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# The Experience of Homelessness and its Effects on Gut Eubiosis

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# The Experience of Homelessness and its Effects on Gut Eubiosis

By

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# Abstract

Microorganisms which populate the human gastrointestinal tract (GIT) have a profound effect on overall human health. The relationship between host health and eubiosis, or balance, of the GIT microbiome is symbiotic and can have reciprocal relationships with quality of sleep, quality of diet, stress and mental health, and the experience of pain. These specific aspects of health are unique in populations experiencing homelessness due to the multi-dimensional and complex nature of their lived experience. Very few studies explore populations experiencing homelessness, with even fewer investigating the intersection between this population and the human GIT microbiome. It is important to do research examining how health is impacted by GIT microbial interactions in underserved populations in order to find solutions to societal public health crises. In this thesis, a literature review explores how quality of sleep, quality of diet, stress and mental health, and the experience of pain are related to both the GIT microbiome eubiosis and the experience of homelessness. Furthermore, a qualitative study (n=15) done at Rose Haven, a women, children, and gender-inclusive day shelter in Portland, Oregon, works in parallel to offer powerful perspectives that are underrepresented in this field. Further research is needed to consider potential microbial-tools as therapeutic treatments for health issues faced by this specific population.

# Introduction

## The Experience of Homelessness and General Health Implications

The experience of homelessness, displacement, or poverty is not one dimensional. The definition of these experiences cannot be narrow, as the people experiencing them are not. Many have attempted to summarize the diverse experience of homelessness. The Department of Housing and Urban Development's (HUD) definition of homelessness includes: 1) those living in a place not meant for human habitation including those exiting an institution, 2) people at risk of losing their primary nighttime residence within 14 days, 3) families with children, or youth-headed households, with unstable housing, and 4) those fleeing or attempting to flee domestic violence (HUD, 2009). Others define homelessness in more depth, noting that there are differences between those who are "long-term" homeless, "episodically" homeless, and "short-term" homeless (May, 2000). For the sake of this study, the experience of homelessness will be encapsulated by both definitions and will be broadened to include individuals experiencing poverty and/or abuse. While this definition works to standardize the findings in this thesis, it is important to acknowledge that the experience of homelessness, displacement, and poverty is varied, individual, and most of all, human.

Members of society who experience homelessness face many forms of deprivation, including physiological, mental, and spiritual (Sommerville, 2013). Homeless Link, a national charity in England, opened a survey to people who are experiencing homelessness. Out of the 522 responses, 82% of respondents from 2018-2021 reported having a

diagnosed mental health condition (Homeless Link, 2022). Increased rates of infectious diseases and chronic diseases among those experiencing homelessness were also reported from a study performed in Philadelphia (Hibbs et al., 1994). Further, when compared with the general youth population of Quebec, it was found that mortality rates of youths utilizing the services of community-based street youth agencies were 9 times higher for men and 31 times higher for females (Roy et al., 2004). Those experiencing homelessness are at an extremely high risk for many health issues, especially mental health issues.

In addition to experiencing increased physical and mental health risks, many people experiencing homelessness do not have adequate access to healthcare. This lack of access can come from inability to obtain health insurance due to employment or housing barriers. It can also come from difficulty locating treatment due to transportation obstacles or mental health barriers. These complications can lead to the general undertreatment of medical issues in those experiencing homelessness (Davis et al., 1983). Overall, it is extremely hard to treat illnesses (both physical and mental) when those experiencing homelessness have no opportunity to receive treatment and no safe space to actually apply treatment strategies.

While many dimensions of health and disease have been studied in human populations, very few explore populations experiencing homelessness. One emerging area of human health research is the human gastrointestinal tract microbiome. This field of study is relatively new, and research remains narrow to animal studies or particular human populations including healthy individuals (Arumugam et al., 2011), indigenous populations (Sánchez-Quinto et al., 2020), and special medical cases such as pregnancy (Turjeman et al., 2021). Adding to this research by investigating how health is impacted by GIT microbial

interactions in underserved populations is not only important, it is a necessary step toward reaching solutions to societal health crises.

# Gut Microbiome

## Defining Terms

Microbiota are small single-celled microorganisms, for example, bacteria, viruses, protists, and fungi (Bui, 2023). Microbiota can be beneficial or harmful to humans depending on the nature of the specific microorganism as well as its environment. The gastrointestinal tract, or GIT, is one of the most populated organs in the human body when it comes to microbiota, with the colon containing 70% of all microbiota in the GIT (Iebba et al., 2016) and bacteria making up 98% of these microbiota (Manichanh et al., 2012). When the microbiota in the GIT are in a state of interspecies balance, this is defined as *eubiosis.* The opposite state, or an unbalanced state of microbiota in the GIT, is defined as *dysbiosis.* The entirety of a group of microbiota colonizing a certain area is called a *microbiome.*

A recently discovered and powerful aspect of the microbiome is the influence of the gut microbiome on behavior, specifically mental health. This is explained by a bi-directional connection between the GIT and the central nervous system called the *gut-brain axis* (Kusich, 2018). The gut-brain axis works to connect the GIT and the brain through endocrine pathways, enteric nervous system pathways, immune pathways, efferent, and afferent neuronal signals (Sandhu et al., 2017). The microbiota present in the GIT have the ability to influence these various pathways through interactions with the gut-brain axis. For instance, studies carried out on mice with altered intestinal microbiota have shown changes in behavior, including reduction or decrease in anxiety-like behavior (Foster et al.,

2013). Further, when GIT microbiomes of human subjects were analyzed, it was found that there were differences in diversity and levels of specific bacterial taxa in patients with major depressive disorder (MDD) or clinically significant depressive symptoms compared to those without said symptoms. This shows the dynamic connection between the brain, behavior and the GIT microbiome, emphasizing the importance of the gut-brain axis (Jiang et al., 2015).

