

SciWISE

Intertwining arts and sciences

Issue 2, April 2021



Illustration by Meg Yu

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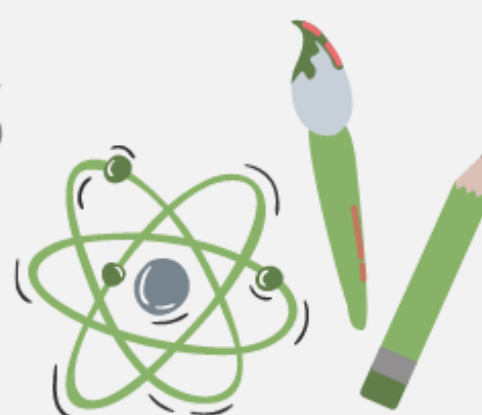
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So Many Diets and You Don't Know Which One to Choose?

An Opinion Piece/ Commentary



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So Many Diets and You Don't Know Which One to Choose?

No sugar, no fat, no meat, or even no food altogether except during a window of time every day- there are countless diets that claim to provide you with specific health benefits. However, the diversity and outcomes of each diet can leave you confused about what really is the best route when it comes to your nutrition. In fact, there are benefits and detriments to each type of diet, and their outcomes vary highly from person to person.

Let's think about this... How many people eat a well-balanced diet? How many people have a truly healthy relationship with food, that is not driven by guilt or overeating? Are people aware of possible metabolic disorders that they might have? Asking such questions and many more is essential in making the most beneficial decision when it comes to nutrition.

Individual metabolic health must be studied with aims to either resolve or mediate the condition with a particular diet. Metabolism is a combination of chemical reactions in the body that help to convert food into energy so that all of our cellular processes are fueled to function appropriately. Humans are biologically adapted to using carbohydrates/carbs (sugars) as a primary source of fuel, and fats as a secondary source. When carbs aren't available, the metabolic trajectory shifts to using fats as the primary source of fuel; this alternative process is called ketosis.¹ The Ketogenic diet that is low in carbohydrates, moderate in proteins, and high in fats, was the most popular option amongst North Americans in 2020. But, how it works and whether it works for everyone, is obscure to most people who choose to face the intimidation of consuming fats and surrendering sugary goodies. Many of those who tried the ketogenic diet for at least a month, reported a rapid reduction in weight which was followed by a stubborn plateau¹. The diet is also accompanied by severe sugar cravings, higher grocery expenses, and inaccessibility of high-fat-low-carb foods at fast-food chains and restaurants¹. Because of this, ketogenic diets do not have a good reputation in the realm of sustainability and most use it solely to lose weight, instead of permanently transitioning to this regimen.

And while the ketogenic diet is certainly not for everyone, there is a specific group of people who would be capable of, or recommended to adapt to the state of ketosis. For some, sugar metabolism forces the body into an inflammatory state² where the immune system tries to defend the cells and tissues against harm because of insulin resistance. These are people who can't naturally process sugar, and it's left in the bloodstream together with insulin, a hormone that would normally mediate sugar breakdown into usable fuel. We can then extend this understanding to those who would physiologically benefit from this diet; those with diabetes, insulin resistance, women with polycystic ovarian syndrome (PCOS), glycogen storage disease, and other conditions exacerbated by high sugar intake.

Let's take PCOS for example. This is a condition in women that is characterized by an elevated production of male hormones, androgens. For some additional context, testosterone, a widely-known hormone that contributes to male sexual development, is an androgen.³ Healthy females have some level of androgens as well, but in women with PCOS this hormone is overproduced contributing to the aforementioned symptoms.⁴ Notably, adipocytes, fat cells,

are one of the primary targets of androgens. Androgen biology is not yet comprehensively understood in the context of PCOS, but it is known that these hormones biochemically affect adipocyte quantity and size.⁴ The effect of androgens is sex and body area-specific, which is why, for instance, fat distribution differs drastically in men and women.⁴

The result of these hormonal differences is an absence or major disturbances of the menstrual cycle, the development of cysts on the ovaries, overgrowth of facial and body hair, stubborn and excess body fat, and insulin resistance.⁵ Most women affected by the disorder have trouble conceiving or become prediabetic or diabetic during pregnancy.⁶ There is currently no known treatment; however, the condition seems to be largely reversible with adherence to a low-carb dietary regimen.⁷ So, how does Keto do its magic then?

It all comes down to insulin, really. When consuming sugary foods, our body releases this hormone to stabilize glucose levels in our bloodstream by guiding glucose into our cells for further utility.¹ This may help to prevent major health concerns including nerve damage, vision problems, stroke, seizure, heart disease, and kidney failure.¹ So, insulin is a good guy, but if you consistently eat too much sugar, our cells struggle to absorb it all, and both glucose and insulin remain in the bloodstream!. Excess sugar floating in the bloodstream then gets sent to adipocytes, which just like all other cells, use it as fuel.¹ Excess glucose also prevents the breakdown of fats in the body because fat, being the secondary fuel source, will not be used.¹

When a person engages with Keto for about a week, the body goes into the state of ketosis. The body, then, is adapted to burning the fat from food and then begins to do so with our stored fat. With this, both the sugar and insulin levels decline, and since the body fat mass declines, androgens have less room to interact with one of their primary targets.⁵

And remember inflammation? Higher levels of sugar induce an inflammatory state in our body, and with the decline or absence of sugars, the body calms down and peacefully proceeds to burn the stubborn fat stores.^{3,5}

Before wrapping up, let's address the following: if a person experiences major difficulties in following the diet and sees little to no long-term benefit - the ketogenic diet is not for them because their glucose metabolism works properly! One should track their current eating habits and behaviours to gauge the degree of changes that may be necessary when establishing a flexible plan for approaching a new dietary territory.

However, good news for the ketogenic dieters who are intimidated by giving up their favorite foods - there are plenty of sugar-free alternatives. Chances are, you won't have to count calories until your body weight naturally plateaus. Your primary goal is just to feed your body what it wants to digest!

Each diet, not just Keto, should be approached with an understanding of one's relationship with food, metabolic health, and long-term sustainability., *in that order*. And so, those who are looking to or are recommended to try a new diet should look thoroughly into their own expectations, health conditions, general lifestyle, and even their budget. Misinformation is prevalent, so to make an educated decision, consider identifying the demographics for whichever diet has caught your interest. Identify common concerns (as well as their solutions), a few simple meals, alternatives to your favorite foods at home and in restaurants, and the reasons behind others' successes and failures with the given diet plan. Taking these considerations should optimize your chances at finding the best long-term dietary plan for you.

REFERNCES:

1. Phinney SD, Bistrian BR, Evans WJ, Gervino E, Blackburn GL. The human metabolic response to chronic ketosis without caloric restriction: Preservation of submaximal exercise capability with reduced carbohydrate oxidation. *Metabolism*. 1983;32(8):769-76.
- 2.. Ruskin DN, Sturdevant IC, Wyss LS, Masino SA. Ketogenic diet effects on inflammatory allodynia and ongoing pain in rodents. *Scientific Reports*. 2021;11(1).
- 3.Najem FI, Elmehdawi RR, Swalem AM. Clinical and Biochemical Characteristics of Polycystic Ovary Syndrome in Benghazi-Libya; A Retrospective study. *Libyan Journal of Medicine*. 2008;3(2):71-4.
- 4.O'Reilly MW, House PJ, Tomlinson. JW. Understanding androgen action in adipose tissue. *The Journal of Steroid Biochemistry and Molecular Biology*. 2014;143:277-84.
- 5.The Role of Obesity in Polycystic Ovary Syndrome. (2002). *Polycystic Ovary Syndrome*, 275-284. doi:10.3109/9780203910948-22
- 6.Paoli A, Mancin L, Giacona MC, Bianco A, Caprio M. Effects of a ketogenic diet in overweight women with polycystic ovary syndrome. *Journal of Translational Medicine*. 2020;18(1).
- 7.Kamalanathan, S., Sahoo, J., & Sathyapalan, T. (2013). Pregnancy in polycystic ovary syndrome. *Indian Journal of Endocrinology and Metabolism*, 17(1), 37. doi:10.4103/2230-8210.107830

A Description of Bioethics as the Study of the Moral and Ethical Paradigms Faced in Medical Research

An Opinion Piece/ Commentary

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Advancements in the medical sciences are mainly owed to human-based research, however the history of such research communicated the lack of ethical consideration. Many past studies are scrupulous, and exploit participants from vulnerable and oppressed populations [1]. The Nuremberg code, established post-World War II in 1947, condemns the violation of autonomy, including informed consent and coercion, reification, which is the undermining of dignity of persons, and the violation of non-maleficence, commonly referred to as do no harm [2]. Studies that fail to follow ethical research regulations, including but not limited to, to the Nuremberg code should not be allowed, let alone receive federal funding and be conducted by major institutions. Specifically, a case study “Research and Medicine collide in Haiti” presents a sex-study conducted in Haiti, which failed to follow ethical guidelines set out in the Nuremberg Code [1]. So, in the Haiti sex-study, it is important to consider whether researchers obtained informed consent following ethical guidelines, whether the potential benefits outweigh the costs, and what information should be shared with participants.

