Indoor study on fine particulates, mould and damp in vulnerable Welsh homes

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The vulnerable group - Cystic Fibrosis patient

- Cystic Fibrosis (CF) is the most common inherited diseases. More than 59% of CF patients are sensitive to *fungal spores*, mostly Aspergillus fumigatus.
- Average survival in the UK is 41 years (Cystic fibrosis Registry).
- Average annual cost for a CF patient in the UK was €48,603 in 2012, including 57% for non-health care and indirect costs (https://doi.org/10.1186/s12913-015-1061-3).
- Respiratory disease costs £11.1 billion each year (2014, 0.6% UK GDP) (British Lung Foundation).
- Damp and mould are more likely to cause respiratory problems.
- Will improved indoor environment potentially reduce mould/damp and reduce the exposure to fungus?
Damp and mould - a common problem in Wales

- Welsh Housing Conditions Survey 2017-18: 7% of homes have a damp or condensation problem
- English Housing Survey: 4% of homes (897,000 dwellings) had problems with damp (via physical survey)
- Around 7.0 million (30%) households reported an issue with condensation, damp or mould (EHS 2017)

Is there a damp or condensation problem in one or more rooms?*

<table>
<thead>
<tr>
<th>Tenure</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner-occupied (%)</td>
<td>6.2</td>
</tr>
<tr>
<td>Social Housing (%)</td>
<td>4.8</td>
</tr>
<tr>
<td>Private rented (%)</td>
<td>12.9</td>
</tr>
</tbody>
</table>

*Source: National Survey for Wales, 2017-18. Sample size: 2,550
The multidisciplinary approach

- Building and Occupancy
  - Building information (EPC)
  - Occupants survey (Questionnaire)

- Photographic Survey
  - Photos
  - Possible causes

- Indoor Environment
  - Air quality measurement
  - Temperature/RH monitoring

- Microbiology Evidence
  - Mould/damp/Air examples
  - Microscopic observations

- Clinical Evidence

- Health Cost
  - SAIL
  - Medical records
• **Award letter** (10/2017)
• Project starts (12/2017)
• Grant joint award agreement (03/2018)
• SAIL IGRP approval (05/2018)
• Sponsor Approval (07/2018)
• IRAS ethical approval (10/2018)
• HRA and HCRW Approval (11/2018)
• Capacity and capability assessment (02/2019)
• DBS checks (01/2019)
• Occupational health check (01/2019)

• Material transfer agreement (02/2019)
• Letter of Access (02/2019)
• Portfolio listing (03/2019)
• Amendment for extension (04/2019)
• Recruitment (04/2019-10/2019)
• **Field visits and data collection** (06/2019-11/2019)
• **Data analysis** (12/2019-01/2020)
• Project event (01/2020)
• **Final report to the funder** (02/2020)
• Publications (03/2020 onward)
• 21 participants
• 21 houses
• Air Particle Counting in 21 rooms
• 68 air samples (in 68 rooms)
• 33 swab samples and photos of damp and mould
• Monitoring of T&RH in 29 rooms (16 houses) over 50 days
Cystic Fibrosis patient Cost Analysis

In **2017**

Total cost of **21** patients  **£558,339***

On **average**  **£26,588***

*Direct health care costs* from SAIL database only, not include nurse consultations, out-of-hour service, pathology tests (blood, urine..), non-GP prescriptions, admission costs, non-health care and indirect costs

<table>
<thead>
<tr>
<th>Band</th>
<th>Costing of patient care</th>
<th>Number of recruited patients (21 in total)</th>
<th>Weighted average cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>£2418.93</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>£7325.01</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>£15252.34</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>£34111.68</td>
<td>3</td>
<td>£13,704.37</td>
</tr>
<tr>
<td>5</td>
<td>£49915.22</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
### Cost of preventing mould and damp

<table>
<thead>
<tr>
<th>Measures</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Replace/repair building defects</td>
<td>High</td>
</tr>
<tr>
<td>(windows/wall/roof)</td>
<td>£2k and above</td>
</tr>
<tr>
<td>• Clean or repair roof gutters</td>
<td>Medium</td>
</tr>
<tr>
<td>• Mould-resistant paints</td>
<td>£2k to £200</td>
</tr>
<tr>
<td>• Installation of high-end dehumidifier</td>
<td></td>
</tr>
<tr>
<td>• Installation of ventilation unit with humidity sensor</td>
<td></td>
</tr>
<tr>
<td>• Display/monitor humidity indoors</td>
<td>Low/none</td>
</tr>
<tr>
<td>• Mop/dry wet surface/floor</td>
<td>£200 and below</td>
</tr>
<tr>
<td>• Open windows to improve air flow when necessary</td>
<td></td>
</tr>
<tr>
<td>• Keep mould off household plants</td>
<td></td>
</tr>
<tr>
<td>• Installation of dehumidifier for mould</td>
<td></td>
</tr>
<tr>
<td>• Regular cleaning</td>
<td></td>
</tr>
</tbody>
</table>
Damp and mould - results from our visits

Percentage and number of houses with mould (out of 21 houses)

Over 50% of houses have mould, significantly higher than 30% from EHS.
The lower EPC rating, more likely to have damp due to building envelope defects.