# The Importance of GIT Microbiota to General Human Health

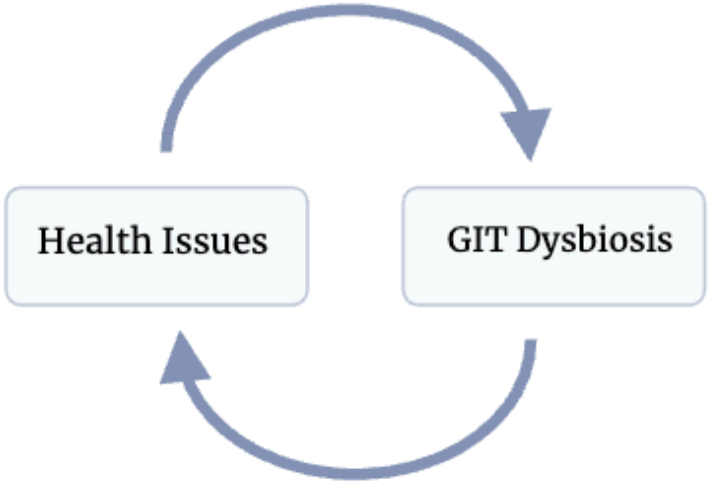


Figure 1. Demonstrates the cyclical relationship between health issues in human hosts and GIT dysbiosis.

The relationship between host health and eubiosis of GIT microbiota is cyclical and symbiotic (Figure 1.) The microbiota in the GIT influence human health just as much as they are influenced by their human hosts' overall health. Health issues influenced by external factors, such as the experience of homelessness, can ultimately end up influencing the balance of the GIT microbiota.

One of the most prominent ways the GIT microbiome influences human health is through aid in digestion and absorption of nutrients. Microorganisms in the GIT can increase or decrease metabolism rates in their human hosts and can also process molecules that humans cannot adequately process, creating products that are necessary for survival, such as B-vitamins, folates, and amino acids (Magnúsdóttir et al., 2015). The GIT

microbiome is also extremely important to the human immune system. Interactions between the GIT microbes and the intestinal immune system are crucial to maintaining homeostasis and inhibiting inflammation in the body. Dysfunction in communication between GIT microbes and the intestinal immune system can cause a number of inflammatory health issues such as irritable bowel disease, rheumatoid arthritis, systemic lupus erythematosus, etc. (Shi et al., 2017.)

Human health is influenced by diet, environment, genetic makeup, and other factors. The state of human health is not solely dependent on the balance of the GIT microbiome. Despite the root causes of certain health issues, however, it is true that the GIT microbiome will be influenced by the state of health of the host and will subsequently further influence the host. This is a crucial acknowledgement, particularly when investigating a population that experiences homelessness. External health factors in this population may exist at extremes and may contribute to persisting chronic conditions, which must be recognized in this work.

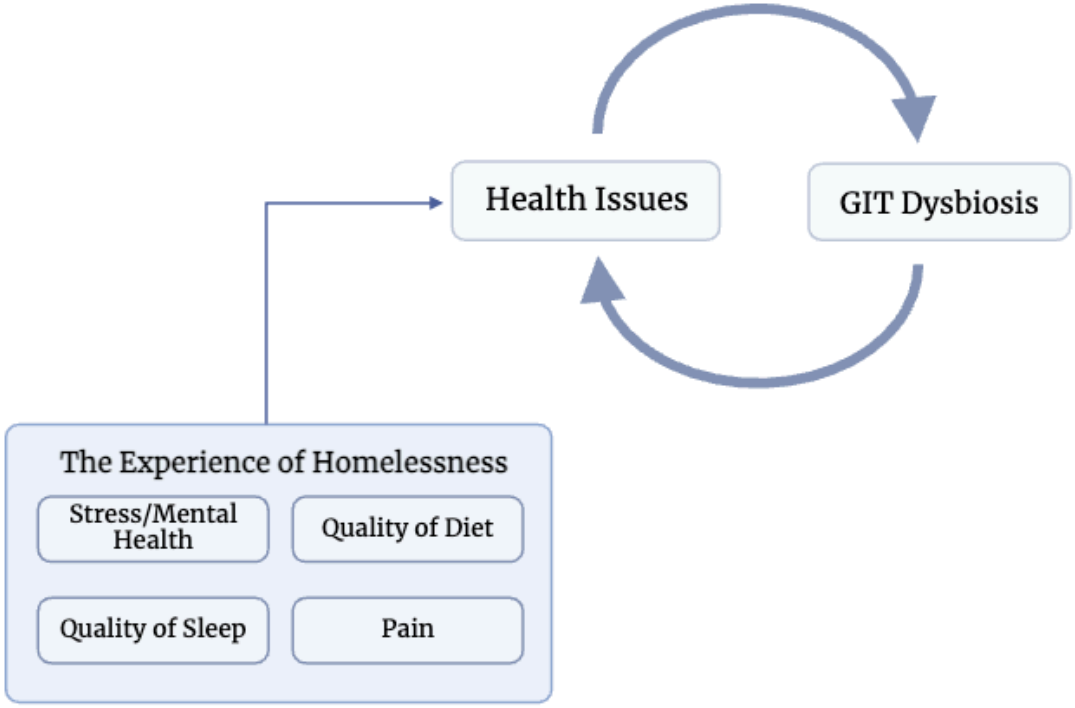


Figure 2. Demonstrates how the experience of homelessness is intertwined with health issues and GIT dysbiosis.

