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Essential Knowledge of the Indoor Environment for Decision Makers: A Benchmark and a Nascent Database

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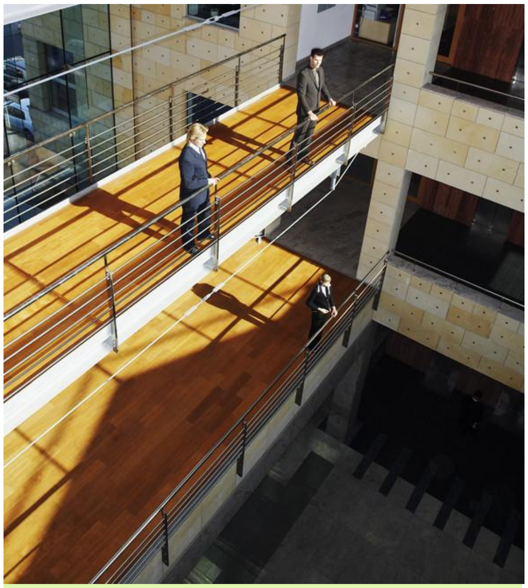
Project Summary



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Goal and Purpose

The goal of this project was to determine the essential knowledge of the microbial ecology of indoor environments (IE) as defined by experts, and to begin to compile a database of the agencies and organizations that are responsible for funding, regulatory, and policy decisions related to IE.

This study provides baseline data that can be used to (1) direct subsequent social scientific study of IE research in the public sphere, and (2) inform and improve the strategic communication of IE research to external audiences including decision-makers and the general public.

Objectives

Reaching this goal required meeting two objectives: (1) establishing a benchmark for essential IE knowledge that IE experts/scientists think decision-makers need, and (2) creating a nascent database of the agencies and organizations that potentially could use this knowledge in future regulatory, policy, and funding decisions.

As we moved through the project, a third objective surfaced: (3) to provide a snapshot of the scientists who are currently studying IE microbiology and related areas, and the challenges they face as they communicate their research.

Deliverables

The project deliverables include:

(1) A database of the 79 IE experts who were interviewed to establish the essential knowledge benchmark,

(2) The interview instrument used to create that benchmark (which can be used to build future assessments),

(3) The actual benchmark for IE knowledge (the raw data, the coding protocol, and the resulting essential knowledge),

(4) An initial database of agencies and organizations believed by these scientists to be most likely to help shape policy or funding related to IE,

(5) Training in IE microbiology research for two communication Ph.D. students and three undergraduate research assistants,

(6) Publication and outreach.

Highlights

- Interviewed U.S. researchers in academia, government, defense and private industry.
- Specializations: microbiology, biochemistry, environmental health science, toxicology, occupational safety and health, pathology, epidemiology, environmental engineering, and medicine.
- Asked to consider information needs of two audiences (lay and decision-makers), the scientists' responses were clustered in four themes: **agents, measures, outcomes, and building structures**.
- Topics they find difficult to explain to lay audiences ranged from acronyms to vector-borne diseases. Most frequently mentioned were **mold, bacteria, and exposure**.
- **Mold, bacteria and exposure** were also the top responses when scientists were asked to list topics that lay audiences ask about most.
- When asked to point out what decision-makers need to know, the focus turned to **impacts and regulations**, including health impacts, building design codes, and the need for regulations and more integrated research programs.
- The most common barriers to understanding for decision makers included: **lack of awareness** of indoor environmental problems, **scientific uncertainty** and difficulty of proving facts and correlations, other financial **prioritie**s, and lack of money and resources for research.
- The most common reasons given for decision-makers not funding IE research were **budget and financial limitations**, and **other political priorities**.
- When asked what agencies likely housed important decision-makers, interviewees mentioned the **EPA, CDC, and NIH, along with more than 70 other local, state, federal and private entities**.
- **Majority see themselves as information sources** for laypeople, especially regarding health concerns. This runs counter to assumptions that scientists do not engage the public about their work.
- **Majority indicated they are known for making their research understandable**, citing their engagement in numerous public communication activities, including talking to journalists, giving lectures, teaching, writing papers, and conversing directly with the public.
- Majority **attributed communication success to their skills and communication failures to audience incapacity**.
- The results suggest 1) **themes that need to be better communicated** and 2) that IE scientists are **willing communicators** who, if better trained in communication, may be able to actively help improve the profile of this nascent research area.

Methods

Our first two goals were to build a database of IE experts and establish an initial list of important terms as indicated in the research literature.

The first step was to comb the research literature. PI Kahlor, along with the funded Ph.D. student (Ming-Ching Liang) and an undergraduate research assistant (Christina Leal) conducted a content analysis of the published research on IE microbiology.[1]

The sample of articles analyzed consisted of articles located through searches of the databases EBSCO Academic Search Complete, ISI Web of Science, Ovid Geobase, Ei Compendex and CSA ASFA, and Oceanic Abstract. The search term, "indoor environment and microbiology," was entered for the searches. The results were further filtered by U.S. affiliated authors and publication year ranging between 2000 and 2010.

This process yielded a final sample of 92 research articles. Authors, affiliations, article title, abstract, and journal of publication were recorded. This database yielded our list of potential interviewees and a searchable database for concepts.

The next step was to analyze the titles and abstracts of relevant IE academic publications to locate the most frequently used words and concepts. This was performed with NVivo software, a widely used tool for implementing content analytic studies (Bell & Bryman, 2007). The content analysis produced a list of the most frequently used terms in the sampled articles. The top 10 results are reported in Table 1 below (see page 9).

Together, these two steps allowed us to reach our initial goals. In the process, we were able to (1) ensure that our team was familiar with IE research and the most frequently published research terms before conducting the interviews, (2) compile a list of key words that surfaced in the literature so that we could later validate the list of concepts and terms that surfaced in the expert interviews, and (3) create a database of 300 researchers publishing in the scientific journals relevant to this project who then became our potential interviewees.

The list of concepts that surfaced in the literature also allowed us to map some key concepts. A team of three researchers (the PI, and students Liang and Moore) met to sort the concepts generated by NVivo into conceptual themes and subthemes. The team met as a group and reviewed each concept on the list.

Concepts were sorted into thematic groups as similarities were noted among them. Sub-thematic groups were created as needed to capture concepts as the team moved through the list. Once the entire list had been sorted, the team reviewed the themes and subthemes that had emerged and revisited which ones could be collapsed, which were superfluous, etc. The team then discussed the overall face validity of the final list of themes and subthemes.

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[1] *A content analysis is a scientific method to quantitatively identify the characteristics of messages (Riffe et al., 2005; Neuendorf, 2002).*

The resulting schematic is depicted in Appendix F. The primary purpose of this schematic was to create a conceptual map that would allow us to triangulate with the interview data once that had been separately analyzed. That is, concepts arising from the interviews were also sorted with this conceptual schematic to judge the consonance between the themes in the literature and the interviews.

The next goal in the project was to conduct interviews with IE researchers. The purpose of the interviews was to identify key concepts in IE research, identify challenges to the communication of IE research, and begin compiling a nascent database of decision-makers whom experts identify as relevant to the future of IE microbiology, particularly as a fundable research field.

We first needed to locate valid contact information for the 300 researchers included in our database. This process took longer than expected, as many of the researchers had moved to other research institutions or entered the private sector since authoring the articles included in our database. Initially, we visited the websites of the researchers' institutions at the date of publication. When affiliations were no longer valid, we conducted Internet searches using the Google search engine and other search tools, made phone calls, and inquired with other researchers. Ultimately, contact information was located for the majority of the database (287 of the original 300 researchers identified). It was during this stage that a second Ph.D. student, Niveen Abi Ghannam, joined the research team.

Next, we practiced our IRB-approved interview protocol. This testing led us to shorten and edit the interview script for clarity. We then contacted via email all the researchers in our database and conducted phone interviews with the first researchers to reply. These initial interviews ranged from 20 to 40 minutes in length.

After completing the first several interviews, we reviewed our protocol again. These interviews were successful, so we conducted the interviews of the remaining researchers in our database who had responded to our email invite and follow-up emails. It should be noted that emails were bounced back to us (undeliverable) for 48 individuals, which reduced our eligible respondents to 239.

All interviews were conducted over the phone and were recorded with the interviewees' permission. This enabled us to generate a printed transcript of each interview for analysis.

Our original proposal to Sloan promised interviews with 40 experts, but our database yielded 79 viable interviews (which was a response rate of about 33% of the 239 we contacted). Ultimately, this response rate doubled the time required to conduct the interviews and analyze the data, but provided a much richer dataset.[2] The

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[2] *We do not know what percentage of our population of interest was sampled, or how representative our interviews are of the population as a whole. However, we actively snowball sampled, which simply means we asked the interviewees to give us the names of anyone else they thought we should interview. In this process, many of our existing names were validated, but we also gained additional interviewees as well. To add further validation to our*

interviews, which were conducted in Spring and Summer of 2011, were conducted by our two Ph.D. students and an additional undergraduate researcher, Mercer Moore. The average interview length was 25 minutes. Appendix B features a list of experts that we interviewed, along with their contact information as of late 2011.

