

**Mold and Moisture Home Interventions**  
**Cuyahoga County Urban Mold & Moisture Project**  
Supported by a grant from the HUD Healthy Homes Office

**OVERVIEW AND SUMMARY OF CLINICAL RESULTS**

The Cuyahoga County Urban Mold & Moisture Program (UMMP) explored the relationship between mold, moisture, asthma triggers and the respiratory health of children living in inner city neighborhoods throughout Greater Cleveland. Simultaneous clinical /environmental assessments and sampling occurred over a twelve month period. A total of 104 homes received environmental interventions focused on the reduction of water infiltration, removal of water damaged building materials, HVAC alterations, lead hazard control, and environmental cleaning.

Clinical samples (blood, urine and nasal washing) were collected from children and the primary caregiver living in the home. These samples were analyzed for a variety of allergens. Environmental dust samples were analyzed for dust mite, cockroach, rodent urinary protein, endotoxin and fungi.

Moderately severe asthmatic children had a significant decrease in symptom score ( $p < 0.006$ ) and symptom days ( $p < 0.003$ ) following remediation while these parameters in parallel control children in homes not receiving the interventions did not significantly change. During the period from 6-months post-randomization to the end of the study, which was primarily post-remediation, asthmatics receiving home interventions had a lower rate of exacerbations compared to control asthmatics (1/29 vs. 11/33, respectively,  $p = .003$ ). Other children, not specifically enrolled because of asthma, had a significant decrease in nine out of 14 upper and lower respiratory symptoms following the home interventions.

**HOUSING TYPES AND CONDITIONS ENCOUNTERED**

- **Pre-WWII two-family homes:**
  - Large leaky basements and/or crawl spaces.
  - Ductwork runs through crawl spaces.
  - Forced air heating system with cold air return ducts that are not directly connected to the cold air return vent on the furnace (the “Cleveland drop”); large metal ducts run from the basement ceiling to within 6” of the basement floor: The furnace pulls its return air across the basement floor from these ducts, usually one for each floor in the residence. The problem is that the furnace sucks air through what can be very dirty, moldy basement spaces, bringing contaminants into the living spaces above
  - Foundations extend under porches: Many older Cleveland homes were built with a full foundation that extends under the front porch. Over time the tongue and groove flooring that was commonly used for porch decks would leak and water would enter the basement, often causing moldy conditions, particularly if vulnerable materials were stored there. Sometimes mold will grow on the underside of the flooring and the floor joists.
  - Old stone foundations with leaky basement walls and storage shelves and framing that absorbs this moisture and becomes a host for mold
- **Post-WWII bungalows with finished basements:**
  - Moisture entering foundation walls causes mold on basement finishing materials
  - Moldy floor coverings on basement floors
- **Post-WWII bungalows and ranch homes on slab:**
  - Leaking sub-slab heating ducts: Many small bungalows built in this area after World War II used slab-on-grade foundations and included downdraft forced air heating systems that included sub-slab ductwork. After about thirty years, this ductwork starts to develop leaks and

it is not uncommon to find an inch or two of water in these ducts when you lift a floor register. In the winter, the heat moving through this ductwork turns it into a humidification system and these poorly insulated structures soon have mold growing on walls and ceilings where they meet on an outside wall.

- **All housing types:**
  - No bath or kitchen ventilation.
  - Kitchen stoves used for heating.
  - Clothes dryers not vented to exterior.
  - Leaking toilet, tub and sink waste lines.
  - In this region most communities, by code, require all downspouts to enter a sub-grade storm drain system which carries the water to the city storm water system. As houses age, this storm drain system (usually old clay piping) begins to deteriorate from roots that get into it or salt weathering of the pipe itself and water begins to spill around the foundation walls. In addition, as the population in the area increased, there was more and more storm water being forced to travel through city storm systems that could not handle it any more. It is therefore, not uncommon for water to be leaking through the foundation walls from leaking or backed up storm drains.

