



CANADIAN
JOURNAL
of UNDER
GRADUATE
RESEARCH

COVID-19
Vaccination

“Our findings did not provide evidence that thinking styles or working memory capacity predicted vaccination status ... concerns regarding the safety of the vaccine, were significant predictors of vaccination.” (p.7)

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Performative
Documentary

“Rigg’s filmography is an important cross-section of documentary filmmaking and the culture of 1980s America from which it emerged.” (p.18)

Kombucha pH for
Food Safety

“These findings may provide valuable insights for consumers, producers, and regulators regarding the food safety of blue tea kombucha.” (p.30)

CANADIAN JOURNAL *of* UNDERGRADUATE RESEARCH

A student-led publication that aims to highlight research by undergraduate students of all disciplines

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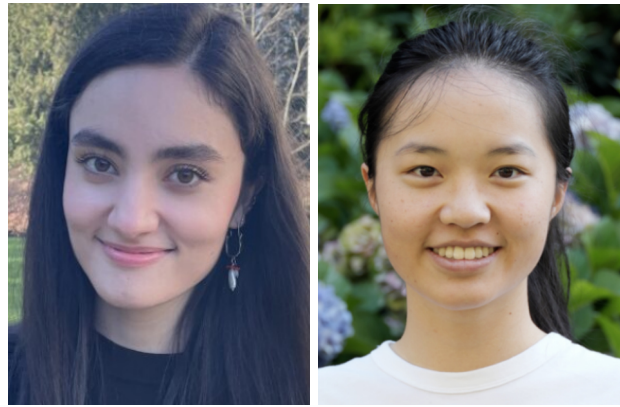
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This issue is published on the traditional, ancestral, and unceded territory of the Coast Salish Nations, including x^wməθk^wəyəm (Musqueam), Sḵwxwú7mesh (Squamish), and səliwətał (Tseil-Waututh).

Letter from the **editors-in-chief**



We are delighted to present Volume 9 Issue 1 of the Canadian Journal of Undergraduate Research (CJUR). This issue showcases six articles from undergraduate students across Canada, with research topics as diverse as using working memory to predict COVID-19 vaccination, the impact of spinal chord injury on the sexual experiences of queer people, the power of performative documentary, regulating hypoxic behaviour in tumors, analysis of kombucha pH,

and how binge-watching evokes vicarious nostalgia. The CJUR team is honoured to be able to provide a platform for displaying the impressive work of our undergraduate contributors.

CJUR currently has 30 active papers in our editorial and copyediting queue, and we continue to receive high quality manuscripts from various disciplines throughout the year. We thank our authors for entrusting us with the final product of their scholarly labours. We are also profoundly grateful for the dedication of our graduate, postdoctoral, and faculty reviewers, without whom this work would not be possible.

As new editors-in-chief, we aim to support our editorial team of eight dedicated senior undergraduate students to continue publishing high quality work. Over the past months, our editors have been working tirelessly to ensure the utmost care is taken with each new submission, and it has been a great privilege to work alongside them. We would also like to express our immense gratitude towards our senior advisors, for their generosity in lending their mentorship and insightful expertise.

We hope you will enjoy Volume 9 Issue 1 as much as we did, and we thank you for your continued support.

Yours sincerely,

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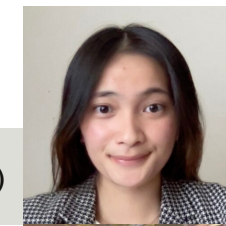
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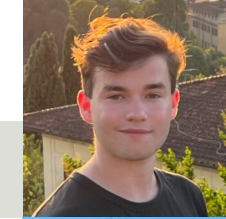
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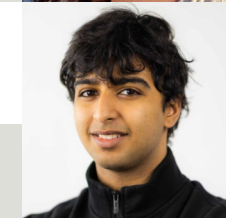
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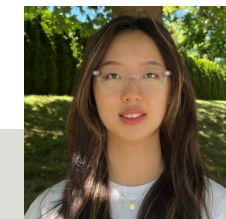
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Working Memory Capacity and Thinking Styles Unable to Predict COVID-19 Vaccination

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ABSTRACT Failure to comply with vaccination mandates during the coronavirus disease 2019 (COVID-19) pandemic posed a great challenge to the Canadian health care system. Choosing not to vaccinate may reflect concerns about the costs of vaccination and dismissal of its public health benefits. This study investigated if this decision-making is associated with limits of one's mental capacity, specifically working memory capacity. In addition, the degree to which individuals choose to approach decisions with either experiential (intuitive) or rational (logical) thinking styles were considered. To measure these cognitive functions, participants completed the n-Back task as well as the Rational Experiential Inventory-40 questionnaire. The purpose of this study was to investigate if working memory capacity and individuals' thinking styles can predict attitudes towards COVID-19 vaccination status. However, our findings did not provide evidence that thinking styles or working memory capacity predicted vaccination status. Notably, we found that attitudes surrounding COVID-19 vaccination, such as concerns regarding the safety of the vaccine, were significant predictors of vaccination. The results of this study propose that executive functioning levels cannot predict vaccination.

INTRODUCTION

The novel coronavirus disease 2019 (COVID-19) posed a great challenge to the Canadian health care system. As COVID-19 vaccines became available, many individuals had chosen not to be vaccinated (Troiano & Nardi, 2021). This may be partly due to the concerns associated with vaccinations. In one study assessing reasons around vaccine hesitancy, uncertainty around future effects post-vaccination were indicated in 42.7% of respondents, worries about side effects in 11.4% of respondents, and a lack of trust in vaccines in 7.7% of respondents (Robertson et al., 2021). Decision-making regarding costs over benefits is therefore a critical cognitive process underlying COVID-19 vaccination status and attitudes. However, the cognitive abilities and biases underlying this decision remain unclear. This study aims to investigate whether and how core cognitive functions, primarily working memory capacity, as well as dual-processing cognitive styles, are associated with individual differences in attitudes and behaviours toward COVID-19 vaccinations.

The term "working memory" refers to a cognitive system that is responsible for the storage and manipulation of information required for ongoing cognitive processes (Baddeley, 1992). Individual differences in the ability to store items in working memory are referred to as working memory capacity (WMC). WMC can account for the variation in complex cognitive functioning, such as comprehension, reasoning, learning, and fluid intelligence (Shelton et al., 2009; Unsworth & Engle, 2006). Fluid intelligence is a reliable predictor of how people reason and adapt to complex environments (Yuan et al., 2006). Working memory abilities can be dependent on several factors, such as sleep consolidation, age, life stresses, presence of mental illness, neurological disorders, and mood (Jarrold & Towse, 2006). Studies suggest that higher WMC can be associated with positive affective and cognitive outcomes, such as higher learning capacity under stress (Otto et al., 2013), evaluation of costs and benefits (Hofmann et al., 2008), and decision-making (Bagneux et al., 2013).

In addition to WMC, the variation in decision-making processes that individuals engage in may also be of importance when they are faced with vaccination decisions. The Cognitive-Experiential Self-Theory (CEST) argues that individual differences in information processing are expressed in two systems: the experiential and the rational (Epstein, 1998). The

experiential system is rapid, emotional, and minimally demanding of cognitive resources. In contrast, the rational system is composed of slower, analytical, and logical thinking. In a meta-analysis by Phillips et al. (2016), the authors found that dual-processing preferences accounted for the variability in decision-making. Rational system processing was found to be more beneficial in situations that required more complex and high-stake decisions, as this system utilizes the cost-and-benefit ratio. Okuhara et al. (2020) revealed that anti-vaccination messages that use fear to convey the message activated the experiential system, and messages that promote vaccinations activated the rational system.

Previous research has attempted to elucidate vaccine hesitancy prior to COVID-19 vaccinations. A review by Dubé et al. (2013) found that despite vaccination being one of the most successful measures to protect public health, many perceive vaccination practices to be unnecessary or even unsafe. Prior work has illustrated that vaccine hesitancy can be a danger to both the individual refusing to vaccinate, and to their community, as well as health care resources (Coustasse et al., 2021). Individual characteristics, including socioeconomic status, health literacy, previous vaccination status, race/ethnicity, level of education, and political affiliation have been shown to predict vaccine status (Raja et al., 2021).

We conducted an online study to examine working memory capacity and classify participants' decision-making styles given the critical roles of these cognitive functions in decision-making. We hypothesized that individuals with higher WMC and those who primarily engage their rational system will better understand the personal and public health benefits of COVID-19 vaccination and consequently show less vaccine hesitancy.

METHODS

Participants

Participants were recruited through Red Deer Polytechnic's learning management system. A total of 105 participants contributed to the online survey. We conducted quality checks on the data and removed data from participants who did not complete the whole survey and cognitive task. After removing these participants, the final sample used for analysis consisted of 68 participants whose ages ranged from 18-79 years old ($M_{age} = 25.25$, $SD = 9.94$). Most respondents self-identified as female ($n = 53$, 78%). Approximately 72% ($n = 49$) of the respondents were enrolled in or have completed a baccalaureate degree. Individuals that were under the age of 18, who had known neurological conditions, such as Attention Deficit Hyperactivity Disorder, or learning difficulties were not permitted to participate to reduce confounds when measuring cognitive functions (Jarrold & Towse, 2006).