The completed interview recordings were transcribed into Microsoft Word documents. These transcripts were then entered into the NVivo software for descriptive and conceptual analyses. The summary results of these analyses are included in the next section. It was at this point that Anthony Dudo, Ph.D., an expert in the public communication of science, joined the project to help guide the analysis and interpretation of the results.

The interview transcripts allowed us to address the remaining goals, which were to (1) build a benchmark of essential IE knowledge, (2) create a nascent database of the agencies and organizations that scientists think house decision-makers whose work impacts IE research, and (3) provide a snapshot of the scientists who are currently studying IE microbiology and related areas, and

An excerpt from a transcript

Interviewer: *So are there any specific important words or terms you use when describing your research to non-experts?*

Respondent: *Gosh, I think that I usually have to try and describe what climate change means. A lot of people think of global warming as sort of the only kinds of things that are going on… and they don't understand the actual meaning of what climate change implies. So I often have to use that term and then really fully define it and describe what it actually means to the lay person. And some terms that I use… instead of 'infectious agent' I might say something like for 'bugs' or 'the thing that makes you sick'…things that are not technical terminology. So those would be things that I would use for a lay person that I wouldn't use for some of the scientists.*

Interviewer: *So are there any [terms] that you are surprised that people don't understand, terms you think are basic.*

Respondent: *I would say things like pathogen which I would expect people would know. I guess now my expectations have changed. When I first was starting my course in epidemiology I thought people should understand what that means because epidemic is pretty common in peoples mind; they know what an epidemic is. So I thought 'oh well don't make that link' but they don't [know it] and so I guess my perceptions have changed and what I used to think people should understand is different than what I now have come to realize people understand. But I certainly was surprised…*

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sample, we conferred with a UT scientist, Rich Corsi, who helped organize Indoor Air 2010, an international conference held every two years and focused on indoor environmental research. This year the conference featured a panel on IE microbiology, which gave Corsi a sense of this population and could validate names and offer the names of a few additional experts. Finally, we conferred with Alfred P. Sloan Foundation Program Director Paula Olsiewski, who also had a sense of the "top names" in IE microbiology. She reported that the database was comprehensive.

the challenges they face as they communicate their research.

In addressing the first two goals, we used content analysis software to examine the research articles that we had located in the early stages of the research, and then we used that initial content analysis to guide computer-coded and human-coded content analysis of the interview transcripts. This is to say that our research assistants read the transcripts to look for themes, but we enhanced this subjective reading with content analysis software that offered a quantitative assessment of the most frequent research terms.

To address the last goal, our research assistants employed qualitative research methods to locate and build a theoretical framework from the data that could offer a snapshot of what these researchers study and the communication challenges they face.

The theoretical framework that initially surfaced from multiple reads of the data was "attribution theory." Attribution theory is a social psychological theory intended to explain patterns in how people attribute causes for events in their lives. The theory suggests that people tend to attribute positive outcomes to their own efforts and negative outcomes to external forces (Heider, 1944).

With this theory in mind, we conducted hierarchical template analyses (Coffey & Atkinson, 1996) to identify patterns embedded in the scientists' responses to one specific interview question: "Do you find it difficult to explain your research to non-experts? Why?" That is, we read the responses using attribution theory as a template for locating patterns within the data.

The flexibility of this approach allowed the team to explore additional insights and adjust the analysis while examining the patterns (King, Cassell, & Symon, 2004).

The themes included success or failure in communicating, reasons invoked for the success or failure, and whether those reasons were attributed to internal or external factors. Internal factors included practice, skill, good choice of words, and other positive qualities of the self. External factors included the public's inability to understand the topic, the public's lack of interest in the topic, the science itself being difficult to explain, and other external qualities that were framed as hindering communication success.

Results

The IE Research Articles

The search of the literature produced a database of 92 articles. This database is available on request. Using software, we content analyzed the text in the titles and abstracts from all of those articles to locate the most common research terms. This allowed us to become familiar with the scope of the research before the interviews. Table 1 reports the top 10 research terms or concepts that surfaced in that database of articles.

This search of the literature also allowed us to comb the larger list of concepts generated to produce a conceptual map of IE microbiology. That framework is offered in Appendix F. The major themes we identified were: agents (including microorganisms), measurement (e.g., detection), carriers (e.g., aerosol), outcomes (e.g., health, efficiency), external factors (e.g., cultural, climate), and built structures. Those themes captured the majority of the concepts we encountered in our review of the literature.

Table 1: Frequently Used Concepts in Publications Reviewed

Rank	Title (Frequency)	Abstract (Frequency)
1	Air (14)	Air (124)
2	Fungal, Fungi (14)	Fungal, Fungi (113)
3	Buildings (14)	Buildings (104)
4	Airborne (13)	Samples (91)
5	Detection (9)	Concentrations (71)
6	Bacteria (8)	Exposure (70)
7	Mold (8)	Mold (60)
8	Dust (6)	Dust (55)
9	Chartarum (5)	Health (55)
10	Damage (5)	Methods (51)

Major themes identified in the literature were agents, measurement, carriers, outcomes, external factors, and built structures.

The IE Researchers

The final sample of interviewees (*N*=79) consists of academic researchers[3] (n=56), government and US army researchers (n=13), and private industry researchers (n=10). The interviewees' specializations included microbiology, biochemistry, environmental health science, toxicology, occupational safety and health, pathology, epidemiology, environmental engineering, and medicine. The majority of the interviewees were males (71%).

The Interview Prompts

Each interview was guided with a script (see Appendix A) containing the same list of open-ended questions. The interviewee responses varied in length, but all questions were answered. Below we highlight and summarize answers to all interview questions.

Are you known for making your research understandable to non-experts?

The majority of researchers indicated that they are known for making their research understandable to non-experts (n=54, 68%). The remainder indicated they were either not known for making their research understandable or they did not know whether they were known for this. Government and army researchers were more likely than academic and private researchers to consider themselves as able to make their research understandable to non-experts (92% of those researchers).

When the researchers were asked how they knew whether they are known for making their research understandable, they referred to their engagement in numerous public communication activities, including talking to journalists, giving lectures in universities, teaching, writing journal papers, and communicating directly with the public through conversations.

Is it difficult to explain your research to non-experts?

Overall, only about 30 percent of the sample indicated that they have difficulty explaining their research to non-experts (n=24). This was about a quarter of academic researchers, a quarter of government and army researchers, and over half of the private researchers.

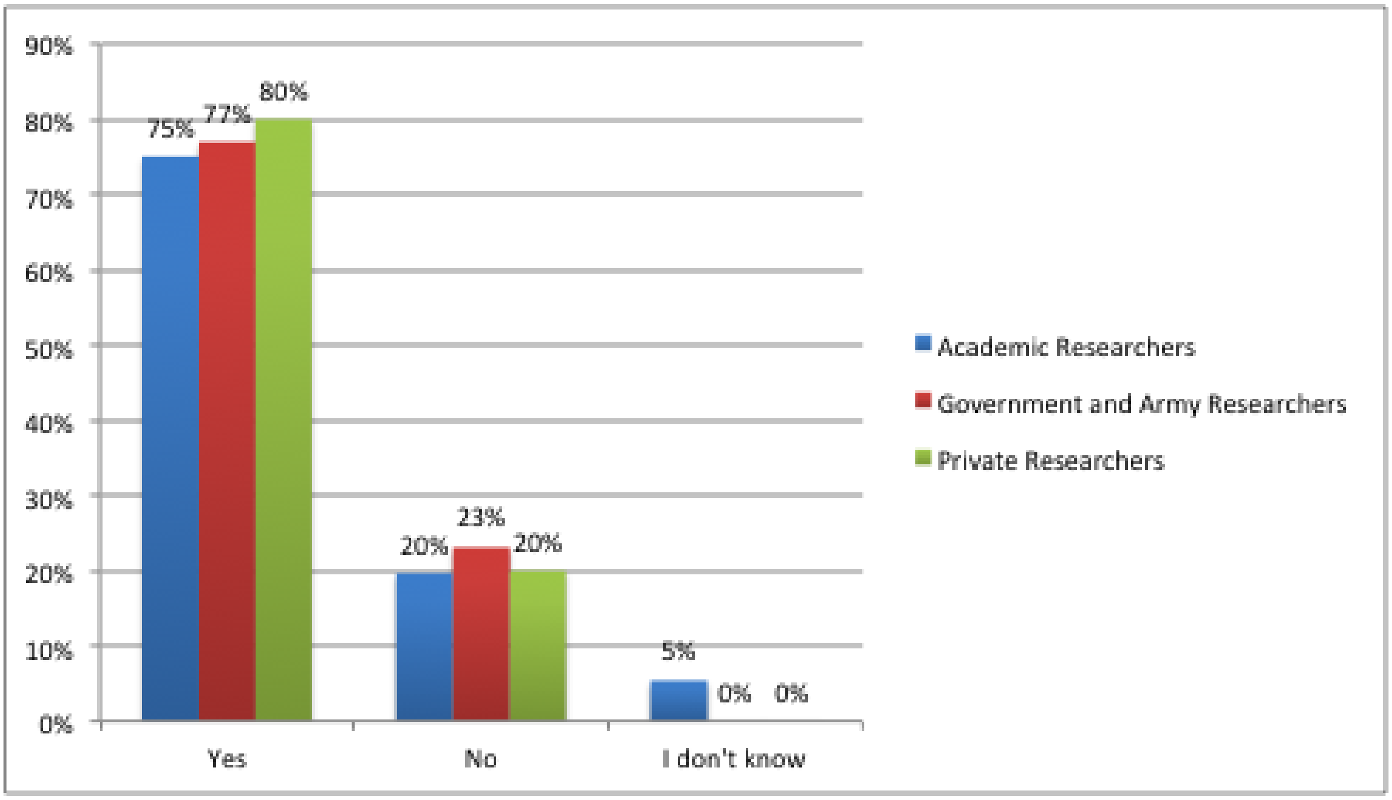
About three fourths of the sample categorized themselves as IE information sources for laypeople.

