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Engaging Publics on Asthma and Bacteria: Understanding Potential Negative Social Implications of Human Microbiome Research

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Introduction

When new science and technology are developed to address particular health conditions, they do not simply resolve existing problems in a linear fashion. Rather, they emerge within a societal context that itself changes and adapts in often unforeseen ways (Burns, O'Connor, & Stocklmayer, 2003). Novel science and technology thus emerge in the context of pre-existing relationships, vested interests, and institutional

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practices (Wynne, 1992). The uptake and consequences of new knowledge and technologies are therefore not simply a matter of their relative utility and effectiveness, but rather are subject to political, cultural, and institutional arrangements and contingencies. Perhaps more important for the current study, emerging science and technology have social and ethical ramifications beyond the technical purposes they are seen to serve (O'Doherty & Einsiedel, 2012). It is for these reasons that scholars have increasingly called for scientific and technological developments to be accompanied by meaningful public engagement (Collins & Evans, 2007). Such public engagement is not intended to be a marketing of scientific knowledge to the masses, nor is it intended to be a one-directional "polling" of public sentiment used to facilitate translation of new technologies. Rather, meaningful public engagement involves the creation of mechanisms for dialogue, in which publics are introduced to novel areas of science and technology, encouraged to contemplate their implications relative to personal experiences, needs, and values, and are then given the opportunity to articulate their perspectives on the topic. These perspectives can be fed back into scientific and regulatory discourse with the goal of shaping the particular manifestation of technologies (PytlikZillig & Tomkins, 2011).

In this chapter, we consider the role of emerging microbiome science in the context of the lives of people with asthma. In particular, our purpose is to investigate possible social and psychological consequences that may result from biomedical research linking asthma with bacteria. We do this by considering the views of those who are most directly affected by new scientific understandings and medical treatments: individuals who live with asthma and parents of children living with asthma. We begin by presenting an overview of biomedical research linking asthma with bacteria and the human microbiome. We then present an analysis of interviews conducted with individuals who have asthma and parents of children with asthma to understand their perspectives of the potential implications of microbiome research on asthma. We observe, in particular, participants' concerns that associations of asthma with bacteria may inadvertently create negative implications for individuals with asthma. We conclude that care needs to be taken in the translation and dissemination of research linking asthma with bacteria to avoid and/or mitigate such consequences.

Microbiome Science and Biomedical Research on Asthma

There is a growing interest in examining the microorganisms that live on and in the human body (Wang, Yao, Lv, Ling, & Li, 2017). These microorganisms are collectively referred to as the human microbiome.¹ Research has focused on examining the microbiome in several body sites including the gut, skin, mouth, and vagina. Considered to be an essential part of the human body, the human microbiome has been shown to play an important role in basic biological processes such as regulating the body's immune system (Rees, Bosch, & Douglas, 2018; Ursell et al., 2014; Wang & Li, 2015; Wang et al., 2017). Importantly, perturbations of the microbiome have been linked to the trajectory or development of an increasing number of conditions including asthma (Arrieta et al., 2015), cystic fibrosis (Maughan et al., 2012), inflammatory bowel disease (Kostic, Xavier, & Gevers, 2014), and vaginal health (Albert et al., 2015; Chaban et al., 2014). Asthma, in particular, is a condition which is increasing in prevalence dramatically, with more than 300 million people believed to be affected worldwide (Sullivan, Hunt, MacSharry, & Murphy, 2016). While there is much about asthma that is still unknown (Subbarao, Mandhane, & Sears, 2009), biomedical research has provided new insights into the role that microbes play in the development of asthma (Arrieta et al., 2015; Azad et al., 2013; Couzin-Frankel, 2010; Hahn, 1999; Thomas et al., 2014).

First, human and animal studies suggest that a balance of bacteria and other microbes is important in healthy immune development. Disruption of this balance may lead to the development of diseases including asthma (Couzin-Frankel, 2010). Antibiotics given at a young age may damage the gut microbiome which is critical in the development of the human immune system and thus potentially result in the development of asthma (Arrieta et al., 2015). Studies also suggest that babies born via C-section are more likely to develop asthma

¹Lederberg and McCray (2001) define the human microbiome as the 'ecological community of commensal, symbiotic, and pathogenic microorganisms that literally share our body space' (p. 8).

than those born vaginally owing to a difference in infant gut bacteria (Azad et al., 2013). Additionally, a mother's use of antibiotics during pregnancy may influence asthma development in early life (Stensballe, Simonsen, Jensen, Bonnelykke, & Bisgaard, 2013). Early antibiotic use may also affect the lung microbiome and future immune responses (Atkinson, 2013). Although microbiome research is relatively young, evidence developed in this field supports the link between antibiotic use, the alteration of microbial ecology and the onset of asthma (Arrieta & Finlay, 2014; Ivanov et al., 2008; Jedrychowski et al., 2011; Russell et al., 2013).