Materials and Procedure

All surveys and experiments were implemented and presented using the online PsyToolKit platform (Stoet, 2010; Stoet, 2017). The survey included questions regarding demographic characteristics of age, education, and gender, questions regarding attitudes towards COVID-19 vaccination, vaccination hesitancy as well as COVID-19 vaccination status. The attitudes towards COVID-19

vaccinations were measured using structured questions based on the Center for Disease Control and Prevention's (CDC) guidelines (CDC, 2020). This section consisted of two questions regarding positive attitudes towards COVID-19 vaccination (e.g., I believe that COVID-19 vaccines are safe) with a five-point Likert scale (Likert, 1932) ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Conversely, negative attitudes towards two vaccine questions (e.g., I do not trust the public health agencies that recommend me to get a COVID-19 vaccine) were reverse coded as 1 (*strongly agree*) to 5 (*strongly disagree*). Vaccine hesitancy was measured by how long it took participants to decide to get vaccinated and was scored as follows: 4 = a few days, 3 = a few weeks, 2 = more than a month, 1 = no vaccination. Participants were also asked COVID-19 vaccination status ("Have you received a COVID-19 vaccination?") by responding *yes* = 1 or *no* = 0.

The Rational Experiential Inventory-40 (REI-40) questionnaire (Pacini & Epstein, 1999) was used to determine the degree to which individuals use faster intuitive thinking (experiential) and slower logical thinking (rational). Participants were asked 40 questions such as "I try to avoid situations that require thinking in depth about something" or "I often go by my instincts when deciding on a course of action" and responded on a 5-item Likert scale. Experiential and rational scales exhibited good internal consistency with Cronbach's alpha ranging from .87-.90 (Phillips et al., 2016). Finally, WMC was measured using a 2 trial n-Back task (2-Back task) implemented using PsyToolKit software (Stoet, 2010; Stoet, 2017). During the task, participants monitored a series of letters and were asked to indicate if the current letter matched the one presented 2 trials back. Participants completed 4 blocks of 25 trials. In accordance with n-Back guidelines from previous studies, letters were presented for 500 ms followed by a black screen for 2500 ms, giving participants a total of 3000ms to respond if the letter matched the letter 2 trials ago (Kirchner, 1958; Jaeggi et al., 2010). Data on reaction times and accuracy on trials were used to compute working memory capacity.

Participants were given a link to begin the study on a computer. After obtaining informed consent, the participants completed the surveys and the n-Back cognitive task.

Data analysis was conducted using SPSS Statistics. Separate hierarchical logistic regression analyses were conducted. One model was used with WMC and thinking styles as predictors, and vaccine hesitancy/acceptance as the outcome variable. The second model employed COVID-19 attitudes as predictors, and vaccine hesitancy/acceptance as the outcome variable. One-way ANOVAs were conducted with Tukey HSD post hoc tests to determine if n-back accuracy scores influenced reaction times, and another to determine if differences in WMC account for variation for concern regarding the severity COVID-19.

RESULTS

Cognitive Variables to Predict Vaccine Hesitancy/Acceptance

We conducted a hierarchical logistic regression using the "enter" method. Results are presented in Table 1. Three models are presented; the outcome variable in each was whether the participant is vaccine hesitant (0 = hesitant, 1 = non-hesitant). Each model included different blocks of independent variables.

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The main objective of this study was to examine the influence of participant's WMC on vaccine hesitancy. WMC was entered as a predictor in the model, and the results from Model 1 indicated that WMC was not a significant predictor of vaccine hesitancy (see Table 1). Model 2 added the thinking styles as a predictor of vaccine hesitancy. The results from Model 2 did not improve predictive qualities over Model 1. Model 3 included the interaction between WMC and thinking styles. The results from Model 3 did not yield an improvement over the other models.

Reaction Times and WMC

Table 1. Logistic Regression Results of Cognitive Functions to Predict Vaccine Hesitancy/Acceptance. Model 1 included the predictor of WMC, Model 2 included the additional predictor of Thinking Styles, and Model 3 included the interaction between both predictors.

	x^2	df	p
Model 1	0.144	2	0.93
Model 2	0.261	1	0.609
Model 3	0.771	2	0.68

Using a one-way ANOVA, we found a statistically significant difference between accuracy groups on *n*-back reaction times ($F(2, 63) = 3.971, p = .024$).

WMC to Predict COVID-19 Attitudes

Using a one-way ANOVA, we found a statistically significant difference between 2-back accuracy groups on the concern to get COVID-19 ($F(2,63) = 3.897, p = .026$). Tukey HSD post hoc tests revealed that the lowest accuracy group (25-50% accuracy, $n = 6$) had greater concern of getting COVID-19 than the moderate accuracy group (50-75% accuracy, $n = 21$) ($p = .02$). There was no significant difference in concern of getting COVID-19 between the moderate and high accuracy groups (75-100% accuracy, $n = 39$), ($p = .439$) or between the high and low accuracy groups ($p = .085$).

COVID-19 Behaviours to Predict Vaccine Hesitancy/Acceptance

A second hierarchical logistic regression using the "enter" method was conducted to analyze the influence of COVID-19 behaviours on vaccine hesitancy/acceptance. Results are presented in Table 2. Four models are presented; the outcome variable in each was whether the participant is vaccine hesitant (0 = hesitant, 1 = non-hesitant). Each model included different blocks of independent variables.

The results from Model 1 indicated that the belief in safety in vaccines predicted vaccine acceptance ($2 = 29.70, p < .005$). Belief in vaccine safety was associated with an odds ratio [$exp(B)$] of 4.51, which indicates that individuals who believed the COVID-19 vaccines are safe were 4.51 times more likely to be non-hesitant towards COVID-19 vaccination than individuals who believed the COVID-19 vaccines to be unsafe. The final regression model is presented as follows:

$$P(y) = \frac{1}{1 + e^{-(1.507x - 6.06)}}$$

Model 2 added the predictor of concern of getting COVID-19 to predict vaccine hesitancy. This model did not improve predictive qualities over Model 1 (see Table 2). Model 3 included the additional predictor of belief in necessity for COVID-19 vaccines to overcome the pandemic, and Model 4 included the predictor of trust in governing institutions that issue vaccines. The results from both Model 3 and Model 4 did not indicate a significance improvement of predictive qualities over the previous models.

Table 2. Logistic Regression Results of COVID-19 Attitudes to Predict Vaccine Hesitancy/Acceptance. Model 1 included the predictor of Belief in Vaccine Safety, Model 2 included the additional predictor of Concern of COVID-19, Model 3 included the additional predictor of Belief in Necessity for COVID-19 Vaccines, and Model 4 included the additional predictor of Trust in Government.

	x^2	df	p
Model 1	29.7	1	< 0.005
Model 2	3.684	1	0.055
Model 3	0.205	1	0.65
Model 4	0.122	1	0.726

DISCUSSION

Here, we investigated whether WMC and decision-making styles are reliable predictors of COVID-19 vaccine hesitancy/acceptance. We conducted an online study consisting of a survey to measure participants attitudes and hesitancy towards COVID-19 vaccination, the cognitive *n*-back task to measure WMC, as well as the REI-40 questionnaire to measure participants dual-processing systems in decision-making. We did not find significant empirical evidence suggesting that WMC or thinking styles can be used as predictors for COVID-19 vaccine hesitancy/acceptance. Our findings suggest that individuals with higher WMC had shorter reaction times on the *n*-back. Moreover, individuals with lower *n*-back accuracy scores had the highest concerns regarding COVID-19 severity. Furthermore, we found that belief in vaccine safety was able to predict vaccine hesitancy. However, our findings did not show that belief in necessity of COVID-19 vaccines or trust in governing institutions were significant predictors of vaccine hesitancy or associated with WMC.

Surprisingly, we did not find any empirical evidence that WMC predicted for vaccine hesitancy, despite the abundance of supporting literature suggesting that cognitive functions impact decision-making. However, a large study of approximately equal numbers of vaccinated and unvaccinated participants reported that higher executive dysfunction did not increase the likelihood of being unvaccinated against COVID-19 (Hudson et al, 2022), which corroborates our findings.

In addition, thinking style preferences were not significant predictors of vaccine acceptance/hesitancy or any of the attitudes towards COVID-19 vaccinations. Our findings are supported by Tomljenovic et al. (2021), as these authors argue that vaccine-hesitant participants do not differ in rationality skills or other cognitive abilities compared to participants who were not vaccine-hesitant. In addition, previous research has suggested that thinking style preferences were not able to predict help-giving behaviours (Kinnunen & Windmann, 2013), as vaccination can be

viewed as a helping behaviour (Coustasse et al., 2021).

Our results suggest that WMC and thinking styles are not significant predictors for vaccination acceptance/hesitancy. A possible explanation for these discrepancies may be due to the unique nature of COVID-19 vaccination policies. As proof of COVID-19 vaccinations or proof of recent testing negative for COVID-19 was required to gain access to restricted activities such as air travel and social activities, this may account for the high vaccine acceptance across participants, regardless of their cognitive abilities and biases (Walkowiak et al., 2021). Indeed, countries that implemented proof of COVID-19 vaccination certification had higher vaccine uptake (Mills & Rüttenauer, 2022).

Previous literature has associated higher accuracy on working memory tasks with shorter reaction times (McVay & Kane, 2012). Our findings support the previous literature, as participants with the highest accuracy scores on the *n*-back had the shortest reaction times.

In addition, we revealed that *n*-back accuracy is significantly associated with concern of COVID-19, which is consistent with previous literature (Fellman et al., 2020). Specifically, individuals with the lowest WMC had the highest concern of COVID-19. A possible explanation for these results is that threat of a natural disaster provokes stress, which may elicit a stronger disruptive effect on cognition, and therefore adversely affect working memory abilities (Helton et al., 2011).

As expected, we found that concern regarding the safety of the vaccine was a predictor for vaccine hesitancy. Concern over the perceived safety of the COVID-19 has predicted vaccination intentions in previous studies (Karlsson et al., 2021; Neumann-Böhme et al., 2020). Several studies have reported that vaccinations are still incorrectly seen as a possible cause of autism and are therefore perceived to be unsafe (Karlsson et al., 2021; Wang et al., 2019). Concerns over the accelerated speed of research, development, and approval regarding COVID-19 vaccines has also contributed to belief that COVID-19 vaccines are not safe (McAteer et al., 2020; Tasnim et al., 2020). Furthermore, our findings support the notion that individuals who perceive vaccines as safe are more likely to be non-hesitant to vaccinations (Betsch et al., 2010.)