[3] *Including two practicing medical doctors who are affiliated with universities and teach and publish academic research related to indoor environmental health.*

Are you an information source for laypeople when it comes to IE?

About three fourths of the sample (n=60, 76%) categorized themselves as information sources for laypeople about IE issues. That is, they indicated that the public contacts them with inquiries about indoor environment issues. Specifically, 75 percent of academic researchers, 77percent of government and army researchers and 80 percent of private researchers said they consider themselves information sources (see Figure 1).

Figure 1: Information Source for Non-Experts (N=79)



Defining one's research to non-experts

Interviewees were asked to describe their research as they would to non-experts. As was the case above, the responses were recorded, transcribed and uploaded into a database for NVivo-aided data analysis.

This portion of the analysis involved more than quantification (which drove the above sections of the report) – it also involved a member of the research team who read all of the responses and made subjective categorization decisions about the most frequently used terms and words generated by the NVivo software. That is, NVivo was able to generate a comprehensive list of the most frequently used words, but the researcher needed to decide which ones were relevant to the scope of this project and to confirm that the use of any given term within the text was in relation to IE research.

For instance, one respondent said: "I do research in mold allergies." The concepts identified in this response are: mold and allergy. All of the interviewee's responses to this question were coded in this way. NVivo was then able to rerun word counts consistent with this coding standardization and categorization.

The resulting data indicated that the most frequently used words invoked when describing their research were bacteria, microbes, and biological agents; and buildings, such that 32 out of the 79 interviewed researchers indicated that they use those terms in describing their research to non-researchers. Other concepts that were frequently invoked were: health, indoor air pollutants and their transport, human exposure, indoor air quality, and mold (Table 2).

Table 2: Describing Own Research to Non-Experts	**Frequency**
Bacteria, Microbes and Biological Agents	32
Buildings (schools, offices, homes)	32
Health	27
Indoor Air Pollutants and their transport	17
Human Exposure	16
Indoor Air Quality	15
Mold	15
Allergies and Asthma	11
Fungi	11
Infectious Diseases	9
Moisture, Water and Humidity	8
Airborne Particles	6
Chemicals	6
Prevention	5
Children	4
DNA Studies	3
Energy Issues	3

Engineering and Technology	3
Environmental Changes	3
Food	3
Insects	3
Viruses	2
Aerosols	1
Planetary Protection	1

Important terms used to explain own research to non-experts

Researchers were also asked to identify terms and concepts that really matter when they describe their research to non-experts. The same methods used in the previous question were used to extract the concepts mentioned by researchers. In this case, the most frequently used words were 'Bacteria, Microbes, and Biological agents," such that 24 out of the 79 have mentioned them. Other concepts that were highly used as well were: health, indoor air quality, mold, human exposure, allergies and asthma, buildings, indoor air pollutants and their transport, fungi and infectious diseases (Table 3).

Table 3: Important Words and Terms for Own Research	Frequency
Bacteria, Microbes, Biological Agents, and Benefits of Bacteria	26
Health	19
Indoor Air Quality	12
Mold	11
Human Exposure	10
Allergies and Asthma	8
Buildings	8
Indoor Air Pollutants and their Transport	8

Infectious Diseases, Epidemiology	8
Fungi	7
Aerosols	5
Chemicals	5
DNA Studies	5
Moisture, Water and Humidity	4
Airborne Particles	3
Children	3
Engineering and Technology	3
Food	3
Viruses	3
Comfort	2
Dust	2
Insects	2
Occupational Safety and Health	2
Prevention	2
Climate Change, Environmental Change	2
Amputation	1
Bio-containment	1
Bio-terrorism	1
Bootstrapping and Simulation	1
Energy Issues	1
Interdependency	1

Invisible	1
Planetary protection	1
Purification	1
Toxicology	1
Ventilation	1

Research terms that non-experts do not understand

Researchers were also asked about the terms that they think (based on their personal experiences) lay people have a hard time understanding. Using the same methodology described above, those terms were extracted from the interview responses. Twenty-two out of the 79 interviewed researchers indicated that nothing specific came to mind. Among those who did offer terms, 16 researchers indicated that people do not know the definition of mold, and 14 researchers indicated that people do not know the definition of bacteria and micro-organisms. Other terms that researchers mentioned included: exposure, health issues, epidemiological terms, ventilation effects on air quality, DNA studies, definition of fungi and moisture, as well as the uncertainty in scientific research (Table 4).

The concepts most likely to perplex lay audiences were mold, bacteria and micro-organisms.

Table 4: Terms that Non-Experts Do Not Understand	Frequency
Mold Definition	16
Bacteria/ Micro-organism Definition, Activity, Heterogeneity	14
Exposure	9
Health Issues	7
Scientific Uncertainty, Probability, Math, Risk	7

Epidemiological Terms	6
Air conditioner-ventilation Effects on Air Quality	5
DNA	5
Fungi Definition	5
Moisture Definition	5
Chemical Components	4
Infections	4
Research Methodology	4
Indoor Airborne Particles, Air Pollution, Source Pollutants	4
Exaggeration, Overreacting	3
Heat Transfer	3
Indoor Environment Quality	3
Myco-toxins	3
Virus Definition	3
Allergens, Allergies, Asthma	3
Evolution, Biodiversity	3
Aerosols Definition	2
Climate Change Definition	2
Correlation and Causal Relationship	2
Data Distribution	2
Everything	2
Importance of Research in the Field	2
Transmission of Pollutants	2

Building Designs	2
Acronyms	1
Engineering	1
Measurement of Carbon Dioxide	1
Pathogens	1
Radiation	1
Radon Exposure	1
Spores	1
Vector-borne Diseases	1

What non-experts ask about research and IE more generally

Researchers were also asked to identify frequently asked questions from non-experts. The same methods were used to extract concepts and issues (Table 5). The most frequent inquiries involved human health effects of indoor environments (N=24). Other frequent topics of inquiries were: mold-related issues, the actions needed to be taken by people for better indoor environments, contaminant sources and controls, air quality problems, exposure, probability and risk, safety of the indoor environment, the effects of research done on people, and toxicity.

Table 5: What Non-Experts Ask About Research and IE	Frequency
Health Effects	24
Mold (types, effects...)	17
Needed Action	12
Contaminants Sources and Controls	11
Air Quality Problems	8
Exposure	8
Probability and Risk	8
Safety of their Indoor Environment	8

Effects of the Research on People	7
Toxicity	7
Fungi	6
How to Measure what's in the Environment	6
Prevention	6
Research Process, Methods and Techniques	6
Workplace Environment	6
Asthma and Allergies	5
Microbes	5
I don't get approached by Lay People	4
Types of Air Purifiers and Respirators	4
Building Problems	2
Chemicals	2
Food Exposures	2
Insects and Animals	2
Moisture Effects	2
School Problems	2
Airborne Infectious Agents	1
Biological Attacks	1
Drinking Water Safety	1
Energy Efficiency	1
Government Role	1
Lead Contamination	1
Odor Complaints	1
Sick Building Syndrome	1
Sustainable Building Design	1

The Hygiene Hypothesis	1
Transmission of Bacteria	1
Virus	1

What decision makers need to understand about IE

Researchers were asked what aspects of the indoor environment decision makers need to understand. Using the same methods, those responses were analyzed. Table 6 shows the issues and concepts that researchers listed. The most important concepts or issues were: exposures and multi-exposures, indoor environment's effect on health, that contaminants are different in different places, building design codes, importance of indoor environment, and the need for indoor environment regulations.