<table>
<thead>
<tr>
<th>EPC Grade</th>
<th>EPC rating</th>
<th>Damp due to building envelope</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td></td>
<td>82</td>
<td></td>
</tr>
<tr>
<td></td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>80</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>74</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>72</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>72</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>71</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>71 (10 yrs ago)</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>59</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>57</td>
<td>Y</td>
</tr>
<tr>
<td>E</td>
<td>43 (10 yrs ago)</td>
<td></td>
</tr>
</tbody>
</table>
Damp and mould - results from our visits

Percentage and number of houses with mould (out of 21 houses)

Over 50% of houses have mould, significantly higher than 30% from EHS.

![Mould distribution chart]

- 11 houses have mould
- 7 houses have mould caused by shower splash
- 2 houses have mould caused by kitchen sink splash

Occupants behaviour

With mould: 50%
Mould caused by shower splash: 10%
Mould caused by kitchen sink splash: 20%
Mould caused by windows/glass door condensation/thermal bridge: 0%
Mould caused by penetrating damp on wall: 0%
Air quality monitoring

Large particles (pollen, etc) during the visits

16, 21, 31, 43 and 60 have higher values than others.
Small particles (bacteria, mold, etc) during the visits

16, 21, 31, 43 and 60 have higher values than others
At Collection

At 48 hours

At 72 hours
Fungi grow and clinical test results

- Surface swab samples
  - Phoma sp
  - Candida sp
  - R rubra
  - Yeast/Cladosporium sp.
  - ...

- Air samples
  - Penicillium sp
  - Cladosporium sp
  - R Rubra*
  - A fumigatus sp. Complex
  - ...

- Airway samples
  - A.Fum
  - Penicillium
  - Exophiala
  - ...

Mould/damp swab and agar plates results

<table>
<thead>
<tr>
<th></th>
<th>Air samples</th>
<th>Swab samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of samples taken</td>
<td>68</td>
<td>33</td>
</tr>
<tr>
<td>Total number of organisms isolated</td>
<td>229</td>
<td>90</td>
</tr>
<tr>
<td>Predominant organism isolated</td>
<td>Penicillium sp.</td>
<td>No</td>
</tr>
</tbody>
</table>

- All samples contained more than one organism; some have seven to eight different organisms according to phenotype study.
- Penicillium sp. and Aspergillus fumigatus sp. complex were the only isolates that were isolated from both air and swab samples.
- Both of them are prolific spore producers and have been implicated in either human allergic response or disease.
Final thoughts

• This study has a small number of participants
• It is a descriptive study
• No intervention
• Fungal presence as an indicator of building performance
• Fungi linked to relative humidity (should be below 75%)
• What is the acceptable airborne spores levels at ...
  • home setting (e.g. 500 Colony Forming Units cfu/m3 when dry)
  • Vs. the clinically setting (<15cfu/m3),
• Patient are well looked after in hospitals. What about patients at home?
The Knowledge Economy Skills Scholarships (KESS) PhD project: Domestic ventilation technologies to improve air quality and reduce health risks (2019-2022)

• Analyse current practice of domestic ventilation technologies and strategies
• Gather monitoring data and establish validated CFD models to quantify the effectiveness of common ventilation technologies
• Develop optimal low carbon ventilation strategies for domestic buildings in the UK with the goal of good air quality and low energy consumption
With special thanks to the team

Cardiff University
- Dr Hu Du, Senior Research Fellow (project lead)
- Miltiadis Ionas, Research Assistant

Adult Cystic Fibrosis Centre, University Hospital Llandough
- Dr Jamie Duckers, Research lead and Consultant Physician
- Dr Lewis White, Head of Unit
- Dr Rishi Dhillon, Consultant Microbiologist
- Lorna Vale, Senior Biomedical Scientist

Public Health Wales Microbiology Cardiff

Swansea University
- Professor Gwyneth Davies, Clinical Deputy Head
- Professor Deborah Fitzsimmons, Personal Chair in Public Health
- Dr Mohammad Al Sallakh, Researcher
- Professor Paul Lewis, Director of CHEMRI
“Good housing pays for itself over time. Provide better housing and you will need less hospitals!”

NHS Director of Sustainability