0.187	0.004	0.044	0.059	0.166	0.155	0.090	0.149	-0.183	0.120
VOCs	rank	-0.429	-0.059	0.022	-0.088	-0.235	-0.512	-0.416	-0.320	0.039	0.040	-0.387
Number of cigarettes smoked	rank	0.104	0.031	0.200	-0.219	0.198	0.020	0.141	0.081	-0.004	-0.005	0.080
Behavioral patterns sum 1-12	rank	-0.055	-0.137	-0.107	0.094	0.044	-0.084	0.007	-0.199	0.294	-0.141	0.063
am peak flow (% of estimated)	rank	0.099	-0.028	0.212	-0.190	-0.014	-0.030	0.100	0.046	0.043	-0.090	-0.132
am-pm average peak flow/pred	rank	0.046	0.019	0.009	0.075	-0.027	-0.002	0.006	-0.079	-0.007	0.005	-0.129
CD4CD8CT	rank	-0.110	-0.173	-0.085	0.011	-0.161	-0.209	-0.220	-0.191	-0.244	0.201	0.142
CD45O3CT	rank	-0.041	0.068	0.141	-0.090	-0.057	-0.056	0.046	-0.012	-0.041	0.226	-0.068

	Mn + SD	Mean CO2	air change rate	source	complicating factors	Wood Burners	Mold Area	Endotoxin	Ergosterols	Mite F	Mite P	CFU Glys
Units	rank	rank	rank	rank	rank	rank	rank	rank	rank	rank	rank	rank
Age												
Occupants												
Occ. Density												
Heated Volume												
Eave Height												
ELA												
Tracer gas test est. air change												
AIM2 estimated air change rate												
Mean Temp												
Mean RH												
Std Dev RH												
Mn + SD	1.000											
Mean CO2	0.365	1.000										
air change rate	-0.244	-0.564	1.000									
source	0.074	-0.168	0.602	1.000								
complicating factors	0.058	0.230	-0.251	-0.135	1.000							
Wood Burners	0.120	0.056	-0.038	0.163	-0.081	1.000						
Mold Area	0.143	0.155	0.163	0.260	-0.051	0.139	1.000					
Endotoxin	-0.038	-0.205	0.252	-0.098	0.122	0.033	0.001	1.000				
Ergosterols	-0.211	-0:087	0.156	**0.377**	-0.135	0.287	0.141	0.030	1.000			
Mite F	0.189	0.151	0.080	**0.196**	-0.067	0.254	0.147	-0.097	0.262	1.000		
Mite P	0.525	0.060	0.113	**0.428**	-0.105	0.062	0.125	-0.009	0.178	0.622	1.000	
CFU Glys	0.119	-0.117	0.173	**0.340**	-0.183	0.062	0.179	0.158	0.268	0.299	0.403	1.000
G-index	-0.159	0.006	0.054	0.125	0.231	-0.255	-0.047	0.253	0.094	-0.119	-0.133	0.032
VOCs	0.004	0.397	-0.527	-0.150	0.170	-0.143	0.057	-0.034	0.023	-0.073	-0.125	-0.069
Number of cigarettes smoked	0.017	0.032	0.118	0.046	-0.252	-0.106	-0.005	0.070	0.188	0.259	0.095	0.008
Behavioral patterns sum 1-12	-0.122	-0.097	-0.079	**-0.316**	0.020	-0.069	-0.102	0.015	-0.151	0.048	-0.172	-0.059
am peak flow (% of estimated)	-0.095	-0.203	0.075	-0.060	-0.002	-0.003	-0.027	0.082	-0.106	0.158	0.013	0.112
am-pm average peak flow/pred	0.003	-0.036	0.062	0.047	0.177	0.033	-0.165	-0.223	0.003	0.046	-0.066	0.007
CD4CD8CT	0.214	0.167	-0.226	0.094	-0.138	-0.068	-0.213	-0.233	-0.120	-0.005	0.176	-0.135
CD45O3CT	0.212	-0.073	0.047	-0.001	-0.077	0.346	0.083	0.133	0.150	0.099	0.068	0.265

	G-index	VOCs	Number of cigarettes smoked	Behavioral patterns sum 1-12	am peak flow (% of estimated)	am-pm average peak flow/predicted	CD4CD8CT	CD45O3CT
Units	rank	rank	rank	rank	rank	rank	rank	rank
Age								
Occupants								
Occ. Density								
Heated Volume								
Eave Height								
ELA								
Tracer gas test est. air change								
AIM2 estimated air change rate								
Mean Temp								
Mean RH								
Std Dev RH								
Mn + SD								
Mean CO2								
air change rate								
source								
complicating factors								
Wood Burners								
Mold Area								
Endotoxin								
Ergosterols								
Mite F								
Mite P								
CFU Glys								
G-index	1.000							
VOCs	0.102	1.000						
Number of cigarettes smoked	0.088	-0.060	1.000					
Behavioral patterns sum 1-12	-0.061	-0.021	-0.113	1.000				
am peak flow (% of estimated)	-0.076	-0.062	0.021	0.312	1.000			
am-pm average peak flow/pred	0.037	-0.074	-0.070	0.102	0.256	1.000		
CD4CD8CT	-0.197	-0.072	0.061	-0.260	-0.365	-0.018	1.000	
CD45O3CT	-0.066	-0.076	-0.078	0.139	0.101	0.288	-0.177	1.000