Table 6: What Decision Makers Need to Understand	Frequency
Exposures, Multi-exposures	23
Indoor Environment Effect on Health	20
Contaminants are Different in Different Places	8
Building Design Codes, Material Selection	8
Importance of Indoor Environment, Need to Study	8
Need for Indoor Environment Regulations	7
Majority of Time is Spent Indoors, Indoor More polluted than Outdoor	6
Complexity of the Issue	5
Expenses to Improve Building Conditions are Good Investment	5
Importance of Ventilation	5
Riskiness of Indoor Environment	5
Uncertainty in Indoor Environment Research	5
It's Difficult to Have Standards	4

Indoor Environment Quality and Energy Efficiency should not be Contradictory	3
Litigation Issues, Legal Issues Prevent Research	3
Transmission of Contaminant, Viruses and Bacteria, Disease	3
Don't Know	2
Listen to all Scientists	2
Case studies are Important to Explain Science to Lay People	1
Cleanliness from Particles Versus Cleanliness of Microorganisms	1
Effect of Microbes on Infrastructure Decay	1
Effect on the Military	1
Effects on Productivity of Workers	1
Fungi can be Pathogens	1
Hazards are Controllable	1
Impact of Thermal Control	1
Microbes are Everywhere	1
Mold isn't the Biggest Problem in Indoor Environments	1
Most Microbial Exposures are Indoors	1
Outdoor Environment affects the Indoor One	1
Susceptibility	1
The Artificiality of Today's Indoor Environment	1
The Interaction Between Humans and Microbes Indoor	1
They Need to do More	1
Water Damage Leads to Trouble in Indoor Environments	1

What stands in the way of decision makers understanding IE research?

Table 7 shows the reasons offered as to why decision makers do not understand the indoor environment. The most common reasons named are insufficient education on issues, lack of awareness of problems in the indoor environment, scientific uncertainty and the difficulty of proving facts and correlations in indoor research, other financial priorities, lack of money and resources for research, lack of regulations, and that other issues take priority.

Table 7: Barriers to Decision-Makers Understanding IE	Frequency
Insufficient Education on the Issues and their Importance	14
Unawareness of the Problems	12
Hard to Prove Facts and Correlations and Scientific Uncertainty	10
Financial Priorities Prevent Engagement with Issue	9
Lack of Money and Resources for Research	9
Lack of Regulations	8
Other Priorities	7
Complexity of Applying Policies Indoors	6
Biased Media or Lack of Coverage by the Media	5
Lack of Time	5
Misinformation	5
New and Inaccessible Field of Research	5
Lack of Interest	4
Politics	4
Disconnect Between Scientists and Politicians	3
Complexity of Indoor Environment	2
Don't Know	2
Lack of Regulating Agency	2

Apathy by the Public	1
Insufficient Coverage in the Literature	1
Lack of a Holistic View	1
Lack of Champions Pushing this Agenda	1
Power of Insurance Companies	1

Barriers to decision makers allocating more resources to IE research

Table 7 lists the barriers that were identified when the researchers were asked what prevents the allocation of more resources to indoor environment research. The most common reasons are budget and financial limitations, other political priorities or interests, lack of understanding of the problem, scientific uncertainty and no established correlations, and lack of regulations

Table 8: Barriers to Funding Indoor Environment Research	Frequency
Other Political Priorities or Interests	21
Budget and Financial Limitations	18
Do Not Understand the Problem or Importance	11
Scientific Uncertainty and No Established Correlations	8
There are No Regulations	6
Fear of Invasion of Personal Space by Trying to Apply Policy Indoors	4
Policy Focused on Short Term Effects Not on Long Term Financial Benefit through Cutting Down Medical Costs	4
Only Few Agencies are Interested in Funding Such Research	3
There is No Regulating Agency	3
Think People are Exaggerating the Problem/ Not a Threatening Issue	3

Disconnect Between Science and Politics	2
Don't Know	2
There are No Barriers	2
Attempting to Add More Regulations	1
Confusion of Reliable Science with Advocacy Opinions	1
Insurance Industry Doesn't Want to Pay for Damaged Buildings	1
Lack of Cooperation Between Concerned Agencies	1
Small Research Community	1
Think Research is Already Done	1

"Three more" concepts the public and decision-makers need to understand

The above questions focused on the researchers' initial responses to our inquiries about (1) their communication with non-experts and (2) the understanding of IE among non-experts and decision-makers. After acquiring their initial impressions, we followed up with questions that asked them to provide "three more" concepts that they really want the public and decision-makers to understand.

Complete lists of these concepts are listed in Appendices C and D. Some concepts were related to scientific and technical definitions, while others were concerned with research methods, detection and outcomes. Because we explicitly asked each researcher to list three concepts, the lists generated are longer that those depicted in Tables 3 and 5 above. However, there is notable overlap among the concepts these researchers found most important (as reported above) and the more extensive list of concepts reported here.

In considering the information needs of the public, some of the most frequently named concepts included the ubiquity of microbes and that they can be "good," the ubiquity and diversity of mold and fungi, that ventilation is important in indoor environments, principles of exposure including amounts and paths, disease and pathogen transmission, and health effects of indoor environments.

The most frequently named concepts for decision-makers were health effects of indoor environments, efficiency and green buildings, infections disease and transmission, importance of data collaboration and integration, issues in workplace environments, and relative risk and risk assessment.

There was more agreement on the important concepts for the public than on the important concepts for decision-makers. For example, the top 10 most frequently mentioned concepts for the non-experts accounted for 46% of the concepts coded, whereas the top 10 concepts for decision-makers accounted for 30% of the concepts coded.

One interpretation is that any discussion of decision-makers is likely to invoke concern not just about what they need to understand, but what they need to prioritize and fund. For example, when it came to decision-makers, the topic of public education and development of an integrated research infrastructure came up repeatedly; these issues did not really surface on the list of concepts that matter for public understanding.

Although Appendices C and D list these concepts in their entirety, we also offer a summary in Figure 3 of how the concepts sorted out in relation to the typology developed in our review of the IE microbiology literature (that typology is listed in Appendix F).

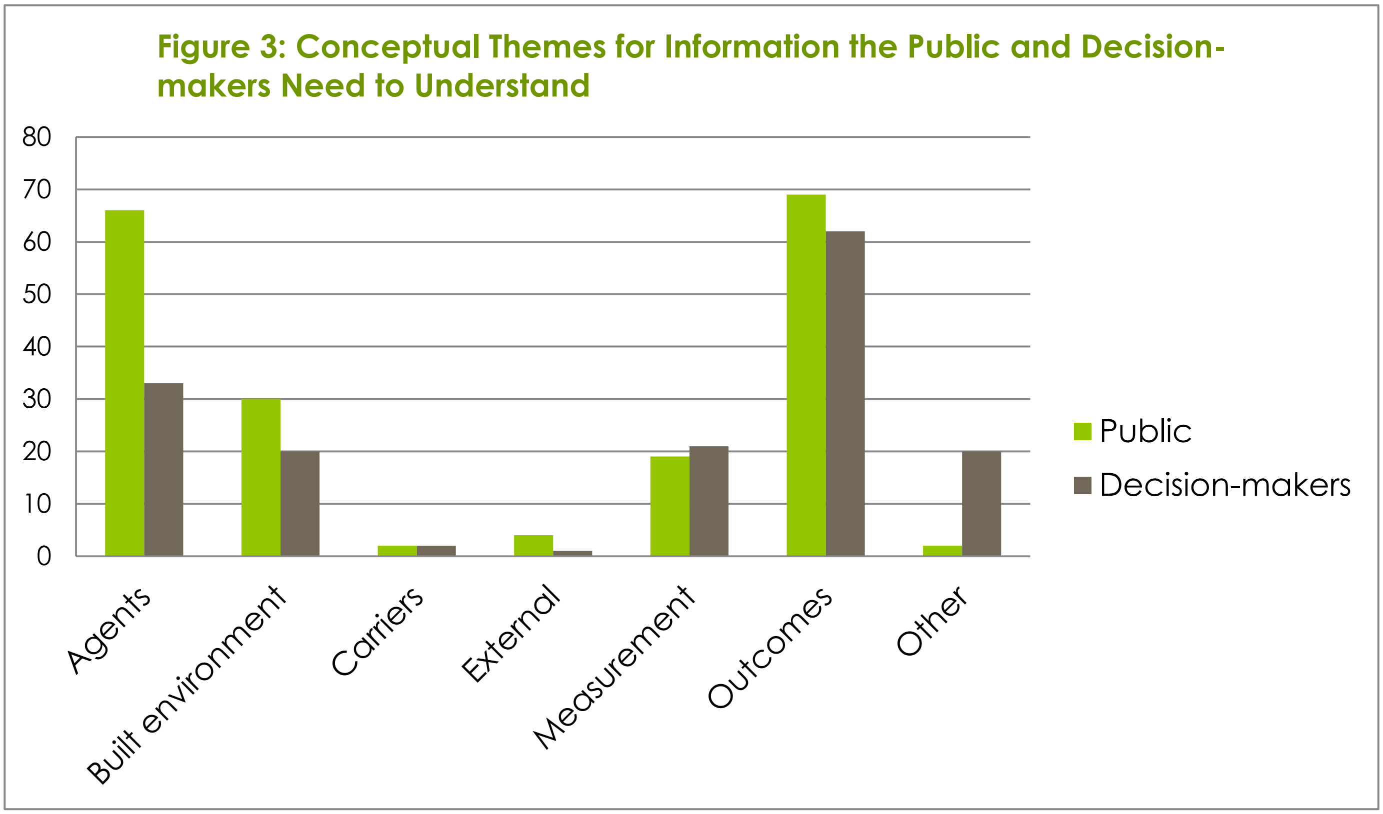
The typology/schematic is also described above. In sum, it was the list of concepts that surfaced most frequently in the literature which we then sorted into themes and sub-themes. Our hope was to see if those themes/subthemes resonated in both the literature and the interviews. We applied the typology only to these more extensive lists.