Second, research has also linked the onset of asthma to bacterial infections (Hahn, 1999). This includes acute respiratory infections such as pneumonia, bronchitis, or influenza-like illness (Hahn, 1995). Other evidence has associated chlamydia pneumonia and mycoplasma pneumonia with new-onset wheezing and decrements in lung function which suggests that these bacterial infections play an important role in the development and severity of asthma (Sutherland & Martin, 2007). Antibiotic therapy has become one means of treatment for asthma developed from bacterial infections which usually has its onset between infancy and 5 years of age. Some research has shown a link between antimicrobial treatment and a reduction of atypical infection and airway inflammation in individuals with asthma (Blasi, Cosentini, Tarsia, & Allegra, 2004). Although antibiotic therapy has been controversial, there is evidence that it can have beneficial effects in reducing asthmatic symptoms (Black, 2007). The term "infectious asthma" is used in some parts of the medical literature to describe asthma believed to be developed from acute respiratory infections such as pneumonia, bronchitis, or influenza-like illness (Hahn, 1995). Given the link between asthma and microbes, the role of antibiotics as a medical intervention relating to asthma is thus somewhat paradoxical: antibiotics may be a key therapeutic tool in resolving or alleviating some forms of asthma, but they are also implicated in damaging the gut microbiome in early childhood in ways that increase subsequent risk of asthma.

In short, there are important implications of microbiome research for individuals who live with asthma (Haw & O'Doherty, 2018). Arrieta et al. (2015) argue that this research can contribute toward the

advancement of microbial therapies that prevent individuals from developing asthma. This research also shows promise in understanding the role of the gut microbiome in developing a healthy immune system. Thus, from a biomedical perspective, the positive implications of microbiome research seem relatively uncontroversial. However, existing biomedical literature does not consider potential wider social consequences of emerging microbiome science, nor does it consider the views of those most affected by new knowledge and treatments. Below, we demonstrate a first step to understanding the social and psychological implications of emerging microbiome science, by involving individuals with asthma and parents of children with asthma in conversations about the implications of this new science in their lives.

Methods

The analysis presented here is part of a larger study investigating experiences of individuals with asthma and parents of children with asthma (see also Haw, Cunningham, & O'Doherty, 2018). This study was approved by the University of Guelph Research Ethics Board. A community sample ($n=70$) was recruited across Southwestern Ontario. Participants were informed of the study via posters, internet classified advertisements, and by other participants. Participants were individuals who had been diagnosed with asthma and/or were the parent of a child with asthma. We used a purposive sampling strategy by first screening potential participants through telephone or email to maximize diversity with respect to education, socioeconomic status, age, sex, place of residence in Ontario, and severity of asthma. Participants provided written consent and received a \$20 gift card for their participation. Semi-structured interviews were conducted by SC either in person or over the telephone. Interviews were audio recorded for later transcription and lasted between 45 and 120 minutes. During the interview, participants were introduced to new research linking asthma with a microbial etiology and then asked for their perspectives on potential implications of this research for them. Transcripts were coded thematically by the authors until saturation was reached both inductively and deductively, guided

by a focus on concerns explicitly raised by participants and by our research questions. Seventy interviews were conducted over a one-year period (2012–2013). In the transcripts, participant and interviewer are abbreviated as “P” and “I”, respectively.

Analysis

Negative Associations with Bacteria

We spoke to our participants broadly about research linking bacteria and asthma. Participants and the interviewer together explored the implications of this link. Notable in this exploration was a lack of positive associations with bacteria. In fact, across the entire data set only three examples of positive associations of bacteria were found. In contrast, there are numerous examples of negative associations with bacteria. For example, Participant 47 describes her visceral reaction upon hearing the word bacteria, and her desire not to have asthma connected with bacteria:

I think...when you say the word bacteria uh I just cringe cause I thought that's the last thing I want to be put with the word asthma.