Table 5.6 Correlations - Bad House Data Set

	Units	Age	Occupants	Occ. Density	Heated Volume	Eave Height	ELA	Tracer gas test est. air change	AIM2 estimated air change rate	Mean Temp	Mean RH	Std Dev RH
Units		yrs	#	#/m3	m3	m	m2	ACH	ACH	deg. C	%R.H.	%R.H.
Age	yrs	1.000										
Occupants	#	0.027	1.000									
Occ. Density	#/m3	0.295	0.570	1.000								
Heated Volume	m3	-0.391	-0.091	-0.794	1.000							
Eave Height	m	0.526	0.064	-0.067	0.056	1.000						
ELA	m2	0.616	0.229	-0.043	0.110	0.455	1.000					
Tracer gas test estimated air cl	ACH	0.375	0.411	0.250	-0.118	0.277	0.573	1.000				
AIM2 estimated air change rate	ACH	0.748	0.240	0.256	-0.208	0.595	0.767	0.627	1.000			
Mean Temp	deg. C	-0.148	-0.209	-0.057	-0.152	-0.082	-0.278	-0.267	-0.266	1.000		
Mean RH	%R.H.	-0.023	0.183	0.482	-0.231	-0.247	-0.200	0.000	-0.108	-0.449	1.000	
Std Dev RH	%R.H.	0.119	0.233	0.381	-0.145	-0.006	0.164	0.297	0.254	0.095	0.350	1.000
Mn + SD	%R.H.	-0.009	0.200	0.502	-0.237	-0.237	-0.173	0.032	-0.076	-0.442	0.995	0.442
Mean CO2	ppm	-0.407	0.076	0.151	0.062	-0.190	-0.481	-0.464	-0.386	0.016	0.316	-0.068
air change	ACH	0.843	0.250	0.258	-0.262	0.608	0.808	0.603	0.902	-0.142	-0.321	0.267
source	kg/hr	0.652	0.163	0.172	-0.098	0.295	0.504	0.162	0.471	-0.314	0.266	0.065
comp factors		-0.274	0.198	0.018	0.096	-0.257	-0.097	-0.222	-0.340	0.277	0.092	0.136
Wood Burners		-0.427	0.322	-0.096	0.361	-0.322	-0.150	-0.116	-0.307	-0.251	0.090	-0.241
Mold Area	m2	-0.163	-0.105	-0.166	0.164	-0.014	-0.187	-0.092	-0.122	-0.151	0.001	-0.109
Endotoxin	rank	0.183	0.126	0.232	-0.307	0.070	0.129	0.204	0.247	-0.013	0.051	0.171
Ergosterols	rank	0.006	0.091	-0.009	0.082	-0.076	0.092	0.024	0.032	-0.003	-0.109	-0.018
Mite F	rank	0.004	0.115	0.038	0.035	0.123	-0.073	-0.111	0.028	-0.086	0.101	-0.206
Mite P	rank	0.263	0.061	0.382	-0.305	-0.097	-0.011	-0.048	0.146	-0.299	0.534	0.159
CFU Glys	rank	0.407	-0.101	0.164	-0.212	0.255	0.095	-0.105	0.086	-0.112	0.403	-0.061
G-index		0.085	0.164	0.010	0.100	0.078	0.283	0.095	0.176	-0.164	-0.071	0.131
VOCs	mg/m3	-0.234	-0.288	-0.205	0.047	-0.125	-0.297	-0.209	-0.260	0.057	-0.003	-0.443
Number of cigarettes smoked	#	0.118	-0.085	0.080	-0.164	0.023	-0.171	-0.094	-0.013	-0.030	-0.031	-0.072
Behavioral patterns sum 1-12		-0.182	0.030	-0.074	0.081	0.025	-0.066	0.058	-0.154	0.405	-0.059	0.126
am peak flow (% of estimated)		-0.003	0.118	0.208	-0.220	-0.022	-0.221	-0.075	-0.117	0.065	0.173	-0.174
am-pm average peak flow/predicted		-0.100	0.029	-0.152	0.154	0.033	-0.053	-0.087	-0.204	0.123	-0.095	-0.116
CD4CD8CT		-0.049	-0.327	-0.293	0.211	-0.113	-0.042	-0.230	-0.103	-0.279	0.034	-0.086
CD45O3CT		-0.226	0.253	0.216	-0.034	-0.043	-0.302	-0.207	-0.225	0.021	0.381	-0.059

	Mn + SD	Mean CO2	air change rate	source	complicating factors	Wood Burners	Mold Area	Endotoxin	Ergosterols	Mite F	Mite P	CFU Glys
Units	%R.H.	ppm	ACH	kg/hr			m2	rank	rank	rank	rank	rank
Age												
Occupants												
Occ. Density												
Heated Volume												
Eave Height												
ELA												
Tracer gas test estimated air ch												
AIM2 estimated air change rate												
Mean Temp												
Mean RH												
Std Dev RH												
Mn + SD	1.000											
Mean CO2	0.296	1.000										
air change	-0.298	-0.511	1.000									
source	0.270	-0.093	0.636	1.000								
comp factors	0.103	0.275	-0.140	0.011	1.000							
Wood Burners	0.060	0.171	-0.354	-0.080	-0.022	1.000						
Mold Area	-0.011	0.173	-0.180	-0.189	-0.002	0.106	1.000					
Endotoxin	0.067	-0.348	0.279	0.047	0.175	-0.177	-0.170	1.000				
Ergosterols	-0.107	0.107	0.072	**-0.069**	-0.054	0.120	0.018	-0.312	1.000			
Mite F	0.075	0.224	0.077	**0.177**	-0.069	0.284	0.218	-0.188	0.218	1.000		
Mite P	0.528	0.055	0.201	**0.308**	-0.058	0.027	-0.076	0.068	0.080	0.620	1.000	
CFU Glys	0.380	-0.023	0.184	**0.358**	-0.159	-0.155	-0.010	-0.029	-0.147	0.266	0.467	1.000
G-index	-0.054	-0.054	0.086	0.094	-0.097	-0.154	-0.077	0.149	-0.312	-0.221	-0.165	0.057
VOCs	-0.051	0.228	-0.457	-0.214	0.082	-0.075	0.162	0.039	-0.183	-0.159	-0.309	-0.115
Number of cigarettes smoked	-0.038	0.031	-0.032	-0.052	-0.266	0.016	-0.016	-0.136	0.195	0.353	0.162	0.126
Behavioral patterns sum 1-12	-0.043	-0.104	-0.164	**-0.361**	0.064	0.020	0.001	-0.078	-0.208	0.065	-0.182	-0.044
am peak flow (% of estimated)	0.147	0.083	-0.153	0.024	0.137	-0.003	0.004	0.136	-0.347	0.202	0.138	0.280
am-pm average peak flow/pred	-0.104	-0.077	-0.001	0.128	0.118	-0.045	0.147	-0.280	0.042	-0.050	-0.111	0.138
CD4CD8CT	0.025	-0.023	0.015	0.120	-0.285	0.083	0.022	-0.033	0.079	-0.164	-0.075	0.007
CD45O3CT	0.376	0.128	-0.264	-0.267	0.138	0.249	-0.058	0.163	-0.119	-0.091	0.120	0.067

	G-index	VOCs	Number of cigarettes smoked	Behavioral patterns sum 1-12	am peak flow (% of estimated)	am-pm average peak flow/predicted	CD4CD8CT	CD45O3CT
Units		mg/m3	#					
Age								
Occupants								
Occ. Density								
Heated Volume								
Eave Height								
ELA								
Tracer gas test estimated air ch								
AIM2 estimated air change rate								
Mean Temp								
Mean RH								
Std Dev RH								
Mn + SD								
Mean CO2								
air change								
source								
comp factors								
Wood Burners								
Mold Area								
Endotoxin								
Ergosterols								
Mite F								
Mite P								
CFU Glys								
G-index	1.000							
VOCs	0.093	1.000						
Number of cigarettes smoked	-0.175	-0.095	1.000					
Behavioral patterns sum 1-12	-0.191	-0.090	-0.151	1.000				
am peak flow (% of estimated)	-0.200	-0.085	0.126	0.243	1.000			
am-pm average peak flow/pred	-0.321	-0.149	-0.047	0.033	0.276	1.000		
CD4CD8CT	0.084	-0.156	0.202	-0.263	-0.380	-0.041	1.000	
CD45O3CT	-0.114	-0.030	-0.104	-0.077	0.010	0.120	0.005	1.000

