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Science AMA Series: We're members of the authoring committee of the report, Microbiomes of the Built Environment: A Research Agenda for Indoor Microbiology, Human Health, and Buildings. AMA!

BUILTMICROBIOME R/SCIENCE

Research on indoor environments has been conducted for decades, but new molecular tools and collaborative efforts are generating a deeper understanding of the complex interactions among human occupants, built environments, and associated microbial communities. Let us introduce ourselves – we're:
Diane Gold, Professor of Medicine at Harvard Medical School, Professor in the Department of Environmental Health at the Harvard T. H. Chan School of Public Health, and Associate Physician at Brigham and Women's Hospital
Vivian Loftness, University Professor, Paul Mellon Professor, and Andrew Mellon Professor in the School of Architecture at Carnegie Mellon University;
Jordan Peccia, Thomas E. Golden, Jr. Professor of Chemical & Environmental Engineering at Yale University
Today we'll be discussing the current state of this knowledge, examples of knowledge gaps and challenges, and areas where a research agenda is needed so that indoor interactions can be better predicated and managed. Learn more about the report at http://nas-sites.org/builtmicrobiome/.
We'll be back at 1 pm ET to answer your questions, AMA!

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Are there any good studies of the effectiveness of old-fashioned brass doorknobs, with their natural copper-based antimicrobial properties, in combating the spread of disease?

drsjsmith

FROM JORDAN: Yes, sort of. Copper is certainly antimicrobial and can kill bacterial and viral pathogens. I've seen this work in practice. When we've sampled air conditioner cooling coils, we observe a lot of microbial growth on the aluminum fins, but never on the copper tubing. There is one 2013 study in the journal of Infection Control and Hospital Epidemiology where 3 hospital rooms were fitted with copper surfaces. Patients in these rooms showed a significantly lower rate of hospital associated infections. Cost seems to be the major barrier toward broader implementation.

What is the best thing a single family home can do to improve or protect their health in relation to the indoor microbiome?

nhuddleston

FROM JORDAN: If I had to pick one (or two or four) thing(s), I would say: 1)Keep your home dry. Fix all water damage as soon as possible, don't let the relative humidity raise above 70%. 2) Improve your

home ventilation rate (this one isn't always simple). 3). Keep your home clean. Clean homes do not cause allergies or asthma, see answer to the get a dog question below for more on the hygiene hypothesis. 4) If you or a family member has allergies, air purifiers with a filter can help.

Hi and thanks for joining us today!

Do you think the built environment in California plays a factor in the higher rates of infant botulism versus other parts of the US and world? If yes, how so? Or is it simply an epidemiologic artifact due to the world experts of IB being based in California?

PHealthy

FROM JORDAN: Maybe. botulism is caused by the bacterium Clostridium botulinum. This pathogen is naturally occurring in soils throughout the U.S. It seems to be more concentrated in some regions of California and other specific soils in the US, but scientists aren't sure why. The link with buildings is that when this soil is disturbed, it ends up on shoes and in the air, and this can be tracked into homes or enter through open windows or other form of ventilation. My guess is that there likely is NOT something specific about homes in California, rather it is the combination of high Clostridium naturally occurring in the soil and high soil disturbances from agriculture and development.

Do you have any comment on the so called "portfolio effect" of microbiome research and its potential for biasing indoor microbiome data?

dopn

Hmm. That is an interesting question. Are you talking about idea that with more diversity, there is more stability of certain aggregate microbial processes due to statistical averaging? The crazy thing is, that most microbes in buildings are NOT growing because of the lower water content of surfaces. If there is no growth and very little interaction with chemical or substrate gradients, then some concepts in ecology may not apply. Interestingly, microbial communities in buildings are mostly assembled by PHYSICAL processes, like aerosol deposition, resuspension, and penetration into building cracks. Microbes grow in buildings when they are on humans or when they are in liquid (toilets, pipes) or when surfaces are damp. In these latter two cases, the portfolio effect may apply and may cause some bias, but I'm not aware of studies that have addressed this effect in indoor environments.

Should I get a dog to make my indoor environment healthier?

lbalimtas

While there is epidemiologic evidence that exposure to dogs in early life may be protective against allergic disease, not everyone is protected, and some may have adverse responses. So whether or not you get a pet is a personal choice that may also be dictated by your real life circumstances and whether or not you love and can care for the pet. Keeping a dog could be a health risk if there is someone in the family who is allergic to dogs and who knows that they have clinical allergic responses to dogs. Some people don't have a choice about pets because of regulations in their apartments.