Interestingly, the current study did not find that concern regarding severity of COVID-19 was a statistically significant predictor for vaccination acceptance, despite previous literature (Karlsson et al., 2021). In particular, young adults are less likely to believe that COVID-19 infections are severe (Aw et al., 2021), and therefore concern of getting infected by the virus may not be the driving factor for vaccination intentions.

Our findings suggest that belief in the necessity for COVID-19 vaccines to curb the pandemic was not able to predict vaccine acceptance. A possible explanation for this disruption comes from misinformation regarding COVID-19 vaccines. Misinformation that questions the necessity, efficacy, and safety of the vaccines is rampant (Rodriguez-Morales & Franco, 2021), and our findings indicate that individuals may not base their decision to receive the COVID-19 vaccine on the importance of vaccines in controlling the pandemic.

An unforeseen finding is that a lack of trust in the governing institutions responsible for issuing vaccines did not correlate with vaccine hesitancy, as previous research suggested otherwise (Van Oost et al., 2022). Therefore, participants may not trust the government, but are more willing to trust scientific or health experts regarding vaccination, as reported in previous studies. For example, Sturgis et al. (2021) revealed that vaccine confidence is higher in countries with a high level of trustworthiness towards science. Additionally, Jennings et al., (2021) suggested that trust is a core predictor in vaccine acceptance, as mistrust in government raised vaccine hesitancy, however, our findings do not support this.

Limitations

The current study has limitations. First, our sample did not contain equal proportions of vaccinated and vaccine hesitant participants which means we might not have been able to test our hypotheses with sufficient power. As suggested by Hudson et al. (2022), quota sampling of half vaccine-hesitant participants is needed for substantial statistical power to determine the moderating impact of vaccination status on potential findings. However, our effects of WMC and thinking styles on vaccination hesitancy are in line with the effects of executive function on vaccination status as reported in Hudson et al. (2022), suggesting our findings are not a false negative.

Second, our sample was based primarily in a politically conservative region, and therefore concerns over COVID-19 severity and vaccine necessity may not accurately represent those of the broader population. Those with conservative political beliefs are more likely to believe in COVID-19 conspiracies or misinformation (Romer & Jamieson, 2021). Individuals in our sample may have held these beliefs, as every electoral district outside Edmonton and Calgary in Alberta voted for the Conservative Party of Canada in the 2021 Canadian federal election (Elections Canada, 2021).

Third, we did not employ a validated COVID-19 hesitancy questionnaire in the study as none existed at the time of study. These results warrant replication using a validated questionnaire, such as the C19-VHS which was developed after the data collection in this study (Grossman-Giron et al., 2023).

Fourth, most participants were college students. Higher education may be a protective factor against refusing COVID-19 vaccines (Dodd et al., 2020; Troiano & Nardi, 2021). In addition, cognitive abilities are predicted by education level (Brown et al., 2008). Thirty-nine participants were categorized into the "high" WMC group, and only six participants were in the "low" WMC group. Therefore, conclusions regarding low WMC as a predictor should be interpreted with caution.

Future Directions

Given that the current study and Hudson et al. (2022) propose that cognitive abilities are unable to predict vaccination hesitancy/acceptance, future research should aim at looking to other cognitive avenues or factors such as inhibitory control, biases, and reasoning abilities that might influence vaccination. In addition, since the uniqueness of proof of COVID-19 vaccination certification may have mediated the effects of WMC or thinking

styles on vaccine hesitancy, it will be beneficial to examine the effect of these cognitive variables on attitudes toward other vaccines. Future research may also explore the COVID-19 vaccination intentions in scenarios in where vaccine certification was not required.

CONCLUSIONS

In conclusion, the current study suggests that cognitive abilities and decision-making preferences were not associated with the likelihood of being vaccine-hesitant for COVID-19 vaccination. Vaccination decision-making is complex, and other factors such as belief in misinformation and concern regarding vaccine safety may influence this decision. These results propose new insight to the existing literature regarding vaccination hesitancy and elucidate potential predictive qualities of WMC and thinking styles amidst a public health crisis.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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Sex, spinal cord injuries, and queerness: Critical narrative review of sexual experiences of Queer people with vaginas who have spinal cord injuries

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ABSTRACT The experiences of straight, cisgender “women” constitute nearly all of the research on sex and sexuality in people with vaginas (PWV) who also have spinal cord injuries (SCI). This critical narrative review aims to explore the sexual experiences of Queer people with SCI, particularly Queer PWV, an underrepresented group in existing literature. PWV who have partially or completely severed SCI can experience sexual arousal through both bottom-up and top-down neural processing pathways. Pleasure is defined similarly among Queer and non-Queer PWV. However, Queer self-identifying women experience more sexual satisfaction with self-stimulation than non-Queer PWV, and self-identified lesbians experience greater sexual satisfaction. Higher rates of sexual satisfaction for Queer PWV can be explained in part by the expectation of partnered orgasm, depth of cognitive and behavioral engagement in sexual activity, less incongruities in reading body language cues, and a congruent conception of the factual influences on sexual arousal, compared to heterosexual PWV. The outcome of internalized homophobia on sexual activity ranged from avoiding sexual activity to engaging in sexual activity under the influence, with both commonly leading to a mental disconnect between the brain and the body. This mental disconnect impacted the ability for a person to communicate their needs with a partner, as well as the ability to reach orgasm. Lastly, this narrative review serves as a reminder that ableist, patriarchal, and heteronormative epistemologies must evolve to better capture the experiences of diverse populations.

INTRODUCTION

According to the World Health Organization (WHO) “Sexuality is a central aspect of being human” (World Health Organization, 2007, p. 3). Considering that sexuality is important in the human experience, it is paramount to consider how it may change with injuries that impact sexual sensation and perception. Globally approximately 40 million people are affected by spinal cord injuries (SCI) (Zárate-Kalfópulos et al., 2006). Research from one trauma center in Québec, Canada reported between 10 to 83 traumatic SCI cases per million people annually (Thompson et al., 2014). As of 2018, Statistics Canada reported 4% of the population over fifteen years of age identify as LGBTQ+ (Statistics Canada, 2021). Considering the number of people who have SCI and who identify as Queer, it is necessary to understand both of their experiences. Queer is referred to as “relating to, or characterized by sexual or romantic attraction that is not limited to people of a particular gender identity or sexual orientation” (Merriam Webster, n.d.). This narrative review uses the term Queer as an umbrella term for diverse sexual identities outside of two-partner heterosexual relationships. Thus, this narrative review aims to critically explore research at the intersection of Queerness, people with vaginas (PWV), and spinal cord injuries (SCI).

The population this narrative review targets is largely understudied. Queer people with disabilities (inclusive of SCI) continue to experience sex, sexuality, pleasure, intimacy, and desire regardless of the physical parameters of their body (Drummond & Brotman, 2014; Loeser et al., 2018; Kattari, 2014; Rainey, 2011; Santinele Martino, 2017). In a review of 348 sexual and gender minorities (SGM) studies, only one was found to be on the topic of SGM’s experiences with SCI (Rosendale et al., 2021). This 1988 case study focused on a cisgender gay man with HIV and a SCI and their experiences with rehabilitative services (Meythaler & Cross, 1988). Methaler and Cross (1998) noted that unique needs of people with HIV/AIDS in disease classification, rehabilitation, psychological, and social strain warrant a need for broad rehabilitation programming. Beyond this single case study, different intersecting identities (i.e., sexuality, gender identity, gender expression) of PWV who have disabilities are often aggregated together; thus it is difficult to disentangle identities that are not

explicitly researched or discussed (Drummond & Brotman, 2014). O’Toole (2000) stated “Disabled lesbians and their issues are invariably ignored.” (p. 207). Beyond disabled lesbians, the population of this literature review (Queer PWV with SCI) is also disregarded. Existing research covers topics of orgasm in people with vaginas (PWV), Queer sexuality, and sexuality in people with SCI in isolation, which fails to capture the intersectional experiences of this population that very much exists (Drummond & Brotman, 2014; Caldwell, 2010; Campbell, 2017; Fraley et al., 2007; Kattari, 2015; O’Toole, 1996; Richards et al., 1997; Vaughn et al., 2015).

This narrative review aims to critically address the following research question: What are the sexual experiences of Queer people with vaginas who have SCI? Narrative reviews fit within a non-exhaustive process of understanding, analyzing and presenting existing literature (Sukhera, 2022). A critical narrative review incorporates reasonable scrutiny and critical interpretation of selected literature (Saunders & Rojon, 2011). The authors approached literature (sexual arousal in PWV and SCI, Queer sexuality, and sexuality in people with SCI) from an intersectional and interdisciplinary perspective. Databases (PsycInfo, PsycArticles, PubMed Central), and search engine (Google Scholar) were used to identify research that relates to the research question alongside the following keywords: Queer, sexuality, SCI, assigned female at birth, women.

LITERATURE REVIEW

Biological perspectives on sexuality and sexual arousal in PWV and SCI

The importance of sexuality in all people has previously been discussed by the WHO (2006). It is therefore imperative to understand how sexuality is affected by SCI. Some researchers have investigated the neural pathways responsible for sexual arousal in people with SCI. Whipple and Komisaruk (2002) aimed to identify if genital stimulation in people with SCI uses the vagus nerve pathway between the vagina, cervix, and uterus. A small sample of participants with SCI above T-10 and one without SCI experienced both control (foot stimulation) and experimental (cervical self-stimulation) conditions alongside positron emission tomography-magnetic resonance imaging (PET-MRI) measurement strategies. The PET-MRI is a hybrid test that combines PET and MRI imaging. The PET-MRI was used to identify activation of the nucleus of the solitary tract (NTS), which uses the vagus nerve as its main projection site. Preliminary results indicated that the NTS of all participants were activated during cervical self-stimulation. These findings tentatively suggested that sexual response in PWV employs the use of the vagus nerve regardless of SCI. This study cannot rule out other spinal or nerve pathways involved in cervical stimulation that are unaffected by SCI.