Table 5.7 Summary of Mold Growth Reports

	Location	No of Reports	% of Total	Mold Area Rep'ed	% of Total	If Hs. 111 omitted % of Total
0	Bathroom	64	34.22%	10.23	20.29%	31.26%
2	Index child's bedroom	20	10.70%	2.01	3.98%	6.14%
3	Adult(s) bedroom	20	10.70%	0.70	1.39%	2.15%
4	Other bedroom	9	4.81%	0.19	0.37%	0.57%
5	Living/dining/family rooms above grade	24	12.83%	1.96	3.89%	6.00%
6	Kitchen	11	5.88%	0.45	0.90%	1.39%
7	Attic	3	1.60%	6.80	13.49%	20.78%
8	Basement	25	13.37%	25.61	50.79%	24.17%
9	Crawl Space	0	0.00%	0.00	0.00%	0.00%
10	Other	11	5.88%	2.47	4.90%	7.55%
		187	100.00%	50.42	100.00%	100.00%

	Problem Area	No of Reports	% of Total	Mold Area Rep'ed	% of Total	If Hs. 111 omitted % of Total
0	Attic sheathing/framing	3	1.60%	6.80	13.49%	20.78%
1	Closets at exterior walls	12	6.42%	0.52	1.02%	1.57%
2	Corners of exterior ceilings	12	6.42%	1.71	3.39%	5.23%
3	Corners of exterior walls	7	3.74%	0.11	0.22%	0.33%
4	Walls shielded by furniture, etc.	4	2.14%	0.20	0.40%	0.61%
5	Window edge/frame	55	29.41%	4.65	9.23%	14.22%
6	Foundation walls	16	8.56%	25.20	49.99%	22.93%
7	Slab on ground	3	1.60%	1.16	2.29%	3.53%
8	Areas below pipes or fixtures with cold water	2	1.07%	1.08	2.14%	3.30%
9	Other cold surface	6	3.21%	0.35	0.69%	1.07%
10	Bathroom	40	21.39%	7.19	14.27%	21.98%
11	Below or behind sink	2	1.07%	0.03	0.06%	0.09%
12	By clothes washer	1	0.53%	0.00	0.00%	0.00%
18	Other surface wetting concern	1	0.53%	0.01	0.01%	0.02%
19	Fridge pan	8	4.28%	0.35	0.69%	1.06%
20	Sump pit	3	1.60%	0.23	0.46%	0.71%
21	Other	12	6.42%	0.84	1.66%	2.55%
		187	100.00%	50.42	100.00%	100.00%

	Source of Water	No of Reports	% of Total	Mold Area Rep'ed	% of Total	If Hs. 111 omitted % of Total
1	from exterior precipitation	5	2.67%	1.90	3.77%	5.81%
2	wicking from ground	12	6.42%	5.31	10.53%	16.22%
4	condensation on envelope	96	51.34%	29.55	58.60%	36.21%
5	condensation on pipes/ducts	13	6.95%	0.78	1.55%	2.38%
6	plumbing accident	8	4.28%	1.77	3.51%	5.41%
8	other	53	28.34%	11.11	22.04%	33.97%
		187	100.00%	50.42	100.00%	100.00%

Table 5.8 Characterization of Condensation Related Mold Growth Sites

	Location	No of Reports	% of Total	Mold Area Rep'd	% of Total	If Hs. 111 omitted % of Total
0	Bathroom	9	9.38%	0.55	1.88%	4.68%
2	Index child's bedroom	20	20.83%	2.01	6.80%	16.96%
3	Adult(s) bedroom	20	20.83%	0.70	2.38%	5.92%
4	Other bedroom	8	8.33%	0.18	0.62%	1.55%
5	Living/dining/family rooms above grade	22	22.92%	1.96	6.64%	16.57%
6	Kitchen	2	2.08%	0.10	0.35%	0.87%
7	Attic	2	2.08%	5.80	19.63%	48.96%
8	Basement	6	6.25%	17.97	60.81%	2.26%
9	Crawl Space	0	0.00%	0.00	0.00%	0.00%
10	Other	7	7.29%	0.26	0.89%	2.23%
		96	100.00%	29.55	100.00%	100.00%

	Problem Area	No of Reports	% of Total	Mold Area Reported	% of Total	If Hs. 111 omitted % of Total
0	Attic sheathing/framing	2	2.08%	5.80	19.63%	48.96%
1	Closets at exterior walls	12	12.50%	0.52	1.74%	4.35%
2	Corners of exterior ceilings	8	8.33%	0.30	1.03%	2.57%
3	Corners of exterior walls	5	5.21%	0.10	0.34%	0.84%
4	Walls shielded by furniture, etc.	4	4.17%	0.20	0.68%	1.69%
5	Window edge/frame	53	55.21%	4.65	15.74%	39.27%
6	Foundation walls	3	3.13%	17.88	60.52%	1.52%
10	Bathroom	1	1.04%	0.01	0.03%	0.08%
21	Other	8	8.33%	0.08	0.29%	0.72%
		96	100.00%	29.55	100.00%	100.00%

6. ANALYSIS AND DISCUSSION

6.1 House Characteristics

The two sample populations in the study were selected based on the Phase 1 test results for biologically active materials. Therefore, examination of the differences in the two housing samples can provide some clues as to the factors which affect development of biological contamination. However, it is also important to understand some of the differences in the sample population when trying to analyze all other data elements. The researchers have the following comments.

The median **age** of the two samples were virtually identical, However, a closer examination of the data shows that there is a significant difference in the age distribution (Figure 6.1). There is a disproportional high percentage of houses in the bad house sample set that were constructed in the seventies. The good house sample set has a higher proportion of houses constructed in 1986 or later.

As expected age appears to correlate with leakage area and various measures of air change. It shows an inverse correlation with internally generated contaminants such as CO_2 and VOCs. There was also a strong correlation with calculated moisture source strength and with the number of colony forming units found in Phase I

The mean **size** of the bad house data set was generally smaller than for the good house set. Figure 6.2 shows that the size distribution was also skewed with the bad house sample set with a substantial higher proportions of houses with a heated volume of less than 500 cubic metres.

Eave Height (ground to ceiling height) of the houses was a strong predictor of air change and related variables. This could be expected since stack driven air change is directly related to height of the heated space. The "bad" houses had a lower mean eave height.

