OneBeacon
TECHNOLOGY INSURANCE

A Member of OneBeacon Insurance Group®

Microbiome: What is your gut telling you?

Author: Elizabeth Marazzo, Medical Technology Risk Control

Published: February 2017

Executive Summary

We live in a time where medical technology is evolving faster than we can imagine. For that we have exceptional and dedicated scientists and researchers to thank. In 1990, the Human Genome Project spurred a revolution in biotechnology around the world, which paved the way for a completely new approach to healthcare called Personalized Medicine. In the late 1990s researchers began studying the role that intestinal microbes might play in the human immune system.[1] Since then it has become the subject of great interest for researchers across disciplines. In 2008, the Human Microbiome Project was established, "with the mission of generating resources that would enable the comprehensive characterization of the human microbiome and analysis of its role in human health and disease."[2]

What is the Human Microbiome?

First let's talk about microbes. To put it plainly, microbes are microscopic organisms--a living thing too small to be seen with the naked eye. They are categorized in six different life forms: Bacteria, archaea, fungi, protists, viruses, microscopic animals (e.g. arthropods, crustaceans, rotifers, mites), and microscopic plants (e.g. green algae). The human body is home to all of these different microbes, except for microscopic plants.[3]

Microbiome is defined as the collection or an ecological community of micro-organisms that inhabit an environment creating a "mini-ecosystem." Our human microbiome consists of communities of symbiotic, commensal and pathogenic bacteria that share our body space and call it home.[4] Joshua Lederberg PhD, the winner of the 1958 Nobel Prize for his discovery of how bacteria transfer genes[5] came up with the term "microbiome." His study emphasized the importance of microorganisms living in our bodies both in good health and disease.[6]

Until 2014, articles and publications noted that an average person's microbiome (bacteria and microbes within the body) outnumbered their body's cells ten to one. At a National Institute of Health lecture in 2005, David Relman, a microbiologist at Stanford, explained that human bodies were made up of 100 trillion microbes and 10 trillion cells – hence the ten to one ratio. This ratio has been cited by researchers in scientific journals, books, TED talks[7] and continues to be noted on the Human Microbiome Project website.

So where did this ratio originate? In 1972 a microbiologist named Thomas Luckey made his calculations based on one gram of feces. His study was presented in a visionary symposium he organized that helped put intestinal microecology in motion.[8]

However, modern day scientists believe that this was a crude estimate that established itself as fact through repetition and decades of citations. More recently, a 2014 report issued by the American

Society of Microbiology showed that the ratio of microbes to human cells is closer to three to one. Peter Turnbaugh, a University of California at San Francisco microbiologist, said that there is tremendous diversity and abundance making it a challenge to determine the absolute number. "The most important thing is that much of what makes us human—many of important aspects of health and the predisposition to disease and recovery—depends on metabolic activity of these microbes. I don't think it's all about numbers."[9]

So why does this crude estimate continue to linger? Perhaps it's the "wow" factor of the dramatic ratio, or people's astonishment, much in the same way we react when we hear we only use 10% of our brains.

Role of Human Microbiome

The communities of bacteria that make up our microbiome complement each other and are present on our skin, eyes and mouth, with the majority of it, of course, in our intestines. Some of these bacteria are known as commensal, which means they are just along for the ride while others are considered symbiotic. A third type, which is usually present in small numbers are pathogens—the disease-causing microbes. In a healthy microbiome, these pathogens remain in check and their numbers remain small and manageable limiting any harmful effects. However, if this goes out of balance, the individual may suffer a disease.

Recent studies have shown that we have approximately 10,000 different microbial species that occupy our microbiome.[10] These communities perform a variety of functions which are not only vital to our health and well-being but also to our very own survival.

Our microbiome lays the groundwork in which our bodies judge whether or not something is friend or foe. It keeps balance, harmony and order among the communities making sure that pathogens are kept at bay, and at the same time ensuring that the host system doesn't attack itself.

Our gastrointestinal tract (gut) microbiome is crucial in breaking down and absorbing the nutrients from the foods we eat. Without it, food would be indigestible and we would be unable to extract the important nutritional compounds our bodies need to function. In addition, they secrete beneficial chemicals as a natural part of their metabolic cycle.

Development of the Microbiome

Our microbiome begins at birth with our first exposure to these micro-organisms through the birth canal, followed by nutrition from the mother's milk or other sustenance such as baby formulas. This establishes the foundation on which we build our microbiome. A recent research study also indicated that the mode of delivery affects the diversity of gut microbiota during the first three years of an infant's life, with natural birth being better than Caesarean section deliveries for microbiome development.