Are there specific predictions you would make about what will eventually be learned or accepted as true within your research community that isn't now a consensus belief? That is, anything about the relationship between indoor microbiology and human health? If you have such predictions would you care to quantify your confidence in them?

Metaculus

FROM VIVIAN: There are a number of significant questions about the most significant microbe transfer mechanisms related to human health - in water, in air, and on surfaces - and where action should be focused that research will be needed. In addition, the importance of "good microbes" and design responses to eliminate the bad are critically needed areas of research, discussed in the NAS report.

Are there specific predictions you would make about what will eventually be learned or accepted as true within your research community that isn't now a consensus belief? That is, anything about the relationship between indoor microbiology and human health? If you have such predictions would you care to quantify your confidence in them?

Metaculus

Diane: Here are just a few examples about what might eventually be learned about the indoor microbiology and human health that isn't now a consensus belief: 1. how microbial communities in the built environment, indoor pets and pests, and humans are related to each other. 2. how some microbial communities in buildings (like those coming from dogs) may protect some people against inflammatory diseases like allergy and asthma. 3. how stage of life, dose, genetics or route (like breathing in microbes vs ingesting them) influence microbial health effects 4. how ventilation, occupant behavior and the characteristics of known and new emerging infectious disease influence strategies for their control

How does indoor water damage (from hurricanes, flooding, and storms with significant rain and flooding) affect health?

Ibalimtas

FROM JORDAN: It is not an exaggeration to say that your home is teaming with bacteria and fungi.....waiting for the opportunity to grow. The thing that keeps them in check is that the surfaces in homes are dry and microbes need water to grow. With water damage from storms, fungi and bacteria will grow. Study after study has shown that adverse health symptoms (respiratory and allergenic) occur in the occupants of homes with visible mold growth. In fact, homes with reported moisture or dampness are associated with poor occupant health.

How does indoor water damage (from hurricanes, flooding, and storms with significant rain and flooding) affect health?

Ibalimtas

FROM VIVIAN: Indoor water damage can occur from heavy rains and flooding penetrating inside, but also from indoor plumbing failures, and even high indoor humidity condensing on surfaces or within walls. There are significant asthma and allergy health implications discussed in a different NAS study Damp Indoor Spaces and Health https://www.nap.edu/catalog/11011/damp-indoor-spaces-and-health

What 1-3 key practical implications for behavior would you want a layperson to take away from the report?

What about 1-3 key practical implications for building design?

Thank you!

charismatic_mu_fauna

FROM VIVIAN keep the building dry (from all sources of water). keep the building clean (with simple soap and water, and hepa vacuuming). maintain the fresh air paths from source to room. and maybe spend time in nature (the healthy microbiomes) - but this is a major area of needed research identified in the report.

What is the most recent study conducted that shows a link between poor indoor air quality and chronic illness? (mold and asthma) Or, are you aware of any trials that are in the planning phase? We are having an increase of doctors asking for IAQ tests, including mold, indoor allergen panels and microbiological results. They are interested in understanding what else may be going on in the patient's home environment. As a result, they are asking for research or proof that there is firm data out there. Below is one of several from Mendell and Fisk. Other suggestions on where I can find out about additional research? Fisk, William., Lei-Gomez, Quanhong., Mendell, Mark J. (2007) Meta-Analyses of the Associations of Respiratory Health Effects with Dampness and Mold in Homes. Indoor Air Journal, vol. 17, pp. 284-295.

GHS2018

Diane: The EPA, American Thoracic Society, the CDC and American Lung Association have reviews and practical guidelines on poor indoor air quality and health (especially respiratory health) Also please see the NIH workshop report which reviews trials and also the National Academy report, which is available online

Here are two reviews that we hope you will find useful.

Gold DR, Adamkiewicz G, Arshad SH, Celedón J, Chapman MD, Chew GL, Cook DN, Custovic A, Gehring U, Gern JE, Johnson CC, Kennedy S, Koutrakis P, Leaderer B, Mitchell H, Litonjua AA, Mueller GA, O'Connor GT, Ownby D, Phipatanakul W, Persky V, Perzanowski MS, Ramsey CD, Salo PM, Schwaninger JM, Spira A, Suglia SF, Togias A, Zeldin DC, Matsue EC. NIAID, NIEHS, NHLBI, MCAN Workshop Report: The Indoor Environment and Childhood Asthma: Implications for Home Environmental Intervention in Asthma Prevention and Management. J Allergy Clin Immunol. 2017 Oct;140(4):933-949. doi: 10.1016/j.jaci.2017.04.024. Epub 2017 May 10. PMID:28502823.