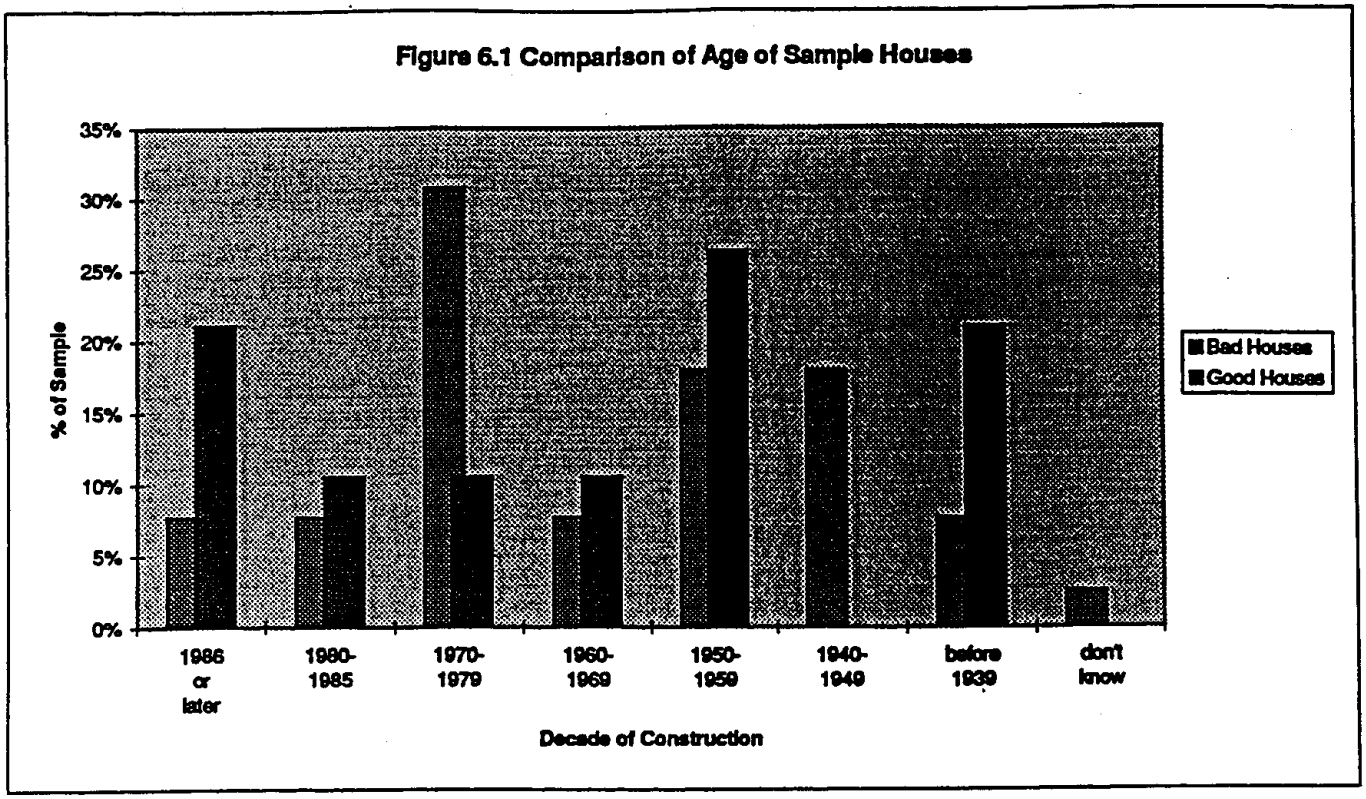


Figure 6.2

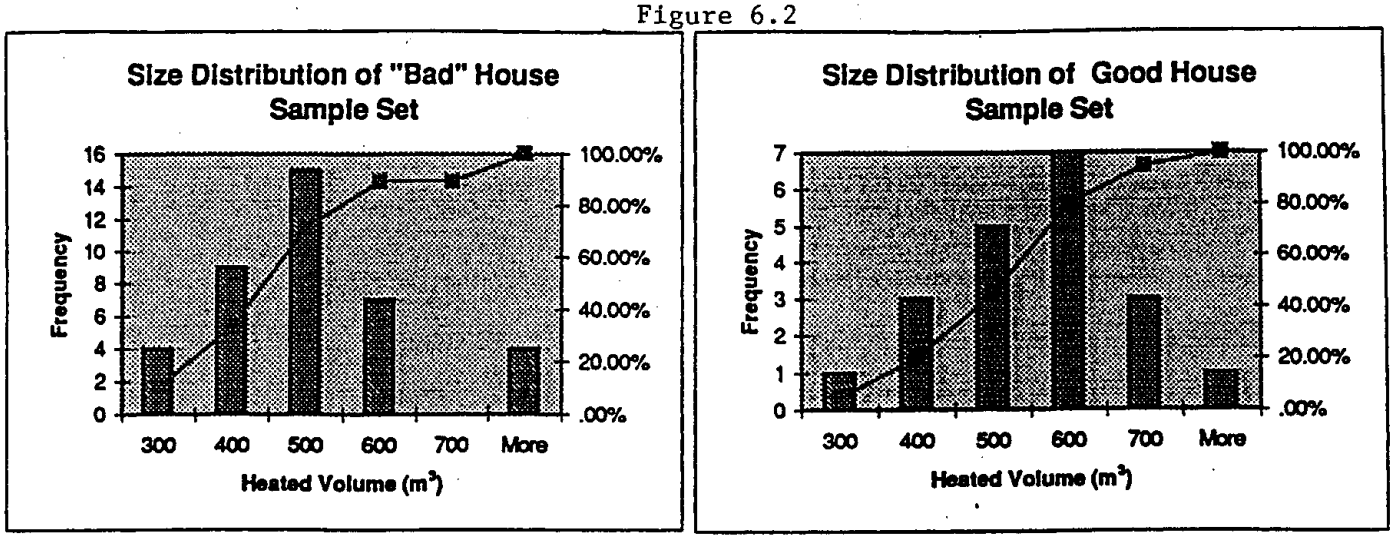
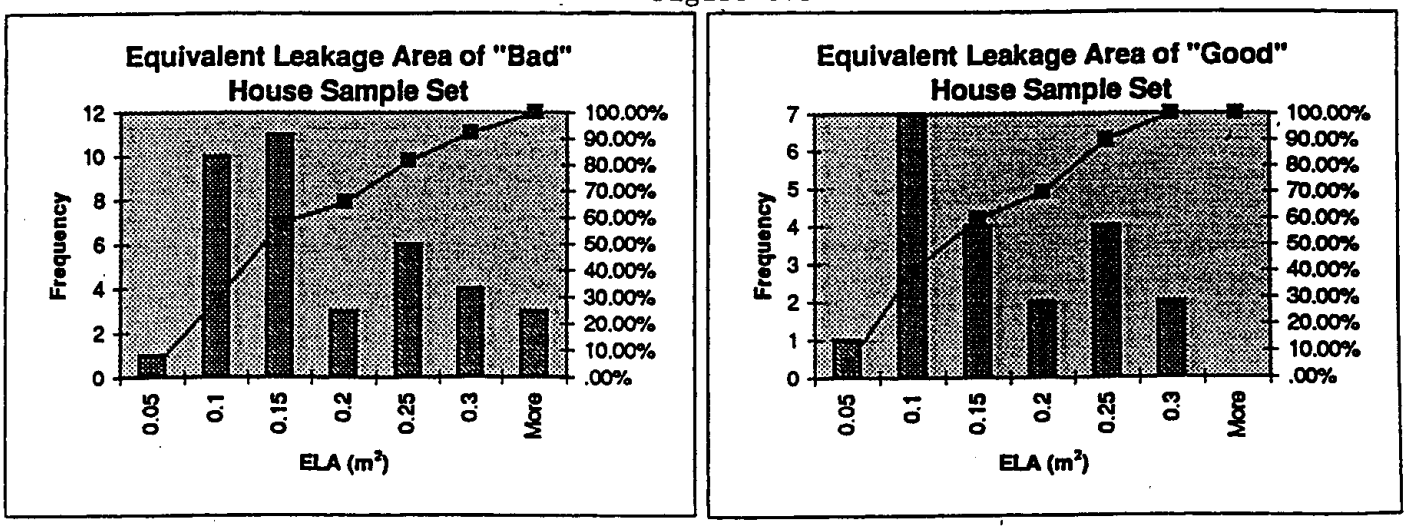