In this thesis, I will look at the intersection of the human microbiome, the experience of homelessness, and health. I will first focus on specific health factors that those experiencing homelessness face in the form of a literature review. These specific health factors include: quality of sleep, quality of diet, stress and mental health, and the experience of pain. I will then investigate how these health factors interact with the GIT microbiome (Figure 2.) In a separate research section, I will analyze original surveys administered to guests at Rose Haven, a local women, children, and gender-inclusive day shelter, in order to evaluate the health states of those experiencing homelessness. Through this research, I

hope to generate interest into solutions or further research about chronic pain, stress, and other health conditions tied to gut health that those experiencing homelessness face.

# Literature Review

## Sleep

### Sleep & GIT Microbiome

Sleep is extremely interrelated with the microbiota in the GIT. Despite not being exposed to the light-dark cycle, GIT microbes are still impacted by daily host-driven environment changes such as nutrient availability, antimicrobial peptides, and autoantibodies. The microbes in the GIT work in symbiosis with their human host, exhibiting different structural and compositional functions at different times of the day (Liang et al., 2017). Not only do GIT microbiota change in concert with their host environment, increased GIT microbiome diversity has also been found to be significantly correlated to sleep efficiency (Smith et al., 2019). More specifically, increased diversity and richness within the *Bacteroidetes* and *Firmicutes*, two key microbial phyla in the GIT microbiome, were found to increase sleep efficiency.

In order to understand this complex relation between GIT microbiota and sleep in humans, a fundamental understanding of circadian rhythms must be established. Circadian rhythms are an internally derived cyclic mechanism that organisms have adapted to fit the 24 hour light-dark cycle. These rhythms time events such as feeding, temperature regulation, sleep-wake cycles, hormone secretion, and more. This cycle is crucial in maintaining physiological processes in many organisms, including mammals and microorganisms.

Specific pathways in bacterial metabolism have been shown to fluctuate within the 24-hour cycle, suggesting that GIT microbiota in human hosts change in makeup and function in correlation with the circadian rhythms of the host. Furthermore, a study using mice as a model organism found that changes in sleep and circadian rhythms (such as simulated jet-lag) led to dysbiosis in the gut (Thaiss et al., 2014). A separate study found that microbiome diversity is significantly and positively correlated with sleep efficiency (Smith et al., 2019). This symbiotic connection between circadian host rhythm and GIT microbiota is key in understanding how important sleep is in balancing the GIT microbiome.

Microbiota in the GIT also modulate the synthesis or secretion of neurotransmitters, cytokines, and metabolites that influence sleep through their metabolic activity. For example, some gut bacteria can influence chromaffin cells in the gastroenteric tract into secreting serotonin, a necessary neurotransmitter known for its role in sleep and mood. Further, *Lactobacillus* and *Bifidobacterium*, two common members of the gut microbiome, can secrete GABA, an inhibitory neurotransmitter known for producing a calming effect. Abnormal expression of GABA mRNA happens in patients with insomnia and depression (Li et al., 2018). Through the production of these metabolites, microbiota in the GIT are able to influence sleep.

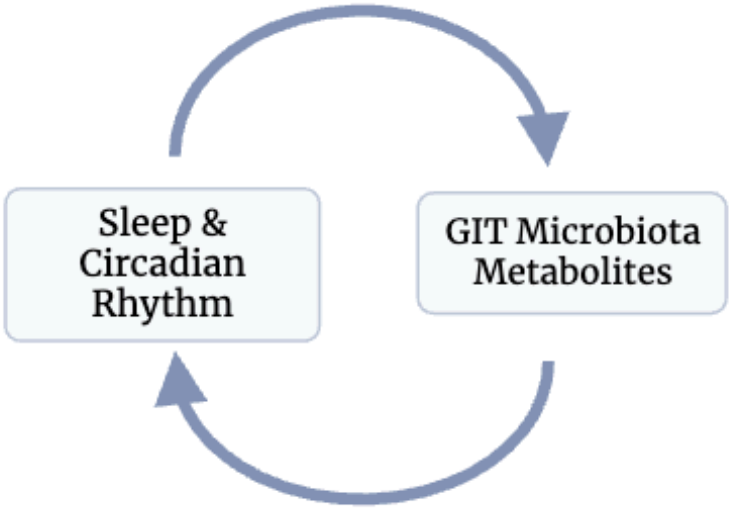


Figure 3. Shows the relationship between sleep, circadian rhythm, and GIT microbiota metabolites.

The association between sleep and GIT microbiota is a complex symbiotic connection. GIT microbiota are affected by human host circadian rhythms, and are able to influence human hosts through metabolites (Figure 3). This connection is cyclical, and changes in either microbiota activity or human host circadian rhythm have the potential to cause dysbiosis.

## Sleep & Homelessness

For those experiencing homelessness and poverty, sleep is a uniquely challenging physiological and emotional experience that can affect the GIT microbiome. In the community, “sleeping rough” is a term that describes the common experience of attempting to sleep in urban nooks and crannies, abandoned buildings, bus shelters, under bridges, or urban encampments located in parks or industrial areas (Larissa Larsen, et al). This terminology can also refer to temporary or permanent shelter which may be inadequate for sleep. It is possible for an individual experiencing homelessness and/or poverty to experience sleeping rough despite having shelter. Sleep interruptions or disturbances are the main factor in rough sleeping.