The study was conducted by physician-researchers from Cornell Medical College on impoverished individuals in Haiti [1]. Cornell is known to provide one of the best AIDS treatments, which Haiti needs as a country that is undergoing an AIDS epidemic [1]. In Haiti, patients are provided free human immunodeficiency virus (HIV) testing, via blood tests [1]. However, the problem arises when couples are not informed of their diagnoses, the purpose of the study, or treatment options [1]. Autonomous persons have the right to a fully informed decision towards participation in a research study, and in this case, participants were not informed of their diagnoses, any expected benefits, foreseeable risks, alternative treatments available, and their right to refuse participation without consequence. Participants received consent forms originally written in English and only verbally translated to Creole, leading to potential miscommunication [1]. The form was lacking in the objective of the study, only mentioning the regular blood samples collection from participants [1]. The primary duty of a physician to care for their patient was substituted for a researcher-subject relationship, shifting the focus away from patient wellbeing, which is outrageous. The lack of participants’ right to be fully autonomous took precedence over ethical considerations, and informed consent was not obtained from participants.

Unknowingly, the couples continued to have unprotected sexual intercourse, breaking the ethical principle of nonmaleficence or what we commonly refer to as , ‘do no harm’ [1]. The healthcare facility took repeated blood samples from the HIV-negative partner, in hopes of identifying the mechanisms/molecules that may act as natural protections to HIV contraction [1]. The study poses physical, psychological, and emotional harm to the participants via exposure of an HIV-negative partner to a HIV-positive partner, the omission of diagnosis and preventing immediate treatment, and the risk of losing one or both participants. This violates and may attenuate future autonomy, or the ability to make informed decisions. However, providing antiretrovirals to participants of this study would be an unethical incentive to participate, as they are not widely available to everyone in Haiti due to its high cost [1]. The clinic did provide access to free condoms, however, due to the cultural stigma surrounding them and the lack of safe sex education, participants may not have opted for this option [1].

¹ In some cases, the HIV-positive partner was informed of their diagnosis, however, researchers did not notify the HIV-negative partner, leaving this decision upon the positive partner. Researchers reported that at least 60% of them did not inform their partners of their diagnosis [3].

Exploitation of vulnerable populations in developing countries has previously occurred; however, the benefits of research are only available to developed countries [1]. Haitians were considered ideal for this study due to the insufficiency of antiretrovirals in the country, the cultural stigma and lack of safe sex education, and the prevalence of AIDS [1]. Together, the disparities in the standard of care, autonomy, and respect between participants of the Haiti study and other studies conducted by Cornell in New York, oppose the ethical standards of research set by the Nuremberg Code, and Kant's formula of humanity, of providing equal standard of care to all persons in clinical trials [1]. The cost of violating a person's autonomy and nonmaleficence outweigh the utility aspect of a potential vaccine development for HIV, hence the study is not justified.

Information pertaining to a patient's health must be disclosed to them as per a physician's obligation to truth-telling. Not discussing information pertaining to health with the patients, as mentioned above, prevented the individuals' from making informed decisions in their best interest [1]. This information would have allowed them to make an autonomous decision regarding their relationship, possible treatment strategy, and participation in the study. Moral philosophers Kant and Thomasma believe that truth-telling is an absolute duty and an essential part of respecting persons, respectively [1]. Thus, there is no doubt that information regarding their health should be disclosed to the HIV-positive participant. However, disclosure of test results to both partners may have a detrimental effect on their relationship. Seeing this, should information have been shared with the other partner? Ackerman states that biological life may be inferior to intrinsic values such as dignity, relationships and liberty [1]; supporting that the subjects should only receive their own test results. However, according to Mill's harm principle, the HIV-positive partners' autonomy can be restricted to prevent harm to others, such as their sexual partner [1]. Thus, I believe that both partners should receive full disclosure of their health status and future steps. The researchers should have been obligated to disclose all information pertaining to health matters to all concerned participants in the study.

Due to the violation of several regulations outlined in the Nuremberg code including autonomy, reification and non-maleficence, this study was unethical and should not have been conducted. The significance of human research is well understood, however, it should not be at the expense of minorities and vulnerable populations [2]. Studies should not be conducted unless they follow ethical principles, treat all individuals equally, provide quality standards of care, obtain informed consent, and respect participant autonomy. Research protocols should be universally regulated to prevent similar studies from exploiting subjects and risking their lives.

References

- 1Vaughn L. Bioethics: Principles, Issues, and Cases. 4th ed. New York, N.Y: Oxford University Press; 2020. 287-291.
- 2Shuster E. Fifty years later: the significance of the Nuremberg Code. New England Journal of Medicine. 1997 Nov 13;337(20):1436-40.
- 3Bernstein N. STRINGS ATTACHED -- A special report.; For Subjects in Haiti Study, Free AIDS Care Has a Price [Internet]. New York Times. 1999 [cited 11 April 2021]. Available from: <https://www.nytimes.com/1999/06/06/world/strings-attached-special-report-for-subjects-haiti-study-free-aids-care-has.html>

Rachael Finnerty

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Intertwining Arts and Science Through Music Therapy

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BIOGRAPHY

Rachael Finnerty has been an accredited music therapist since 2001. Music therapy is a healthcare profession that focuses on using music to achieve various healthcare goals. These sessions are conducted by licensed music therapists who work with people of all ages and diagnoses. Professor Finnerty is the founder and Director of Education at The Music Therapy Academy; an institution that provides mentorship opportunities, including supervising McMaster thesis students. The academy also hosts workshops for current music therapists and other healthcare professionals wanting to incorporate music into their work. Her passion for education led her to develop and teach two music therapy classes at McMaster University: Introduction to Music Therapy & Introduction to Music Therapy Research. Finnerty is the co-chair of the “Take your Seat Campaign” for LIVElab at McMaster University. This initiative supports research at the McMaster Institute for Music and the Mind. She also serves as the Chair on the advisory board for the Drive Foundation, another initiative that supports mental health.

ABSTRACT

The Music Therapy Academy (MTA) is an organization that was founded by Rachael Finnerty in 2014. This institution is committed to mentorship, research, and community engagement by providing continuing education workshops and webinars for music therapists and other healthcare professionals in Ontario. Through her organization, Professor Finnerty supervises research that studies the effects of music therapy on dementia, mental health, pain perception, and autism spectrum disorders. The MTA also sponsors community events including the Music Care Conference and The Drive Foundation. The Music Care Conference was sponsored by the MTA because of its shared vision of promoting the use of music therapy within one’s scope of practice. The Drive Foundation was sponsored because just like the academy, they want to use music to remove the stigma around mental illness and promote mental health.

INTERVIEW QUESTIONS

What does a typical day as a music therapist look like?

Rachael Finnerty: I would say there is no such thing as a typical day for a music therapist. The profession is so broad that a typical day varies depending on the area the music therapist is working in. For example, a music therapist can work full time at a children’s hospital, like Sick Kids in Toronto. A typical day there is most likely going to include attending rounds, meeting with families, consulting with other health care teams, and doing one-to-one bedside visits with children. On the other hand, music therapists who work in private practice may have a range of tasks which differ from day to day. Possible work environments include: long term care facilities, day programs for adults with autism, special education programs in schools, and private sessions with clients working on rehabilitation goals.

What inspired you to start the Music Therapy Academy?

Throughout my career, I’ve learned how beneficial music can be in different healthcare professions. For example, physiotherapists realize that their clients are more likely to engage in sessions if they are paired with music. Psychotherapists, counselors, and psychologists recognize that song writing can be a very powerful engagement tool. Social workers also use music to engage with youth; you can create a much more natural rapport with young people using music. Speech therapists are aware that singing is a very effective way to facilitate speech goals, but this is not usually taught in other healthcare fields. It’s difficult for these professionals to learn how to use music within their scope of practice, so they would often reach out to me and ask for some in-house workshops on these topics. What motivated me to create the Music Therapy Academy was that, at the time, music therapists and other healthcare professionals in Canada did not have anywhere to seek professional development through the lens of music therapy. The MTA is the first and only music therapy academy in Canada that serves this purpose. It’s for accredited music therapists too, because even though you’re a music therapist, there’s always more to learn. The MTA is also for people in the community who have loved ones with dementia or Parkinson’s and want to know how they can use music meaningfully with them.