## MOLD AND MOISTURE CONTROL INTERVENTIONS

<b>General Strategy -</b>
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| <ul style="list-style-type: none"> <li>○ Remove moisture damaged material.</li> <li>○ Remove mold exposure pathways.</li> <li>○ Clean mold from hard surfaces.</li> <li>○ Stop rain water intrusion.</li> <li>○ Exhaust water vapor.</li> <li>○ Repair plumbing leaks.</li> </ul> |
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<b>Key specifications developed –</b>
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| <ul style="list-style-type: none"> <li>○ Duct cold air return directly to the furnace (repair the “Cleveland drop”).</li> <li>○ Flash the soil to the house.</li> <li>○ Treat the porch like a roof.</li> <li>○ Eliminate sub-slab duct and heating systems.</li> <li>○ Disconnect and redirect downspouts.</li> <li>○ Reduce moisture in crawlspaces.</li> </ul> |
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- **Duct cold air return directly to the furnace (repair the “Cleveland drop”):**  
If the forced air heating system had cold air return ducts that were not directly connected to the cold air return vent on the furnace (the “Cleveland drop”), this was corrected. However, sometimes, when the Cleveland Drop is corrected, contractors use the space between floor joists to carry the air toward the furnace. This is called “panning” the joists, affixing sheet metal across two joists to create an enclosed air space. There are two problems with doing this 1) the joist cavity itself can be very dirty, even moldy and 2) if there is excess moisture in the house, it can be pulled into the joist cavity where it can contribute to mold growth. Similar practices should be discouraged in any forced-air furnace installations.
- **Flash the soil to the house:** Bill Rose, a research architect, at the University of Illinois, has coined the term “flashing the soil to the house” for a low cost system he developed that greatly reduces surface water from entering foundations of residential structures (see *Fine Homebuilding Magazine*, Aug-Sept, 1998 issue, “Ideas for Wet Basements”). The method involves excavating a trench along a foundation wall that is permitting water to enter from the

exterior. The trench should be about 12-16" deep and 2-3' wide and sloped away from the foundation. EPDM, a rubber roofing material, is placed against the foundation wall and along the trench. It is then fastened to the side of building using a metal strip that is secured to the mortar joints of the wall with Tapcon screws.

- **Treat a porch floor like a roof:** First, an underlayment material was installed (much like roof sheathing), then felt paper was installed (again, like on a roof surface), then new flooring would be installed over it. It is quite expensive. Because of our limited funds, for this project we installed two layers of 6 mil plastic on the old flooring surface and sealed it around its perimeter. We then installed indoor/ outdoor carpet over the plastic surface. The result is a sealed surface that will not permit water to enter the flooring and provides an attractive, low cost finish. Another benefit is sealing in the lead paint that is inevitably on old porch floors of this vintage. A possible downside, which needs to be tested, is whether using the indoor-outdoor carpeting creates a sink for lead dust that people track onto the porch from soils around the house and from the street. Is this a lead exposure hazard for children or does the carpet act as a lead dust trap?
- **Eliminate sub-slab ductwork and heating systems:** There is no remedy for this condition using the existing system. The solution we have found to be most effective includes sealing off the old ductwork and the space under the furnace with cement, installing an updraft furnace and installing new ductwork in soffits created along the center wall in the houses. This ends the moisture problem, thus the mold problem, and the only downside is slightly less comfortable floors because there is no longer any heat traveling through them. While no study has been done of energy savings to date, residents report lower heat bills because there is less heat lost to a cold sub-floor and they experience greater overall comfort in their living spaces.
- **Disconnect and redirect downspouts:** Some communities are now permitting downspout disconnection and this dramatically reduces water entry in many basements. However, it is critical that the downspout leads be placed at the bottom of each disconnected downspout and these leads should be at least 5' long to be sure water is carried away from the foundation of the host structure and any neighbor's foundation. We have also found that resloping gutters so they carry water in a direction that carries the water closer to the street before it drops can eliminate the need for much of the underground storm system.
- **Remove wood shelving in basements:** Removing this old wood material and replacing it with plastic shelving to keep paper, cardboard, clothing and other such materials off the damp floors and away from damp walls can significantly reduce mold growth in many of these homes.
- **Reduce moisture levels in crawlspaces:** There are literally hundreds of homes in Cleveland with crawlspaces that are usually just dirt floored and are vented deliberately and/or have plenty of air leakage that allegedly vents the moisture levels emerging from the soils. We have been learning that the best way to treat these crawlspaces is to first solve any moisture problems (standing water especially), then cover the soils with heavy plastic sheeting that is carried up along the foundation walls to at least above grade level on the exterior; then we insulate the perimeter walls, eliminate the vents into the crawlspace and open the crawlspace to the warm portion of the basement. Before this is done, all debris which is lying in the crawlspace is removed and this often includes all manner of cellulose products that have mold growing on them.

In this project, we were only able to install plastic sheeting after removing debris, which reduces the moisture entry into the space. Here is a potential interface between healthy housing and weatherization work. An additional health problem that we could not address with this program is rat control where rats come into the houses by burrowing under the

foundation walls and into the crawlspaces. When funds are available, it is common practice to install what we refer to as a “rat slab” of concrete about 2” thick to reduce this problem. The concrete is poured on top of the plastic to reduce moisture wicking through the concrete and into the crawlspace.