According to an analysis of surveys performed on adults experiencing homelessness in Denver, Colorado, participants reported sleeping only 3.6 hours each day or night. On average, participants only slept 2.87 hours without being interrupted (Calhoun & Chassman, 2021). The American Academy of Sleep Medicine as well as the Sleep Research Society developed a consensus recommendation for the amount of sleep needed to prompt optimal health in adults, a contrasting 7 or more hours per night on a regular basis. The obvious disparity not only increases health issues in those experiencing homelessness, but perpetuates a cycle of poverty due to increased pain, impaired immune function, increased errors, and greater risk of accidents (Watson et al., 2015). This cycle of sleep interruption and health issues has the potential to cause dysbiosis of the GIT microbiome.

Further, sleep interruptions or disturbances are correlated to both emotional security and state of mind. In a survey conducted on transition age youth experiencing homelessness in Los Angeles, California, it was found that sleep disturbances were

positively associated with feeling unsafe in one's sleep environment (Redline et al., 2021). In a separate study which focused on qualitative interviews with women experiencing homelessness, many participants expressed a constant state of stress which led to sleep disturbances. "You don't get to relax and rest because you're fighting a battle all the time," one subject stated in an interview (Groton & Spadola, 2023). Exposure to violence has also been shown to be significantly associated with insufficient sleep, emphasizing the importance of fear based emotions and sleep (Agwrawal et al, 2024). As mentioned in the previous section, circadian rhythms are crucial in maintaining the symbiotic relationship between sleep and the GIT microbiome. Sleep interruptions which homeless community members face can have the potential to cause circadian rhythms to become unstable. Organisms in the GIT microbiome which have adapted to these rhythms can be affected negatively and increase gut dysbiosis.

Additionally, legislature and social stigmas actively discriminate against those who experience homelessness, and directly impact accessibility to safe, restful sleep. For example, local Portland, Oregon Ordinance 191311 in compliance with HB 3115 instills a constant fear of police interaction, threatening up to 7 days in jail or fines up to $100 for camping in public spaces. This directly targets the quality and availability of safe sleep among those experiencing homelessness. Furthermore, availability to safe overnight shelters is extremely difficult to secure, with many waitlists and/or specific requirements.

Inadequate sleep environments lead to an overall decreased quality of sleep for those experiencing homelessness. This community struggles significantly with sleep health, and particular discriminatory obstacles also contribute to this sleep deprivation. It is important to note the ways in which sleep is uniquely affected by intersectional barriers.

These barriers, through their impacts on overall health, can interact with the GIT microbiome. As explained in the previous section, microbiota in the GIT modulate and are modulated by host activity. When hosts are facing unique sleep challenges, it could be possible that the GIT microbiome itself will also experience changes which lead to dysbiosis.

# Stress & Mental Health

## Stress, Mental Health, & GIT Microbiome

Microorganisms are involved in multiple routes of communication between the GIT and the brain. These communication paths include the vagus nerve, gut-hormone signaling, tryptophan metabolism, and microbial metabolites (Foster et al., 2017). This connection between the gut and brain is also called the gut brain axis, previously defined as the bi-directional connection between the GIT and the central nervous system, and is one of the major pathways through which stress related responses and mood are related to gut dysbiosis. There is a large body of evidence suggesting that this route of communication is important in regulating stress, which is a persistent component of the experience of homelessness.

Microbes can interact with host stress in several different ways. In an animal study performed in 2004, it was shown that germ-free mice had an elevated response to restraint stress, portraying an exaggerated hypothalamic-pituitary-adrenal (HPA) reaction through the measurement of elevated corticosterone and plasma adrenocorticotropic hormone. This increased HPA reaction was able to be reversed by recolonization of the mouse GIT with *Bifidobacterium infantis* (Sudo et al., 2004). Not only have specific microbes been found to affect stress responses, but certain microbial metabolites (short-chain fatty acids) have been found to alleviate increased stress responsiveness and anhedonia in mouse models (van de Wouw et al., 2018).

Furthermore, there is also a strong body of work suggesting a connection between the GIT microbiome and various mental health conditions. People experiencing homelessness endure many mental health-related conditions including anxiety, major

depressive disorder, irritable bowel syndrome, and bipolar disorder (Nguyen et al., 2018), and Alzheimer's (Karout, 2022). These specific mental health conditions have shown to be influenced by the GIT microbiome. In a study comparing fecal microbiota composition in patients with major depressive disorder, it was found that there were both differences in overall diversity levels as well as levels of specific bacterial taxa (*Lachnospiraceae* and *Ruminococcaceae*) when compared to a control group (Jiang et al., 2015). GIT microbial community differences have also been observed in those with bipolar disorder, specifically showing decreased representation of *Faecalibacterium* and a member from the *Ruminococcaceae* family (Nguyen et al., 2018). Infection and increased gut inflammation is correlated with an increase in anxiety-like behavior. Multiple animal studies have shown that the presence of pathogenic bacteria in the GI tract can increase anxiety-like behavior (Foster et al., 2018).

Stress and mental health have been shown to be extremely interrelated with the GIT microbiome. Proof of direct effects of GIT microbiota on the HPA-axis as well as correlations between certain mental disorders and specific bacterial taxa in the GIT are prevalent in literature. The importance of GIT microbiota on stress and mental health is unmistakable, and further research is promising in showing further connections. As described in the previous section, those experiencing homelessness are at a higher risk for mental health disorders and stress-related disorders. Given these overlapping patterns, more research needs to be done to investigate the connection between stress, the GIT microbiome, and the population of those experiencing homelessness.