A healthy gut microbiota promotes a healthy development of the immune system, while an abnormal gut is considered to possibly cause gastrointestinal infections during the infancy.[11] Our lifestyles, including our dietary choices and exposure to different environments throughout our lives, especially in the developing years, will cultivate an ecosystem that will play a significant role in the determination of our overall health for life.[12]

Microbiome: What is your gut telling you?

Poor "Gut Flora" Linked to Diseases

Although microbes are present on the skin, mouth, and eyes, their balanced presence in the gastrointestinal tract is most critical to our well-being. Studies on the significance of the gut microbiome have led researchers to understand how small imbalances in our intestinal microbial populations can cause diseases. That same study also indicated that these imbalances can be restored and may possibly lead to cures. This new understanding could lead to better and more effective treatments that will kill only the harmful bacteria, unlike antibiotics which target both good and bad microbes.

Recent studies also indicate that human gut flora also plays an important role in the metabolism and efficacy of how pharmaceuticals are absorbed by our bodies.[13]

Some of the conditions that are likely to be affected by our microbes include:[14]

- Acne – This occurs when P. Acnes, a type of bacteria that inhabits your skin, invades hair follicles causing irritation and infection. An imbalance between P. Acnes and other protective bacteria can result in severe cases of acne. Such cases are treated with topical or orally ingested antibiotics that may target beneficial microbes as well.
- Antibiotic-associated diarrhea – People who take antibiotics for an infection sometimes suffer from diarrhea as antibiotics affect both good and bad microbes resulting in an imbalance. For treatment many have turned to probiotic foods like yogurt and bacteria-containing pills. However, the types of bacteria in these foods represent a very small proportion of the microbes in our intestines. In rare cases, fecal transplants (fecal matter from a healthy family member is transferred to the sick person's intestine) have proven effective and leads to complete recovery within a few days. Yes, it appears unseemly but there are companies developing techniques for growing complex mixtures of intestinal bacteria in a lab setting.
- Asthma/Allergies – Researchers believe that the increase in asthma and hay fever rates (tripled in the last 30 years) in the U.S. has something to do with the environment and possibly our microbes. The use of hand sanitizers, air filters and anti-microbial cleaners could be the problem. By living in a clean environment, children are not building immunity to typical bacteria, viruses and parasites that would otherwise be beneficial or aid in the development of their immunity.
- Autism – Research into what causes autism has revealed some weak genetic links and possible environmental triggers. New research has shown that microbes may play a part in it. Studies[15] indicate that children with autism have different microbes inhabiting their intestines compared to children without the disorder. This study could lead to finding more ways to fight the disorder by possibly readjusting the microbe balance in the intestinal tract.
- Autoimmune diseases – These diseases arise when the immune system is confused and attacks one or more of the body's normal tissues/organs as if they were invaders, causing inflammation and damage. Examples include multiple sclerosis, rheumatoid arthritis, lupus, Hashimoto thyroiditis, etc. Researchers believe that this is more likely to happen when our immune system does not develop or is not properly trained during childhood. Much of this training happens within the large intestine with microbes being part of the process. Some microbes protect us from autoimmune diseases while others seem to make us more vulnerable.
- Cancer – Recent research also indicates that microbes have an indirect role in causing cancer. Inflammation caused by certain microbes appears to increase cancer risk. Bacteria such as H. pylori, a common cause of stomach ulcers, are also seen in cancers of the stomach and esophagus. Other viruses such as Hepatitis B and C increase the chances of liver cancer, HPV increases cervical cancer, and Epstein-Barr virus is associated with lymphomas and other cancers.