I see that you did your master’s thesis on music therapy as intervention for pain perception. How did you study this, and ultimately, why is music therapy effective as an intervention for pain perception?

When I was working at Sunnybrook Hospital in the transition unit, I realized that a major complaint of hospitalized individuals is pain, which is often treated with pharmaceuticals.

And that's great - there's nothing wrong with pharmaceuticals besides the possibility of having some side effects like nausea or a loss of appetite. What I did at Sunnybrook was, I provided music therapy sessions to individuals. Before and after each session, I asked them to rate their pain on a scale from zero to ten, with ten being the most pain imaginable and zero being no pain.

In addition to that, we also made observations. For example, let's say one of the patients was complaining about pain in their left shoulder. But meanwhile, throughout the music therapy session, they used their left arm to play the drum. Essentially, we observed their body movements, despite what they had described for their pain. We also took observations from the nursing staff about the patient’s mood before and after the session.

Finally, we also took note of the comments made by patients. The patients may have said things like, “Oh, if I knew it was music therapy today, I would not have taken my pain medication”. These kinds of statements positively support the use of music therapy in managing their pain.

An important distinction is that pain is an emotion, while nociception is the biological event of the brain translating pain. For example, if somebody pokes you with a pin in your arm, there are some transmitters that go to your brain, and then the neurotransmitters traveling back tell you to move your arm away from the pin. That is nociception. In contrast, pain is an emotion which is influenced by stress, anxiety, or mood.

If our mood is elevated, we have more endorphins running through our body. Music enhances these endorphins, and through it, we can lessen the experience of pain.

I see that you are currently completing your Ph.D. under Dr. Laurel Trainor, with research focusing on music therapy for stress and anxiety. How effective is using music therapy to treat the symptoms of anxiety and why?

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In terms of looking at music therapy as an intervention for stress and anxiety to manage mental health, the existing research is pretty slim. People typically only turn to therapy when they are in crisis. However, this study aims to show that undergraduates should be using therapy as a way to maintain wellness, similar to the way you would exercise in order to stay healthy.

The study uses five groups: a music therapy group with active intervention, a music therapy group with receptive intervention, a verbal therapy group, a control group, and a waitlist group. All five groups give a hair sample at the beginning of week one and at the end of week six. Using the hair sample, we will analyze for the biomarker, cortisol, which has been correlated with stress. We’ll compare cortisol levels from week one to those of week six in the study, to see if there is any lessening of cortisol after six weeks of music therapy intervention.

For the therapy groups we also collect physiological data, such as heart rate, before and after each session. The last piece we will collect is the psychological data. We're going to have participants complete the State-Trait Anxiety Inventory (STAI) as well as the perceived stress scale to see if there are any changes in stress and anxiety.

This research will be the first of its kind to gather a biomarker, physiological data, as well as psychological data to support music therapy as an effective method of managing stress and anxiety for one's mental health.

How does music therapy compare to other pain and anxiety management strategies, for example drugs like morphine and Xanax?

There have been a couple of studies supporting the use of music therapy alongside pharmaceuticals. For example, one paper compared two groups of patients who were on pain medication; one group listened to music, while the other did not. Researchers found that people in the group that listened to music self-medicated less. This example shows us that using music in conjunction with pain medication reduces pain and the need for pharmaceuticals.

What are some challenges associated with research at the Music Therapy Academy, or in the field of music therapy overall?

We definitely need more funding for music therapy research in order to really show its effectiveness. A lot of published research is based on the work of thesis students, who often work on a shoestring budget. The sample sizes used in studies are often small and based on the researcher's convenience; it would take money and time to gather data from facilities where there is no pre-existing music therapy program.

Let's compare music therapy to physiotherapy. Physiotherapy is relatively well funded and recognized, with many physical therapists working full time in a wide range of settings. It wouldn't be difficult to gather data from ten physiotherapists working at ten different long term care centers in Hamilton in order to make comparisons between those places. If each physical therapist sees 50 people a week, you immediately have five hundred data points for five hundred participants..

There is also a lack of diversity in study participants in most fields, and music therapy is no exception. Participants tend to be from what we call a W.E.I.R.D sample. W stands for Western, which could also be replaced with White. "E" stands for educated, "I" is for industrialized, "R" is rich, and "D" is democratic. A lot of research generally, whether we're talking about research for pharmaceuticals, mental health, or cancer care, is predominantly done on white middle-class people.

This lack of diversity also extends to the music therapists themselves, who tend to be white, middle-class women. Part of the reason why music therapists are predominantly white females is that in order to get into the music therapy training programs, you need to be proficient in playing an instrument. And in order to be proficient in playing an instrument, you need to have the financial support to have music lessons. So right away, it eliminates a certain group of people who don't have access.

In addition to that, the training programs have historically favoured training in classical music, which again disproportionately benefits the white middle class. The reality is you do need high musicianship in order to be a music therapist, but musicianship does not necessarily have to be certified by the Royal Conservatory of Music (RCM). There are some amazing musicians that don't have RCM training and have never participated in a music exam, but are excellent musicians. They may have grown up learning to play reggae or jazz and blues by ear, but don't feel invited to apply to music therapy training programs.

This is important because research has shown that clients tend to prefer working with people who look like them. Patients tend to gravitate towards people with the same skin color, but it is difficult to find non-white therapists. Music therapy, like any form of therapy, is a vulnerable process. When working on their healthcare goals, people feel more connected when they see their own identities reflected in their music therapist.

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GLOBAL CITIZENSHIP



Treasure OR TRAGEDY

GLOBAL CITIZENSHIP: TREASURE OR TRAGEDY

An Opinion Piece/ Commentary

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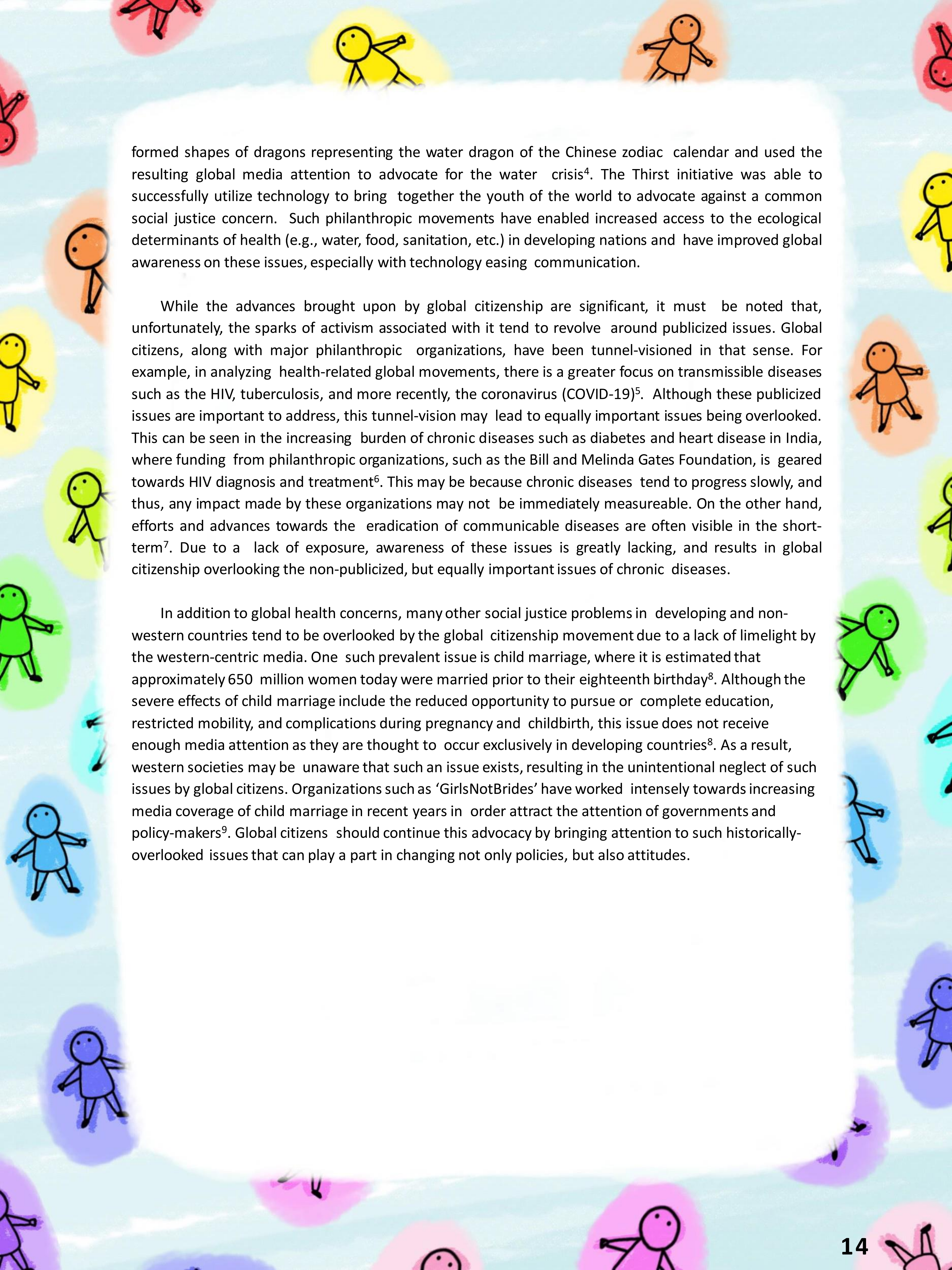
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Global citizenship refers to the civic responsibilities that an individual has to not only their geographical locality, but also to the world in its entirety¹. It involves understanding one's place in the world in order to actively engage in global issues and the development of a more sustainable planet. This active involvement increases the overall level of awareness and understanding within the global society, and is becoming increasingly pertinent due to the rise of technology. In this digital age, young individuals, mononymously known as 'digital natives', play a critical role in bringing attention to important issues in our society. This was recently seen in the 'Black Lives Matter' campaign, where many individuals, particularly youth, demonstrated solidarity by advocating through various social media platforms². Activism was sparked in not only those directly impacted, but also in those from distant communities worldwide, all striving towards a more equitable planet. Although the 'Black Lives Matter' campaign exemplifies the extent to which global citizenship can be a treasure through its inclusive and advocative nature, this concept can also be considered a tragedy due to its tunnelled focus on publicized issues and its ephemeral impact. This begs the question— is global citizenship ultimately a treasure or a tragedy?