## Stress, Mental Health & Homelessness

Struggles with stress and mental health in populations experiencing homelessness are unfortunately extremely pervasive and thus another threat to healthy symbiosis between people and their microorganisms. As discussed in the previous section, microbes are involved in both the regulation of stress response pathways as well as bi-directional pathways between the GIT and the brain. Of all those experiencing homelessness, a minimum of one third self-report one or more psychiatric illnesses (Lippert et al., 2015). According to the Substance Abuse and Mental Health Services Administration, individuals experiencing homelessness face an increased mortality rate due to suicide, with more than half reporting suicidal thoughts or attempts. The increased risk of stress and mental health disorders in this population can increase the prevalence of GIT dysbiosis.

Various factors unique to those experiencing homelessness contribute to disproportionate mental health crises. These factors indirectly affect and are affected by the GIT microbiome through their shared connection to physiological stress and mental health responses. General health problems, lack of access to medical care, and exposure to violence are main contributors which escalate mental health disorders in this population. In general, mortality rates due to mental health conditions are significantly higher among those experiencing homelessness than the housed population. For example, a cohort of unsheltered homeless subjects in Boston had a calculated standardized mortality ratio of nearly 3.0, where a ratio greater than 1.0 indicates more deaths than expected (Richards & Kuhn, 2023). Not only are mortality rates and health issues strikingly higher in this population, there is also an association with lower health-care utilization. This is often due to a lack of health insurance or financial stability required to consistently utilize healthcare

in the USA (Davis et al., 1983). Furthermore, unsheltered women are extremely likely to experience physical assault and robbery, increasing the occurrence of violent trauma and injuries. All of these barriers culminate in a largely unmet physical and mental-health need in the population of those experiencing homelessness. Increased exposure to obstacles which exacerbate stress and mental health crises in homeless populations can also increase the probability of GIT dysbiosis. As discussed in the previous section, there are multiple pathways between stress related responses, mood, mental health and the GIT microbiome. The bi-directional gut-brain axis directly affects both overall diversity of the GIT microbiome as well as the presence or absence of certain microbial taxa. It is important to explore this relationship in more depth, with the intention to find therapeutic and systemic solutions.

# Pain

## Pain & GIT Microbiome

Microbial dysbiosis in the gut also influences pain regulation, which people experiencing homelessness experience in unique ways. Pain can be defined as a subjective sensory and emotional experience which may or may not be associated with actual damage to tissues (Guo et al., 2019). Through extensive animal and human research, the GIT microbiome has been shown to be an extremely important regulator when it comes to visceral pain (i.e. pain originating from internal locations) as well as chronic pain (pain that persists longer than an average recovery period).

The GIT microbiome modulates visceral pain through several mechanisms. Visceral pain is the most common type of pain, manifested by the physical and emotional experience which occurs when internal organs are inflamed, diseased, damaged, or injured (Collett, 2013). The experience of visceral pain is linked to peripheral sensory nerves as well as spinal and cortical pathways in the central nervous system. These pathways can be altered by GIT microbiota. In rodent studies, various probiotic bacterial strains such as *Bifidobacteria*, *Lactobacillus acidophilus*, *Faecalibacterium*, and *Lactobacillus paracasei* NCC2461 improve visceral pain. Interestingly, in contrast, antibiotic administration of Vancomycin and other antibiotic cocktails benefits humans experiencing abdominal pain. In a separate study, visceral hypersensitivity was shown to be transferred via fecal transplant of mice with IBS to germ-free mice (Guo et al., 2019). Through the addition of microbes to the GIT via probiotics, as well as the potential decrease in certain microbes in the GIT via antibiotic administration, visceral pain has shown to be affected. The complex nature of

interactions between GIT microbes and pain regulation may manifest differently in those experiencing homelessness due to their unique and multi-faceted exposure to pain.

Furthermore, gut microbes may also regulate the experience of chronic pain. Many signaling molecules and other metabolites that are derived from gut microbiota act on receptors which ultimately mediate the development of chronic pain. In general, it has also been found that chronic widespread pain (CWP) is associated with decreased alpha diversity of the GIT microbiome (Freidin et al., 2021). Additionally, chronic abdominal pain due to various gastrointestinal (GI) disorders such as functional dyspepsia and irritable bowel syndrome (IBS) are well linked to alterations in the GIT microbiome.

Newer evidence suggests that GIT microbiota may also be involved in other types of chronic pain, including inflammatory pain. A recent study investigating the connection between the GIT microbiome and CWD found that the bacterium *Coprococcus comes* significantly decreased in those with CWD compared to those without (Freidin et al., 2021). Unsurprisingly, *C. comes* is a microbe which produces butyric acid, a strong compound that exhibits exceptional anti-inflammatory effects on the gut. The importance of this metabolite in regulating inflammatory pain is paramount. For populations experiencing homelessness, chronic pain is not uncommon. Research discovering relationships between chronic pain and certain microbial species, such as *C. comes*, offer hope for potential therapeutic solutions which can be offered to this population.

## Pain & Homelessness

Acute, visceral, and chronic pain affect those experiencing homelessness in extreme and unique ways. Those experiencing homelessness face increased financial instability, transportation obstacles, and lack of access to medical care, all of which can exacerbate the experience of pain. Pain is also intricately interwoven with bi-directional neural pathways between the GIT and the brain. Through these pathways, the balance and makeup of the GIT microbiome impacts how pain is experienced.