- Depression and anxiety – Doctors and researchers also believe that there is a connection between microbes and behavior. For instance some infectious microbes such as the rabies virus can cause insomnia, agitation and fear of water. Some microbial intestinal disorders can result in anxiety, depression and other mental symptoms. Interestingly, the skin appears to be a part of the connection, too. Research has shown that people with acne rosacea, a severe skin disorder, have a higher incidence of depression. There is also evidence that ingesting certain types of bacteria can improve both acne and the associated depression.
- Diabetes – People with diabetes are less responsive to insulin and without treatment their blood sugar levels can become dangerously high, potentially damaging their blood vessels, nerves, eyes and kidneys. The rise of this disease stems from our high-fat/high-sugar diet, which negatively affects the balance of the beneficial, intestinal microbes. By lowering our fat and sugar intake we can increase the population of these microbes to a healthier state. In an experiment performed in Amsterdam obese men with insulin resistance received microbes from thin healthy men. Within six weeks the obese men became more responsive to insulin and their blood sugar levels dropped to a healthier state.
- Hardening of the Arteries or Atherosclerosis – This occurs when plaque develops inside the walls of blood vessels, which may cause a heart attack or stroke if the plaque breaks off and obstructs blood vessels. Unfortunately, symptoms are not evident until it's too late. Years ago doctors noticed that heart attack patients also had red irritated gums. They later noticed that plaque in the blood vessels contain bacteria normally found in the mouth. They surmised that bacteria from the unhealthy gums were entering into the blood stream.
- Inflammatory Bowel Disease – This affects the intestines causing vomiting, diarrhea and anemia. Some cases are so severe that surgeons must remove damaged sections of intestine. For some patients, certain types of bacteria irritate the intestinal wall, while those with Chron's Disease have a genetic variation that changes how their cells interact with microbes. Beneficial bacteria can detect the harmful ones and protect the intestinal wall. If there is a defect in this mechanism then harmful bacteria will invade the wall resulting in disease. Possible treatment may include encouraging growth of the beneficial bacteria to suppress the invader.
- Obesity –Heart disease is the number one cause of death (614,348)[16] and is associated with obesity. More than 1/3 of the U.S. adult population is obese (34.9% or 78.6 million).[17] Obesity-related conditions include heart disease, stroke, type 2 diabetes and certain types of cancer. These are all preventable. Research has shown that thin and obese people tend to have different intestinal microbes. When obese people lose weight their microbiota changes for the better. Furthermore, several studies have linked obesity to the microbiome. Our body weight is obviously influenced by diet, so our environment and habits also play a major role. A diet high in fat, sugar and simple carbohydrates does not encourage "healthy" gut microbes and promotes "unhealthy" microbes that may play a part in making us obese. An interesting experiment performed on mice could give us hope in the near future. Researchers transplanted microbes from overweight mice into thin mice causing the thin mice to gain weight. The opposite could be true as well.

There are numerous other studies on the effect of the microbiome to specific diseases such as liver, metabolic and cardiovascular, and impaired bone mass and quality.[18 19 20]

Microbiome and Healthcare Challenges

Healthcare is facing two significant challenges at this time:

- Non-communicable Diseases and Conditions (NCD) – There has been a significant increase in cases of multiple, NCDs such as asthma, food allergies, obesity, type 1 and type 2 diabetes, IBD, heart disease, Parkinson's, Alzheimer's and cancer. These diseases already account for the

majority of deaths worldwide and are expected to increase in the coming decades.[21] Unfortunately, most NCDs are not cured but instead managed throughout one's lifetime at staggering costs, while at the same time reducing the quality of life.

- Multi-drug Resistant Bacterial Pathogens - The emergence of these bacterial pathogens is outpacing the discovery and production of antibiotics.[22] Overuse of antibiotics is thought to play a part in the rise of these multi-drug resistant bacterial pathogens.[23]

With these two challenges the healthcare industry needs to assess several conditions.

- effectiveness of treatments
- level of care required
- global economic resources required to treat these diseases

The microbiome research over the last few decades has brought forward a completely new view of our human make-up, which is affecting the direction of healthcare. The healthcare industry believes the solution to these challenges lies within our microbiome. New research data has spawned different techniques in medical approach as well as having the potential to thwart ongoing epidemics. This brings personalized medicine to its full potential and sets us on a path to sustainable healthcare.

How to Restore and Improve Your Gut Flora

Prebiotics are dietary fibers that purport to promote the growth of healthy bacteria in the digestive tract. Probiotics are live bacteria and yeast that can help balance your gut flora. There are many types of probiotic bacteria with purportedly different benefits. However most are classified into two groups: [24]

- Lactobacillus – the most common and found in yogurt and other fermented foods
- Bifidobacterium – found in dairy products

Taking prebiotics/probiotics is just one facet of a healthy lifestyle. However, simply ingesting large quantities of these biotics won't make you healthy if your lifestyle continues to include habits that damage gut bacteria.

For gut microflora to be healthy it needs a stable environment in which to grow and flourish. This means that the pH in the colon should be slightly acidic (lower than 7 pH),which will inhibit the growth of undesirable bacteria like Salmonella, Shigella, and E. Coli, and will promote the growth of healthy bacteria such as Lactobacillus.

The best way to accomplish this is through diet. Consider whole, unprocessed, unsweetened foods as well as traditionally fermented or cultured items. Reduce the intake of grains and sugar, and avoid genetically engineered ingredients, processed foods and pasteurized foods. Sugar promotes the growth of pathogenic yeast and other fungi and is also known to fuel cancer cells.

Conclusion

Published research since microbiome studies began in the late 1990s makes it clear that microbiomes are a fundamental component of human physiology. Changes in the microbiome can trigger changes in our bodies which could either result in a disease or improve our health. The ability to understand these mechanisms and the disease process is very important as we move towards better therapeutic interventions for everyone.

Contact Us

To learn more about how OneBeacon Technology Insurance can help you manage online and other technology risks, please contact Dan Bauman, VP of Risk Control for OneBeacon Technology Insurance at dbauman@onebeacontech.com or 262.966.2739.