Participant 47 further described her understanding of how the word bacteria is perceived unfavorably by society:

P: The first thing that comes to my mind is automatically you cannot use the word bacteria. You cannot use the word bacteria because automatically people are going to hear it and whether there's words that come after that word or not, it's going to stop in people's brains. Um there's gotta be some other word in the medical industry that they can use other than the word bacteria

[...] even the word microbe is better than using bacteria because people already have a pre-formed view of what bacteria is and unfortunately, they don't comprehend that there's two types most of the time. So, I mean if you use the word microbes, then that's something that people

aren't necessarily used to hearing all the time and might be able to be used as the new word for positives, you know? But I- I think the second you say the word bacteria no one's gonna hear what comes out of your mouth after that, they're automatically gonna assume bacteria bad, gross, you know, the illness blah blah blah and that's it, because there's been too many bad bacteria's...we were talking about how releasing...and I was sitting there thinking Thinking 'oh man, not that word'.

Participant 47 suggested that the word “bacteria” is associated with dramatic negative representations (“bad, gross”). Due to these negative representations, she expressed very serious reservations about associating asthma with bacteria. The term “microbes”, on the other hand, was viewed as less problematic because of a lack of familiarity in public discourse.

Other participants similarly expressed negative reactions toward associating asthma with bacteria, with participants commonly referring to bacteria as germs. The word “germs” was often used by participants in the context of descriptions of a society fearful of bacteria. Participant 28, for instance, described her perspective on broad social perceptions of germs in response to a question around ways to educate individuals about scientific findings relating to a bacterial etiology of asthma:

P: How should we educate people on this? I don't know. You're gonna have to get a positive outlook on it, but I think that you're right, the probiotic stance and you know, under teaching people that we are germaphobic, I get that everywhere, everywhere we go you know, people are afraid to touch things, like uh constantly sanitizing my hands at work like uh it like it's my job.

Participant 28's description and her use of terms such as “germaphobic” suggest a pervasive and irrational fear of germs across society. Indeed, she implicates herself in this phobia in speaking of her “constantly sanitizing my hands at work”. Given these negative reactions to bacteria, many participants spoke strongly against associating asthma with bacteria owing to potential negative social consequences that might follow from this association. We explore this next.

Consequences of Associating Asthma with Bacteria

The imperative of avoiding the word *bacteria* in connection with asthma was expressed by many participants because of the potential for negative social consequences. In particular, linking asthma with bacteria was a concern to participants because it wrongly implies that asthma is contagious to others. This concern is raised in the following excerpt by Participant 28 in response to being asked to expand on why she believes asthma should not be associated with bacteria:

Um you know trying to avoid, like bacterial and stuff like, trigger words that are sort of hot buttons in society right now like infectious like bacterial like you know, things like that that you want to avoid because people tend to see that word and then they don't necessarily read all the words around it they just focus in on that and go eww, I'm staying away from that.

Participant 28 suggests that linking asthma with bacteria has negative social consequences because asthma will be viewed as “infectious”, here implied to mean contagious. She suggests that the negative associations with bacteria are so strong that people seeing the word might not be sensitive to contextual meanings of particular uses of the term. Furthermore, her description of bacteria as a “trigger word” reflects concerns other participants had around people believing that they can get sick if they come into contact with an individual who has asthma (“ewww, I'm staying away from that”). For some participants, this raised issues around how individuals with asthma manage their illness publicly. For example, Participant 7 describes her negative experience relating to managing her asthma symptoms in public in the following excerpt:

Like, ‘Stay home. Don't spread your germs’. But I'm like ‘I don't have germs to spread. It's just [asthma]...’... because we do have this germophobic society where people are, like, constantly scared of getting sick. Um, I definitely think that's a factor. I could see parents, like, not wanting their kids to associate with other kids cause that they think they're sick, but really just have asthma or allergies. I could definitely see that being a factor.

When exhibiting symptoms of asthma (e.g., coughing, wheezing, throat clearing), these are commonly interpreted as symptoms of a communicable illness such as a cold or flu. Participant 7 highlights the social challenges of exhibiting asthma symptoms owing to their similarity to those of communicable diseases. In a “germaphobic society”, symptoms attributed to communicable conditions (correctly or incorrectly) are a risk that could lead to people to “not wanting their kids to associate with other kids cause they think they’re sick, but really just have asthma or allergies”.

Importantly, participants observed that public fears of contagion were associated with bacteria. Participants raised concerns about how representations of the link between asthma and bacteria in health care educational materials could inadvertently stigmatize individuals living with asthma. In particular, Participant 26 discusses in the following exchange how there is a need to differentiate between bacteria that are “contagious” and bacteria that are “not-contagious” in health care education materials to avoid lay public misunderstandings of asthma:

P: Like just [use] accurate portrayals...it’s just a respiratory illness. Like it’s nothing contagious, it’s not a contagious bacteria. It’s just something you have.

