Investigating Pathogen Trails As A Design Strategy to Combat Invisible Health Dangers in Everyday Environments

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Abstract
An individual's living environment has the ability to serve as both an aid and a hindrance to their health management. Addressing the environment as a strategy of care can become increasingly difficult when concentrating on the "invisible living environment", a space inhabited by microbiota such as harmful bacteria, archaea, protists, fungi and viruses. In the case of infectious diseases, designing solutions for this may be assisted in the study of the transmission paths of the pathogens involved in the process, while incorporating location points of risk mitigation involving human health behavior change. Our work notes existing data on transmission and proposes a solution to explore in future work. Implications of the use of the bacterial transmission paths are suggested to be of interest to researchers and designers involved in the development of related health solutions.

Author Keywords
Home; Health Behavior Change; Microbiome; Augmented Reality, Design Research; Pictorial

CCS Concepts
•**Human-centered computing** → **Human computer interaction (HCI); Visualization;** *Mixed / augmented reality;*

Figure 1: The Invisible Living Environment. Sometimes the most harmful elements to our health go unseen. As designers can we use data about pathogens found in common environments to build effective health solutions?

Introduction

Recent years have seen a sharp increase in the availability of environmental microbiome information to non-expert users. The microbiome is the genetic material of all the bacteria, virus, fungi or other microorganisms that live around and inside the human body. Some of these microorganisms, known as pathogens, can produce disease and allergies. Popular testing services produce data about the microbiome of people (e.g. skin or gut) and about their living environment (e.g. kitchen counter, bathroom surfaces) [2, 3]. People with no formal training in the life sciences can thereby get access to this data by sending a self-collected sample to a direct-to-consumer provider, and results are delivered online. These consumers then need to interpret large amounts of complex data involving sensitive issues such as disease risk and carrier status. The interpretation of the data may impact lifestyle decisions (e.g. change in diet, cleaning habits) and well-being of users, as well as relevant others (e.g. family members, non-related cohabitants, or local community members). Rapid DNA tests of surfaces in living spaces (e.g. bed, floor) can also detect potential health allergens such as bed bugs, and cockroaches[1].

Environmental microbiome information is of high social relevance. Consider a family or a group of roommates who share a living space. Such groups are likely to share bacteria in their living environment, and their commensal microbiota can be influenced by common lifestyle elements such as travel, illness, and pets. Within such shared contexts, built environments have distinct profiles of microbiome trails as shown in Figures 2; however, while users have access to this information, they may not be sure how to make sense of and engage with these invisible trails.

In this pictorial, we present a speculative mode of engagement through exposure to pathogen trails in homes. This

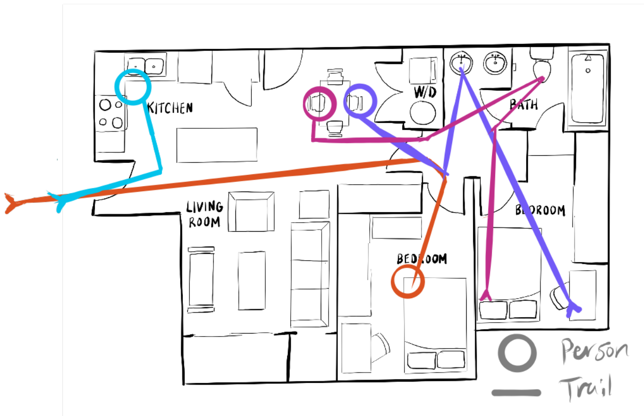


Figure 2: Home Trails. In this project we propose visualizing common pathogen trails to encourage individuals and families to engage in proper hygiene to decrease their risks of infections.