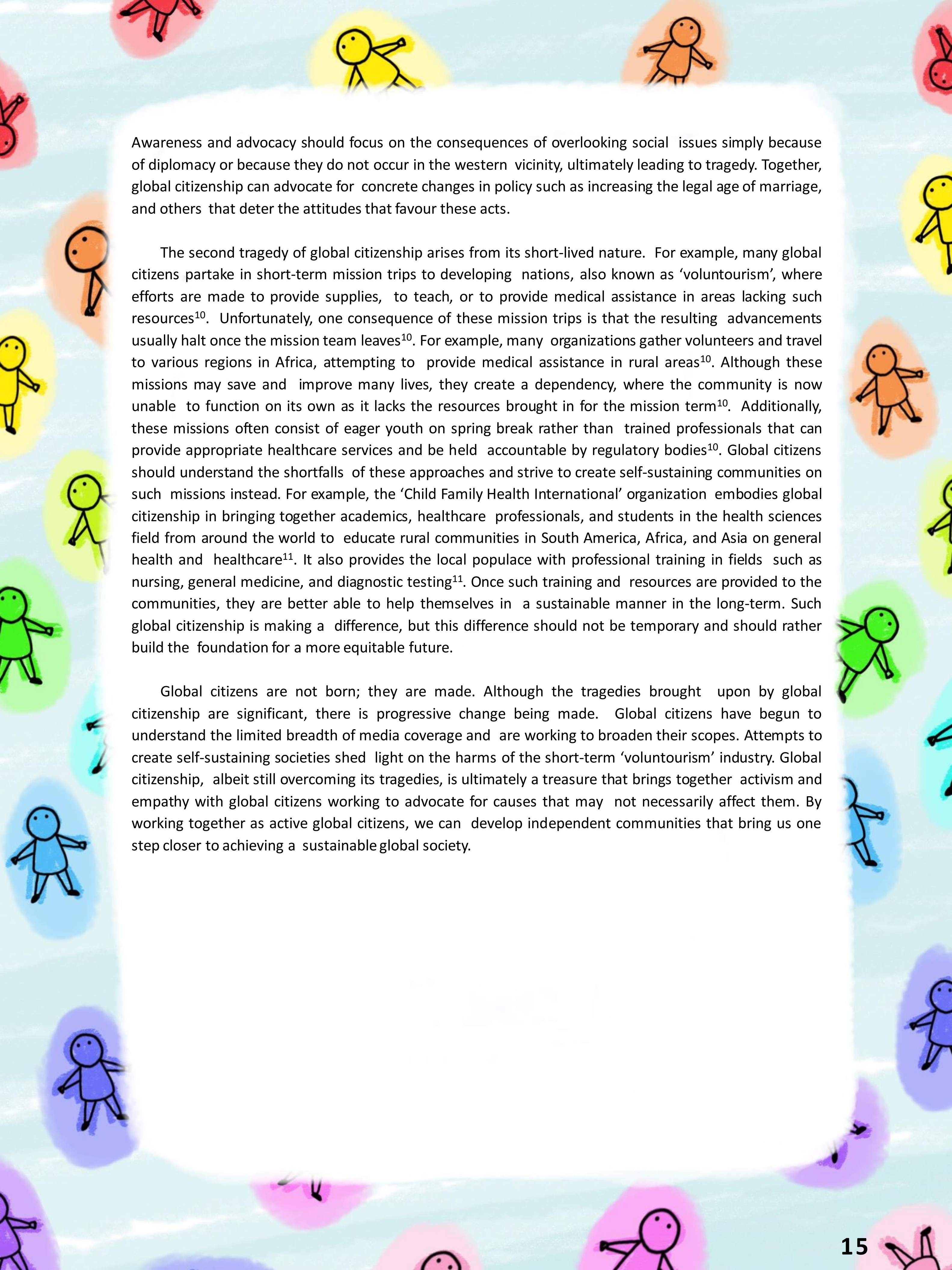
In considering this idea, it is notable that global citizenship fosters a community presence that rises above societal differences. This allows for any concerns to be raised at a larger-scale through the involvement of a greater number of informed individuals from various walks of life. For example, access to clean drinking water has been a large problem in developing countries for decades; however, this issue was only recently brought to light as 'the water crisis'³. Many global organizations have been working towards increasing awareness to and advocating for this issue, with one such organization being Thirst⁴. This organization works with youth around the world to raise awareness about the industrial uses of freshwater that take away from the availability of drinking water in developing countries through means such as petitions, online forums, and social media platforms⁴. On World Water Day in 2012, blue-clad students in China



formed shapes of dragons representing the water dragon of the Chinese zodiac calendar and used the resulting global media attention to advocate for the water crisis⁴. The Thirst initiative was able to successfully utilize technology to bring together the youth of the world to advocate against a common social justice concern. Such philanthropic movements have enabled increased access to the ecological determinants of health (e.g., water, food, sanitation, etc.) in developing nations and have improved global awareness on these issues, especially with technology easing communication.

While the advances brought upon by global citizenship are significant, it must be noted that, unfortunately, the sparks of activism associated with it tend to revolve around publicized issues. Global citizens, along with major philanthropic organizations, have been tunnel-visioned in that sense. For example, in analyzing health-related global movements, there is a greater focus on transmissible diseases such as the HIV, tuberculosis, and more recently, the coronavirus (COVID-19)⁵. Although these publicized issues are important to address, this tunnel-vision may lead to equally important issues being overlooked. This can be seen in the increasing burden of chronic diseases such as diabetes and heart disease in India, where funding from philanthropic organizations, such as the Bill and Melinda Gates Foundation, is geared towards HIV diagnosis and treatment⁶. This may be because chronic diseases tend to progress slowly, and thus, any impact made by these organizations may not be immediately measureable. On the other hand, efforts and advances towards the eradication of communicable diseases are often visible in the short-term⁷. Due to a lack of exposure, awareness of these issues is greatly lacking, and results in global citizenship overlooking the non-publicized, but equally important issues of chronic diseases.