R: If you wanted to design...you talked about pamphlets that you’ve seen. Now if you were to design a pamphlet that was to inform people just about asthma in general, just to let them know what it was like and that, what would you put in it?

P: Information on what it feels like...and the fact that it’s not contagious because yeah, like you said, everyone is so concerned with germs and sanitation.

In addition to arguing for accurate portrayals, Participant 26 describes later in his interview how there is a need to be “very careful” when explaining to the lay public how asthma is linked with bacteria. For Participant 26, being “careful” implies here to avoid the suggestion that asthma is linked with a “contagious” form of bacteria, as this could result in increasing public fears around asthma being transmittable. More specifically, participants expressed concerns that linking asthma

with a bacterial etiology would lead to further stigmatizing and isolating individuals living with asthma.

Given that many participants were concerned about asthma being viewed as contagious as a result of increasing links between asthma and bacteria, we decided to ask participants during the course of the interview about the term “infectious asthma”. None of our participants had heard of the term before the interview, and upon first hearing it almost all of them interpreted the term as referring to a form of asthma that is contagious. When we discussed the intended clinical meaning of the term (i.e., that it refers to asthma that is the result of an infection), participants speculated that the term infectious asthma would similarly be interpreted more broadly as implying asthma that is contagious. Our participants also suggested that any implications that asthma might be contagious would lead to increased stigma of people with asthma. This is illustrated in the following excerpt involving Participant 3 and Participant 4, who are a mother and son who both have asthma:

P3: Anytime you bring in the word infection they believe it's going to spread like-rapid fire, 'infectious hepatitis'.

P4: When you bring infection into anything, it's automatically stigmatized as being contagious.

P3: No matter, no matter the truth of it.

P4: Yeah.

P3: No matter how solid the truth is behind that.

The word “infectious” is noted by both participants as a term that prevents them from seeing past the pejorative connotations and overshadowing any other context provided about asthma. The comments by Participant 3 and Participant 4 suggest that any kind of associations that are made between asthma and infection in public discourse may lead to difficulties for people with asthma. The word “infection” carries negative connotations that may exacerbate negative portrayals and stigmatization of individuals with asthma. As a result, participants suggested that any association between asthma and bacteria, even if it is part of a medical term like infectious asthma, can lead to negative social consequences for individuals living with asthma. For example, in the following quote,

Participant 53 suggests the terms infection and bacteria should be avoided entirely because these terms could be misconstrued by the lay public and media outlets:

P: In some ways you have to stay away from the word bacteria and infection and that cause however you explain it to them, the average person is going to twist it that they don't really get the message anyways...I had a quit- quite a bit of experience over the last few years in dealing with the press and what people get and what they don't get. Ah whatever you think they should be getting they don't get.

In addition to concerns that the lay public won't "really get the message", Participant 53 expressed apprehensions in his interview about speaking to the press because they "turn [information] the way they want to turn it". Similar concerns around the uncertainty of how scientific research linking asthma and bacteria would be taken up by the lay public and media outlets were expressed by other participants. This further added to fears some participants described relating to the impact and damaging effects misconstrued information can have around increasing societal beliefs that asthma is transmittable.

Counteracting Attributions of Contagiousness

Participants in our study described social situations in which they needed to counteract perceptions of contagiousness because of their asthma-related coughing. Many of our participants described using the phrase "it's just asthma" to diffuse social situations in which others treated them as if they were the source of a communicable disease (see also excerpt from Participant 7, above). That is, across the interviews a highly consistent finding was that to counteract attributions of contagiousness for symptoms like coughing, individuals with asthma were able to successfully claim the condition of asthma as one that is not associated with contagiousness ("I don't have germs to spread. It's just [asthma]"). For example, the phrase "it's just asthma" was used by Participant 37, a woman diagnosed with asthma since her early teens, as a way to reduce others' concerns around her coughing:

P: [If] I'm really coughing I'll be like, 'it's just my asthma like I just, you know I'll say it like if people are looking, 'it's just asthma, like you're fine, like I'm not sick' or if we're visiting people and I'm having coughs and wheezes I'm like, 'I'm not sick it's just my asthma, you know like don't worry you know you're fine, I'm not gonna leave anything'.