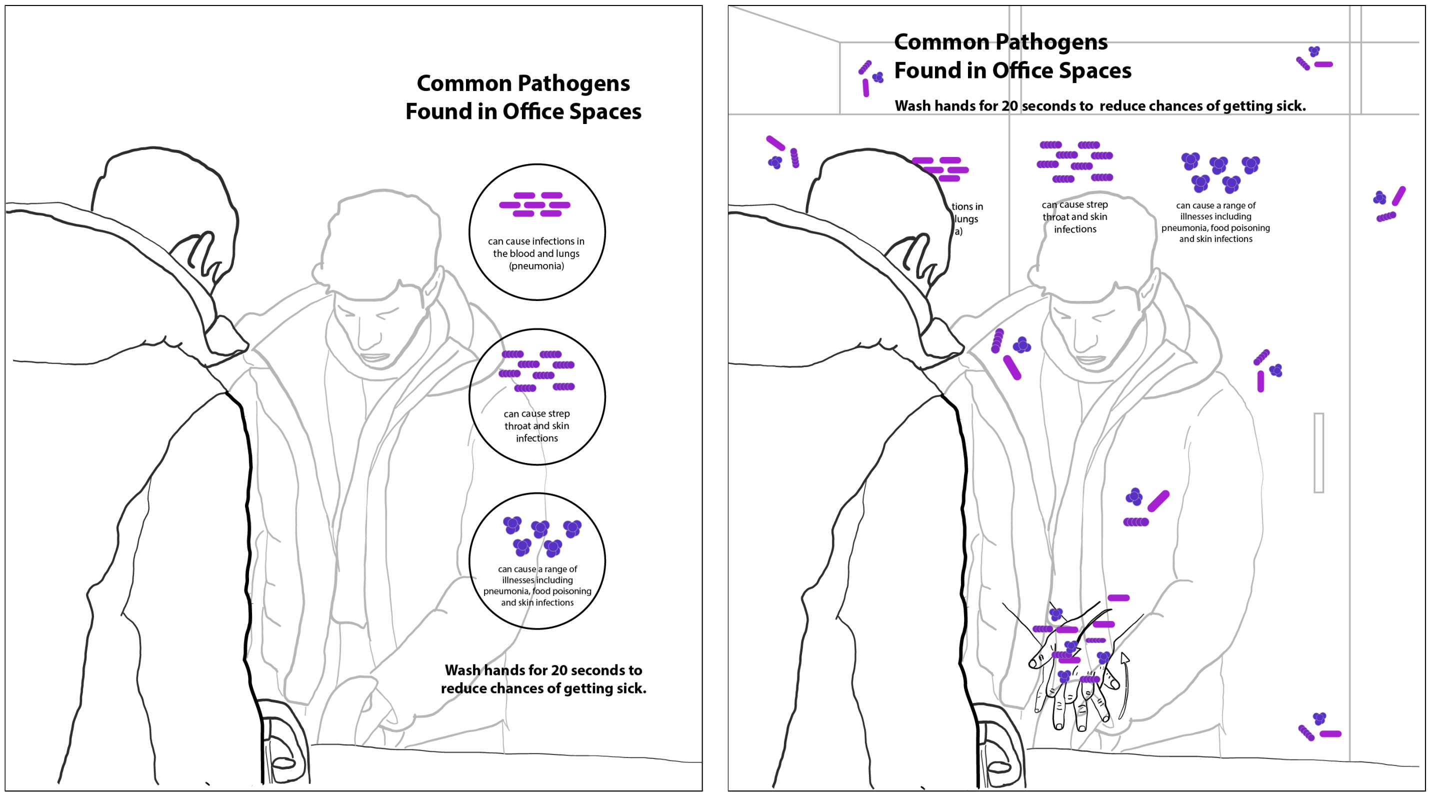
paper visualizes and re-conceptualizes the mirror as a focal point for social understanding and exploration of emerging microbial trails left behind in the home. Such a tool provides non expert users the opportunity for literacy and understanding of their health behaviors following engagement with microbiome trails. To this end, we speculate on the effect of visual environmental omic information on hand hygiene behavior with the use of augmented mirrors.