Komisaruk and colleagues (2011) mapped cortical areas involved in clitoral, vaginal, cervical, and nipple self-stimulation. In independent and randomized trials, participants were asked to self-stimulate either the clitoris, anterior wall of the vagina, the cervix, or the nipple. Results indicated that distinct areas of the medial paracentral lobule (PCL) are activated during genital stimulation. Interestingly, they found that nipple self-stimulation

activates both the thoracic area of the homunculus and similar areas in the PCL that are activated during clitoral, vaginal and cervical self-stimulation. These results are important in understanding that a pleasurable sensation may be experienced in people with SCI above their injury point.

Another topic of interest is the perceptual experiences of arousal after SCI. Adapting to life with a SCI has resounding impacts on daily life including sex and sexual arousal. Angel and Kroll (2020) showed that SCI impacted internal perception of attractiveness, created a need to manage physical impairment, changed engagement in sexual relations, led to a rediscovery of sexuality, and may have led to a loss of intimacy and sexual activity. Semi-structured interviews by Parker and Yau (2012) with “women” with SCI highlighted the need for reimagining a positive sexual identity through education and interactions with others. Participants shared that they have sexual identities regardless of SCI and that society needs to recognize this (Parker & Yau, 2012). The research on sexuality in people with SCI is not complete without considering diverse sexual and gender identities. In the following sections, Queer experiences of sexuality and sexual arousal are discussed.

Sexual satisfaction in Queer versus heterosexual PWV

Cohen and Byers (2014) aimed to gain an understanding of the affective, cognitive, and behavioral sexual experiences of non-heterosexual women. Higher sexual satisfaction among non-heterosexual women in committed relationships was positively correlated with reports of high self-esteem, sexual desire, and sexual activity and negatively correlated with anxiety surrounding sex and negative thoughts about oneself. Participants over 18 years old who had been in a same-sex relationship for a minimum of one year were recruited. Using questionnaires and surveys, Cohen and Byers (2014) measured the sexual frequency, desire, satisfaction, anxiety, esteem, and automatic sexual thoughts of participants. Researchers found that the frequency of sexual activity for non-heterosexual PWV is on par with heterosexual women, regardless of gender identity. After controlling for age and length of relationship, sexual activity remained just as important to sexual satisfaction, high self-esteem and sexual desire. Overall non-heterosexual women felt positively about themselves, their sexuality, and engaging in sexual activity with their partner.

Thus far, research on solitary and partnered sexual experiences has been conducted through an androcentric and heteronormative lens (Goldey et al., 2016). In their study, Goldey and colleagues (2016) aimed to understand how “women” define sexual pleasure, how those definitions related to pleasure in solitary versus partnered sexuality, and if the experience of pleasure differs based on sexual identity. The researchers took a phenomenological approach and collected qualitative data from thirteen focus group sessions. Participants were separated into two comparison groups (one consisting of heterosexual participants and the other consisting of Queer participants) and were asked general questions about how they experience and perceive pleasure in the context of solitary or partnered sexuality and sexual activity. Thematic analysis was used to interpret the data.

The results of this study (Goldey et al., 2016) found that pleasure was similarly defined regardless of gender identity and regardless

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of whether it was in a solitary or partnered setting; however, the experience of both solitary and partnered pleasure was found to be different. In contrast to heterosexual women, Queer women experienced less discomfort with solitary pleasure, likely due to the male sexual scripts in heterosexual relationships in which men hold ownership over the orgasms of their female partners (Andrejek et al., 2022). Additionally, “the sexual double standard, which imposes shame upon women for the same behavior as men, influences the perceptions concerning expectations about heterosexual sex, as well as perceptions of women’s right to sexual pleasure” (Andrejek et al., 2022, p. 193). These gendered sexual scripts consider solitary sex as “challeng[ing] male partners’ ownership of women’s orgasms” (Goldey, 2016, p. 2147). Additionally, the perspective on partnered orgasm for heterosexual women was that it was not expected, and in some cases, even non-existent; this was the opposite for most Queer women.

Orgasm and pleasure differences in Queer versus heterosexual PWV

Arousal is experienced somewhat differently for Queer PWV than for heterosexual PWV. Using the Sexual Arousal Inventory rating scale as well as additional questionnaires about demographics, lifestyle, and sexual behavior, Coleman and colleagues (1983) explored arousal and sexual satisfaction in lesbians and heterosexual women. They found that lesbians, in comparison to heterosexual women, had sex more frequently, had more sexual partners, and experienced higher rates of orgasm. Even when orgasm through masturbation was controlled for, lesbians experienced orgasm at a higher frequency. Bolsø (2005) analyzed interview data from self-identified lesbians on the influence of power and its connection to orgasm. It was found that providing an orgasm for their partner was positively correlated with the giver’s own sexual desire and that they valued mutually satisfying orgasmic and sexual experiences (Bolsø, 2005). For example, sometimes the giver was able to achieve their own orgasm without being touched by their partner or themselves while pleasuring their partner.

The higher rates of sexual satisfaction in Queer people may be attributed to a multitude of reasons. Heterosexual women often did not expect to orgasm in partnered experiences, while most Queer women did (Goldey et al., 2016). Generally, when Queer PWV were engaging in sexual activity the focus was on mutual pleasure and satisfaction for both partners (Bolsø, 2005). Queer PWV usually took turns giving their partner an orgasm, or at least did whatever possible to make that happen for their partner (Bolsø, 2005). Additionally, because of how prevalent sexual anxiety and negative automatic thoughts are during sexual activity in all PWV, the higher level of sexual satisfaction among Queer PWV suggests that they were more cognitively and behaviorally engaged in the sexual activity (Cohen and Byers, 2014; Beaber and Werner, 2009).

Sexual satisfaction and arousal in Queer people with vaginas

The differences in and causes of arousal between Queer and heterosexual PWV could also be due to a number of influences. Sexual arousal is understood through an extremely narrow, biological perspective. The common conception is that PWV have

less overall desire for sex than those assigned male at birth (AMAB); however, this conception is slowly being challenged. The sexual desire of AMAB people may not be higher than PWV, just more stable (Leiblum, 2002; Leiblum & Rosen, 1988; Fisher, 1999). Studies have found that arousal in PWV is more variable and can be even stronger in the right situation—namely when distractions are minimized, they feel emotionally and physically safe, and their partner is enthusiastic and willing to learn and listen (Leiblum, 2002; Leiblum & Rosen, 1988; Fisher, 1999). When Queer PWV were having sex, they tended to be more skilled in reading and understanding their partner’s body compared to heterosexual men, and therefore this biological sex empathy aids them (Coleman et al., 1983). Further evidence of differences in communication through role socialization is that Queer PWV were much less likely to see the rejection of their sexual advances by a partner or rejection of their partner’s sexual advance as negative (Bell & Weinberg, 1978). The final major influence is the relationship between sexual drive and sexual attraction. For heterosexual men, sex drive and attraction to other men were negatively correlated (Lippa, 2006, 2007). In contrast, for heterosexual PWV, there was a positive correlation between sex drive and attraction to both men and PWV. However, it has been shown that Queer PWV had a stronger positive correlation between sex drive and attraction to PWV (Lippa, 2007). Furthermore, these results were consistent when replicated in other countries and across ages (Lippa, 2007, 2006).

Queerness, sexuality, and sexual arousal: Internalized homophobia

This review suggests that Queer PWV experience sex differently than heterosexual PWV. This was especially apparent when examining internalized homophobia and its effects on sexuality and sexual arousal in Queer PWV.

Although Queer PWV report higher sexual satisfaction than heterosexual PWV, as stated above, the sexual satisfaction of Queer PWV was still negatively affected by internalized homophobia (Pascoal et al., 2019). The effect on sexual satisfaction may stem from the way that internalized homophobia manifests in Queer PWV. External homophobia may create internalized homophobia and result in behavioral changes that then negatively impact sexual satisfaction (Holmberg & Blair, 2009). Behaviors resulting from internalized homophobia included delaying or ceasing in engagement with sexuality or sexual activity, feeling disgusted by the idea of sexual activity and towards their own body or self, avoiding necessary healthcare, exploring same-sex attraction through pornography, and engaging with sexuality and/or in sexual activity through sex while under the influence of substances (chemsex) (Holmberg & Blair, 2009). The outcome of the behaviors caused by internalized homophobia may negatively affect sexual satisfaction by decreasing the ability to communicate openly and honestly with a partner about what feels pleasurable and what fantasies one might have, which in turn also increases sexual anxiety (Frost and Meyer, 2009; Cohen & Byers, 2014). Additionally, because orgasm often requires focusing on the body’s sensations and connecting to positive or neutral cognitions, reaching orgasm can be more difficult when you are ruminating on shame or dissociating from your body (Pascoal et al., 2019; Li and Samp, 2019).

CONCLUSIONS

This narrative review brings to attention the importance of exploring the unique sexual experiences of complex intersecting identities. Specifically, the experiences of Queer PWV who have SCI are absent in existing research. In 2023, it is not enough to solely base the understanding of a phenomenon from the experiences of straight, cisgender “women.” Therefore, this review aims to bring sexually and gender diverse voices to the forefront.