Figure 6.3



The average **number of occupants** in the "bad" houses was slightly higher so that the average **density of occupants** per cubic metre was about 17% higher than in the good house sample set. The occupant density showed correlation with humidity levels (as could be expected) but also with air change. Occupant density did not show the strong correlation one might have expected with calculated moisture source strength.

The **heating systems** used in the majority of houses were forced air, gas fueled. The bad house sample set did have a higher proportion of houses heated with alternate sources and those without forced air distribution. The researchers believe the lack of forced air distribution could be a contributing factor to the growth of biologically-active contaminants but we would be very cautious about drawing that conclusion from a limited sample of alternative systems obtained in this project.

Most of the houses in the survey had some kind of **air conditioning** with a very high proportion of the good house samples having central air. Only a limited number of the houses used **special air cleaning devices** such as electronic air cleaners . A higher proportion of the good house samples used them.

In all but three houses **ventilation** was limited to occupant control fans. One house, Number 250 (bad), had a heat recovery ventilator and two houses (100 (bad) and 352 (good)) had fresh air inlet ducts directly connected to this return air duct.

The impact of **wood burning equipment** warrants more detailed examination. 18% of the bad sample had wood stoves and 38% had fire-places. This compares with no wood stoves and 25% fire-place presence in the good houses. The correlation data indicates that there was a correlation between the presence of wood-burners and antigen of one species of dust mites (F) and one of the immological test parameters. It was noted that there was one house (111) with a very large area of mold growth discovered during inspection and coincidentally a wood burning appliance. However, the apparent correlations also appear in the rank correlations so this one large area of mold does not explain the found correlations.

Table 5.1 shows that the bad sample set had a higher incidence rate of possible moisture sources such as interior clothes drying or unvented dryers, operating humidifiers, or open sumps. However the count of these **complicating factors** did not appear to correlate with mold growth parameters or calculated moisture source strength.

6.2 Testing and Inspection Findings

Visible evidence of **water damage** and visible **area of mold growth** found by inspection does not appear to be a very good predictor of whether houses have high levels of biologically-active contaminants. Certainly, the bad house sample set had a higher observed incidence of water damage and mold growth area than the good house sample set. However, water damage was noted in a relatively high proportion of the good house sample set, particularly at windows, and the area of mold growth detected by inspection was still significant.

A key component of the testing and monitoring plan was to explore the relationship between building leakage area, air change and indoor humidity. Some of the findings of the test program are surprising. Conventional logic would assume that tighter buildings result in lower air change which results in high humidity and higher levels of condensation and biologically active contamination. This is not what was found.

The "bad" house sample set, on average, had higher tested **air leakage areas**, higher estimated **air change rates** (which of course are directly dependent on leakage areas), higher air change rates determined independently with the one hour tracer gas test and lower **average humidities**.

When reviewing the correlation tables one sees that there is the expected inverse correlation between air change related factors and internally generated contaminants such as CO_2 and to a lesser extent **VOCs**. The correlation with Relative Humidity appears to be weaker. We interpret this to mean that moisture source issues, not directly related to occupancy (a primary source of CO_2) play an important role.

One of the analyses that was carried out was an examination of the calculated **moisture source strength.** This calculation effectively calculates what level of internal moisture generation would be required to maintain the humidity found during monitoring assuming the air change predicted by AIM2 for that period. This was calculated for 47 of the test houses. Since estimated air change is one factor in the derivation of the calculated moisture source strength one would expect a strong inverse correlation between the two. We found that there was a strong positive correlation. Physically this was evidenced by the observation that humidity levels were fairly consistent across the sample group but estimated air change rates varied widely. The calculated moisture source strength had to show high positive correlation with air change rate for this pattern to occur.

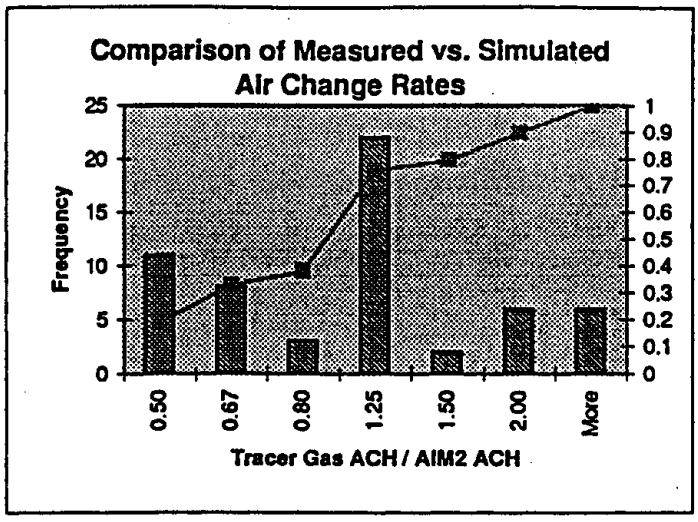
One can put forward theories to explain this apparent relationship, notably that buildings with high air change rates draw in a significant portion of humid air from the soil rather than outside. However, the level of correlation between estimated air change rate and moisture source and the lack of correlation with measured Relative Humidity is, in our opinion, suspicious. The relevance of the moisture source strength calculation warrants more detailed data analysis including testing the proposed physical explanation by relating calculated moisture source to level of soil contact.