Pathogen Trails in Everyday Environments

The prevention of infectious diseases is of high importance. Of particular importance in this effort, is to look at the paths of transmission of pathogens within environments to design effective interventions to control infections. Agents of transmission include animals, humans, and non-living substances (eg. water & air) and modes include direct contact, indirect contact, vehicle transmission (eg. food, water, & air), and vector transmission (eg. mosquitos). Previous research provides us with information on environmental spaces and specific surfaces to focus on [8], exploring the relationship between microbes on humans and their home environments showed that human microbiota's spread quickly in home environments [6] found that the main source of bacteria in the public restrooms analyzed where from human skin. This suggests that the touching of surfaces, and actions before and after contact, may be a point of intervention for fighting pathogen transmission. We seek to make invisible pathogen transmission paths visible as a strategy for developing related health interventions. By investigating how to communicate where and how pathogens travel through and interact with humans, we can develop design interventions, which increase awareness, and influence behavior change that can decrease risks.

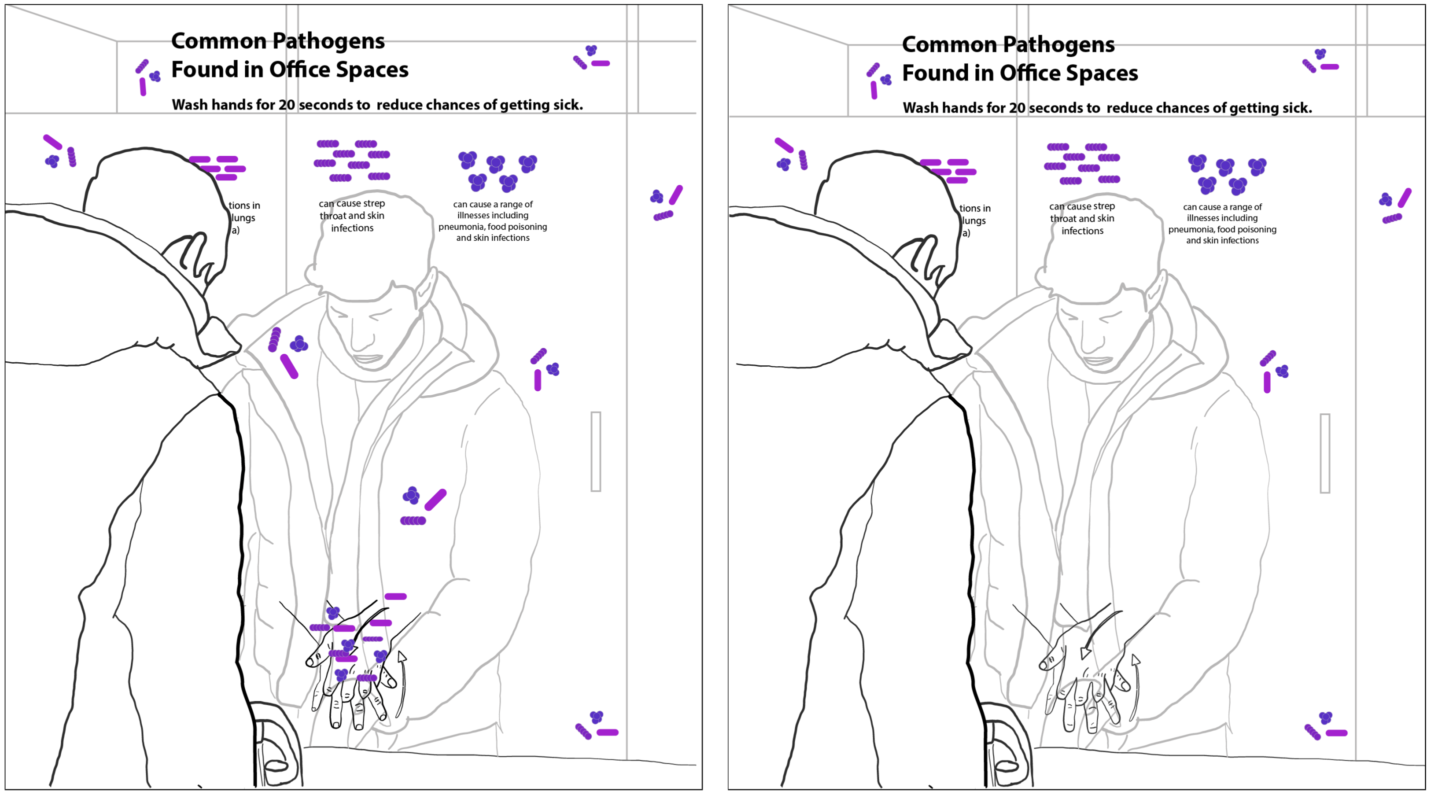
Visualizing Pathogen Trails With Augmented Mirrors To Improve Hygiene