Any discussion of decision-makers is likely to invoke concern not just about what they need to understand, but what they need to prioritize and fund.

Our results suggest that the themes and subthemes serve to effectively capture both the literature and the interview data. Looking at the results below in Figure 3, we see that the interview data maps onto the themes well, and that this mapping allows us to compare overall themes that surfaced in the questions about what the public and decision-makers need to know. These priorities, as depicted by the number of mentions, do show a pattern across the two audiences. For example, agents were mentioned much more often than carriers for both audiences and outcomes and agents were the two most frequently invoked themes for both audiences.

Agents included references to micro-organisms such as fungi, virus, bacteria, and protozoan, and chemicals such as mycrocyclics, metals and pollution.

Outcomes included mentions of health/diseases, material degradation, efficiency, and ecological impact.



Decision-makers that need to be targeted

Our original intention was to cull the names of actual individuals who should be reached with future communication. However, our interviewees had trouble recalling individual names. So, we instead asked for more general information related to the agencies that should be the target of future communication. Those results are listed in Appendix E. The most frequently mentioned agencies were the Environmental Protection Agency, the Centers for Disease Control and the National Institutes of Health. However, the list extended far beyond those obvious choices; more than 70 local, state, federal, nonprofit, for-profit and professional entities were mentioned.

Discussion

In some respects our findings seem intuitive. For example, the most frequently mentioned agencies where we might find key decision makers were the EPA, the CDC and the NIH. However, additional insight can be garnered from the agencies and organizations that made their way onto the list less frequently: the U.S. Army Corps of Engineers, commissioners of health, the U.S. Department of Homeland Security, the Bill and Melinda Gates Foundation, farmers, the transportation business, and the list goes on. The varied expertise of our scientists offers a comprehensive snapshot of who to target with future communication beyond what could be constructed by a small team of advisors.

Likewise, when we asked about topics they find difficult to explain to lay audiences, the responses were comprehensive and varied, ranging from acronyms to vector-borne diseases. However the most frequently mentioned responses included mold, bacteria, and what counts as "exposure." Interestingly, these were also among the top responses when the scientists were asked to list topics that lay audiences ask about most frequently. This suggests that the same topics that are perceived as important knowledge deficits are also the same topics that laypeople are trying to learn more about. This is promising for any plans to educate the general public, but also shows the challenges that such efforts will need to overcome.

Future research will require an interdisciplinary team to capture public knowledge and sentiment (one piece of the political climate), generate compelling evidence for why the current lack of support for IE research is problematic, and identify the most pressing decisions that decision-makers currently face so that IE research can be framed to help address those needs.

When asked to point out what decision-makers need to know, the focus turned more to impacts and regulations, versus specific scientific concepts. Among the topics that were mentioned were health impacts, building design codes, and the need for regulations.

As we look to the future to design effective communication that fills the needs of these two audiences, laypeople and decision-makers, it is important to understand if there are commonalities in the type of information that they need. According to our scientists, there are commonalities. When the scientists considered these audiences, their responses were clustered in four themes for both: agents, measures, outcomes, and building structures. This suggests that (1) future research into the needs of these audiences (i.e., a survey of the general public, interviews with decision-makers) is needed to see if the scientists' perceptions are accurate and (2) future communication with lay audiences and decision makers will likely need to contain some similarities, which will also enhance the positive effects of repetitive message exposure for both audiences.

The Role of Scientists as Communicators

Our third objective for this project was to provide a snapshot of our scientists as science communicators.

To clarify, scientific communication is the "use of appropriate skills, media, activities and dialogue to produce one or more of the following personal responses to science: awareness, enjoyment, interest, opinion-forming and understanding" (Burns et al., 2003).

Interestingly, it is the same topics that are perceived as important knowledge deficits that laypeople are trying to learn more about.

Additionally, science communications has become more crucial at the policy making level as there has been increased emphasis among decision makers, interest groups, and the public on the importance of more science-based environmental policy making at local, regional, national, and international levels. This is based on the belief that scientific objectivity is needed to inform policymakers and the public (Steel, et al, 2004). And informing policymakers and decision-makers is one of the driving purposes of this Sloan project.

Revisiting our findings, the majority of our indoor environmental scientists regarded themselves as frequent and facile communicators. Whether or not this is an accurate perception, more than three-quarters of the sample regarded themselves as information sources about indoor environmental issues for non-technical audiences. More than two-thirds of the sample believed that they are known for making their research understandable, and find it easy to explain their research.

But there is a flip-side to this perception. Prior research suggests that scientists consistently express concerns about how their profession and work are more often than not viewed inaccurately and negatively. This suggests a propensity among scientists to allocate blame for miscommunication on the audience rather than the communicator. Indeed, scientists have low expectations about the public's knowledge of scientific findings and their ability to understand them, as well as the role of the media in reporting science (Hartz & Chappell, 1997; Kohut et al., 2009). Our research findings were consistent with this.

Supplementary analysis of our data using qualitative methods guided by attribution theory suggest that our scientists attributed difficulties in communication to the public, but attributed lack of difficulties in communication to their own skill. That is, success was due to their skill, while failure was due to a lack of skill in their audience. This is problematic of course, as communication is a two-way street, with both communicators and audiences bringing important backgrounds to the exchange.

This again suggests the need for additional research that clarifies public understanding of these issues (including factors that impact their understanding beyond pure factual knowledge – such as tolerance of uncertainty, risk tolerance thresholds, protected values, etc.), so that we can begin to develop outreach materials that can help scientists to achieve more successful communication outcomes.

Communication success was attributed to their skill, while failure was attributed to a lack of skill in their audience.

It also suggests the need for scientists to receive outreach that educates them about effective communication and the role that human decision-making and perceptions play in message receptivity, and information seeking and processing. Because the majority of our scientists were currently working in academia where they deliver lectures in a formal educational setting to tuition-paying students, we assert that the challenges of communicating with lay audiences is more akin to *informal* education and communication. Informal education is much more focused on what the audience brings to the situation – such as attitudes and priorities – in addition to knowledge or lack of knowledge.

That the large majority of IE scientists reported having contact with public audiences with questions about indoor environmental microbiology runs counter to anecdotal presumptions that scientists do not engage the public about their work. Instead, this research complements recent empirical research showing that scientists have relatively frequent contact with non-scientific audiences (Dunwoody, Brossard & Dudo, 2009; Jensen, Rouquier, Kreimer, & Croissant, 2008; Pearson, Pringle, & Thomas, 1997; Peters, et al., 2008).

All this suggests that IE scientists are willing communicators who, if better trained in communication, may be able to further Sloan's agenda to reach decision-makers with the importance of this nascent research area.

This agenda is an important one. Research that traces factors that move issues onto the agendas of policy makers suggests that such movement occurs when the problem is appropriately defined, when compelling decision alternatives are generated, and when the political climate favors the change (Kingdon, 2011).

Thus, a research plan is needed that generates compelling evidence for why the current lack of support for IE research is problematic, captures public knowledge and sentiment (one piece of the political climate), and identifies the most pressing decisions that decision-makers currently face (so that IE research can be framed to help address those needs). This report lays the foundation for this work.

PUBLICATION AND OUTREACH

The following section details our team's outreach activities and plans for future activities.

- In June of 2011, our graduate research assistant, Ming-Ching Liang, presented our initial paper:

  Liang, M. & Kahlor, L. "Essential Knowledge of Indoor Microbial Ecology." Presented at the International Society of Indoor Air Quality's International Conference, Indoor Air 2011, Austin, June 2011.

- In August 2011, we hosted a dinner at the Association for Education in Journalism and Mass Communication (AEJMC) for select members of the Communicating Science, Health, Environment and Risk Division. This is the biggest meeting for mass communication scholars studying science communication. The focus of the dinner was to get young mass communication scholars directly interested in indoor environmental research while they are building their research agendas. Many of them did not know the research existed, yet they understood its importance immediately when they heard about it. Several indicated an interest in collaboration in the near future, including researchers at Nanyang Technological University in Singapore.