When investigating pain, it is first important to note that those experiencing homelessness face many challenges when attempting to access healthcare services. These challenges can cause health issues to worsen, manifesting in an increased experience of pain (visceral, acute, and/or chronic). Lack of access to insurance, financial instability which hinders access to expensive treatments, and difficulty locating treatment due to transportation obstacles exemplify barriers to accessing healthcare in the USA. The Substance Abuse and Mental Health Services Administration states that 60% of those experiencing homelessness lack health insurance, a drastically high number. In addition to a lack of health insurance, the cost of health treatments in the USA is exorbitant. The average cost of a hospital stay in the USA now exceeds $2,000, a cost that most experiencing homelessness cannot afford to pay. Furthermore, a study analyzing those who lack health insurance found that 25% of uninsured folks must travel 30 minutes or more to obtain care, compared to only 18% of those who are insured (Davis et al., 1983). The culmination of these challenges impede on the ability of those experiencing homelessness to access consistent and quality healthcare. The physical repercussions of this manifest mainly in the

form of chronic, untreated diseases, and other forms of unmanageable pain, all of which can be influenced by the GIT microbiome.

Because chronic pain disproportionately affects those who experience homelessness, the GIT microbiome of these populations is also uniquely impacted. To further emphasize the reality of this disparity, it was found that over 35% of participants were classified as experiencing Grade IV (high disability-severely limiting) chronic pain, and over 50% of participants experienced chronic pain in general (Hwang et al., 2011). Compared to the 11% of the general population of the USA which experiences chronic pain, this number is astoundingly high. In a separate study, over 70% of shelter users reported experiencing pain in the past 24 hours, with lower limbs and abdomen regions as the most common site of pain. I propose that the chronic pain faced by populations experiencing homelessness may be effectively managed by microbial-based therapeutics. Those experiencing homelessness are at a higher risk of developing substance abuse disorders (Polcin, 2016), which is why investigating microbial based therapies as a solution to chronic, visceral, and/or inflammatory pain management compared to traditional addictive pain analgesics for this specific population is so important. More research must be done to investigate how these solutions can be mindfully offered to these vulnerable populations, taking into consideration the various obstacles to healthcare described above.

# Diet

## Diet & GIT Microbiome

Quality of diet is one of the most directly impactful factors relating to the GIT microbiome. The microbes which live in the GIT rely on host food residues for both survival and metabolism (Wilson et al., 2020). Many microbes process these residues and ultimately contribute to host health by synthesizing vitamins, essential amino acids, and other by-products which human hosts cannot synthesize themselves. Diet is one of the most important aspects contributing to the symbiotic relationship between human hosts and their microbes, meaning that changes in diet can cause the most alteration of the GIT microbiome, leading to various health issues. The quality of diet should therefore be prioritized in populations experiencing homelessness.

Humans rely on GIT microbiota to synthesize vitamin K and most water-soluble B vitamins (biotin, cobalamin, folates, nicotinic acid, pantothenic acid, pyridoxine, riboflavin, and thiamine) (LeBlanc et al., 2013). Many members of the Bifidobacterium genus are involved in the synthesis of folates which are important to various essential cellular metabolic functions such as DNA replication, repair and methylation, and synthesis of nucleotides and certain amino acids (Pompei et al., 2007). Additionally, vitamin B-12 is synthesized by bacteria and is required for DNA synthesis, methylation, and folate metabolism. Deficiency can cause impairments in cell division, erythropoiesis, DNA stability, and neurological function (Guetterman et al., 2021). Menaquinones (a form of vitamin K) are also synthesized in the gut by bacteria and are important for the function of coagulation factors, osteocalcin, and can also help with bone health (DiNicolantonio et al.,

2015). In general, human hosts form a symbiotic relationship with GIT microbiota in order to obtain vitamins for various physiological functions.

The amount, type, and availability of nutrients which are provided to these microorganisms relies directly on the human host diet. Different types of diets can therefore induce large shifts in microbial activity and diversity (Singh et al., 2017). Multiple studies have shown that fruit and vegetable consumption is correlated with increased microbial diversity. Certain types of plant derived dietary fiber and polyphenols (aromatic plant synthesized molecules) have been proven to both increase and decrease certain bacterial taxa in the gut (Merwe, 2021). Contrarily, “Western” diets (diets with high amounts of animal fat and protein, and processed carbohydrates) cause decreased overall microbial diversity as well as decreased levels of certain beneficial species. The quality of diet is not only important for increasing the ability of microbes to metabolize important molecules, it is also important for improving the general diversity of the GIT microbiome.

## Diet & Homelessness

Diet is intricately linked to the composition of the gut microbiome. Particular diets, such as those high in fiber (Tanes et. al, 2021) are of great benefit to both the health and diversity of the GIT microbiome. However, access to and maintaining a balanced diet is extremely challenging for those experiencing homelessness. Many do not have the resources to adequately store or cook healthy foods (Seale et. al, 2016). Food insecurity due to housing instability causes major disruptions to a healthy diet. In the course of a year, 6 million families with children have experienced food insecurity, and 1.5 million children lived in families experiencing hunger (Gundersen et. al, 2003). Access to food of any kind, healthy or unhealthy, is prioritized in those experiencing food insecurity. This strenuous experience of diet in homeless populations can drastically alter the GIT microbiome through direct relationship between microbes and host nutrient availability.

Those experiencing homelessness face specific obstacles, including housing instability and lack of access to kitchens and storage spaces, which further perpetuate food insecurity. This food insecurity can cause dysbiosis in the GIT microbiome, affecting overall health. According to the USDA, food insecurity can be categorized as low, indicating reports of reduced quality, variety, or desirability of diet, or very low, indicating reports of disrupted eating patterns and reduced food intake. A national study found that among those with housing instability, 76.7% reported food insecurity. This is almost double when compared to the 42.7% of general respondents (Kushel et. al, 2006). Furthermore, those who experience housing instability often do not have access to kitchen, microwaves, or stoves, limiting cooking techniques as well as type of meals (Share, 2017).