In addition to global health concerns, many other social justice problems in developing and non-western countries tend to be overlooked by the global citizenship movement due to a lack of limelight by the western-centric media. One such prevalent issue is child marriage, where it is estimated that approximately 650 million women today were married prior to their eighteenth birthday⁸. Although the severe effects of child marriage include the reduced opportunity to pursue or complete education, restricted mobility, and complications during pregnancy and childbirth, this issue does not receive enough media attention as they are thought to occur exclusively in developing countries⁸. As a result, western societies may be unaware that such an issue exists, resulting in the unintentional neglect of such issues by global citizens. Organizations such as 'GirlsNotBrides' have worked intensely towards increasing media coverage of child marriage in recent years in order to attract the attention of governments and policy-makers⁹. Global citizens should continue this advocacy by bringing attention to such historically-overlooked issues that can play a part in changing not only policies, but also attitudes.



Awareness and advocacy should focus on the consequences of overlooking social issues simply because of diplomacy or because they do not occur in the western vicinity, ultimately leading to tragedy. Together, global citizenship can advocate for concrete changes in policy such as increasing the legal age of marriage, and others that deter the attitudes that favour these acts.

The second tragedy of global citizenship arises from its short-lived nature. For example, many global citizens partake in short-term mission trips to developing nations, also known as 'voluntourism', where efforts are made to provide supplies, to teach, or to provide medical assistance in areas lacking such resources¹⁰. Unfortunately, one consequence of these mission trips is that the resulting advancements usually halt once the mission team leaves¹⁰. For example, many organizations gather volunteers and travel to various regions in Africa, attempting to provide medical assistance in rural areas¹⁰. Although these missions may save and improve many lives, they create a dependency, where the community is now unable to function on its own as it lacks the resources brought in for the mission term¹⁰. Additionally, these missions often consist of eager youth on spring break rather than trained professionals that can provide appropriate healthcare services and be held accountable by regulatory bodies¹⁰. Global citizens should understand the shortfalls of these approaches and strive to create self-sustaining communities on such missions instead. For example, the 'Child Family Health International' organization embodies global citizenship in bringing together academics, healthcare professionals, and students in the health sciences field from around the world to educate rural communities in South America, Africa, and Asia on general health and healthcare¹¹. It also provides the local populace with professional training in fields such as nursing, general medicine, and diagnostic testing¹¹. Once such training and resources are provided to the communities, they are better able to help themselves in a sustainable manner in the long-term. Such global citizenship is making a difference, but this difference should not be temporary and should rather build the foundation for a more equitable future.

Global citizens are not born; they are made. Although the tragedies brought upon by global citizenship are significant, there is progressive change being made. Global citizens have begun to understand the limited breadth of media coverage and are working to broaden their scopes. Attempts to create self-sustaining societies shed light on the harms of the short-term 'voluntourism' industry. Global citizenship, albeit still overcoming its tragedies, is ultimately a treasure that brings together activism and empathy with global citizens working to advocate for causes that may not necessarily affect them. By working together as active global citizens, we can develop independent communities that bring us one step closer to achieving a sustainable global society.

REFERENCES

- 1.What is global citizenship? [Internet]. World Economic Forum. [cited 2021 Jan 31]. Available from: <https://www.weforum.org/agenda/2017/11/what-is-global-citizenship/>
- 2.Teens Are on Front Lines of Black Lives Matters Protests - The New York Times [Internet]. [cited 2021 Jan 31]. Available from: <https://www.nytimes.com/2020/06/23/us/teens-protest-black-lives-matter.html>
- 3.Kummu M, Guillaume JHA, de Moel H, Eisner S, Flörke M, Porkka M, et al. The world's road to water scarcity: shortage and stress in the 20th century and pathways towards sustainability. Sci Rep. 2016 Dec 9;6(1):38495.
- 4.Raising awareness of the global water crisis [Internet]. World Economic Forum. [cited 2021 Apr 19]. Available from: <https://www.weforum.org/agenda/2012/03/raising-awareness-of-the-global-water-crisis/>
- 5.Gellert GA. Non-governmental organizations in international health: past successes, future challenges. Int J Health Plann Manage. 1996 Mar;11(1):19–31.
- 6.Animaw W, Seyoum Y. Increasing prevalence of diabetes mellitus in a developing country and its related factors. PLoS ONE [Internet]. 2017 Nov 7 [cited 2021 Apr 19];12(11). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5675402/>
- 7.India | Bill & Melinda Gates Foundation [Internet]. [cited 2021 Apr 19]. Available from: <https://www.gatesfoundation.org/our-work/places/india>
- 8.Efeybera Y, Bhabha J. Defining and deconstructing girl child marriage and applications to global public health. BMC Public Health. 2020 Oct 15;20(1):1547.
- 9.How can the media do its part to end child marriage? [Internet]. Girls Not Brides. [cited 2021 Apr 20]. Available from: <https://www.girlsnotbrides.org/articles/child-marriage-emerging-trends-in-the-media/>
- 10.Cummings CT. The Positive and Negative Effects of a Short Term Mission Trip [Internet]. Medium. 2018 [cited 2021 Apr 20]. Available from: <https://medium.com/sojourners-heart/the-positive-and-negative-effects-of-a-short-term-mission-trip-c9991876ddc9>
- 11.WHO | Child Family Health International [Internet]. WHO. World Health Organization; [cited 2021 Apr 20]. Available from: https://www.who.int/workforcealliance/members_partners/member_list/cfhi/en/

Tay-Sachs Disease: How Important is Genetic Testing?

Tay-Sachs disease (TSD) is an autosomal recessive condition, which due to its genetic nature disproportionately affects certain populations.^{1,2} French Canadians, Cajun populations, the Old Order Amish community, and Ashkenazic Jews have higher carrier rates than the general public and thus carry a higher chance of having children affected by TSD. Individuals with mutations in the Hexosaminidase A (HEXA) gene in one of their chromosomes are carriers, while those who carry two mutated alleles are affected by TSD.^{1,2} However, families with an unknown history of TSD may also be affected, since a mutated allele can be passed down across many generations before an individual receives the two alleles necessary for the recessive disease.² As a result, genetic testing for TSD should be made available for prospective parents as it can assist them in making an informed decision.

Tay-Sachs disease mainly affects the brain and spinal cord by gradually destroying its neurons.^{1,2} Mutation-based deficiencies in the beta-hexosaminidase A enzyme, which breaks down glycolipids, causes an accumulation of this glycolipid in neurons in the spinal cord and brain.^{1,2} The phenotypic profile, or the presentation of the disease can vary as there are more than seventy identified mutations in the HEXA gene.^{1,2} Current therapeutics are focused on mitigating symptoms of TSD including therapeutic enzyme replacement and bone marrow transplantation, however most of these have been deemed ineffective. Nonetheless, research on potential treatment for TSD is currently underway, with a focus on chaperone therapy, gene therapy, chaperone therapy and cord blood transplants, in hopes of finding a cure.³ Other therapeutic options for the disease include substrate reduction, a process which slows the rate of glycolipid production, and gene therapy, a process which tries to fix the mutations in the HEXA gene.³ These treatments are designed to help restore normal expression of the HEXA gene, which will ultimately help restore normal levels of beta-hexosaminidase A enzyme needed for glycolipid breakdown.¹

Currently, the gold standard for diagnosing Tay-Sachs disease carriers is the enzyme screening method. This method consists of measuring the protein expression of beta-hexosaminidase A using an enzyme assay.⁴



Individuals who suffer from infantile TSD should demonstrate little to no Hexosaminidase A enzyme activity, while individuals who suffer from juvenile or adult TSD, should display Hexosaminidase A enzyme activity in the range of 6-15%.⁴ Genetic carrier screening for TSD can be accomplished by examining the HEXA gene on both copies of the chromosome for mutations.⁴ Unfortunately, obtaining a normal or negative test result does not guarantee non-carrier status, as carriers of a novel or undiscovered mutation for the disease may not be detected.⁴ This phenomenon can be observed in a statement made by Emily Rapp which reads as follows, "I met with two genetic counselors and had every standard prenatal test available to me, including the one for Tay-Sachs, which did not detect my rare mutation".⁵

Individuals affected by TSD experience general weakness, mental and motor developmental delay, atrophy of the optic nerves leading to blindness, seizures, hearing loss, paralysis, and in severe cases death after birth.^{1,3} In infants, certain common neurodegenerative symptoms include eye movement abnormalities, hypomyelination, hypotension, spasms and dysphagia.^{1,3} In juveniles, certain observed symptoms are difficulty swallowing, involuntary muscle contraction, low blood pressure and motor speech disorders. Many of these symptoms can be observed in Ronan, a child affected by TSD.⁵ By age 2, Ronan was paralyzed, blind, experienced daily seizures and had difficulty moving and swallowing.⁵ Unfortunately, TSD is not uncommon in the general population. In high-risk populations, 1 in 3600 children are affected by TSD in comparison to the 1 in 100,000 children affected in the general public. Furthermore, approximately 1 in 30 individuals are carriers for TSD as opposed to 1 in 300 individuals in the general public.^{3,6} Infantile and Juvenile TSD patients have a life expectancy of 4 and 15 years of age, respectively.³



Tay-Sachs Disease: How Important is Genetic Testing?