Due to the lack of understanding of the chosen population, service providers have little understanding of the unique challenges of this population. For example, because conversations surrounding sex and sexuality for PWV usually center on reproduction, which is not typically affected by SCI, sex and sexuality are not given further attention. However, it is important to separate sex and sexuality from reproduction—they are not synonymous. Service providers such as primary care physicians, relationship counselors, and sex therapists do not have a sufficient research base to draw on to engage in research-informed practice. It is the authors’ hope that this review can inform future research and eventually service providers of ways to better support this population. Based on the narrative review findings, practitioners could support sexual partners in recognizing and affirming the sexual identity of Queer PWV who have SCI.

Furthermore, the authors hope that this critical narrative review serves as a way to highlight the experiences of Queer PWV with SCI. The authors are optimistic this work encourages academic researchers to conduct research that meaningfully addresses how ableism, heteronormativity, and patriarchal structures influence their research.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest

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Marlon T. Riggs and the power of performative documentary

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ABSTRACT This paper provides an overview of documentarian Marlon T. Riggs, a key figure in Black and gay art movements of the 1980s, and his filmography, focusing in particular on his use of the performative mode of address. His videos are frequently referenced by documentary theorists as exemplars of the performative mode first defined by film scholar Bill Nichols, which refers primarily to the use of embodied knowledge and a personal voice within the context of nonfiction filmmaking. This review draws from Riggs' documentaries and various analyses of his cultural impact, and it explains and considers competing viewpoints within documentary film studies and, to a lesser extent, cultural studies about Riggs' legacy. Two of his four feature films, *Ethnic Notions* (1986) and *Color Adjustment* (1991), are widely acknowledged as representative of the expository mode of address, characterized by the use of direct address and a clear rhetorical argument. Although they are less celebrated within cinephile circles, they are conventionally educational which makes them culturally significant. However, it is *Tongues Untied* (1989) and *Black Is... Black Ain't* (1995) that are firmly positioned as performative, and their emotional and subjective value make their power as tools for social change clear. That these films were some of the first to portray Black, gay life in unapologetic terms also demonstrates their cultural significance and lasting impact, particularly on broadcast television. Riggs' filmography is an important cross-section of documentary filmmaking and the culture of 1980s America from which it emerged, and its evolution provides valuable insight into the rise of the performative mode and self-representation in television documentaries.

INTRODUCTION

Since the release of filmmaker Marlon T. Riggs' final documentary in 1995, his name largely remains synonymous with the performative mode of documentary filmmaking, especially as a tool for the authentic representation of Black, gay life on screen. Riggs' career was extensive, considering its brevity, and included dozens of poems, four short films, and half a dozen years teaching at his alma mater, the University of California, Berkeley (Bost, 2018). His most significant contributions are his four documentary features, grouped into two unofficial duologies: *Ethnic Notions* (1986) and *Color Adjustment* (1991), and *Tongues Untied* (1989) and *Black Is... Black Ain't* (1995). The latter pair has secured his place in documentary history as an innovator of the performative mode of address, notably cited as a prime example by prominent documentary film theorist Bill Nichols (2017). The performative mode is one of Nichols' six modes of documentary representation (i.e., classifications based on structural and stylistic conventions) which have become a foundational model of documentary theory and criticism. Conventions of the performative mode include the use of embodied knowledge, an emphasis on the sensory and the subjective, a personal voice, and experimental cinematography and editing (Nichols, 2001). Riggs is known equally for his contribution to the formal conventions of documentary and the expansion of its subject matter. Echoing calls for self-representation in media from contemporaries like gay and lesbian documentary scholar Thomas Waugh, Riggs implemented the performative mode to uplift his community (Anderst, 2019). To this end, he successfully leveraged the power of public broadcasting while employing an egalitarian voice by which viewers are not students but peers. This pushed the boundaries of what television documentaries could accomplish and solidified his role in modernizing the broadcast model. Riggs' filmography and its evolution highlight the harmony between the performative mode and self-representation and their symbiotic relationship with public broadcasting.

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DISCUSSION

Before Riggs: Precursors

The 1980s was a decade of considerable change for the documentary tradition, particularly in the US, stimulated by the larger socio-political context, especially the AIDS crisis and the accompanying lack of government intervention (Johnson, 2003). In Riggs' case, attempts to contend with this milieu manifested in part through his use of the performative mode. However, the mode was not defined in those terms until the first edition of Bill Nichols' (2001) foundational textbook *Introduction to Documentary*, wherein he outlined six modes of documentary filmmaking: expository, observational, interactive (later dubbed the participatory mode), reflexive, poetic, and performative. This expounded upon his earlier work *Representing Reality* which defined the first four modes (Nichols, 1992). Traces of the mode's basic conventions can be seen within films of other modes (especially the poetic mode) as early as the 1920s, and its distinct trademarks began to flourish in the post-war years. Early hallmarks can be seen, for instance, in the powerful and influential Holocaust documentary *Night and Fog* (1955). The mechanics differ somewhat from the current classification of the performative mode; for example, its voiceover is contemplative but still closer to that of the expository mode in its quasi-omniscience. Yet, the key creative urges are consistent: its message is communicated primarily on a sensory basis through emotionally resonant images because, as Nichols (2017) argues, there is no rhetorical argument that can make sense of such a devastatingly horrific event.

The 1980s boom for the performative mode was, in part, a reaction to the prevalence of the observational mode (based on undirected, spontaneous events and the absence of intrusive editing) due to the Direct Cinema movement of the 1960s and the subsequent growth of the participatory documentary mode (based on the collaborative interactions between filmmakers and subjects) (Nichols, 2017). This was itself a reaction to the predominance of the expository mode (characterized by its rhetorical argument addressed directly to the audience), which generally represented the "centralized, one way, top-down [information] flow pattern" that many progressive filmmakers aimed to unsettle (Goldberg, 1990, p. 6). The National Film Board of Canada's series *Challenge for Change*, which pioneered the citizen-made approach on broadcast television starting in 1967, was one foundational example of a divergence from that *modus operandi*, employing bottom-up (i.e., citizen to government) and horizontal (i.e., citizen to citizen) flows of information (Goldberg, 1990). It was equally distinguished for its self-representation, a pursuit shared by its contemporary, California Newsreel (Nichols, 2016). Film and cultural studies researcher Ron Burnett (2010) explains that self-representation is invaluable because even the best intentions of a filmmaker outside the community being portrayed cannot substitute the intimacy or understanding that comes with being a member of that community. These preliminary attempts to produce and platform films of self-representation proved its efficacy and prompted further development and experimentation, including from Riggs.

Ethnic Notions and Color Adjustment

Ethnic Notions is a historical examination of pervasive stereotypes about Black Americans, and *Color Adjustment* continues the same subject matter concentrating on television representation specifically. Given that they were produced for and aired by PBS, both documentaries were conceived and executed as education pieces with a general audience in mind (Harper, 1995). Mass culture theorist Chuck Kleinhans (1991) notes *Ethnic Notions'* frequent use in introductory Black Studies courses, which highlights its didactic quality. The use of authoritative, disembodied commentary, talking-head interviews with academics, and a rhetorical framework in these two films evidence their adherence to broadcast conventions, making them representative of the expository mode. That standard public broadcasting format places them within an older PBS tradition, left over from the 1970s when the network was one of the few distribution outlets for independent filmmakers. This gave the broadcaster considerable control of both content and form (Irving, 2015). However, in the years before Riggs' PBS debut, this tide had begun to turn. Because *Color Adjustment* was produced after the prototypically performative video *Tongues Untied*, its compliance with the expository mode indicates a purposeful decision based on audience and aim rather than a linear evolution in directorial style. Still, even working within the established broadcast template, Riggs subtly manages to forward and expand it. For instance, while both programs feature expert interviewees introduced by their professions, they occasionally speak to personal experience alongside their academic expertise (Kleinhans, 1991). Likewise, cultural critic Phillip Brian Harper (1995) highlights the Black perspectives featured within an otherwise 'objective' framework, noting that *Color Adjustment's* narrator recurrently uses the word "we" when referring to Black Americans. Recalling the era's concern with self-representation, Riggs' injection of subjectivity and his elevation of Black authority figures—all while working within the confines of the PBS model—confirms his influence on the form.

Tongues Untied

Riggs' magnum opus, *Tongues Untied*, guides the audience through the collected stories of various Black, gay men naturally and experientially. The widely accessible approach to *Ethnic Notions* and *Color Adjustment* is replaced with the specificity of personal experience. Interviews—not in the apparently spontaneous, question-and-answer style of *Ethnic Notions* or *Color Adjustment* but quasi-performances that use poetic language and recitation—are accompanied by dances, newspaper cuttings, childhood photos, b-roll, archival newsreels, and sparing observational sequences to create a rich, videographic tapestry. Without an overarching narrative, its associational editing creates a throughline between topics like first kisses, childhood bullying, and the looming fear of AIDS to support Riggs' intimate, embodied revelations and express his lived experience more completely than would be possible through a linear narrative. That editing lets the audience move through its world freely and interpret it as they will, guided by titles and structuring motifs but not handcuffed and marshalled by voice-of-God narration, deviating freshly from the expository, PBS tendency towards forthright rhetoric (Irving, 2015). Nichols (2017) characterizes this as an attempt to invite the audience "to experience what it feels like to occupy the subjective, social position of a gay black man" (p. 152). Autobiographical film theorist Leah Anderst (2019), by

contrast, argues that Riggs does not presume to replicate his experience as a Black, gay man for audience members who are none of these things, contending that *Tongues Untied* instead "asks viewers to witness but not to share in the filmmaker's story" (p. 75). Taking, for instance, one exemplary scene that cuts back and forth from Riggs in a closeup, recounting the story of his first kiss, to lips metronomically exclaiming "homo," these cut-ins would be considered an attempt to put the audience in the position of that young Marlon Riggs under Nichols' configuration (Riggs, 1989, 00:12:04). This device is used again when he recalls the racist and homophobic bullying he suffered in school, and a host of lips punctuate his phrases with the bullies' attacks (Riggs, 1989, 00:12:42–00:13:28). As Anderst attests, perhaps the viewers are instead in the position of a bystander, akin to a classmate in the hallway forced to witness the altercation(s) without the capacity to intervene.