  In attendance:

  LeeAnn Kahlor, University of Texas at Austin

  Ming-Ching Liang, University of Texas at Austin

  John Besley, Michigan State University

  Michael Dahlstrom, Iowa State University

  Amanda Hinnant, University of Missouri

  Elliott Hillback, University of Wisconsin

  Chris Clarke, George Mason University

  Shirley Ho, Nanyang Technological University, Singapore

  Janet Yang, State University of NY - Buffalo

  Lee Ahern, Penn State University

  Sol Hart, American University

  Sonny Rosenthal, Nanyang Technological University, Singapore (graduate of Rich Corsi's IGERT program on indoor air)

- On March 21, 2012, we met for 1.5 hours with Mark Fischetti, Environmental & Energy Editor of Scientific American magazine. Fischetti is a frequent broadcaster and has appeared on CNN, NBC's Meet the Press, the History Channel, and NPR News. He discussed with us strategies for making IE microbiology a more compelling topic for coverage in Scientific American, as well as other channels we should target with communication outreach. We will send him a copy of this report.

Among the more compelling advice he gave us was to identify people who link the public to this topic. E.g., homeowners/buyers learn about radon through home inspectors and contractors, and asthma sufferers learn about airborne particles from doctors, other healthcare providers, and OSHA (on the job). He suggests that we reach out to these local contacts (contractors, healthcare, etc.) and that we pitch stories to the media that feature this triangle – the public, the "local practitioner," and the science. And he advised that we should offer something readers can act on.

This advice is consistent with the research on fear appeals, which suggests that people will tune messages out if they elicit fear, but don't offer actions one can take to alleviate the threat (Rogers, 1975). Some relevant action has to be there for the popular and political interest to blossom.

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List of Appendices

Appendix A: The Interview Script

AT THE START OF EACH RECORDING, PLEASE SAY THE DATE AND THE NAMES OF THE INTERVIEWER AND THE INTERVIEWEE. DO THIS BEFORE YOU CALL. THEN TURN OFF THE RECORDER UNTIL THEY GIVE PERMISSION TO BE TAPED.

Please keep a journal of your interviews. Note when interviews take place, with whom, how long they lasted, whether they agreed to answer additional emails, and whether they want a final copy of the study.

Introduction

Hello! Thank you very much for agreeing to participate in our study of Indoor Environment knowledge.

To recap, my name is [insert name here]. I am a student at the University of Texas at Austin and I am studying public understanding of science and science communication.

Recently, my advisor, LeeAnn Kahlor, received funding from the Alfred P. Sloan Foundation for a study titled, "Essential Knowledge of the Indoor Environment for Decision Makers: A Benchmark and a Nascent Database."

The study involves interviews with experts like you.

In these interviews, we are asking you to think of concepts and research terms that – if better understood by government decision makers – might lead to an improved appreciation for your research.

So, several weeks ago, we sent you a copy of this study's IRB consent form. Did you receive it?

Can we proceed with an interview?

Do I have your permission to record the interview so I can revisit it and take better notes later?

TURN ON RECORDER AT THIS POINT.

Ok, let's get started.

Let me make sure I have you name spelled correctly. Your last name is -----------, correct? Ok.

Interview Questions

Let's start with your research.

When you describe your research to others – **to non-researchers** – what do you say?

[probe: what are they key concepts or relationships in your research?]

[If description seems inaccessible to a lay audience, ask: And how would you explain your research to a middle school student?]

Do certain words or terms really matter when describing your research to non-experts?

Are there any basic research terms or concepts that people just don't seem to understand?

Do you find it difficult to explain your research to non-experts?

[probe: why?]

Are you known for your ability to make your research understandable to non-experts?

[probe: how do you know?]

When non-experts ask you questions about your research or about IE more generally, what do they typically want to know?

Ok, now I'd like you to name three concepts you would really like people to understand (when it comes to your research).

Do you see yourself as an information source (a 'go-to' person) for laypeople when it comes to IE?

[probe: why do you say that?]

Ok. We're about halfway done.

As I mentioned earlier, the Sloan Foundation wants to build a better understanding of IE among government decision makers. What types of decision makers do you think Sloan should target?

[probes: in what agencies, any specific offices? Names?]

Above anything else, what do decision makers need to understand about IE?

What currently stands in the way of their understanding?

What barriers keep them from allocating more resources to IE research?

Can you name three more concepts related to your research program that you would like decision makers to understand?

Ok, we are almost done. Just a couple more questions.

Is there any other information that you would like us to consider as we build a body of terms and concepts for decision makers?

Finally, could you name for us two other researchers who you think we should interview to make sure we have spoken with the most active researchers in IE?

Great. Thank you so much.

Just to recap, previously, you agreed to be contacted after this interview in case we have questions or need some clarification. Can we still follow up with you?

By the end of the project, we hope to have a list of the top terms and concepts that could be the target of an information campaign aimed at decision makers in funding agencies. Would you like us to share that final report with you?

Thank you so much for your time. Unless you have any questions or concerns, this concludes our interview.

Appendix B: List of IE Experts Interviewed

Available on request pending permission from those interviewed.

Appendix C: Concepts the Public Needs to Understand

Concepts	Frequency
Microbes can be good, are everywhere, dominant life form, many unknown	15
Mold and fungi are everywhere, diverse, exposure not all bad	15
Ventilation, circulation are important	10
Exposure pathways, exposure levels	9
Transmission of pathogens among people	8
Effects of indoor environment on health	7
Asthma and allergies are affected by indoor air quality	7
Transmission of pollutants from outdoors to indoors, indoor vs. Outdoor air	7
Multi-exposures in indoor environments	5
Bacteria are everywhere	5
Particles, particulate, filtering from air	4
Risk assessment	4
Sources of indoor pollution	4
Importance of indoor renovations	3
People with immunity problems need to mitigate the risk from indoor microbiology	3
Quantifying exposure is very difficult	3
Spending the majority of the time indoors	3
Effects of exposure on children	2
Chemicals used in building products	2
Dose-response	2
Intervention and prevention	2
Knowing how to prevent unwanted exposures	2

The importance of hand washing	2
Minimize the use of antibiotics	2
Differences between bacteria and viruses	2
Analysis methods	1
Assessing mold visibly versus doing quantitative assessment of air quality	1
Bio aerosols	1
Biological diversity is important	1
Biological evolution	**1**
Built environment cannot be sterilized	1
Chemical exposure	1
Chemicals migrate from consumer products into indoor air	1
Clean room environment or indoor environment	1
Climate change doesn't lead to the same problems in different geographic locations	1
Comfort and feedback about building and energy	1
Controlling for indoor environment conditions (temperature, humidity,,,)	1
Direct microscopic examination of air is a better method than culturable sampling	1
DNA sequencing	1
Effects of animals and insects	1
Effects of crowded environments	1
Energy and indoor air quality	1
ERMI	1
Forward contamination	1
Health effects can have various causes	1
How to lead a healthy lifestyle	1

Hypothesis testing	1
Importance of source control	1
Improved efficiency	1
Indoor air quality is determined during the building process	1
Indoor air quality problems are symptomatic	1
Indoor air research is a multi-disciplinary study	1
Infections are not necessarily caused by one organism	1
Internet sites don't always have accurate information	1
Killing bacteria associated with an infection will lead to killing different other kinds of bacteria as well	1
Knowing the size of particles will inform about the type of air filter needed	1
Laboratory cultivation	1
Levels of fungal spores and particles affect human health	1
Many indoor environment problems are preventable	1
Measuring what's in the air is not always beneficial or meaningful	1
Methods to reduce aerosol exposure	1
Moisture content	1
Mycotoxins are not necessarily an issue except in extreme situations	1
Need for funding	1
Not everything is safe in lack of other evidence	1
Nothing is ever without risk in terms of exposure to environmental contaminants	1
People think air cleaners would purify everything	1
Pesticides have real health effects	1
Planetary protection	1

Proper maintenance	1
Regulatory approaches in the U.S. versus precautionary principles	1
Role of personal activities affecting indoor air quality	1
Schools should develop an indoor air quality management plan	1
Sick building syndrome	1
Sustainable business design is associated with human health	1
The box model of indoor environment	1
The environment selects for different kinds of communities	1
The onsets of climate change	1
There are many choices people have of what to bring indoors	1
There are more types of organisms present than what is found in a culture	1
There are ways and techniques to detect and control for bio-contaminants	1
There is a lot of correlation but no clear causation	1
There is a limited number of microbe-caused issues with indoor air	1
There's not always an identifiable environmental cause to their health systems	1
Unplanned air flows in buildings	1
Use energy to control the quality of the environment in buildings	1
Water damage affects building health	1
What is indoor environment	1
When it is appropriate and beneficial to clean surfaces after removal of mold growth	1
Total	192

Appendix D: Concepts Decision Makers Need to Understand

Concepts	Frequency
Health effects of indoor environments	8
Energy Efficiency, Green Building, Pros and Cons	8
Infectious disease and transmission	6
Importance of research/data collaboration, integration and exchange	5
Issues in workplace environments	4
Relative risk, risk assessment	4
IE research takes time, money, is important	3
Indoor environment is complex	3
Importance of overall building design	3
Economic impact of unhealthy indoor environments	3
Importance of microbes (good and bad)	3
Outbreak preparedness	2
Chemical exposures	2
Mold is omnipresent	2
Polymerase chain reaction analysis	2
Susceptible and vulnerable population	2
People spend most time indoors	2
Indoor air is more polluted than outdoor air	2
A systems-based approach is needed to understand how to control indoor air quality-engineers, architects, scientists, physicians	2
Better education of the general public	2
Air conditioning and heating are creating artificial indoor environments	1
Allergic diseases	1