**Follow-up Observations of Mold & Moisture Work**

Follow-up visits were conducted in a total of 43 houses to assess the moisture and mold treatments. All the houses had work completed by the project at least 12 months prior to the follow-up visit. In the 43 houses visited, a total of 347 mold and moisture specifications were rated according to the following categories:

Specification Rating	Number of specs	Percent of specs
Ok	285	82%
Not done	8	2%
Poor work	12	3%
Material failure	7	2%
Did not follow spec	8	2%
Wrong treatment	4	1%
Defeated by occupant behavior	4	1%
Extreme event	0	0%
Other	19	5%

**Summary of follow-up observations:**

- Key specs generally performed well
- Some aspects of overall strategy not adequately conveyed to spec writers and contractors through training and spec language
- Moisture assessment and spec writing more complex than anticipated
- Occupant behavior generally supportive

**Intervention Costs**

Category	Mean	25%tile	Median	75%tile	Max
Lead	2,324	955	1,755	2,925	13,990
Moisture	1,481	665	1,415	1,950	6,260
Mold	1,667	925	1,500	2,120	5,671
Mold & Moisture	3,148	1,630	2,965	4,335	9,464
Other	114	-	-	80	2,460

- Cleveland drop repaired in 30% of houses; average cost \$553; maximum cost \$1600.
- Foundation flashing: average cost \$860.

- Treat the porch like a roof: average cost \$312.
- Eliminate sub-slab duct heating systems: average cost \$2,971.
- Disconnect downspout: average cost \$114; repitch gutters: average cost \$145
- Plastic sheeting in crawl space: average cost \$270; remove debris from crawlspace \$305.

## DISCUSSION

### **Did we create specifications that effectively addressed the mold/moisture problems in these homes?**

The key moisture control specifications developed for the project performed well. We did better on this front than we might have expected. Our specs anticipated almost every condition that we found in the field during this program and when deployed appropriately accomplished the task they were created to address.

### **Did we effectively transfer our concerns to the spec writers and contractors doing this work so that they appropriately applied the specifications and their labor?**

The overall moisture assessment and control strategy developed for the project was not always adequately communicated to the specification writers and contractors through the training and spec language. Moisture assessment and control is a complicated process that requires better training, more oversight, and clearer, more detailed specification language.

In four instances (treatments not houses) the wrong treatments were specified and in eight instances the contractor did not follow the specs properly. However, there were a number of issues that emerged during our follow-up visits to sites that point to our either assuming too much experience for both spec writers and contractors and not providing enough training or detail in the specs:

- When eliminating the Cleveland Drop cold air returns and tying the cold air returns directly to the furnaces, several of the contractors used the basement floor joists covered with sheet metal to carry air from the interior of the house to the furnace (“panning the joists”), which can result in sucking the allergens in these cavities into the furnace and up into the living space.
- Our soil grading and “soil flashing” specs should have called for overfill because in most cases the soils settled too much over a few months and have left a depression rather than a sloping soil grade away from the foundations which could be self-defeating.
- Gutter and downspout work was often not done with a clear thought about where water would flow and the consequences. This work was so consistently off target, that those of us responsible for the specs and training must take some responsibility. Here was a clear case where we assumed too much on the part of the spec writers and contractors. We did not devote enough time to training for this task which proved to be an invaluable one for reducing basement water moisture.
- Several homes had mold in bathrooms that was quite extensive and a bath fan should have been included in the scope-of-work and installed. In several cases this was not done and some mold is reoccurring in these bathrooms.
- In one house, we missed a crawlspace hidden by stuff in the basement. Ductwork traveled through this area to living spaces. There was material in the crawlspace that could have been moldy.
- In one house, a wet floor by a bathtub was replaced, but the moisture source (a leaky shower door) was not corrected and the damage is recurring.

It is important to understand that writing the scope-of-work for moisture reduction is much more difficult than for lead, for example. If it is not raining when a site is visited and specs are written, it is difficult sometimes to know just what would provide the best moisture reduction strategy. The best moisture control work is done over a period of time using a series of simple tests to try to determine where the moisture sources and pathways are found. In programs with limited time and money, it is

difficult, if not impossible, to come back to a site several times to get a clearer reading on conditions that would lead to more effective spec choices.

The good news is that our decision to have contractors with lead abatement training and licenses do the cleanup work was a very good one. In almost every case, the cleanup work was done effectively and thoroughly.