National Academies of Sciences, Engineering, and Medicine. Microbiomes of the Built Environment: Research Agenda for Indoor Microbiology, Human Health, and Buildings. Washington, DC: The National Academies Press. 2017.

LINK TO OUR REPORT https://www.nap.edu/catalog/23647/microbiomes-of-the-built-environment-a-research-agenda-for-indoor

There is also a recent report from a different committee at the National Academies that studied how the human microbiome chemical exposures and how environmental chemicals might in turn affect human microbiome - that link is at https://www.nap.edu/catalog/24960/environmental-chemicals-the-human-microbiome-and-health-risk-a-research

What, if anything, does our understanding of microbiomes of the built environment today suggest about the effectiveness of routine cleaning and disinfection of environmental surfaces to reduce disease transmission in homes, schools, health care, and other settings?

seeping_sko

FROM VIVIAN: Humans can impact the indoor microbiome by introducing microbes into buildings through a number of mechanisms related to building surfaces, including: (1) by direct contact with building surfaces; (2) by tracking dirt, dust, pests and water into buildings from the outdoors; (3) by engaging in activities that re-suspend existing, surface-bound microbes; and (4) by bodily emissions from exhalation, expectoration, and from bladder and bowel waste. So actions for each of these will be helpful - cleaning surfaces that people are often in contact with (handles, tables, keyboards..); using three stage walk-off mats and maybe removing shoes at the door; reducing dust accumulating materials and using appropriate vacuum technologies; and avoiding direct contact with others when you are ill (starting with handwashing).... the report is focused on research needs for quantifying impacts and for innovations in building design and operation and does not recommend any specific cleaning products or cleaning practices.

What, if anything, does our understanding of microbiomes of the built environment today suggest about the effectiveness of routine cleaning and disinfection of environmental surfaces to reduce disease transmission in homes, schools, health care, and other settings?

seeping_sko

FROM JORDAN: We know a few things, but there is a lot to learn. First, cleaning in hospitals, if it is performed properly, does help reduce hospital associated infections. We also know that hospital rooms are not always cleaned properly. Many facilities are moving toward portable UV devices to help with terminal cleaning of hospital rooms. These UV devices have been shown in clinical trials to be effective at reducing infection in patients.

There is less information on cleaning in homes and schools. Certainly cleaning with a disinfectant will kill microbes on surfaces, but equally important is the cleaning schedule. A current study from my lab showed that microbial communities on desks redeveloped fully about 3 days after cleaning....however the school district was cleaning desks only 3 times per year!

In section 6 of the research agenda, you talk about technologies that perhaps exist in some form but that aren't widely used, such as homes incorporating sensors to detect water penetration coupled with modified materials capable of self-sealing in order to minimize leaks. You go on to describe a few other technological developments, such as increased use of sensors that regularly sample air, water, and dust.

Which technologies do you see being readily adopted on a wide scale and by when? Presumably this will depend on some combination of the pace of the technology, the ease of installation in homes, the public's awareness and specific policy initiatives, and the magnitude of the particular problem solved by the given technology.

If you have such predictions about any technologies and their penetration, can you provide them along with a % of your confidence in such claims?

Metaculus

FROM VIVIAN: increasing challenges from flooding and water system failures are being addressed by the design community. As the NAS report discusses, sensor technology especially for hidden spaces in buildings are becoming more affordable, reminders for critically needed maintenance and action. There are several NAS reports on the seriousness of mold and human health that go into more detail on available and needed design solutions to water entering buildings. Vacuum technologies are improving rapidly to address the challenges in dust, including robot vacuums that will help the elderly.

Can any of you please talk a little bit more about study designs for learning more about the health effects/impacts of the microbiome? Are there particular developments in animal models needed to better understand the health impacts of changes to the human microbiome or the build microbiome?

ahodgson319

Diane: We review the complementary nature of epidemiologic observations and animal models (with references that detail different study designs) in Chapter 6 of our report: https://www.nap.edu/catalog/23647/microbiomes-of-the-built-environment-a-research-agenda-for-indoor There have been some great examples of the use of animal models (with descriptions of their designs) in recent articles about potentially protective effects of microbes related to dogs or farm animals LINK TO OUR REPORT https://www.nap.edu/catalog/23647/microbiomes-of-the-built-environment-a-research-agenda-for-indoor