Allergies cause people to be much more sensitive to certain levels of biological material in the air	1
Antibiotic resistance	1
Bacteria and fungi are toxins in home	1
Bioinformatics	1
Building codes are health codes	**1**
Buildings are people	1
Characterizing contaminant exposure indoors is very limited	1
Concentrations to exposure are important	1
Decontaminations of hospital rooms	1
Difference between culturable and nonculturable organisms	1
Difference between particle pollution and gaseous pollution	1
Differences among infectious processes	1
Disinfectants and cleaners reduce and do not eliminate bacteria	1
Effect of indoor air is large on children	1
Exposures	1
Exposures and symptoms are not directly linked	1
Exposures for many pollutants are really dominated by time spent in the indoor environment	1
Filtration and cleaning devices	1
Fluidity between different types of media	1
Fungal toxins	1
Gases and pollutants that are invisible but harmful	1
General comfort	1
Genomics	1
Hospital acquired infections kill more than HIV and breast cancer combined	1

How can we control infectious agents	1
How can we test infectious agents in the air	1
Importance of a bottom-up approach	1
Importance of chemicals in consumer products and building material	1
Importance of molecular technologies and understanding microbial communities and environments	1
Importance of people's activities as they affect their exposure	1
Importance of thinking on the long term	1
Indoor outdoor relationships	1
Indoor particulates	1
Indoor protein exposure	1
Influence of multi-unit structures on indoor air quality	1
Mechanical analysis	**1**
Microbial communities are different in different places and seasons	1
Micro environmental modeling	1
Mold resistance	1
Multiple sources of pollution	1
Need for more resources to repair indoor environments such as schools	1
Need for training for those who analyze airborne exposures	1
Need for ventilation of space	1
Neurotoxic health	1
Neurotoxicity	1
Not everyone respond in the same way to pollutant exposure	1
Not scientific	1
Other technologies need to be considered to improve air quality	1

Particle size	1
Particulate matter indoors	1
People still use toxic products because of their marketing	1
Pollutant mixtures interact with other social and societal stressors	1
Positive flora microbiome	1
Prevention is better than cure	1
Problems can be resolved in the workplace	1
Protection of healthcare workers	1
Proteomics	1
Quality of construction in the U.S. is poor	1
Radon exposures	1
Relationship between acute technologies and energy use and operating costs of buildings	1
Relationship between indoor air quality and personnel in buildings	1
Research can work on improving indoor air quality	1
Researchers can't tell what the characteristics of the next pandemic or when will that happen	1
Response to poor indoor air quality is different to everybody	1
Sampling issues	**1**
Secondhand smoke	1
Source apportionment	1
Spores can cause respiratory problems	1
Survival of microorganisms in the environment	1
The concept of cultivation	1
The current fundability standards on the use of chemicals and consumer products in building	**1**

The false market system is so sophisticated to deal with the extra novelty of choices in the indoor environment	1
The interaction and complexity of biofilms	1
The need for a standardized way for testing indoor exposures	1
The need for quantitative measurement	1
The need for tests to detect airborne concentrations	1
The need to measure chemical and biological exposures	1
The peaks of exposure to airborne biological material are relevant	1
The use of ultraviolet light is not as effective as the proponents claim	1
There's a tendency in the society to be fascinated by technology	1
They have a role to play in funding and making available fundamental information about how people are exposed to biological contaminants	1
Understanding the climate and its impact on the design in a building is essential	1
Understanding the sources of pollution	1
Valuing avoided consequences for the health of the population and the buildings	1
Ventilation of buildings with clean outdoor air is an important aspect of healthy buildings	1
We can't control every single problem	1
When fungi grow in buildings, the produce micro toxins which are poisonous	1
When to use an exhaust while cooking	1
Workers productivity can improve energy efficiency	1
Total	159

Appendix E: List of Agencies with Relevant Decision Makers

Agencies	Frequency
EPA	46
CDC	26
NIH	20
HUD	10
Department of Energy	9
OSHA	8
Congress	7
Homeland Security	6
NIEHS	6
NIOSH	6
NSF	6
Federal Agencies	5
State Regulators	5
Department of Defense	4
Health and Human Services	4
Local Health Departments Decision Makers	4
Not Sure	3
Physicians	3
State Health Departments	3
City and County Health Departments	2
Department of Agriculture	2
Elected Officials	2
General Services Administration	2
Hospital Association	2
IAQ	2

Legislators	2
Military	2
NASA Institute of Environmental Health	2
National Institute for Allergy and Infectious	2
Schools	2
Sloan Foundation	**2**
ACAC	1
AASTHO	1
Building Codes	1
California Energy Commission	1
California Health Department	1
Combined Agencies Efforts	1
Commissioners of Health	1
Community Decision Makers	1
Corps of Engineers	1
Curators for Information	1
Deans	1
Defense Agencies	1
Department of Health	1
Department of Housing	1
Department of Transportation	1
DHS	1
DLE	1
Environmental Agencies	1
Farmers	1
Federal Environment and Protection Agency	1
Funding Agencies	1

Gates Foundation	1
General Office of Accounting	1
Global Health Departments	1
GSA Government Service	1
Healthcare Facilities	1
Healthcare Professionals	1
Healthy Home Initiative	1
Human Services	1
Industry People	1
Institute for Inspection and Cleaning	1
Insurance Industry	1
International Society for Indoor Air Quality	1
ACO	1
Law Schools	**1**
Local Building Inspectors	1
Medical Officers of Health	1
National Center for Environmental Health	1
National Planning Committee	1
NIAQ	1
Not Applicable for my Research	1
Not EPA and other environmental agencies	1
People in the Business of Transportation	1
Politicians	1
Professional Societies	1
Public Health Officials	1
Radon National Safety Board	1
SIEMA	1

Technical Librarians	1
The American Conference of Governmental	1
The American Lung Association	1
The Healthy Home	1
The Military	1
The Mycotics	1
Trade Associations	1
University Environmental Health Programs	1
WHO	1