**What was the overall quality of work done in these homes?**

Contractors generally performed well, but there were some lapses in quality of work and in fully carrying out the intent of the specs. Of all 347 treatments reviewed, 285 (82%) were rated “OK.” Twenty-eight treatments (7%) were rated as “poor work,” “not done,” or “did not follow spec.” On some jobs there were annoying omissions that should not have occurred. Examples:

- For homes with sub-slab ductwork that leaked over time requiring the abandonment of the old heating system and the sub-slab ductwork, the specs called for filling the register openings in the concrete floors with cement. In some cases this was not done, so the essential moisture problem was solved, but the musty odor of the ductwork was still getting into the living space.
- Sub-flooring in kitchens and baths where flooring materials were replaced were sometimes not nailed effectively so it feels like you are walking on bubbles and it will decrease the effective life of the subfloor and finish flooring.

**Did the residents learn new behaviors that help them reduce moisture problems spaces?**

Some residents reported and demonstrated behavior changes that improve moisture and mold control, but some resident behaviors defeat the repairs made by the project. People reported a number of asthma trigger control actions:

- using ventilated basement shelving the project provided;
- using mattress and pillow covers provided and washing bedding frequently;
- getting rid of a pet;
- doing special cleaning;
- discontinuing use of household products with strong odors.

Some recommendations from the asthma trigger control education were not followed. Three people reported using rodent poisoning, whereas snap traps were recommended. And several people reported cleaning mold with bleach, despite the fact that the education session suggestions that the use of a biocide was not necessary.

In four houses we found significant new mold growth, apparently because of resident behavior:

- newspaper on a basement floor where a puppy was being kept developed severe mold;
- cardboard boxes sitting on the damp basement floor and mold growing on them, right in front of the shelving we had installed to keep such boxes off the floor;
- mold on cardboard covering sections of a basement floor;
- mold recurred in a bathroom and the occupant reported not using the exhaust fan.

In some cases people were so energized by the project, that they took steps to increase the value of the work done. For example, where we had disconnected downspouts, one homeowner buried the horizontal extensions. A great idea and it works well.

DRAFT 1/4/05

Further Observations on Implementation of Moisture Reduction Interventions  
– Jim LaRue

1. Cold Air Returns:

- a. Use ducts and not panned joists for returns whenever possible.
- b. Where panned joists are “necessary evil,” be sure they are sealed.
- c. Make sure cold air return grilles in rooms are isolated and sealed from the exterior walls; otherwise cold air is pulled into the furnace from exterior walls.
- d. Create heat run in basement near furnace for makeup air for furnace combustion; do not leave an open cold air return or create a new grille in the floor of the living space to provide make up air, so basement pollutants are not delivered into the living space when exhaust fans in house are being used.

2. Gutters and Downspouts:

- a. As much as 85% of serious water issues in older homes comes from clogged and broken storm drains that are very old and sometimes completely deteriorated. Disconnecting downspouts can significantly reduce basement moisture problems.
- b. It is critical that disconnected downspouts have their water drain away from the perimeter of the foundation so water will flow away from the house and not toward it.
- c. When gutters run from the rear to the front of the house, disconnect the rear downspout and seal the gutter hole; repitch the entire gutter from the rear to the front. If there is evidence of water penetration in the front of the basement, disconnect these downspouts and run them to driveway or down front lawn.
- d. When gutters have pulled free from ice backup or other damage, do not resecure them with gutter nails or screws. Use gutter brackets that are screwed to the fascia board and the gutter is then clamped into them.
- e. If the fascia board is severely damaged, install new fascia board (pressure-treated wood) after priming and painting it before installation. If rafter ends are rotted, splice a piece of pressure treated framing material to side of the joist that is same dimension as the rafter.
- f. Where gutters do not run to the front, but are contributing to moisture in the basement, make sure the disconnected downspouts do not direct water so it pools in the backyard. If necessary, use a section of corrugated drain tile to carry the water to a place where it can be safely distributed.
- g. Make sure all gutter seams are properly sealed.

3. Tub caulking:

Many of the tubs we see in homes have moisture leaking around the upper rim of the tub and along the floor, because caulking has failed or never was there. In many of these tubs, there is sufficient movement when one gets into and out of the tub, that the caulk is quickly compromised. Also, many of the caulks grow mold or at least hold dirt that permits mold to grow on it.

Before using caulk to seal around the tub edges, test to see if there is movement of the tub; if there is movement do, not use caulk, but instead use a “plastic sealer strip” that bends in the middle so half of it is on the tub and half on the wall. It has a peel away strip on the back to expose the adhesive. Apply this after carefully cleaning and drying the tub and wall surface. You can use it along the tub/floor edge as well. This product is less likely to grow mold and it is easier to clean.