However, both these interpretations are arguably contingent on the forum in which the film was aired: the PBS documentary series *P.O.V.*, a venue for 'alternative' voices and first-person accounts that would otherwise not fit the neutrality PBS sought (Irving, 2015). The equivalence in the video's presentation of conceptual and situational information elevates the embodied knowledge to the same status as the formal knowledge. This differs from typical expository documentaries that privilege journalistic and academic knowledge because of their rhetorical framework. As is evidenced by PBS's reticence to platform more subjective accounts, confining these films to one series amongst their wealth of programming, *Tongues Untied's* ability to challenge that hierarchy is admirable. Though it was aired to a diverse audience in its national broadcast, it was originally intended only for a gay audience (Kleinhans, 1991). As a result, it employs a hybrid of the "I speak about myself to you" and "we speak about us to ourselves" formulations of the filmmaker-subject-audience relationship as conceived by Nichols (Geiger, 2020; Nichols, 2017). From the film's first lines—Riggs' voice rhythmically repeating "Brother to brother"—*Tongues Untied* establishes its relationship to the audience (Riggs, 1989, 00:00:00–00:00:29). Unlike the didactic *Ethnic Notions* and *Color Adjustment*, Riggs made *Tongues Untied* for his peers. Although it is often mentioned alongside the quintessential Queer documentary *Paris Is Burning* (1990), Jennie Livingston's ethnographic portrayal of Black and Latine Queer ballroom culture is filtered through its White lesbian director (Bui, 2014, para. 29).

With the audience-based distinction between Riggs' two duologies in mind, New Left film scholar Chuck Kleinhans (1991) considers the video not "merely a report on gay males in the African-American community, but a major intellectual intervention which [helped] create the terms in which black gay men are collectively thinking and imagining their identity" (p. 160). The film's intended audience (members of Riggs' constituency, i.e., Black, gay men) do not need an expository report on what it means to be a Black, gay man generally—hence the performative accounts from these Black, gay men specifically. This is reinforced through a consistent use of "us" and "we" language. Certain moments may read as 'reporting,' most clearly the lesson from the fictitious "Institute of Snap!thology," but they are (semi-discreetly) a thoughtful meditation as Kleinhans suggests (Riggs, 1989, 00:08:08–00:11:24). That sequence is superficially a how-to video, 'teaching' its audience the techniques of the Diva Snap, but when Riggs asks the camera "You know why we do this?" before

snapping, he makes it a statement—even more so when he answers, "'Cause we can't always get our arms free to do this," before a group of other men join him on screen to snap collectively (Riggs, 1989, 00:11:14–00:11:22). The community focus in that scene is seen throughout the documentary, which Harper (1995) considers a collectivization of the disparate lives of individual men to create a self-portrait of a marginalized subculture.

Despite its artistic and academic legacy, the documentary's dissemination was unduly limited. Of the 284 PBS affiliates that aired the *P.O.V.* documentary series, 110 would not broadcast *Tongues Untied* as part of a larger pattern of the suppression of Queer "propaganda" (Geiger, 2020, p. 179). Its so-called "pornographic" content was even famously denounced on the US Senate floor by Republican Jesse Helms (DeClue, 2019, p. 47). In addition to the puritanical and homophobic underpinnings behind Helms' claim, the performative use of embodied knowledge likely played a role; to an untrained or biased eye, its sensory communication and on-screen inclusion of bodies can be conflated with the sexual (Gaines, 1999). Because the decision to air the film nationally only came to be after its production, Riggs (somewhat suddenly) advanced mainstream representation of Black and Queer lives, voices, and bodies—almost by accident.

Black Is... Black Ain't

Riggs' final documentary, *Black is... Black Ain't*, operates within a mosaic-like framework similar to *Tongues Untied*, but in place of the latter's dance-sequence transitions, this video is tied together by two motifs: interviews with Riggs in his hospital bed, having been admitted due to complications from AIDS; and the video's medley framing of his grandmother making gumbo while Riggs reads, via voiceover, a recipe of the elements that constitute a person (Riggs, 1995, 01:21:46). Like Riggs' poetic recipe, the diversity of Black voices featured create an all-embracing medley (Johnson, 2003). Tragically, Riggs died during the production of *Black Is... Black Ain't*, and it was completed by his collaborators Nicole Atkinson and Christiane Badgley with the assistance of his detailed instructions (Harper, 1995). His authorial vision shines through, though there is a distinction that differentiates it from his other features. His story is still present, but the documentary's scope is more similar to *Ethnic Notions* and *Tongues Untied* in its breadth, touching on racism, identity labels, misogyny, masculinity, homophobia, religion, and family. In the view of performer and communications scholar E. Patrick Johnson, *Black Is... Black Ain't* suggests that Black Americans must discuss and accept their internal diversity before the dominant culture can cultivate that same diversity and acceptance, echoing Kleinhans' assessment of *Tongues Untied* as a community discussion about identity (Johnson, 2003).

Fittingly, given that focus on the democratization of media and the drive for self-representation highlighted by Johnson, *Black Is... Black Ain't* was distributed by California Newsreel. In their early years (1968 through 1970s), their leftist goals inspired a collective approach to filmmaking. They had been collaborators with the National Education Television, a precursor of PBS, and the similarity in journalistic intent is visible (Nichols, 2016). Their most notable works from this time period, *Off the Pig* (1968) and *San Francisco State: On Strike* (1969), are primarily observational, but as they progressed into the 1980s, they began to shift their

strict collectivity to an approach that embraced individual, auteurist works alongside their previous content (Nichols, 2016). It was here that Riggs flourished, and having already innovated the use of the performative mode at PBS, he helped modernize California Newsreel's catalogue in turn.

Once again, Riggs uses the performative mode to forward this goal of self-representation. Anderst's claim about the performative power of "witnessing" the stories on-screen is made explicit in bell hooks' interview, recounting an especially violent domestic disturbance: her father threatens to kill her mother, and while her siblings try to ignore the situation and go to sleep, she refuses, thinking, "I've gotta witness this" (Riggs, 1995, 00:46:16–00:46:37). As her voice echoes ("Witness this... Witness this..."), the video fades back to a man dancing (Riggs, 1995, 00:46:37–00:46:40). Akin to the intercutting of the lips in *Tongues Untied*, the way sequences are punctuated by home-video quality archival footage, childhood photos, and the dancing motif creates a pattern that successfully links the diverse experiences of its subjects together. These elements make the video fit predominantly in the performative mode, but it revives expository interviews of *Ethnic Notions* and *Color Adjustment* to a degree; again, most of the interviewees are academic experts, yet the titles below their names do not show their profession but their hometowns. Again, Riggs connects his work to this struggle for horizontal media, challenging television's tendency to venerate authorities and experts rather than allowing audience members to take an active role in production (Goldberg, 1990).

After Riggs: Legacy

Riggs' innovative documentaries played a key role in shaping the way theorists discuss the documentary form and how they understand the filmmaker-audience relationship (Geiger, 2020). The performative mode has continued to evolve in the decades since Riggs' death. Animated documentaries like *Ryan* (2004) have been especially popular within the performative mode to portray subjective experiences, continuing Riggs' efforts using animation in place of associational editing or experimental cinematography (Nichols, 2017). These hybrid films use performances much like Riggs' use of recitation and dance. In the years after Riggs' influential work, PBS sustained the advancement he had championed and exemplified. A scholar of activist media, Patricia Aufderheide (2019) observes a shift through the mid- to late-1990s from the network's 'two-sides' approach to one that focuses on individual stories and perspectives within larger issues. She cites, among others, *A Healthy Baby Girl* (1997)—a film chronicling the filmmaker's battle with cancer caused by the pregnancy drug DES (Aufderheide, 2019).

Likewise, Riggs enabled the truthful portrayal of under- and misrepresented groups in an era when Queer life onscreen was still very stigmatized (DeClue, 2019). As evidenced by their wholly uncensored nature, Riggs' autoethnographic videos were not restrained by the politics of respectability surrounding gay art seen by a straight audience and, in doing so, altered the kinds of programming one could conceive of being on mainstream television (DeClue, 2019). Riggs' legacy endures today in both fiction and nonfiction film and video, particularly the New Queer Cinema movement which emerged in his last years, typified by postmodern aesthetics and questions of marginalized identities

(Bui, 2014). For example, the documentary *Silverlake Life* (1993) uses "interweaving" editing that echoes *Tongues Untied* and *Black Is... Black Ain't* (Geiger, 2020, p. 24). The unapologetic portrayal of Black, Queer bodies in the narrative drama *Pariah* (2011) is evocative of that of Riggs (DeClue, 2019). PBS also grew from Riggs' work. The network's roster from the 2010s abounds with films on underrepresented groups, like the story of the racist, arson-fuelled destruction of a predominantly Black Philadelphia neighbourhood in *Let the Fire Burn* (2013) (Aufderheide, 2019). Riggs' artistic and institutional impact speaks to the revolutionary power of his work.