Similarly, Participant 63 describes how until she says, "it's just asthma", people are concerned that they may contract a virus from her. In the following excerpt, Participant 63 recalls an experience of needing to explain to the passenger seated next to her on a plane that her coughing was not contagious:

P: I was on a plane um a short while ago and I I didn't have anything wrong with me I I it was just my asthma. And this lady sat beside me and I coughed um and my lungs were getting a little funny so I took out my inhaler and she looked at me and she said um, she asked if I was uh if I had something contagious because she wanted to move if I did...I thought and I said it's just asthma, I am not contagious, you know don't worry.

Managing the mistaking of symptoms of asthma for symptoms of a cold, in particular, was a common experience of participants. Distinguishing between asthma and a cold was therefore a common task in participants' lives, to reassure others that their coughing was not associated with a cold and therefore not contagious. Participant 2, a mother of a son with asthma, recalls needing to reassure her son who has asthma that he is not contagious despite his brother's persistence that he cover his mouth when coughing:

P: Yep. Um, I always say to [my son], I always say 'You're not contagious. It's-it's asthma.' And you need to just, like his brother sometimes will say 'Cover your mouth' and Sterling will say 'I'm covering it the best I know how'...But then I have to explain that you know what, it's, it's asth-that's the, that's not a cold cough, that's an asthma cough. And I've gotten to the point where I know the difference between the asthma cough, the cold cough and the allergy cough.

Our analysis suggests that individuals with asthma already experience negative reactions from others who observe asthma symptoms and erroneously attribute these to a contagious condition. The possibility of associating asthma explicitly with a bacterial etiology was viewed by many participants as likely to exacerbate these reactions. Most importantly, it would potentially diminish the rhetorical efficacy of the defense “I’m not contagious, it’s just asthma”, if asthma came to be seen as contagious.

Discussion and Conclusion

Our analysis suggests that emerging microbiome science in the context of bacterial etiologies of asthma has the potential to lead to negative implications for individuals with asthma. It is important to emphasize that our analysis is not intended to be a criticism of this science. To the contrary, it is our belief that microbiome science has much to offer both in the treatment and the prevention of asthma and other conditions (O’Doherty et al., 2014). Our main point, therefore, relates to the emergence of this science into a social context characterized by strong aversion to “germs” and the possible or even likely transfer of negative associations from *bacteria* to *asthma*. Our participants’ concerns around associating asthma with bacteria is warranted given that previous studies have documented largely negative public perceptions surrounding bacteria. For example, in a study on antibiotic use by Norris et al. (2013), participants expressed a belief that a balance of bacteria was necessary for a healthy body and essential to human survival. Yet, it was noted by participants that widespread advertising of disinfectant products such as cleaning products has led to paranoia about bacteria. In a study on bacterial resistance to antibiotics, Davey, Pagliari, and Hayes (2002) argue similarly that the widespread advertising of antibacterial products, home cleaning agents, and antibiotics has led to strong negative messages in the public about bacteria or germs. This negative perception is described by Davey et al. (2002) as a cultural bias against germs and as leading to the widely held impression that antibiotics are necessary to keep “an overwhelmingly hostile world of bacteria at bay” (p. 44).

These negative public perceptions of bacteria also extend to diseases which are believed to be spread by bacteria. Research has shown that stigma is associated with conditions that are believed to be contagious or harmful to others (Herek, 1999). For example, studies on public perceptions of tuberculosis (TB) suggest that diagnosed individuals are partly stigmatized due to perceived risks of transmission through microbes (Courtwright & Turner, 2010; West, Gadkowski, Ostbye, Piedrahita, & Stout, 2008). This public perception prevails despite medical research suggesting that transmission risk of TB through, for example, airborne microbes from coughing or sneezing, is low unless an individual is exposed to these microbes over a long period of time (American Lung Association, 2016). In addition, according to the World Health Organization (2016) the majority of individuals who are exposed to these microbes do not develop the active disease. The stigmatization of individuals with TB leads to individuals being hesitant to disclose their disease to others for fear of being socially excluded and in some cases being reluctant to adhere to treatment (Dhingra & Khan, 2010). Other diseases associated with stigma because of (incorrectly) perceived transmission risk include disorders such as psoriasis (Halioua et al., 2016) and eczema (Griffiths, Barker, Bleiker, Chalmers, & Creamer, 2016), as well as HIV (Lekas, Siegal, & Leider, 2011) and Hepatitis B (Ellard & Wallace, 2013). These studies support the rationale behind the need many of our participants expressed in having to manage others' perceptions about their symptoms. In particular, the fact that our participants commonly used phrases such as "it's just asthma" to disassociate their symptoms from those of a cold or flu suggests that guarding against attribution of contagiousness is an important aspect of their social management of asthma. It also suggests that if asthma were to become seen as a communicable condition in public discourse, individuals with asthma would lose an important rhetorical resource in the social management of their condition.