References

[1] Penders, J.; Stobberingh, E. E.; den Brandt, P. A.; Thijs, C. (2007). "The role of the intestinal microbiota in the development of atopic disorders." Allergy. Accessed September 2016. https://www.ncbi.nlm.nih.gov/pubmed/17711557

[2] NIH Human Biome Project. Accessed September 2016. http://hmpdacc.org/overview/about.php

[3] "What are Microbes?" Accessed September 2016. http://learn.genetics.utah.edu/content/microbiome/intro/

[4] "Microbiome 101: Understanding Gut Microbiota." Accessed September 2016, http://www.prescript-assist.com/intestinal-health/gut-microbiome/

[5] Adams, Amy. (February 6, 2008). "Geneticist Nobel laureate Joshua Lederberg dies at 82." Stanford Report. Accessed September 2016. http://news.stanford.edu/news/2008/february6/med-lederberg-020608.html

[6] Peterson, Jane; et al. (Dec 2009). "The NIH Human Microbiome." Genome Research. Accessed September 2016. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2792171/

[7] Smith, Peter Andrey. (September 14, 2014). "Is your body mostly microbes? Actually, we have no idea." The Boston Globe. Accessed September 2016. https://www.bostonglobe.com/ideas/2014/09/13/your-body-mostly-microbes-actually-have-idea/qlcoKot4wfUXecjeVaFKFN/story.html

[8] Abbott, Alison. (January 8, 2016). "Scientist bust myth that our bodies have more bacteria than human cells." Nature. Accessed September 2016. http://www.nature.com/news/scientists-bust-myth-that-our-bodies-have-more-bacteria-than-human-cells-1.19136

[9] Ibid 7

[10] Ibid. 2

[11] Rutayisire, E; Huang, K; Liu, Y; Tao, F. (July 30, 2016). BMC Gastroenterol. "The mode of delivery affects the diversity and colonization pattern of the gut microbiota during the first year of infants' life: a systematic review." Accessed September 2016. http://www.ncbi.nlm.nih.gov/pubmed/27475754

[12] Lim, ES; Wang, D; Holtz, LR. (October 24, 2016). Trends Microbiology. "The Bacterial Microbiome and Virome Milestones of Infant Development." Accessed September, 2016. http://www.ncbi.nlm.nih.gov/pubmed/27353648

[13] Jourova, L; Anzenbacher, P; Anzenbacherova, F. (September 2016). "Human gut microbiota plays a role in the metabolism of drugs." Accessed September 2016. http://www.ncbi.nlm.nih.gov/pubmed/27485182

[14] "The Microbiome and Disease." Accessed September 2016. http://learn.genetics.utah.edu/content/microbiome/

[15] Ibid 14

[16] Hernandez, CJ; Guss, JD; Luna, M; Goldring, SR. (September 2016). "Links Between the Microbiome and Bone." Accessed September 2016. http://www.ncbi.nlm.nih.gov/pubmed/27317164

[17] "Adult Obesity Facts." CDC. Accessed September 2016. https://www.cdc.gov/obesity/data/adult.html

[18] Betrapally, NS; Gillevet, PM; Bajaj, JS. (July 2016). "Gut microbiome and liver disease." Accessed September 2016. http://www.ncbi.nlm.nih.gov/pubmed/27477080

[19] Meyers, KA; Bennett, BJ. (October 2016). "Diet and Gut Microbial Function in Metabolic and Cardiovascular Disease Risk." Accessed September 2016. http://www.ncbi.nlm.nih.gov/pubmed/27541295

[20] Ibid. 14

[21] Bloom, D.E.; Cafiero, E.T.; Jané-Llopis, E.; Abrahams-Gessel, S.; Bloom, L.R.; Fathima, S.; Feigel, A.B.; Gaziano, T.; Mowafi,M.; Pandya, A.; et al. (September 2011). "The Global Economic Burden of Noncommunicable Diseases." World Economic Forum; Geneva, Switzerland. Accessed September 2016. http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf

[22] Cantón, R.; Horcajada, J.P.; Oliver, A.; Garbajosa, P.R.; Vila, J. "Inappropriate use of antibiotics in hospitals: The complex relationship between antibiotic use and antimicrobial resistance." Enferm. Infecc. Microbiol. Clin. Accessed September 2016. https://www.ncbi.nlm.nih.gov/pubmed/24129283

[23] Hughes, D. (August 2014). "Selection and evolution of resistance to antimicrobial drugs." IUBMB Life. Accessed September 2016. https://www.ncbi.nlm.nih.gov/pubmed/24933583

[24] DiLonardo, Mary Jo. "What are Probiotics?" WebMD. Accessed September 2016. http://www.webmd.com/digestive-disorders/features/what-are-probiotics