CONCLUSION

Riggs' filmography presents a microcosm of the development within the documentary tradition throughout the 1980s and 1990s where attention expanded and shifted from the overwhelming use of expository, observational, and participatory modes to the performative mode. *Ethnic Notions* and *Color Adjustment* highlighted important social issues through subtly subversive techniques within a chiefly expository framework. *Tongues Untied* and *Black Is... Black Ain't* employed the performative mode masterfully in service of Black and Queer visibility and documented his reality through a previously unseen combination of techniques. Riggs' innovative use of first-person voice, subjective editing, and embodied knowledge influenced the documentary tradition enduringly. His work signalled a turning point for Black and Queer representation with Riggs at the forefront. As a filmmaker and an activist, Marlon T. Riggs was a trailblazer for the performative mode, the broadcast documentary form, and mainstream Black and Queer representation. The documentary tradition is forever better for it.

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CONFLICT OF INTEREST

The author declares no conflicts of interest.

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Regulating Hypoxic Behaviours in Solid Tumors

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ABSTRACT Adaptation to hypoxic environments allows malignant tumors to outcompete normal cells. This microenvironment increases treatment resistance and favours tumor progression. However, certain cellular responses can be anti-tumorigenic. Understanding and utilizing oxygen dependent pathways like hypoxia-induced factors (HIF) can enhance therapy efficacy for different types of cancer by regulating glycolysis, metastasis, and immune invasion. This article focuses on the HIF pathway, eukaryotic elongation factor kinase (eEF2K) stabilization, protein disulfide isomerases (PDIs), and the immune response to hypoxia. These four key components bridge hypoxic stress and cancer, highlighting their potential therapeutic implications.

INTRODUCTION

Cancer is a multifactorial disease involving the interaction of diverse environmental conditions and several genetic pathways (Sanchez-Vega et al., 2018) (Table 1). Recently, there has been growing interest in understanding the complex and dynamic environment surrounding a tumor, known as the tumor microenvironment (TME). This includes immune cells (T-cells, B-cells, and macrophages), residential cells (stromal cells, endothelial cells, and stellate cells) and the extracellular matrix (endosomes, and collagen) that support tumor progression (Anderson & Simon, 2020; Baghban et al., 2020). A key condition in cancer progression is hypoxia signaling and its effects on the surrounding environment where tissue experiences inadequate oxygen supply (Brahimi-Horn et al., 2007; Eltzschig & Carmeliet, 2011). In the first section, we provide a general background on hypoxia and its association with cancer, as well as outline the key components covered in this review. Subsequently, we discuss how oxygen dependent pathways enable tumor cells to adapt to the hypoxic microenvironment, evade immune responses, and enhance treatment resistance.

Table 1. Major Oncogenic Pathways. This table depicts critical pathways implicated in cancer progression. Genetic analyses identified multiple pathways involved in cancer and the cellular effects of disrupting these pathways. Recent studies show that hypoxia is a key in cancer progression. The hypoxic pathway (denoted by the *) plays a central role in modulating key processes such as angiogenesis, cell proliferation, and cell growth (Sanchez et al., 2018).

Oncogenic Pathways	Cellular Effects
Receptor tyrosine kinase/Rat sarcoma (RTK/RAS) pathway	Proliferation, cell survival and translation
Nuclear factor erythroid 2-related factor 2 (Nrf2) pathway	Oxidative stress response
Phosphoinositide 3-kinase (PI3K) pathway	Cell growth
NOTCH pathway	Cell growth and apoptosis
Wingless/Integrated (Wnt) pathway	Cell proliferation
Cell cycle pathway	Cell cycle
MYC pathway	Cell growth, Proliferation and apoptosis
p53 pathway	Proliferation, cell survival, apoptosis and senescence
HIPPO pathway	Cell proliferation & differentiation
Transforming growth factor β (TGF β) pathway	Proliferation, stem/progenitor phenotype
Hypoxia pathway*	Cell growth, proliferation and angiogenesis

The TME actively participates in tumorigenesis by recruiting factors like tumor necrosis factor (TNF), and vascular endothelial growth factor (VEGF) favoring tumor progression

(Anderson & Simon, 2020; Baghban et al., 2020; Massagué, 2008; Yuan et al., 2016). As a tumor expands, it grows further away from vasculature leading to oxygen deprivation, creating a hypoxic microenvironment (Albadari et al., 2019). Hypoxia, or low oxygen levels, is a common feature of solid tumors and impacts various cancers (Muz et al., 2015). Hypoxia impacts solid cancers found in the brain (Rampling et al., 1994; Vaupel et al., 2007), breast tissue (Vaupel et al., 1991), cervix (Höckel et al., 1991), kidney (Lawrentschuk et al., 2005), liver (Brooks et al., 2004; Leary et al., 2002), lungs (Le et al., 2006), pancreas (Koong et al., 2000), and rectum (Kallinowski et al., 1995). Numerous studies over decades have delineated pathways linking hypoxic stress to cancer. Here, we will concentrate on four primary components: hypoxia-inducible factor (HIF), eukaryotic elongation factor kinase 2 (eEF2K), protein disulfide isomerases (PDIs), and the immune response to hypoxia.

A hypoxic microenvironment induces HIF signaling pathway which plays a crucial role in cancer progression by regulating cellular responses to low oxygen levels (Albadari et al., 2019; Qannita et al., 2024). HIF proteins are stabilized and activate the transcription of genes involved in metabolic adaptation, cell survival, metastasis, and invasion (Näthke & Rocha, 2011; Z. Wang et al., 2018). Hypoxic changes in transcriptional processes can create pro-tumorigenic or anti-tumorigenic behaviours by activating or inhibiting oncogenic signaling (Lee et al., 2020; Sebestyén et al., 2021). This increases acidification (D'Aiuto et al., 2022), and alters cellular organelles and transcription factors (Albadari et al., 2019; Jun et al., 2017). Furthermore, hypoxia increases protein disulfide isomerases (PDIs) which are multifunctional enzymes involved in the folding and maturation of proteins in the endoplasmic reticulum (ER) (Won et al., 2017). In hypoxic TME, PDIs are upregulated and contribute to the adaptive response by promoting protein folding and ensuring the proper assembly of HIFs and other proteins involved in hypoxia signaling pathways (Kobayashi et al., 2021).

Oxygen dependent regulation of eukaryotic elongation factor kinase 2 (eEF2K) is also implicated in cancer pathogenesis in response to nutrient deprivation and metabolic stress that occurs with hypoxic environments (Leprivier et al., 2013; X. Wang et al., 2017). Dysregulation of eEF2K has been linked to various cancers, where its activation promotes tumor cell survival, proliferation, and metastasis (X. Wang et al., 2017; Zhang et al., 2018). Additionally, hypoxia has been shown to modulate various aspects of the immune response, including the function of immune cells, the expression of immune checkpoint molecules, and the production of cytokines and chemokines (Lewis et al., 1999; Tripathi et al., 2014). Immune cell infiltration may be impaired leading to immunosuppression and evasion of immune surveillance by cancer cells (Eltzschig & Carmeliet, 2011). Additionally, hypoxia-induced factors such as HIFs can promote the expression of immune checkpoint molecules like PD-L1, which dampen antitumor immune responses by inhibiting T cell activation (Eltzschig & Carmeliet, 2011; Han et al., 2020).

In this review, we highlight the importance of managing TMEs through modulating cellular pathways. Due to the range of genes, proteins, and tissues that are affected by hypoxic stress there are many unknown mechanisms that can cause treatment to be unpredictable. For example, PDIs have been implicated in the regulation of redox homeostasis and the activation of pathways

associated with tumor cell survival and resistance to therapy (Samanta et al., 2017). They have also been shown to negatively interact with *HIF1a* (Kobayashi et al., 2021). Therefore, understanding these trade-offs will be essential to developing more effective treatments in solid tumors in specific tissues.

METHODS

Investigating the relationship between hypoxia and cancer has exploded in the last three decades, with more than 40,000 articles indexed in PubMed. This review provides a thorough overview of existing research on hypoxic tumors and its effects on cellular pathways and organelles. A thorough search and selection of articles in English was conducted between 2023-2024, the following three hypoxic pathways in relation to oxygen dependent tumor progression, HIF, eEF2K, and PDIs as well as the interactions between hypoxia and immunotherapy. The databases used include "hypoxia", "HIF", "eEF2K", "PDIs", "cellular adaption", "cancer", and "resistance" which yielded over 1,240,000 search results. Articles published prior to 1990 were excluded to ensure accuracy and reflect the current state of knowledge. A total of 65 articles were screened by their abstracts with focus on articles exploring genetics pathways that respond to hypoxic environments.

Hypoxia-Induced Factors (HIFs) under Normal (Normoxia) and Hypoxic Conditions

Cells under hypoxic stress upregulate HIF production. The pathway responsible for HIF coordinates oxygen sensors and responds to hypoxic conditions by regulating its own concentration. Under normoxic conditions, both HIF α and von-Hippel-Lindau (VHL) complex hydroxylates two proline residues within Oxygen-Dependent Degradation or ODD domain (Lee et al., 2020). This reaction is catalyzed by prolyl hydroxylases (PHDs) which requires molecular oxygen, iron, and α -ketoglutarate (Stoehr et al., 2016). Importantly, PHD2 has been identified as the primary enzyme that degrades HIF α (Lee et al., 2020). Loss of function of PHD2 is embryo lethal in mice, compared to the loss of other isoforms (Takeda et al., 2006). This highlights the significance of PHDs to the HIF degradation pathway. HIF α is then polyubiquitinated into a chain recognized as a signal for proteasomes, leading to degradation (Figure 1). Normoxia also diminishes HIF α transcription via Factor Inhibiting HIF-1 (FIH-1) preventing the recruitment of transcriptional coactivators p300 and cAMP-responsive element binding protein (CBP) (Lee et al., 2020).