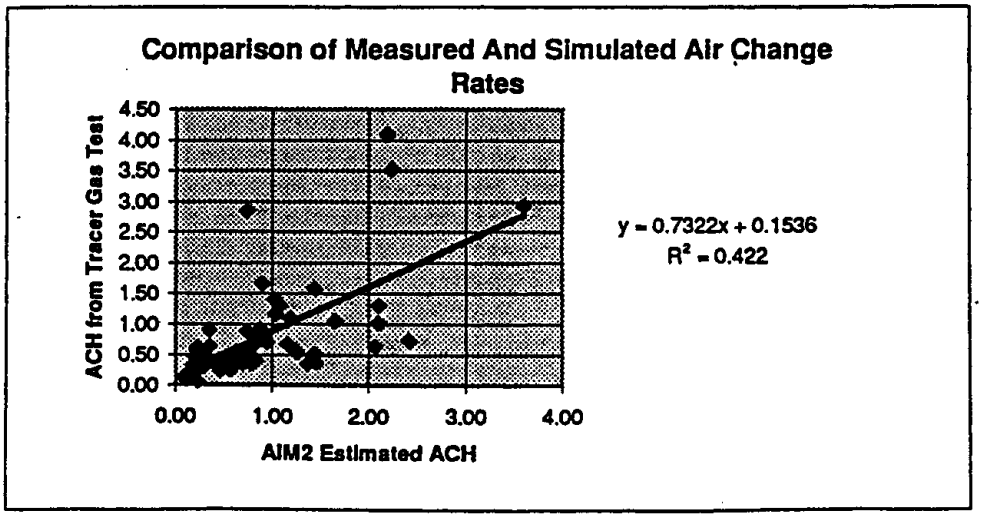
If one accepts the moisture source strength calculation, it turns out to be one of the strongest predictors of Phase I results. The average of calculated moisture source strength of the bad house sample set was more than double that of the good house sample set and the correlation tables show significant correlations with measured levels of endotoxins, egosterols, dust mite antigens and Colony Forming Units. There was also an interesting (and to us, inexplicable) correlation with the behavioral patterns score.

Calculated moisture source strength did not show the expected correlation with either the measures of occupancy, CO_2 levels (a measure of air chance per occupant), average relative humidity, the presence of moisture sources counted as complicating factors. We interpret this to mean that the moisture sources in the houses were not driven by occupancy factors and that the control of moisture sources is not solely a ventilation issue.

Another issue that will be of interest to many building researchers is the comparison between the air change rates predicted using the **AIM-2 simulation** and that found by **tracer gas decay testing.** In looking at the results of our testing in the form of ratio between tracer gas testing results divided by the AIM 2 estimate for the same hour, we find that the average result was very close to unity. However, there was a fairly wide range of this ratio, with a maximum and minimum differing from the mean by a factor of 4 (Figure 6.4). A preliminary examination of the relationship between this ratio and other test variables, such as building heated volume, ELA, weather conditions and test temperature, did not find any unexpected relationships. We believe that a more detailed examination of the available data could lead to a better understanding of the use of simulation models in predicting air change in buildings.

Figure 6.4 Comparison of Measured and Simulated Air Change Rates





Two different types of **indoor temperature** data was collected . Spot measurements at the time of the site visit, and continuous data collected during the monitoring period. In the spot temperature measurements, the average temperature of the bad house sample set was slightly (but statistically tested as significant) cooler in living areas. For houses with basements, the difference between average basement temperature was larger in bad houses. However, the average temperatures (taken in the child's bedroom) over the monitoring were slightly warmer in the bad houses.

The bad house sample sets had slightly lower **Relative Humidity** than the good house sample set. Relative humidity did show, at moderate levels, the expected correlation with occupant density and inverse correlation with ELA, air change measures and temperature. There was not the expected correlation with calculated moisture source strength. With respect to Phase I data, there was a strong correlation with antigen to one species of dust mite (F) and a weaker one with Colony Forming Units. There was also an apparent correlation with the two immunological test variables.

The mean monitored CO_2 concentration of the two sample sets was quite similar but the good house samples did have higher levels, probably reflecting the difference in ELA and air change rates. CO_2 is often used as a measure of the level of ventilation per person in an occupied space. Our readings were taken in the Index Child's bedroom which would not be occupied full time. The facts that the average mean CO_2 level was in the 800 - 900 ppm range with the highest mean over 2300 ppm and standard deviations (in each house) that averaged a significant fraction of these values lends credence to the opinion of many building researchers that bedrooms in many houses receive inadequate ventilation. Further study of the means and ranges during occupancy of the Index Child's bedroom is certainly warranted. As would be expected, CO_2 levels showed a strong inverse correlation with air change related variables. The correlation for occupant density was much weaker. With respect to measures of health, CO_2 level appears to have an inverse correlation with peak flows and a correlation with CD4/CD8 ratio (see section 6.4).

VOC sampling shows relatively modest concentrations, with TVOC levels typically less than 1 mg/m^3. The correlation tables shows an inverse relationship with air change factors but that the mean value in bad houses was higher even though the bad house samples generally had higher air change rates. This would indicate that the bad

house sample sets may have had, on average, higher source rates of VOCS. There was a relatively high inverse correlation with the age of the house, which was not unexpected since older houses had fewer materials known to emit VOCs. In future analysis, the VOC source strength could be estimated using the air change estimate derived for calculating moisture source strength.

VOC levels did not appear to correlate well with measures of health. In considering plans for further analysis of VOC impacts, it is worth noting that the measuring technique used provides an electronic trace that can be analyzed to determine specific compounds present. This detailed analysis was not done systematically for this project but was done for several houses as part of the quality control procedures. In these limited cases, most of the compounds present were from the lighter-weight side of the spectrum and may be associated gaseous fuels. The output data traces are being stored and are available for detailed analysis when desired.

6.3 Medical Questionnaire Results

A review of the medical questionnaire results shows relatively few areas where there is an apparent difference of significance in the good house and bad house samples sets. From the point of view of housing characteristics, we would note that the bad house group seemed to have a higher proportion of **smoking** houses, an unusually high proportion of **water beds**, a higher proportion of **humidifiers** in the bedrooms and a significantly lower **income level**. the preliminary analysis could detect no consistent pattern with **reported health problems**.

It was noted that the bad house samples had a higher proportion of houses with furry pets than the good house sample but Phase 1 results for cat antigen were very similar.

6.4 Medical Testing

Peak flows, our measure of respiratory function, showed some difference. The average level of adjusted morning peak flow (normalized) being lower in the bad houses and the difference between morning and evening being higher.

When looking at the correlation data for peak flows, one finds apparent correlations appearing and disappearing depending on how one looks at the data (directly, rank correlation, or correlation within the bad house sample sets). More detailed data analysis appears warranted.

Immunological testing was carried out under the direction of Dr. Lazarovits. The testing carried out on nasal secretions proved to be inconclusive. Only two samples showed nasal eosinophils. In the blood testing, Dr. Lazarovits' concluded that the differences in cell count between the good and bad house sample sets is both marked and significant. The following his analysis of the results and their significance

ANALYSIS OF PERIPHERAL BLOOD LYMPHOCYTE POPULATIONS FROM CHILDREN EXPOSED TO HIGH BIOLOGICALS IN WALLACEBURG ONTARIO.

Venous blood samples were obtained after informed consent from 37 children exposed to high biologicals (bad house) in their homes and 20 children who acted as controls. The latter were exposed to low biologicals (good house) in their homes.

The majority of this work was done using three colour FACS analysis. Approximately 200,000 peripheral blood mononuclear cells were stained with optimal dilutions of monoclonal antibodies. Analysis for all three colour immunofluorescence utilized the Becton Dickinson FACSCAN.