Animal validation studies: Controlled studies in animals can be useful in testing and refining observational correlations. One study, for example, tested the observation that exposure to a diverse microbial community was associated with reduced allergic responses by feeding dust from a house with a dog to mice and then studying changes in their gut microbiomes and how those changes affected immune response (Fujimura et al., 2014). Animal studies can both provide greater control over exposures and environmental conditions relative to human observational studies and help establish important dose-response relationships. (pg. 168 of the the report)

References: Fujimura, K. E., T. Demoor, M. Rauch, A. A. Faruqi, S. Jang, and C. C. Johnson. 2014. House dust exposure mediates gut microbiome Lactobacillus enrichment and airway immune defense against allergens and virus infection. Proceedings of the National Academy of Sciences of the United States of America 111(2):805-810. Stein, M. M., C. L. Hrusch, J. Gozdz, C. Igartua, V. Pivniouk, S. E. Murray, J. G. Ledford, M. M. dos Santos, R. Anderson, N. Metwali, J. Neilson, R. Maier, J. Gilbert, M. Holbreich, P. Thorne, F. Martinez, E. von Mutius, D. Vercelli, C. Ober, and A. I. Sperling. 2016. Innate immunity and asthma risk in Amish and Hutterite farm children. New England Journal of Medicine 375(5):411-421.

Thanks so much for doing this AMA. I'm actually in the building sciences, working as a unique breed of mechanical engineering firm in Austin, and we are such big fans of your work. We know Dr. Corsi at UT quite well and we've all literally have the book copy of your report on each of our desks. We've also got a podcast with a sizable audience to educate the public on why building science matters to anyone who lives indoors.

I have a few questions for you all:

1. Would any of you be willing to be interviewed for a podcast episode?
2. How do you hope to see this work codified by bodies like ASHRAE in the coming years?
3. What do you think building scientists can do to better work with/educate architects about what kinds of design decisions can positively affect microbiome outcomes in homes/buildings?

Thanks again!

Edit: For those with too much time on your hands, join us over at r/buildingscience for a crawlingly slow conversation about the relationship of buildings, scientific inquiry, human health, and the practice of architecture.

schmeeglez

FROM VIVIAN: There were a number of key issues in both the air and waterborne microbe that relate

to ASHRAE standard development. The importance of intentional ventilation rather than infiltration and space to space air migration; the importance of designing to avoid concealed spaces where moisture and microbial communities may flourish; and the importance of designing to avoid condensation and microbial growth in cooling coils and cooling towers. Two Other Committee members, Andrew Persily and Hal Levin, will certainly be advancing these issues in codes and standard development.

Are dogs healthier for people than cats? Do either one protect against asthma, for example?

BarbMurphy

Diane: One size doesn't fit all: Dogs and cats carry microbes as well as allergens. Studies suggest that some (but not all) children exposed in early life to either dogs or cats may be protected against allergic asthma, and those studies have been reviewed in the literature. The literature about potentially protective effects of having dogs in early life is a bit more consistent than the literature about cats, but in both cases the response is probably partly modified by genetic inheritance. Dogs and cats can carry microbes that do not cause harm and may stimulate an immune response in early life that protects against allergy, but they can also carry parasites that may contribute to ill health.

If a child is allergic to dogs (or cats) and has asthma, then the asthma symptoms may worsen if the family keeps the pet. For families with pets who have pet allergic asthmatic family members it is important to know that pet allergen can be hard to control, it aerosolizes very easily, and is carried on furniture and clothes.

What is your position on a variety of air purification technologies that currently offered that claim to kill most the bacteria, viruses in the air? If some part of the microbiome is in fact beneficial to human health, would it still be advisable to use these air purifiers indiscriminately?

nmrguy12

FROM VIVIAN: There is research on the use of ultraviolet light (effectively sunshine) on cooling coils in mechanical systems that shows measurable gains in reducing microbial growth that can become airborne and be harmful to human health. Air filtration is also shown to be very beneficial in reducing particulate and dust distribution and with appropriate filters even chemical VOC distribution into occupied spaces. So maybe quality MERV filters and UV could be advised indiscriminately...

What is your position on a variety of air purification technologies that currently offered that claim to kill most the bacteria, viruses in the air? If some part of the microbiome is in fact beneficial to human health, would it still be advisable to use these air purifiers indiscriminately?

nmrguy12

FROM JORDAN: A few things to consider here:

1) Make sure any cleaner that is used does NOT produce ozone. Ozone is a hazardous pollutant and is regulated by the EPA. You don't want ozone in your home.