Food insecurity caused by housing instability in populations experiencing homelessness is a complex experience which can have detrimental health outcomes that ultimately modify the balance of the GIT microbiome. Studies have shown that food insecurity is associated with decreased nutrient intakes, increased mental health issues, diabetes, hypertension, poor sleep outcomes, and more (Gundersen et. al, 2015). Those experiencing homelessness and food insecurity have proven to experience malnutrition, specifically possessing significantly lower vitamin A, zinc, magnesium, potassium, and selenium levels. In general, those experiencing food insecurity and homelessness also have significantly less energy intake as well as dietary fiber (Sprake et. al, 2014). As previously discussed, microbes which live in the GIT rely directly on host food residues for both survival and metabolism. The significant changes in diet described above which those experiencing homelessness face can have the potential to cause GIT dysbiosis.

# Community Surveying

## Rose Haven

Rose Haven is the only day shelter and community center specifically serving women, children, and gender-diverse people in Portland. The organization offers an array of services to help homeless and abused women, children, and gender-diverse folks improve their lives. Services include resource referrals, one-on-one counseling, support groups, showers, clothing and outdoor gear, an on-site clinic, financial assistance, laundry, and much more. Rose Haven is also a space of healing. They are open five days a week from 9AM to 4PM. The work at Rose Haven is made possible by an exceptionally dedicated staff of 24, more than 1000+ volunteers, 59 interns, 100+ community partners, and thousands of in-kind financial donors. According to the 2023 Annual Report, 29,935 visits were made during hospitality hours and 66,280 nutritious meals were served to the community. Over 4,000 guests were able to take private showers, promoting dignity and respect. Over 500 guests received  individual counseling sessions. Rose Haven enters its 27th year and continues to serve the greater Portland community.

# Research Methods

Fifteen randomized surveys were conducted during services at the Rose Haven Day Shelter in Portland, Oregon. The studies were conducted with pen and paper anonymously, with verbal consent as a substitute for written consent due to privacy and safety concerns. All materials and methods were approved by the Institutional Review Board. I was able to walk around community tables, areas, and cafeteria areas to ask if anyone would be interested in taking the survey. The surveys were eleven questions long and took approximately 3-5 minutes for each subject to finish. Survey questions are included in Box 1.

## Box 1. Survey questions

1. Do you sleep more at night or during the day?
   - ❑ Night
   - ❑ Day
2. On average, how many hours of sleep do you get every 24 hours?
   - ❑ 1-3
   - ❑ 4-6
   - ❑ 8-10
3. Where do you sleep for the majority of the week (4+ days)?
   - ❑ Outside
   - ❑ Inside
4. Are you currently experiencing any physical pain?
   - ❑ Yes
   - ❑ No
5. Do you experience chronic pain? (This is pain that lasts weeks or even years.)
   - ❑ Yes
   - ❑ No
6. On average, how would you rate your daily stress level?
   - ❑ Low stress
   - ❑ Average stress
   - ❑ High stress
7. Do you experience any mental health conditions such as depression, anxiety, bipolar disorder, or PTSD?
   - ❑ Yes
   - ❑ No
8. How many meals a day do you eat?
   - ❑ 0-1
   - ❑ 2-3
   - ❑ 4-5
9. How often do you eat vegetables?
   - ❑ Never
   - ❑ Rarely
   - ❑ Sometimes
   - ❑ All the time
10. How often do you eat fresh fruits?
    - ❑ Never
    - ❑ Rarely
    - ❑ Sometimes
    - ❑ All the time
11. How often do you eat processed/packaged food?
    - ❑ Never
    - ❑ Rarely
    - ❑ Sometimes
    - ❑ All the time

# Research Ethics

When deciding to pursue community surveying for this thesis, the question of research ethics due to the vulnerable nature of this specific community came to light. As mentioned in the introduction, the experience of homelessness, displacement, or poverty is not one dimensional. When using "vulnerable" to describe this population, it must be clear that the descriptor is assigned *situationally* through a lens of intersectionality rather than ascribed simply and categorically. A person may find themselves in a situation of experiencing homelessness due an accumulation of life experiences, identities, and discrimination. This lens is important when working with those in vulnerable situations because it allows researchers to appreciate the stories, needs, and humanity of those behind the data.

One of the most important concerns with this survey was the sensitive nature of privacy. Many guests at the specific shelter where community surveying was done are victims of domestic violence. Ensuring their privacy and safety when creating public knowledge was of the utmost importance. In order to ensure safety for all guests, all surveys were done in accordance with the Institutional Review Board with an amendment for signatureless consent. This meant that absolutely no identifying information at all was included on any survey. Consent was asked for verbally using a pre-written script. If guests did not speak English, a translation was provided.

Another important concern was whether or not monetary or non-monetary compensation was to be provided for the completion of these eleven question, multiple choice surveys.  It is important to find a balance between a rate of payment that is high

enough to not exploit subjects, but still low enough that it does not have a coercive effect on subjects (Beauchamp et al., 2002). Those who are lacking in resources, experiencing poverty, and/or experiencing homelessness are in a vulnerable position and non-monetary inducements that are hard to quantify (such as bus tickets or extra clothes) for participation in studies may be exploitative, coercive, and will discredit true, informed consent and were not used in this study. The questionnaire in this study was concluded to be non-harmful by the Institutional Review Board, in that exposure to participants would not cause long lasting emotional or physical harm. After review with staff at Rose Haven, it was decided that the surveys would be completely voluntary and no monetary compensation would be provided. In general, the qualitative data obtained from these surveys was meant to be anecdotal and powerful, to show a perspective that is underrepresented in this field. The data obtained works in parallel with the information found in the literature review of this thesis.