Carrier screening is a useful resource to help parents make informed reproductive decisions based on their likelihood of transmitting a genetic disease to their children.⁷ The ability to conduct carrier screening prior to conceiving a child does not guarantee non-carrier status, however it affords couples the ability to explore other reproduction methods in cases where both parents are carriers.⁷ Additionally, the possibility of having a genetic test can help alleviate stress and anxiety that parents may be experiencing regarding their carrier status.⁷ There are drawbacks of genetic testing such as the cost of conducting the test and the requirement that a family member must have been previously diagnosed with the disease.⁷ This criterion prevents certain prospective parents from qualifying for the test. Although testing is expensive, the long-term emotional and financial costs for families may be lower in comparison.⁷ To emphasize the burden afflicted upon the parents, Shari Ungerleider discusses her experience with her son's TSD diagnosis.⁸ In her article, she discusses how her son Evan was born with TSD, how life changing it was for her and how she wishes that every parent has right to make an informed choice about whether they want to proceed with the pregnancy.⁸ Shari further mentions that her son has been diagnosed with blindness, deafness, and experiences multiple daily seizures as a result of TSD.⁸ This experience was emotionally draining for Shari and her family because they had to accept that Evan may die at a very early age even with the best medical care. She also mentions realizing early on how her son was developing at a slower rate than the other children and how concerned that made her. This case is a prime example of the emotional suffering that comes with having a child with TSD considering that the condition progressively worsens. The predictive power of genetic testing can benefit couples in family planning by allowing them to determine carrier status, and emotionally prepare themselves for the possibility of having a child with Tay-Sachs if they chose to get pregnant.

Therefore, TSD testing should be available to prospective parents from populations with high prevalence and carrier rates of the disease, regardless of their personal family history, as their children are more likely to be affected by TSD.⁴ The elimination of the criterion requiring previously known family history of the disease would be a good starting point. This criterion prevents prospective parents from qualifying for the test and thus may hinder their family planning. Family planning is exciting as it is frightening for many couples who have a history of genetic conditions, such as Tay-Sachs disease, in their family lineage. As a result, the ability to determine the carrier status of parents prior to a couple conceiving a child may prevent the emotional distress previously faced by couples having to decide whether to terminate the pregnancy or not.⁷ Genetic testing for Tay-Sachs disease should at the very least be easily available to prospective parents from high-risk populations to allow parents to make informed decisions to prevent them unnecessary pain and suffering.



References

1. Fernandes Filho JA, Shapiro BE. Tay-Sachs disease. Arch Neurol. 2004;61(9):1466-8. <https://doi.org/10.1001/archneur.61.9.1466>
2. Tay-Sachs disease [Internet]. Medline Plus; 2020 [cited 2021 Feb 08]. Available from: <https://medlineplus.gov/genetics/condition/tay-sachs-disease/#inheritance>
3. Solovyeva VV, Shaimardanova AA, Chulpanova DS, Kitaeva KV, Chakrabarti L, Rizvanov AA. New approaches to tay-sachs disease therapy. Front Physiol. 2018;9:1663. <https://doi.org/10.3389/fphys.2018.01663>
4. Tay-Sachs carrier screening [Internet]. Ntsad; 2020 Feb 06 [cited 2021 Feb 05]. Available from: <https://www.ntsad.org/index.php/carrier-screening/tay-sachs-screening#:~:text=Enzyme%20screening%20is%20currently%20the,or%20leukocytes%20isolated%20from%20blood>.
5. Emily Rapp. Rick Santorum, meet my son [Internet]. Slate; 2012 Feb 27 [cited 2021 Feb 05]. Available from: <https://slate.com/human-interest/2012/02/rick-santorum-and-prenatal-testing-i-would-have-saved-my-son-from-his-suffering.html>
6. Tay Sachs Disease [Internet]. Nord; 2017 [cited 2021 Feb 05]. Available from: <https://rarediseases.org/rare-diseases/tay-sachs-disease#:~:text=Affected%20Populations&text=Approximately%20one%20in%2030%20Ashkenazi,Jewish%20heritage%20is%20a%20carrier>
7. Joy K. Pros and cons of genetic testing: what to know before you go [Internet]. Michigan Health. 2017 Dec 8 - [cited 2021 Feb 05]. Available from: <https://healthblog.uofmhealth.org/health-management/pros-and-cons-of-genetic-testing-what-to-know-before-you-gos>
8. Shari Ungerleider. Tay-Sachs: A Parent's Story. Moment Magazine. 2017 Sept. Available from: <https://momentmag.com/tay-sachs-parents-story/>

COVID-19 & ANXIETY

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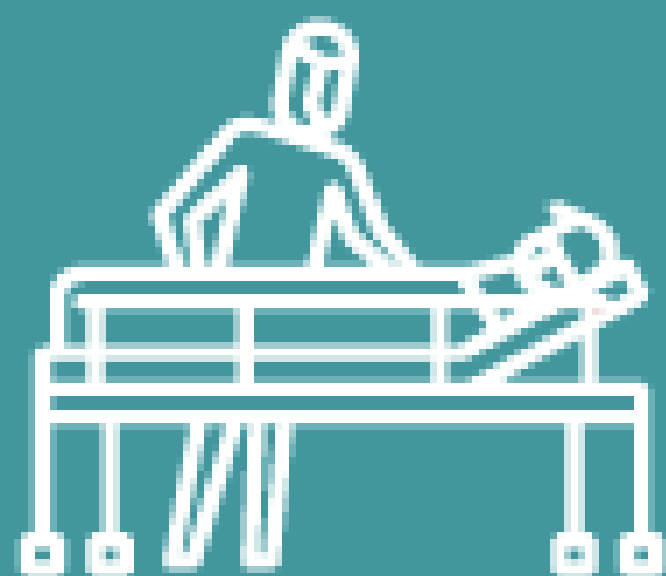
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Abstract

Coronavirus (COVID-19) is a highly infectious disease responsible for 2.65 M deaths globally. In March 2020, it was declared a global pandemic by the World Health Organization. Since then cases of General Anxiety Disorder (GAD) have increased from 5% to 20%. Anxiety symptoms include feelings of restlessness, difficulty concentrating, and difficulty controlling feelings of worry.^{1,3}

Causes for increased cases of anxiety from COVID-19



Fear of contracting the virus



Stay-at-home orders have increased isolation from family and friends



Economic strain



15.7%

ages 15 to 34 years

- concerned about vulnerable people's health and overloading the health system

Severe COVID-19-related anxiety among age groups



5.3%

ages 55 to 74 years

- concerned about their health and the health of their family



11.4%

ages 35 to 54 years

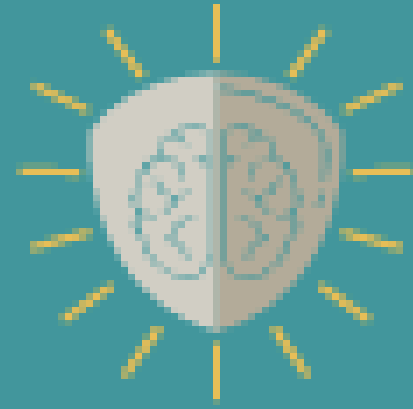
- concerned about vulnerable people's health and overloading the health system

Treatment Options⁴

Mindfulness

Focuses attention on the present moment and limits anxiety-inducing thoughts.

- Includes meditation and journaling.



Medication

Medication may be prescribed by a doctor as a short-term measure for managing anxiety.



Cognitive Therapy

Focuses on changing patterns of thinking and beliefs that are associated with anxiety.