Appendix F: Concept Mapping of Concepts from IE Research Articles

Figure F1: First layer of concept map

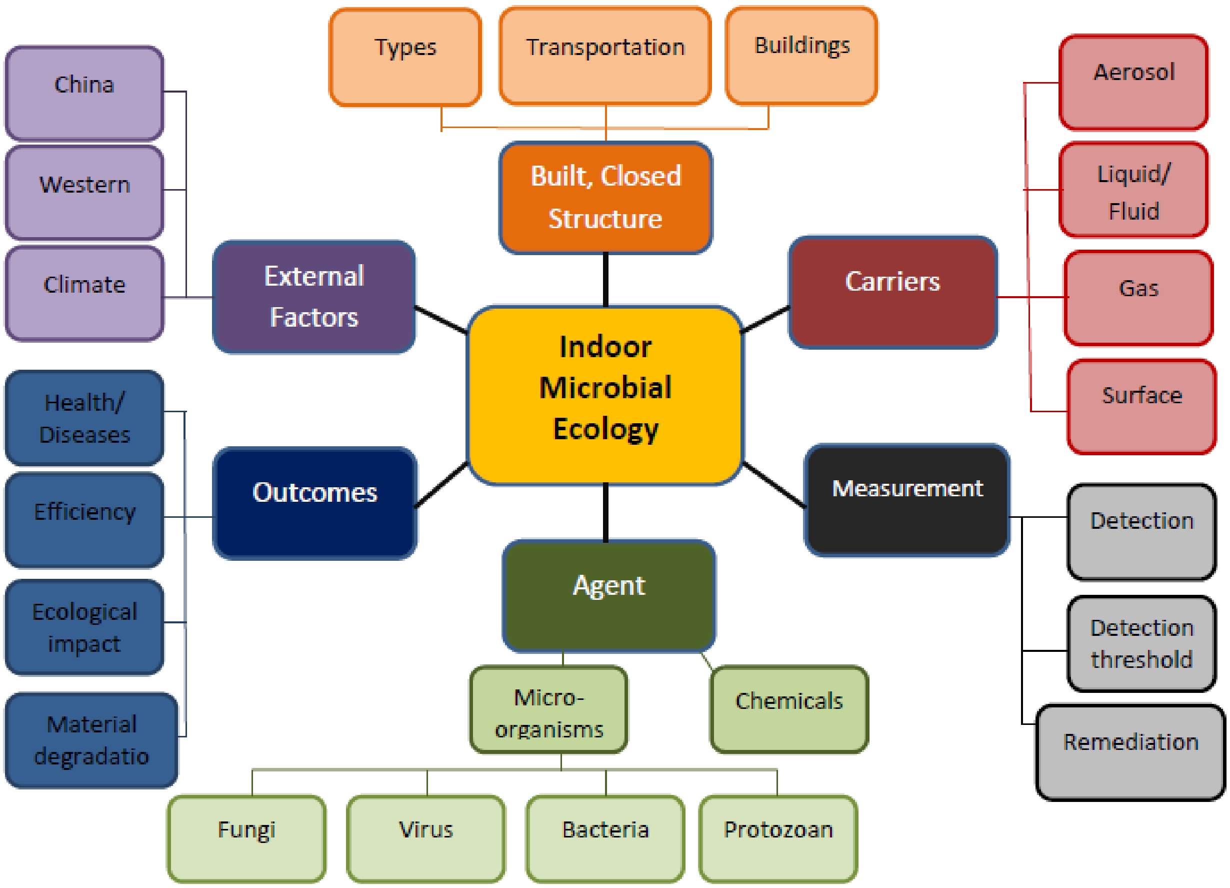

Figure F2: Built, Closed Structure in detail

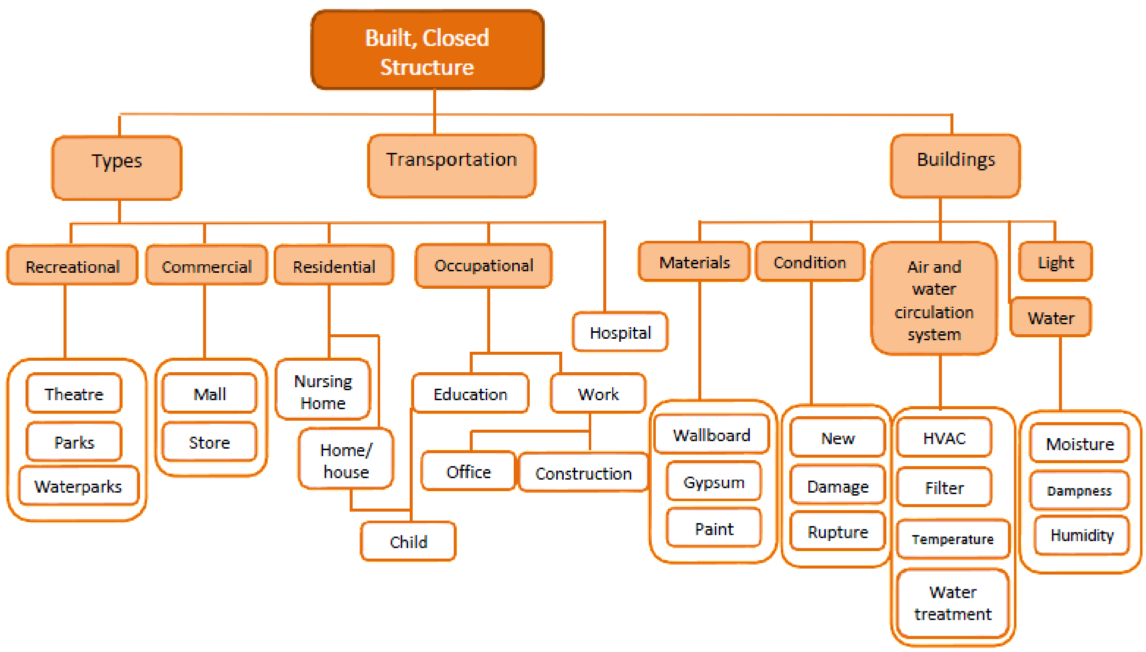

Figure F3: Measurement in detail

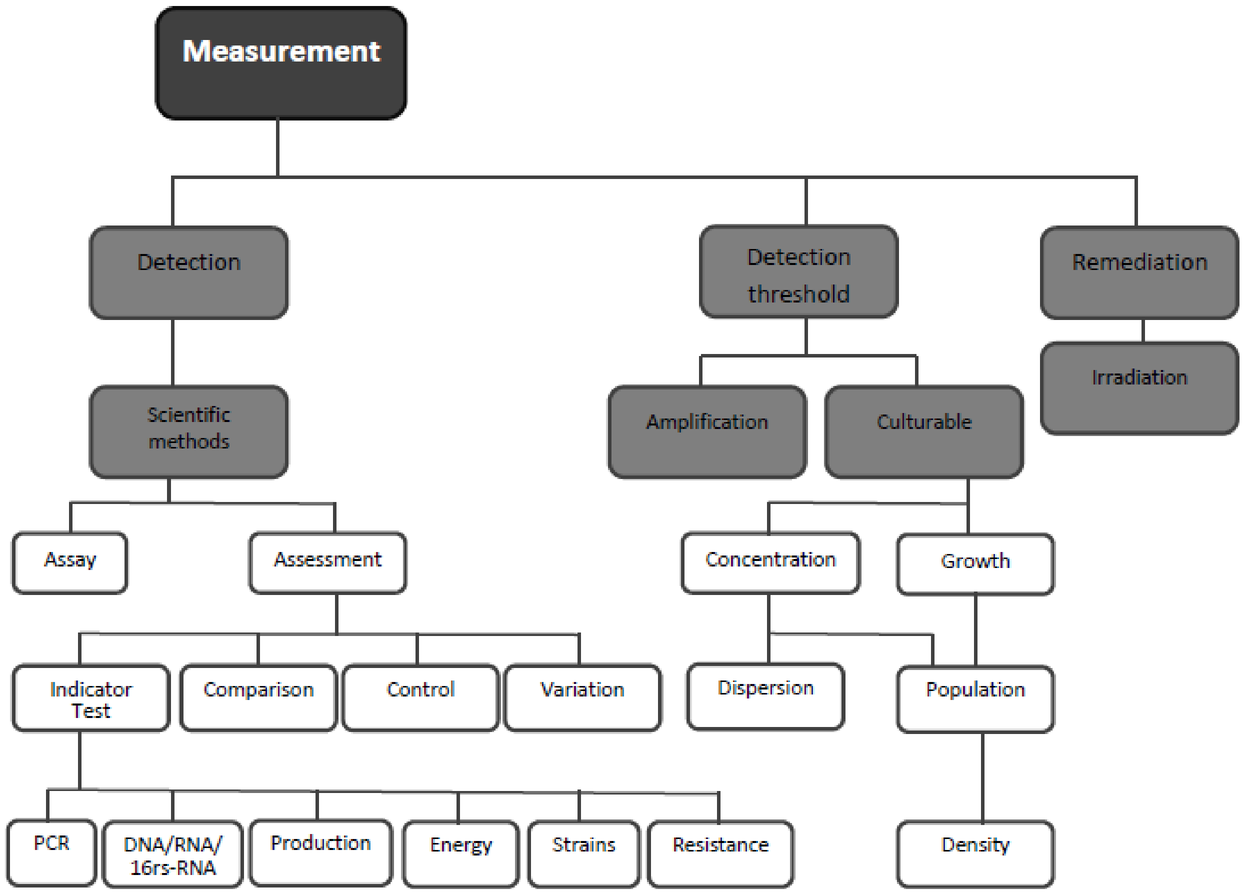

Figure F4: Outcome and Carriers in detail

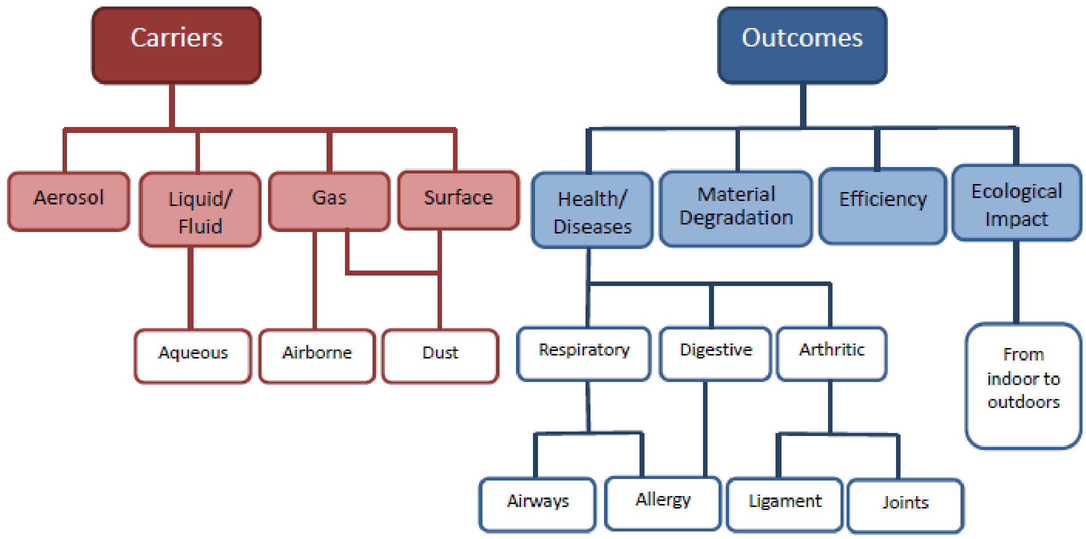

Figure F5: Agent in detail