First B cells were analyzed in the subjects. B cells are characterized by cell surface expression of the CD20 molecule. In mice the subset of B cells which make autoantibodies also carry the CD5 molecule. In man CD5 expression on CD20+B lymphocytes generally indicates activation. 53.5% of children from good houses express CD5 on their B cells whereas the bad house children expressed CD5 on 57.7% of their lymphocytes (p=0.07). These data suggest that the lymphocytes from children in the affected households are chronically activated.

Next T cell subsets were analyzed. The major immunoregulatory T cell subsets are the CD4 and the CD8 populations. While inexact, CD4 molecules are so-called helper lymphocytes while CD8 molecules are so-called suppressor lymphocytes and one can get an overall immunologic assessment using the ***CD4/CD8 ratio****. Patients with a profound absence of CD4+ lymphocytes such as those with human immunodeficiency virus infections have an extremely low CD4/CD8 ration. The CD4/CD8 ratio in the children living in the good houses was 1.8 while the bad houses the CD4/CD8 ratio was 1.5 (p=0.039). The depressed CD4/CD8 ratio implies altered immunoregulation in these children.*

Further experiments were performed to look at T cell development. T cells all express CD3 as part of their T cell receptor complex. T cells also express different forms of the protein tyrosine phosphatase CD45. CD45 isoforms include CD45RA and CD45RO. CD45RA cells are generally believed to be antigen inexperienced or naive T cells while those which are CD45RO+ are generally believed to be those lymphocytes which are antigen experienced or memory. Cells can be CD45RA+CD45RO-, CD45RA+CD45RO+ (which is believed to be a transition stage), or they can be CD45RA-CD45RO+ (which is generally believed to be a terminal differentiation stage). However recent data have suggested that after a few years CD45RO+ cells can revert to RA+. We have found that there is a dramatically increased expression of CD45RO on T cells in children living in bad houses. The control group expresses 43.5% while in the affected houses the percentage is 55.9% (p=0.004). This percentage is also borne out when one looks at the absolute lymphocyte count. In the control houses the count is 1.140 x 10^9/L compared to 1.472 x 10^9/L in the affected houses (p=0.029). These data suggest that the T cells in children living in the bad houses are being chronically stimulated by antigen to become memory T cells.

This notion of chronic antigen stimulation is supported by the analysis of CD29 expression on the CD3+T cells. CD29 is the B1 integrin chain and its augmented expression occurs frequently on memory T cells. Again when one analyses CD29 expression on CD3+T cells, CD29 high expression is 28% in the good houses compared to 32% in the bad houses (p=0.046). This percentage is also consistent with the absolute lymphocyte count which in the control houses the children express 0.707 x 10^9/L, whereas in the bad houses it is 0.843 x 10^9/L (p=0.049). Thus this provides corroborating data that there is chronic antigen exposure with subsequent T cell development towards a memory phenotype in the affected houses.

These data provide evidence that the immune system is affected in the bad houses and has developed in response to antigenic stimuli.

Dr. Lazarovits suggested two data fields for correlation to house testing and Phase I data.

The CD4:CD8 ratio and the Count of CD5 + T-cells expressing CD45RO

The average **CD4:CD8 ratio** was lower in the bad house sample set and the average count of **CD3 + T-cells expressing CD45RO** was higher in the bad house sample set. The lower CD4:CD8 ratio of the bad house seems to correlate with high air change factors, higher temperatures, higher visible mold areas (in rank correlation), higher Endotoxins, higher CFU counts, higher behavioral pattern scores, higher peak flow readings, lower humidity, lower dust mite antigen and lower CO_2 levels. The high CD3+CD45RO measure in bad houses appears to have a positive correlation with RH, the presence of wood burning appliances, CFU counts and the difference between morning and evening peak flows. With the lack of association or inverse correlation with confounding factors such as VOCs, CO_2 levels and dust mite antigens, it appears from this preliminary analysis that the immune system changes detected by the testing are related to mold growth factors. The high correlation with wood burning appliances warrants further examination noting that the presence of wood burners also showed an apparent correlation with several mold measures.

6.5 Mold growth Factors

One element of the Mold Growth Site reports was the inspectors assessment of the **source of water** leading to mold growth based on the visual evidence available. This was done by classifying the suspected source into previously defined categories which are listed in Table 5.7. One important factor to note is the proportion of mold growth that was attributed to condensation on the building envelope since much of the test program was designed to explore this mechanism. As table 5.7 shows 51% of the site reports accounting for 59% of the total mold area was identified with condensation on the building envelope. This data is, however somewhat misleading since one house (111) was found to have a very large area of mold growth (17.7 m^2) attributable to the fact that the basement walls were insulated with fibre glass insulation with no interior finish or covering. The area behind the insulation was wet and showed mold growth. If this one report was deleted the percentage of total mold growth attributed to condensation on the building envelope reduces to 36%.

Condensation on the building envelope was still the largest of the defined categories but less than the "other" category (which included mold on non envelope surfaces of bathrooms, refrigerator drain pans and sumps). The next largest categorized moisture source was "wicking from the ground".

In terms of **locations** where mold was found, bathrooms and basements accounted for the majority of interior locations. Mold on attic sheathing accounted for a significant portion of discovered mold area but its significance should be discounted (but not eliminated) since this would be outside the envelope.

With respect to interior mold growth attributable to condensation on the building envelope, it is not surprising that mold associated with windows was the most frequently reported. Windows have much poorer thermal performance characteristics than virtually all other building envelope elements and they are readily visible.

There were almost assuredly hidden mold growth site not detected in the inspections. It could be argued that visible surfaces are the least likely to support condensation related mold growth because the exposure to heat from indoors would normally keep their temperature above the dew point of indoor air. We suspect that many houses had mold growth sites that would not be visible without destructive test openings.

One premise that was tested in a preliminary fashion was that the rooms with mold growth site were typically colder than the rest of the house. This was done by screening the data to use only the Mold Growth Site Reports completed where the outdoor temperature at the time of the site visit was below -10°C and indoor temperature at the mold growth site was available. The anomalous report of house 111 was also eliminated. This provided a sample of 73 reports. In these only 39%, accounting for 22% of the mold area in the reduced sample, had indoor air temperatures at the site more than 1°C below the temperature recorded in the living room.

Data collected at mold growth sites includes surface temperatures which can be used to calculate temperature indexes of envelope elements ($T_{surface}$ - $T_{outside}$ / T_{inside} - $T_{outside}$). This was done for the screened sample set noted above. It was apparent in the reviewing process that to make sense of this data would require additional screening, almost on a report by report basis, to evaluate whether factors such as solar exposure were having an impact. This was considered a task beyond the scope of this preliminary analysis of the data.