Tips On Overcoming Anxiety⁵

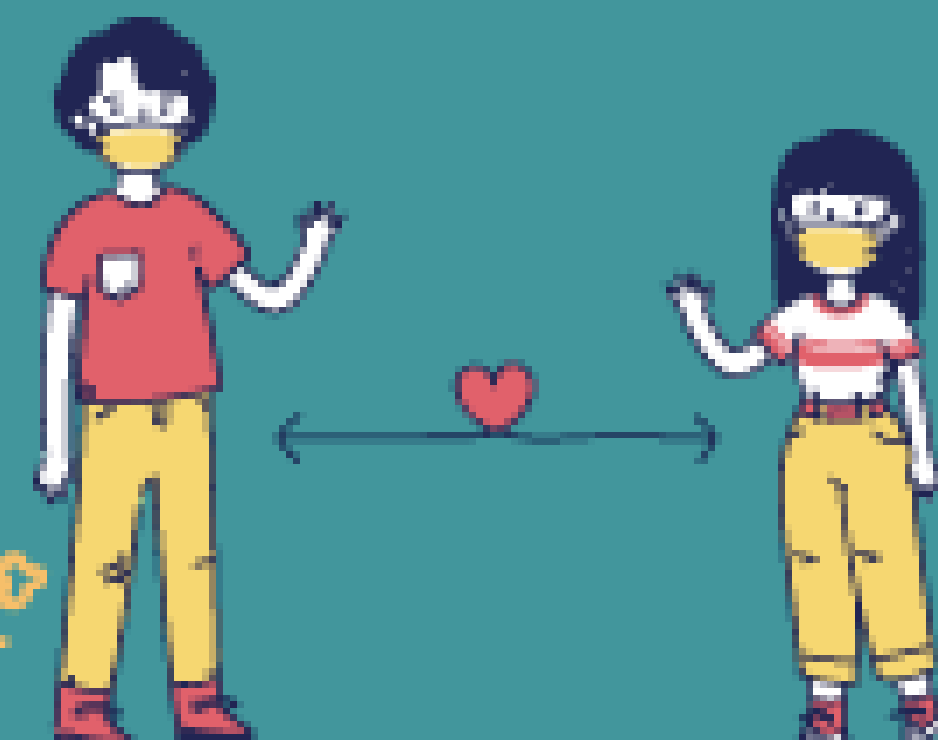
DO ✓

- Practice deep breathing
 - Inhale slowly and deeply through the nose, exhale slowly through the mouth
- Aerobic exercise 30 minutes daily
- Talk to someone (friends, therapist)
 - Maintain social distancing protocols!
- Limit caffeine and alcohol consumption
 - These drinks aggravate anxiety

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DON'T ✗

- Become absorbed by the news
- Make COVID-19 the main point of all conversations
- Consume and spread misinformation
- Isolate yourself



References

1. New York Times. Coronavirus World Map: Tracking the Global Outbreak [Internet]. NYTimes. [cited 2021 Feb 10]. Available from: <https://www.nytimes.com/interactive/2020/coronavirus-world-map.html>
2. National Institute of Mental Health. Anxiety Disorders [Internet]. NIMH. [cited 2021 Feb 10]. Available from: <https://www.nimh.nih.gov/health/topics/anxiety-disorders/index.shtml>
3. El-Gabawy R, Sommer J. "We Are at Risk Too!" The Disparate Mental Health Impacts of the Pandemic on Younger Generations. News, Science, Food & Justice. Les Effets Disparates de la Pandémie sur la Santé Mentale des Générations Plus Jeunes. The Canadian Journal of Psychiatry. 2021 Feb;1-07587515721988762.
4. BetterHealth. Managing and treating anxiety [Internet]. CTV News. [cited 2021 Mar 14]. Available from: <https://news.betterhealth.ca.gov/health/wordsanddeeds/treatment/anxiety/3/treatment-options/4/0/cvcontent>
5. Raughter D. Anxiety and depression have spiked among Canadians: survey [Internet]. CTV News. [cited 2021 Feb 10]. Available from: <https://news.ctvnews.ca/health/anxiety-and-depression-have-spiked-among-canadians-survey/1.4887072>



Antibiotic Resistance and Environmental Human Exposure: A Key Area to Investigate

An Opinion Piece

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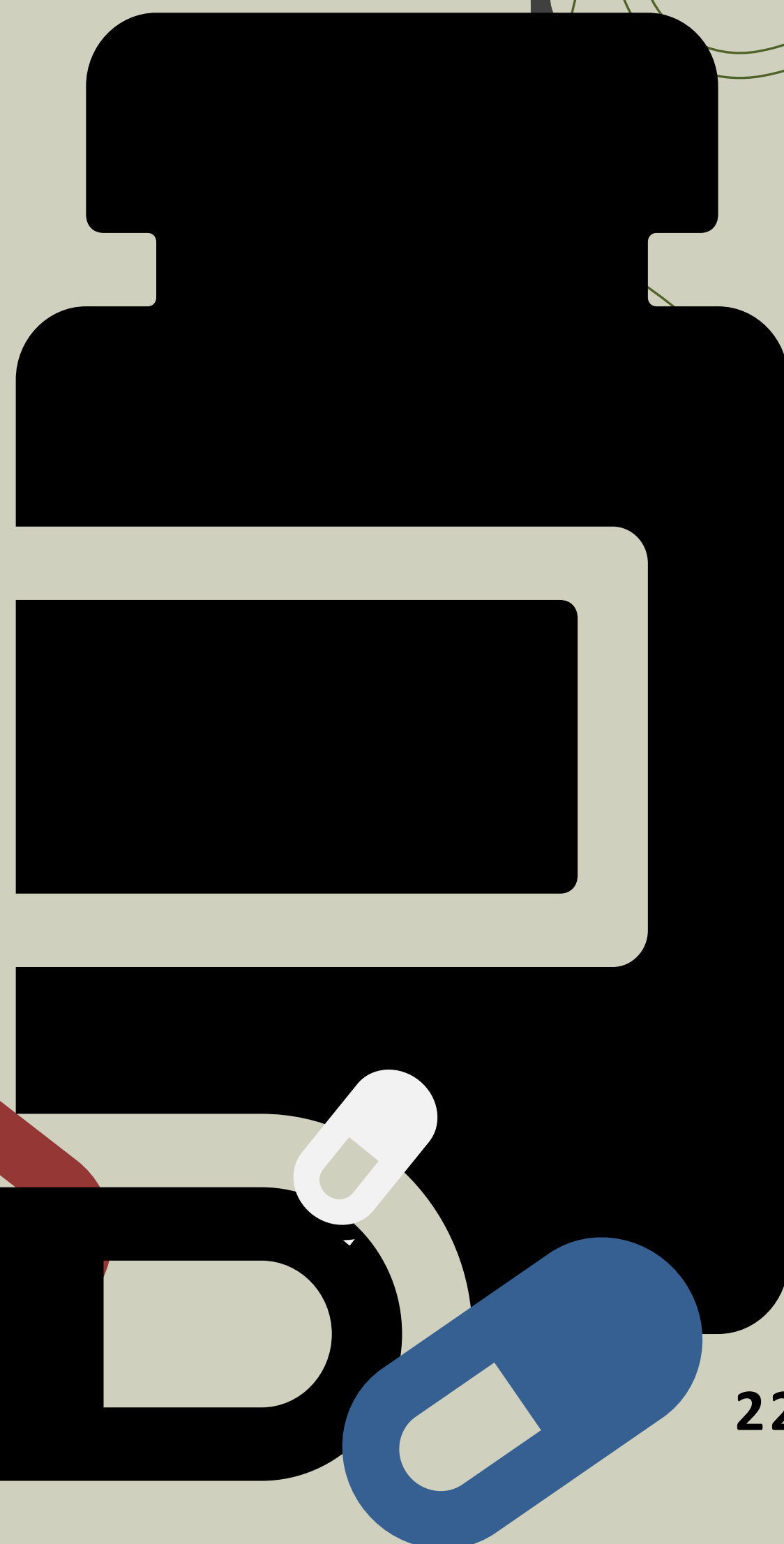
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Antibiotic Resistance and Environmental Human Exposure: A Key Area to Investigate

Introduction

Antibiotics have been called the “magic bullet” that could cure infectious diseases and optimize human health. However, bacterial resistance has emerged as an increasing threat, challenging the effectiveness of current antibacterial therapies.