Dissemination and uptake of scientific knowledge does not occur in a linear fashion, and it is certainly not possible to predict the precise nature of public understandings of microbiome science and asthma as this enters the public domain. However, our participants' experiences and speculations suggest that there may be unintended negative

consequences to this knowledge. An important constraint in our analysis is that participants' statements on the social consequences on microbiome science are speculative. Typically, social scientific methodologies involving surveys, interviews, and focus groups rely on talking with people about topics with which they have intimate familiarity. Conducting an interview study with individuals with asthma and parents of individuals with asthma to learn more about their perspectives about living with asthma is thus not out of the ordinary. However, asking them to comment on the implications of new science and technologies on their lives or on broader society is inherently speculative. This is a potential weakness in studies of this kind and must be taken into account in analysis and interpretation of findings. However, not conducting such studies runs the far greater risk of marginalizing the views of those most affected when scientific and technological advances are integrated into policy frameworks and medical practices. We argue for the importance of conducting studies such as the one we presented in this chapter, while taking care that analytical claims are situated in the context of individuals' speculation about novel science and technology, their experiences of illness and actual and potential stigma, and their experiential knowledge of the health care system into which new biomedical research emerges. For this reason, the concerns they expressed, which are grounded in their everyday experiences of misunderstandings of asthma and stigmatization in a range of life contexts, such as school, work, friendships, and interactions with health care professionals, deserve serious consideration.

It is also important to consider advances in human microbiome research relating to asthma in the context of the success of human microbiome science more broadly. Scientific publications on the human microbiome have increased dramatically over the past few years due to recognition of the potential for microbiome research to transform health care (Slashinski et al., 2013) and lead to important advances in therapies and diagnostics (Gilbert et al., 2016; Haiser et al., 2013; Jia, Li, Zhao, & Nicholson, 2008). This attention from the scientific community has also been taken up in commercial and public domains in the form of companies offering microbiome-based analysis and interventions, as well as heightened media coverage of microbiome related

topics (e.g., media coverage of fecal transplants; Chuong, O’Doherty, & Secko, 2015). All of this has led to increased public exposure to alternative discourses about the nature of microbes and their relationship to humans. In particular, these discourses challenge negative pathogen-based perspectives of human illness, and instead offer metaphors of ecosystems and symbiosis to understand the relationship between human and microbes. While our purpose here is neither to endorse nor to challenge these new metaphors (see Juengst, 2009) we do note the potential inherent in these metaphors to counteract negative public associations of bacteria becoming transferred to asthma. Indeed, research on the human microbiome that makes the connection between bacteria and asthma (Arrieta & Finlay, 2014) specifically points to antibiotics and the killing of “healthy bacteria” as the problem. It is this understanding that needs to be leveraged to counteract potential stigmatization of people with asthma. If symptoms of asthma are associated not with pathogens (“bad bacteria”), but rather with past damage to the microbiome (“good bacteria”), many of the fears expressed by our participants may be overcome. There is no easy intervention through which to achieve such positive associations, but if current trends continue and are further augmented by physicians’ education on the human microbiome and its implications for health, negative social implications of this new science for people with asthma may be mitigated.

With respect to the larger aim of re-articulating the ways in which psychology can contribute to the study of science and technology, this study illustrates some continuities with previous formulations of a psychology of science, but also important divergences. Similar to previous articulations of a psychology of science (e.g., Feist, 2006) this study recognizes the social aspects that accompany the development and application of scientific knowledge. However, in contrast to such attempts, this study goes beyond a characterization of human phenomena in terms of variables (O’Doherty & Winston, 2014). The study integrates principles of *scientific realism* and *social constructionism* in its analysis. In particular, our study relies on the premise that the biological foundations of conditions such as asthma and knowledge about microbes and their relationship with asthma can be usefully described in the language of the natural sciences. At the same time, we see scientific knowledge as

embedded within larger social relations and emerging within particular social contexts. As such, our study orients to the possible trajectories of meaning that may emerge and develop in relation to this field of science and how this may affect people. While we certainly do not claim that all studies that purport to instantiate a psychological study of science and technology need to take such an approach, we do believe that any framework that does not allow for such an approach is at best incomplete or, at worst, flawed.

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