The comfortability of the guests was one of the final most important considerations during these surveys. It was important that the guests knew who I was outside of the surveying environment. This was not intended to cloud the judgment of those choosing whether or not to participate. The main intention was to offer a safe space to comfortably consent. A certain impactful interaction with a guest showed the success in this community-first approach to surveying. When approaching a group of guests to ask for verbal consent to surveying, one person had initially enthusiastically agreed to filling out the survey. I had passed them the paper and pen, when they suddenly said, “Actually, I think I’ve changed my mind, I will pass on the survey today.” I collected the unfilled survey back from her. This interaction proved that I was cultivating a research environment that I was

proud of. This person felt comfortable enough in order to consent to taking the survey, as well as revoke said consent only a few moments later. This was an ethical success due to prioritizing spending time with the community to be surveyed.

# Results

The results of the surveys were analyzed using nonparametric techniques due to the small sample size ($n$ = 15) and the risk of extreme values skewing results. Of the 15 participants, all spoke English except one participant who spoke Mandarin, and a translated survey was provided.

First, I considered the participants' experience of sleep. I found that 33.3% of guests reported sleeping outside for the majority of the week (4+ days). Only 53.3% reported sleeping more at night of the participants, while 33.3% reported sleeping more during the day. Sixty percent (60%) of participants reported an average of 4-6 hours of sleep every 24 hours, and 20% reported 1-3 hours. One individual subject crossed out all answer choices and wrote in "0" when questioned if they sleep more during day or night as well as when questioned about the average number of hours of sleep obtained every 24 hours. A different individual crossed out all answer choices and wrote that they sleep more both during the "day and night".

Next, I examined the participants' experience of mental health and stress. I found that 80% of participants reported experiencing mental health conditions (such as depression, anxiety, bipolar disorder, or PTSD), with one individual writing that they experience complex post traumatic stress disorder (CPTSD). Over 40% of participants reported experiencing high stress levels. I noted that 80% of the participants who live outside for the majority of the week reported high stress levels, double that of the general sample.

Additional questions related to pain found that 66.7% of participants reported current physical pain and 53.3% experienced chronic pain. Fifty percent (50%) of those

who reported experiencing chronic pain also reported a high average daily stress level. Furthermore, 100% of participants who reported experiencing chronic pain also reported experiencing mental health conditions (such as depression, anxiety, bipolar disorder, or PTSD).

Questions about diet included the most alterations to question answers by participants. Sixty percent reported eating 2-3 meals per day, and 26.7% reported eating 0-1 meals per day. When questioned about frequency of consumption of packaged food, 20% answered “Rarely,” 46.7% answered “Sometimes,” and 33.3% answered “All the time.” However, one individual wrote “Most of the time” next to their answer choice (which was “Sometimes”) and a different individual wrote “I HATE IT” (referring to packaged food) adjacent to the question. When questioned about the frequency of vegetable consumption, it is extremely interesting that the same exact proportions were reported: 20% answered “Rarely,” 46.7% answered “Sometimes,” and “33.3%” answered “All the time.” One particular individual wrote “All the time - when provided.” Finally, when questioned about the frequency of fresh fruit consumption, 20% reported “Rarely,” 40% reported “Sometimes,” and 40% reported “All the time.” The same individual as above wrote “All the time - when provided” for this question as well.

# Conclusion & Future Directions

This study found that those experiencing homelessness experience health stressors that could negatively affect their gut microbiome. The survey results indicate a strong disparity in the experience of mental health conditions, stress, sleep, pain, and diet in those experiencing homelessness compared to those who are housed. These results further emphasize the need for creative solutions with a microbial lens that safely and considerately address health crises specific to those experiencing homelessness. Results from the surveys performed at Rose Haven generally align with the literature discussed in this thesis. Overall, subjects self-reported a lower than average amount of sleep (4-6 hours), high stress levels and amount of mental health conditions, increased experiences with pain and chronic pain, and varied responses regarding diet.

Both systemic change and microbial-tools have the potential to work in concert in order to positively shape the GIT microbiome and therefore improve the overall health of those experiencing homelessness. Accessibility to safer, uninterrupted sleep will allow for more stable circadian rhythms, and therefore a more balanced, healthy GIT microbiome. Increased shelter beds and decreased discriminatory legislation are some ways that systemic change in our society can be implemented in order to improve sleep health, and therefore GIT eubiosis, of those experiencing homelessness. Furthermore, increased access to healthy, consistent food will also improve GIT eubiosis. Government programs, charities, and other programs which offer healthy options to those experiencing homelessness are of great importance to this issue. Additionally, more affordable and accessible health resources are critical when considering stress, mental health conditions, and pain in those

experiencing homelessness. Microbial tools, such as prebiotics, probiotics, antibiotics, and fecal transplants may be potential therapeutics to regulate both stress/mental health conditions and pain. Investigating microbial based therapies as a solution to mental health conditions and pain management compared to traditional pain analgesics or sedatives for this specific population is extremely important. It offers a medical alternative that is non-addictive and non-triggering to those in or attempting substance abuse recovery. Conscious and ethical studies exploring the GIT microbiome of those experiencing homelessness have a great potential to provide information regarding which specific microbial tools will be of most help to this population. More research is needed to discover how the GIT microbiome and microbial tools can be used to specifically improve the health and lives of those experiencing homelessness, and such research must acknowledge the complex, intersectional challenges this population faces.

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