Resistance is defined as a state in which an infected individual is unable to achieve a “cure” from a clinical standpoint, regardless of the drug or amount prescribed.¹ The misuse and overuse of antibiotics, in addition to the lack of drug development by the pharmaceutical industry, has increased the spread of resistant genes.^{2,3} It is estimated that 40-90% of administered antibiotic doses enter the environment, contaminating soil, water, and plants.⁴ Large quantities of antibiotics in the environment allow bacterial genes to adapt and emerge as new forms of resistance.⁵ This reduces the efficacy of medications and lengthens the duration of infections.⁵

Recently, the environment has been identified as a factor stimulating antibiotic resistance by becoming a known reservoir for resistance genes.⁵ Specifically, the evolution and spread of antibiotic resistant bacteria (ARB) has been intensified by human activity.⁶ The majority of bacteria incorporated into modern medicine comes from the natural environment, including soil and water.⁶ This highlights the importance the environment has on influencing bacterial genetic diversity, specifically resistance.⁶ Most studies in this field have evaluated the spread of antibiotic resistance through drinking water.⁵ However, humans are exposed to antibiotic resistant genes (ARG) through various activities, such as swimming outdoors, aquatic sports, occupational practises, drinking water, and consuming produce that has been sprayed with contaminated water.^{4,7}

Today, it is difficult to determine whether resistance is natural (no human interference) or acquired (due to interference).⁸ Approximately 1% of all strains of resistant bacteria present in soil and 5-10% in wastewater are culturable.^{6,8} Therefore, the knowledge of genetic diversity of environmental reservoirs is limited.^{6,8} This is attributed to the lack of research in identifying environmental bacteria and sampling areas where no antibiotics are present.⁸

Therefore, the lack of measurable side effects and proper assessment of exposure to antibiotics has made it crucial to examine the risks associated with introducing antimicrobials (agents that kill or slow microorganism growth) into the environment. This presents a call to investigate the threat to humans when exposed to environmental antibiotics and determine the adverse health effects within the body.⁹

Discussion

Antibiotic resistant genes within the human body: the mechanism

According to researchers, the interaction between humans and the environment often results in the unintended absorption of microorganisms.⁷ The absorption of ARGs increases a bacteria’s ability to cause harm by spreading resistance to antibiotics throughout the body.⁸ Although exposure to antibiotics is low in the body, genes can accumulate small resistant mutations, eventually creating hypermutation (high-levels of resistance).¹ At times, cells or tissues can have low exposure to antibiotics. However, cells that are exposed to antibiotics tend to spread the mutation to other cells, causing high-level resistance to occur throughout the body, as it becomes a cascading effect.

Typically, bacteria contribute to the emergence of resistance through gene duplication (GD).¹ In GD, genes are copied from existing genes but function differently due to evolution, cell repair, or new cell formation. Moreover, the presence of a high number of resistant bacteria in the body results in horizontal gene transfer (HGT).¹ During HGT, a particular type of bacteria acquires one resistant gene, allowing it to transfer information from one cell to another when communicating.¹ This leads to the spread of resistant bacteria, as neighbouring cells acquire the knowledge needed to stop future drugs from killing them.¹ Consequently, the body experiences prolonged infection, requiring a mix of antibiotics since first-line medications are ineffective. ARGs that linger in the body alter human gut bacteria, which may cause allergic reactions, chronic conditions like diabetes and asthma, and disturbances to the digestive system.⁴ This allows new opportunistic infections to arise.⁴

Linking human exposure and the environment

Today, research has begun to reveal the relationship between the environment and the spread of antibiotic resistance, particularly surrounding transmission to humans through environmental interaction.

One of the largest recognized reservoirs and transmission routes for antibiotic resistance is aquatic environments.⁷ Using wastewater in practices such as agriculture allows ARB and ARGs to enter the environment.⁷ Therefore, humans can be exposed to ARB and ARGs through basic activities, such as the irrigation of crops and recreational activities in rivers, lakes, and ponds.^{7,8} Furthermore, discharge from direct and indirect sources affects the diversity of bacteria naturally present in the environment by altering the makeup of the gene pool and increasing the quantity of ARGs.⁷ The contamination of these natural environments that humans interact with results in an increased chance of attracting pathogens and ARB into the body.⁷

Resistant genes found in environments today have contributed to our understanding of “natural” resistance.¹⁰ However, our focus is directed towards instances where environmental ARGs use HGT to spread resistance into pathogens, challenging our ability to fight infectious diseases with antibiotics.¹⁰ This is concerning as pathogens that are present in an environment interact with highly resistant genes, allowing them to learn how to become resistant against multiple classes of drugs.¹⁰ This type of environment is called a hotspot.¹⁰ Hotspot environments, where ARB and ARGs are developed, involve bacteria interacting with high and repeated doses of antibiotics, allowing for their rapid growth and survival.¹⁰ Common hotspot environments include hospitals, animal feeding plants, aquaculture, and wastewater treatment plants.¹⁰

The long-term impact of lingering antibiotic residues in aquatic and terrestrial environments remains unclear, specifically whether it disrupts or inhibits ecosystem function, and alters the genetics of surrounding organisms throughout their lifecycle.^{4,10} I believe focusing on hotspots is crucial, as the current data is limited. Therefore, this presents an opportunity to better identify hotspots and quantify the amount of antibiotics being disposed of, in addition to the source of pollution and the amount of human interaction with the infected environment.

Possible Prevention Measures and Future Research

Current treatment focuses on specific bacteria present within water systems; however, this piece clarifies that humans are exposed to them in the environment.⁴ This shows that there is a failure to examine the dissemination of antibiotics through manufacturers, domestic disposal, agriculture or the medical sector. In an effort to provide suggestions to address this serious issue, I strongly believe new leadership is required to properly test acceptable limits, thus ensuring adherence to disposal guidelines, and appropriate environmental surveillance. It has been acknowledged that the proper use of antibiotics will significantly reduce the negative health risks to the general public due to the decline in drug discovery and the financial burden to treat resistant infections.¹⁰ However, the rise in resistance suggests otherwise and proves there is a lack of antimicrobial materials, therapies, and diagnostic testing in place to reduce selective pressures in natural environments.

I believe that current literature has failed to address key research questions, such as whether repeated antibiotic use generates a reservoir of resistance genes for future pathogens, what properties of particular antibiotics allows them to survive in the future (i.e. Do certain properties fail or have very minimal impact on killing resistant genes, making them immune?) and whether dosage strength has a significant impact. I strongly believe to avoid resistance and attain clinical efficacy, a combination of suggested prevention methods and answering the proposed research questions is required.

Conclusion

By the year 2050, antibiotic resistance will result in 10 million deaths per year.⁹ This opinion piece was intended to bring forth a gap in knowledge by presenting evidence in a limited area of research and arguments justifying the need to investigate the link between human health and environmental exposure to ARB and ARGs. Further research is required as environmental antibiotic pollution is not fully understood, and resistance is unknown. Current research on environmental antibiotic resistance focuses on resistant genes found in the environment; however, there is limited analysis of the associated risks of transmission to humans and the impact on health. Addressing this gap is essential in maintaining current health treatments and curing infectious diseases, as antibiotic resistance is a worldwide problem and requires global initiatives.

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References:

- (1) Canton R, Morosini MI. Emergence and spread of antibiotic resistance following exposure to antibiotics. *FEMS Microbiol Rev.* 2011 Sept;35(5):977-991.
- (2) Ben Y, Fu C, Hu M, Liu L, Wong MW, Zheng C. Human health risk assessment of antibiotic resistance associated with antibiotic residues in the environment: A review. *Environ Res.* 2019 Feb;169:489-493.
- (3) Ventola CL. The antibiotic resistance crisis part 1: causes and threats. *Pharm Ther.* 2015 Apr;40(4):277-283.
- (4) Polianciuc SI, Gurzau AE, Kiss B, Stefan MG, Loghin F. Antibiotics in the environment: causes and consequences. *Med Pharm Rep.* 2020 Jul;93(3):231-240.
- (5) Ashbolt NJ, Amezquita A, Backhaus T, Borriello P, Brandt KK, Collington P, Coors A, Finley R, et al. Human Health Risk (HHRA) for Environmental Development and Transfer of Antibiotic Resistance. *Environ Health Perspect.* 2013 Sept;121(9):993-1001.
- (6) Finley RL, Collington P, Joakim-Larsson DG, McEwen SA, Li X, Gaze WH, Reid-Smith R, et al. The scourge of antibiotic resistance: the important role of the environment. *Clin Infect Dis.* 2013 Sept;57(5):704-710.
- (7) Amarasiri M, Sano D, Suzuki S. Understanding human health risks caused by antibiotic resistant bacteria (ARB) and antibiotic resistant genes (ARG) in water environments: Current knowledge and questions to be answered. *Crit Rev Environ Sci Technol.* 2019 Dec;50(19):2016-2059.
- (8) Kummer K. Resistance in the environment. *J Antimicrob Chemother.* 2004 Aug;54(2):311-320.
- (9) Stanton IC, Bethel A, Leonard AFC, Gaze WH, Garside R. What is the research evidence for antibiotic resistance exposure and transmission to humans from the environment? A systematic map protocol. *Environ Evid.* 2020 June;9(12).
- (10) Kraemer SA, Ramachandran A, Perron GC. Antibiotic Pollution in the Environment: From Microbial Ecology to Public Policy. *Microorganisms.* 2019 June;7(180).