While hand hygiene is found to be an effective strategy against the transmission of harmful microbes [4], people often fail to practice this as extensively as they should to mitigate risks. Effective hand hygiene is promoted as a general standard as well as encouraged during epidemics and the rise of novel viruses, as seen in the most recent case of the 2019-nCoV infections [7]. Health behavior changes are linked to health beliefs, such as risk perceptions, which research suggests can be misaligned due to affective factors [5]. In addition to health beliefs the Integrated Theory of Health Behavior Change also takes into account the role of knowledge, self-regulation, self-efficacy, and social facilitation [9] in health behavior change. All of these factors can be impacted by affective factors and can be made increasingly difficult to address when the threat at hand lacks



(a) (b)

Figure 3: Examples of possible design interventions conditions.(a) Pathogen and hand hygiene behavior instruction displayed as decals. (b) Information is accompanied with progressive hand hygiene instruction illustration showing pathogens on the skin and disappearing during later steps



(a) (b)

Figure 4: Examples of possible design interventions conditions (cont.).(a) Pathogens are also displayed on the surfaces within the environment. (b) Pathogens are only depicted on the surrounding environment surfaces and not on the individual or augmented hand graphics.

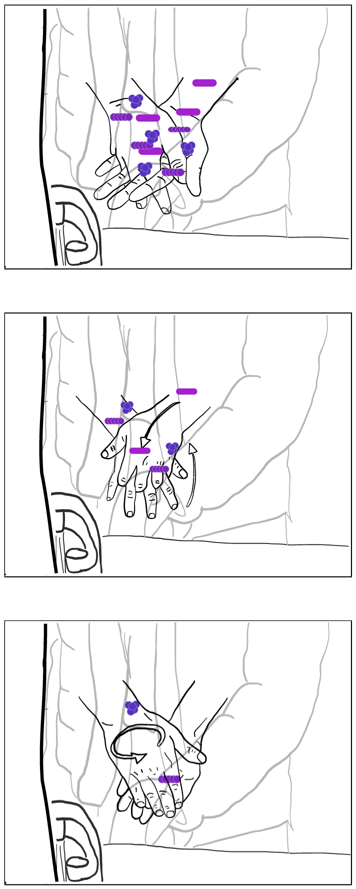


Figure 5: Breakdown of animated condition. As the hand hygiene instructions progress, bacteria will appear to disappear from the hands displayed.

a visual form, as in the case of infectious disease transmission. In order to combat transmission, our goal is to design for facilitating known health behavior challenges in locations that can effectively end a pathogen's typical transmission trail. This point is likely close to the sites of transmission and near hand hygiene areas (sinks & hand sanitation stations).

We propose the investigation of a solution that address the visibility issue as well as health behavior change factors through the use of "smart mirrors", two-way mirrors that include an electronic display. In our case, this serves as a corrective and augmented display. Visualizing invisible environmental bacterial data through this display attempts to combat the knowledge aspect of health behavior change, while the mirror component strives to address affective factors. The mirror may heighten the perceived self-relevancy of the information. In addition, the mirror attempts to explore a possible role of self-observation in the process of self-regulation. The location of this intervention would take place behind sinks in restrooms and where possible in kitchens. This allows the intervention to sit appropriately (1) where health behavior changes would occur and (2) in environments known to be areas of high bacterial contamination. This allows us to embed a solution right in the middle of common pathogen trails while providing means to end them. These initial design interventions for future exploration and testing are visualized in Figures 3-5. These interventions include visual representations of the pathogens reflected in the mirror (1) on the body, (2) on surfaces around the body, (3) both on the body and surfaces, and (4) not on either, but as informational decals on the mirrors. These designs would be accompanied with information on proper hand washing protocol as either (1) text, (2) static illustrations, or (3) an interactive animation one can follow along with.

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