6.6 Growth Potential Simulation

The CMHC defined protocol for the field research included application of the FPLAIM.XLS simulation to predict situations where condensation would occur for long and frequent enough periods to amplify mold growth. Simulations were run for all the major mold growth sites on building envelope elements. The simulation results, as carried out, did not provide very useful information which could be correlated with other factors because their were no results where the definition of a condensation related mold growth period was met. The definition of a mold growth period was predefined as explained in section 4.5. We believe that one reason for the lack of useful results is that conditions in the house and the climate changed often enough to interrupt the continuous period of condensation or high humidity in the surface film required to meet the default definition of a mold growth period. The validity of one key input, the moisture source strength, was also questionable. The moisture source strength used was estimated from occupancy factors only (people present on an hourly basis, number of meals prepared, baths and showers taken, laundry done, etc.) as provided from occupant interviews.

It should also be noted that the program is designed to predict interior surface condensation. As noted in section 6.5 we believe that condensation on these surfaces accounts for only part of condensation related mold growth and a relatively small part of total mold growth.

These comments should not be interpreted to mean that the simulation process is not valuable. Gaining a measure of the extent and duration of moisture produced by surface condensation requires a method as complex as an hour by hour simulation. This project was the first application of the simulation method and the need for some refinement is not unexpected. We feel that the additional simulation should undertaken with the following changes.

- The moisture source strength in the house should be modified to reflect the findings of the monitored relative humidity (the moisture source strength calculation of section 4.9).
- The critical duration of condensation should be varied to allow consideration of "frequent but not continuous" condensation conditions.

- It may also be worthwhile modifying the program to use predicted temperature index instead of assembly R-Value as the basis of predicting surface temperature. This would provide a mechanism to evaluate condensation on surfaces that are separated or protected from interior temperatures.

Regardless of the limitations of the simulation and the accuracy of the absolute results, we feel that the simulation program with appropriate modifications to inputs should provide a reasonable relative measure of the potential for condensation related mold growth. This should be correlated with the house and medical data collected in both phases of the Wallaceburg Project.

7. CONCLUSIONS

Were the protocols developed and used, successful in gaining the required information?

1. It was more difficult to obtain permission for testing from the occupants of "bad" houses (as defined by Phase I tests results) than "good" houses.

2. Visible mold growth area does not appear to correlate well with Phase I data on biologically active contaminates in the house or the measures of health taken in this survey.

3. None of the protocols used were able to identify the presence and location of hidden mold growth or areas where growth was too thin to be visible to the naked eye. We suspect that such growth was taking place.

4. The small sample size (59 total, 39 bad, 20 good) places limits on the significance of many of the found data correlations. However even with this sample size many of the found correlations are good and significant. Most of the good correlations are preserved when data values are replaced by simple rank number.

5. Although the average of calculated air change rates compared well with the average of measured air change rates, individual differences are large.

Why do some houses produce so much biologically active material?

6. The relationship between house construction and operation, biological contamination levels, and health measurements is complex and very individual to the specific house. Virtually all of the houses that were noted as "unusual" by the field researchers were from the "bad" house sample set.

7. Biological contamination problems were **not** strongly related to low levels of air change and resultant high levels of general humidity. In fact, the bad house sample set were leakier that the good house sample set.

8. Local sources of moisture, rather than high general humidity levels, appear to be the dominant factor in visible mold growth.

9. Mold growth from condensation on windows was common, even in the "good" houses.

10. Many of the sources of moisture supporting mold growth were not attributable to condensation on the building envelope. Common locations of mold growth that were not related to envelope condensation were:
    - On bathroom interior surfaces, with the local source of water from domestic use (either injected into the air or escaping from fixtures)
    - Basement walls with apparent inward migration of water from the surrounding soil.
    - Pools of stagnant water (such as slow drying refrigerator drain pans).

11. Many of the moisture and mold growth problems appeared related to soil contact (crawl spaces, below grade basement walls, floor slabs).

What is the apparent correlation between mold growth and measurable health parameters?

12. There does appear to be a correlation of Phase I measures of mold contamination (CFUs endotoxins and egosterols) and changes to the immune systems of the Index Child in each house.

What is the influence of confounding factors on the above correlation?

13. Changes in the immune systems of Index Children do not appear to be explained by levels of VOCs, CO_2, Number of cigarettes smoked or measures of dust mite antigens.

14. The presence of wood burning appliances appears to correlate with egosterol levels, dust mite antigen level and changes in the immune system of the index child. Whether this correlation is direct needs further clarification.

What changes in house construction and operation could alleviate most problems?

15. General ventilation, important as it may be for other reasons, cannot be relied on to control mold growth and biological contamination.

16. Control of moisture sources in the house, particularly in soil contact areas appears to be an important requirement in avoiding mold growth and biological contamination.

17. The data collected in this study is insufficient to make a direct link between specific areas of mold growth and health effects. However, there is an apparent link between overall mold growth factors and health measures. If one accepts that this applies to specific locations some changes to construction practice could reduce some of the most common areas of mold growth.

    a) Recent builder education initiatives and code modifications aimed at reducing the frequency of moisture entry into basements are likely to pay significant dividends in reducing mold growth in houses.

    b) The frequency of occurrence of mold growth on interior surfaces , as well as envelope surfaces, of bathrooms indicates a need for local ventilation in bathrooms of adequate capacity and operating time to deal with high vapour generation rates.

    c) The application of window technologies and mounting methods that improve condensation resistance and the ability to dispose of condensation without mold growth could reduce one of the most common areas of mold growth.

8. RECOMMENDATIONS

1. Health Questionnaire results should undergo detailed examination and comparison with Phase I questionnaire results.

2. The mold measures from Phase I should be adjusted from $\mu g/g$ measures to $\mu g/m^2$ measures to better model probable exposure. The correlation of the adjusted variables with other house and health variables (which should be sensitive to mold mass) should be determined.

3. The apparent importance of the calculated moisture source strength should be tested more rigorously, this would include.
   - using newly available weather data and reasonable assumptions of missing or anomalous data, calculate the moisture source strength for additional houses in the sample set.
   - using available data to test possible physical explanations of the strong relationship of calculated moisture source strength with air change.
   - comparing the differences between calculated moisture source strength and estimates of occupancy generated moisture sources in individual houses and relating this to field data.

4. The reasons for the large variations in AIM2 predicted and tracer gas measured air change should be examined in detail.

5. The condensation prediction simulations (FPLAIM2) should be redone with the following modifications.
   - Use the moisture source strength calculated from the monitored relative humidity.
   - The critical duration of condensation should be varied to allow consideration of "frequent but not continuous" condensation conditions.
   - The factor using the one hour tracer gas test result to "correct" the estimated air change should be closely scrutinized and modified if there is reason to question test results.

   The condensation formation potential should then be correlated with the house and health variables.

6. Multi variant analysis considering possible confounding factors should be done to confirm the link between mold growth factors and measurements of health.

7. The relationship between CO_2 levels, R.H. levels, occupancy and closed door condition in the child's bedroom deserves much more study. Occupancy logs are available in paper form.

8. There were a number of specific questions raised by the preliminary review of the data which warrant more detailed study.

   - Why is there an apparent correlation between the presence of wood burners and the existence of mold growth and measures of health?
   - Is the fact that houses constructed in the 1970's were over represented in the bad house sample group significant? Was this a bad vintage of houses?

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