2) Lets consider allergies next. Microbial allergens will cause symptoms in people whether they are dead or alive. So killing pollen or a fungal spore isn't going to do anything for allergies. The best thing for removing allergens is an air cleaner with an actual filter that physically removes particles from the air.

3) For pathogens: I can't speak for all cleaners, but I would guess that these air filters really do kill

pathogens that pass through them. The question is, do you need this feature. This will only reduce airborne infections. Most infections, like the common cold, come from touching contaminated surfaces, not from air.

4) Make sure the cleaner is rated for the space you use it in. It won't be effective if the cleaner is too small for the room.

5) OVERALL, I like these devices for people with allergies and asthma (as long as they filter the air). I'm not sure they are so important for infectious disease.

It's inconceivable that building science & health issues aren't being taught in our schools being they're the ones so impacted; it's like a civil war on education while profiting & culling the heard. With technology being what it is today I beg you to PBS everything. Nothing has changed except red lines & flat lines costing lives & billions when prevention & mitigation educations is the biggest quickest form to help people. Do N0 HARM- Humidity Assessment Reconnaissance & Mitigation; Quality of Life = Building Science

ILL-ANNOYED

FROM JORDAN: Americans spend 90% of their time indoors. This is where most of our environmental exposures occur! Also, an important concept is that buildings should not be thought of as treatment devices for outdoor environmental pollutants. If children in a school are sick due to outdoor air pollution, the onus should be on reducing the environmental pollution, rather than rebuilding or modifying the school.

Would knowing more about a patients home environment help doctors understand how this may be a contributing factor to their chronic respiratory issue? How might a doctor get this information? Example: John lives in a home with a crawlspace where there is standing water. It is damp and levels of mold are high based on lab testing. Forced air/heat pump is method of heating. Air Ducts have not been cleaned in 25 years. There are animals living in the house. John is a hoarder and there are signs of indoor rodents.

In this scenario, John may not be giving his doctor all the information. He may not think that the home environment would be a drivers of his illness. Would it make sense for a doctor to order the patient to have a home environment evaluation or something else that would give more insights? A doctor does blood testing to understand the body, why not a test to understand the environment? Thoughts/Suggestions/Comments?

GHS2018

FROM VIVIAN: I think this is a compelling proposal for the medical community, if only to raise the understanding of how the built environment impacts human health. Assessing water, air and surface conditions and maintenance in buildings that may relate to respiratory and other microbial health concerns was one recommendation of the NAS committee report.

"Humidity level is thus only a part of the larger, more complex issue of how moisture affects the composition and viability of indoor microbiomes. Different humidity levels in combination with other parameters, such as ventilation and temperature, promote or suppress different viruses, bacteria, and fungi, and a microbe that thrives on one indoor surface may waste on another under the same humidity conditions. Therefore, generic advice about humidity levels needs to be viewed with skepticism."

Does this suggest the recommended 35-50% humidity level is not a rule of thumb?

megborneman

FROM JORDAN: Yes there are a lot of considerations for prescribing a rule of thumb for relative humidity level. Not sure one rule of thumb will work. Here's an example or different rules from the microbial perspective: RH below 50% reduces dust mite growth exposure RH below 50% increases the survival of influenza virus RH above 70% RH favors fungal growth on surfaces

then there is an entire set on "non microbial considerations"

"Humidity level is thus only a part of the larger, more complex issue of how moisture affects the composition and viability of indoor microbiomes. Different humidity levels in combination with other parameters, such as ventilation and temperature, promote or suppress different viruses, bacteria, and fungi, and a microbe that thrives on one indoor surface may waste on another under the same humidity conditions. Therefore, generic advice about humidity levels needs to be viewed with skepticism."

Does this suggest the recommended 35-50% humidity level is not a rule of thumb?

megborneman

FROM VIVIAN: There is significant debate today about the importance of managing humidity to avoid too dry conditions that expose respiratory membranes and too humid conditions that may be conducive to condensation and mold growth. However, humidification can be equally problematic as a growth medium. So the research question is how to design buildings to minimize the need to heat up outside air dramatically (causing low relative humidity indoors) and how to design buildings to avoid unwanted humidity buildup (ventilation, hygroscopic materials)... research truly is needed in this area.

Does the microbiome research community have a definition of a healthy microbiome and how can I make sure my microbiome (and the microbiome of my home) is healthy?

ahodgson319

FROM VIVIAN: This was the toughest question for the committee. There is remarkably little research on healthy microbiomes and the probiotic research is mixed and not long term. There were some remarkable studies about the importance of spending time on the farm and long term health...