Under hypoxic conditions, PHDs decrease in activity due to reduced reactant substrate availability, stabilizing HIF α . Multiple factors decrease the PHDs activity due to its poor ability to compete for substrates. Glycolysis and the citric acid cycle (TCA) compete with PHD for both molecular oxygen and α -ketoglutarate. For example, production of reactive oxygen species (ROS) which is generated by mitochondria (Lee et al., 2020). ROS and PHD2 go through a redox reaction with a cysteine residue rather than a proline residue (T. Wang et al., 2016). This then stabilizes HIF α under the hypoxic conditions (Figure 1). Furthermore, excess ROS can occur under normoxia causing HIF stabilization without hypoxia occurring. Mutations in TCA cycle components can cause an accumulation of succinate and fumarate. This has been linked to rare cases of neuroendocrine and renal

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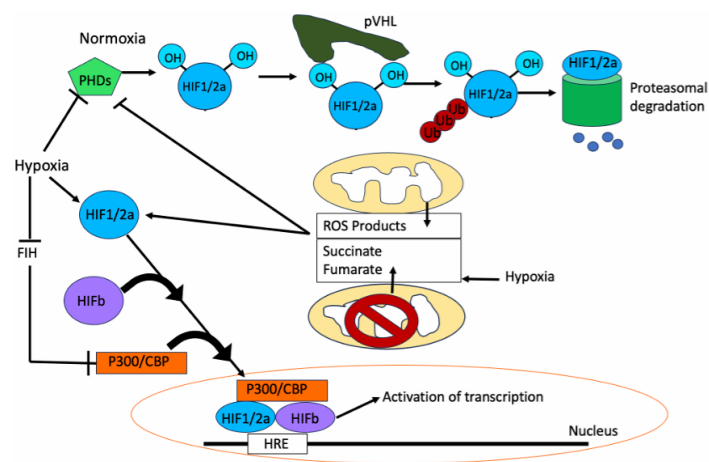


Figure 1. HIF Pathway under Normal (Normoxia) and Hypoxic Conditions. Transcriptional regulation of HIF is oxygen-dependent. The above diagram shows HIF proteasomal degradation and transcriptional activation of HIF. Under normal conditions HIF α is degraded. Under hypoxic conditions HIF1/2, HIF β and p300/CBP are recruited into the nucleus. This complex binds to HRE and activates transcription. The mitochondria also effect the HIF pathway. When active, the mitochondria produce ROS products, inhibiting PHDs and increasing HIF. When inactive due to mutations, large amounts of succinate and fumarate accumulate further diminishing PHDs. Modified from (Lee et al., 2020).

tumors (Selak et al., 2005). The TCA cycle depletes α -ketoglutarate, which PHDs need to initiate HIF α degradation. If HIF α is not degraded, it enters the nucleus with HIF β and forms an active transcription complex on hypoxic responsive elements (HREs). HREs produce factors that upregulate glycolysis, erythropoiesis, angiogenesis, and control cell survival (Brahimi-Horn et al., 2007).

Relationship between Cancer and Hypoxia

Solid tumors create micro-hypoxic conditions in the body. As the cells proliferate into a tumor mass, it typically grows faster than the vascular network. This creates a hypoxic condition and a nutrient-deficient area (Brahimi-Horn et al., 2007). Tumors take advantage of the HIF pathway by inducing angiogenesis or vessel co-option. Typically, vascular growth becomes a distorted network (Lee et al., 2020). This decreases the efficiency of transport for oxygen, nutrients, and medical administration of chemotherapeutic agents. Cells within solid tumors can be categorized into three stages: expanding, hypoxic, or necrotic (Figure 2). Tumors with necrotic cores are often associated with poor prognosis. It is suggested that this is a result of severe oxygen and glucose deprivation which results in cell decay (Brahimi-Horn et al., 2007). Monocytes respond to necrosis by producing surface-bound and soluble receptors for tumor necrosis factor- α (TNF- α). This pro-inflammatory cytokine induces the expression of monocyte chemoattractant protein (MCP-1) which is inhibited under hypoxic conditions (Eltzschig & Carmeliet, 2011; Lewis et al., 1999). Macrophages then become immobile due to the lack of chemoattractant in hypoxic tumors. This would change macrophage behavior to remain within the tumor and allow for tumor immune escape (Negus et al., 1998).

Hypoxia interacts with several pathways, which promote malignant behavior. Thirteen genetic networks have been identified in relation to lung adenocarcinomas that is centered on HIF1 α , HIF1 β (ARNT), HIF2 α (EPAS1), and HIF3 α (Z. Wang et al., 2018). The isoforms HIF1 α , EPAS1 and to a lesser extent HIF3 α , produce heterodimer α subunits that bind to the analogous

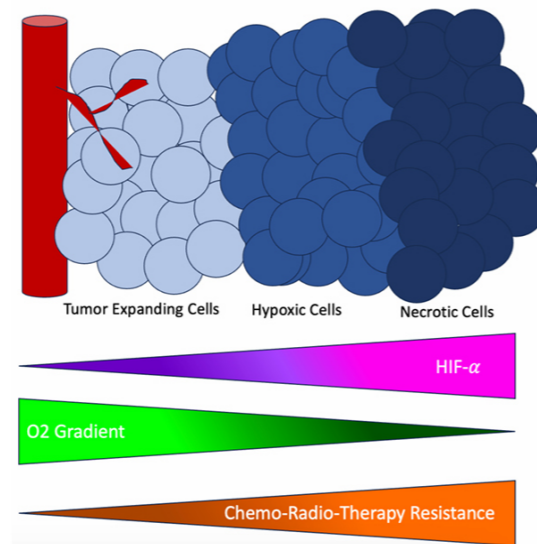


Figure 2. Hypoxic Characteristics of Solid Tumors. Cells in the center of the tumor are necrotic and surrounded by hypoxic cells. In proximity to the capillary are tumor expanding cells. This diagram shows the tumor both in vessel co-option and distorted angiogenesis. Multiple gradients show HIF concentration, oxygen penetration, and resistance to chemo-radiotherapy. Modified from (Lee et al., 2020).

ARNT beta subunit in response to low oxygen levels. With a higher expression in the lungs, EPAS1 cooperates with EGFR and RAS to promote tumor growth, angiogenesis, and invasion (Z. Wang et al., 2018). Single nucleotide polymorphisms (SNPs) of EPAS1 have been associated with the development of renal carcinoma and prostate cancer. A significant SNP is the first intron that binds with C/EBP- β , AP-1, and MYC families. All are transcription factors that correlate with various types of cancers. Targeting HIF or upstream factors has promising effectiveness in antitumor properties. Kamebakaurin, a diterpenoid compound from the plant *Isodon excia* has shown to decrease HIF1 α protein levels *in vivo*. In an experiment with athymic nude mice implanted with human colon tumor cells HCT116 demonstrated that decreased VEGF levels in serum (K. S. Wang et al., 2016). Imperatorin from the traditional Chinese medicine *Angelica dahurica* has also exhibited antitumor effects by inhibiting HIF1 α , mTOR, and other oncogenic pathways (Mi et al., 2017). Both treatments induce G1 cycle arrest in tumor cells. Other inhibitors like PX-478, KF58333 and geldanamycin decrease HIF1 α by increasing degradation by proteasomes. Lowering HIF activity decreases activity of downstream products like VEGF and glucose transporter-1. PX-478 has tumor regression effects and long-term growth delay within human tumor xenografts in mice (Powis & Kirkpatrick, 2004). Thus, demonstrating that HIF is a viable target for cancer therapeutics.

Effects on Protein Translation and Elongation

Hypoxic conditions inhibit most mRNA translation in a process called selective hypoxia response mRNA translation. This can be driven by glucose deficiency, amino acid deficiency or oxygen deprivation. Only HIF factors and other hypoxic-responsive proteins are translated in this state to maintain the cell (Lee et al., 2020). There are many adaptive responses like Activating Transcription Factor 4 (ATF4). ATF4 induces protein synthesis, amino acid transport, and metabolism (Harding et al., 2003). In tumorigenic pathways, ATF4 and the amino acid deficient sensor, general control non-derepressible-2 (GCN2), promote tumor

angiogenesis by the VEGF. Targeting the ATF4/GCN2 signaling pathway by treating amino acid deficiency can reduce the expression of proangiogenic mediators in tumors (Y. Wang et al., 2013).

Oxygen deprivation also affects peptide elongation of eukaryotic elongation factor (eEFs), eEF2. The eEF2 kinase (eEF2K) inactivates eEF2 by phosphorylation. Under normal conditions, eEF2K is targeted for proteasomal degradation by mTORC1. In hypoxic conditions, mTORC1 levels decrease, leading to the stabilization of eEF2K and the decrease of eEF2 (Figure 3). This disrupts the ribosome's ability to move down the mRNA codons, in turn reducing mRNA translation (Lee et al., 2020; Leprivier et al., 2013). This mechanism is important to the survival of glioma and breast cancer cells since it conserves energy, allowing the cell to cope with low oxygen tissue levels. eEF2K is an enticing target as studies have shown that it is not essential under normal conditions (X. Wang et al., 2017). Lastly by an unknown mechanism eEF2K can be anti-autophagy in the colorectal tumors but also pro-autophagy in breast cancer (Liu & Proud, 2016). Directly interfering with eEF2K has not produced consistent results as the role of eEF2K changes with the type and stage of the tumor. A better investigation is required if targeting eEF2K is to be used for immunotherapy.

The tumor suppressor gene adenomatous polyposis coli (APC) and HIF α have antagonistic qualities. The APC promoter has a HRE which binds to HIF α and reduces the mRNA and protein in cells (Näthke & Rocha, 2011). This interaction is significant for colorectal cancer where APC deficient tumors are likely to develop. Loss of APC function leads to mTORC1-mediated inhibition of eEF2K. This inhibits Raptor deletion which is essential for proliferative phenotypes that exhibit APC deletion. Rapamycin administration to APC deficient targets eEF2 through mTORC1 and causes cell arrest and differentiation. Therapeutics targeting mTOR signalling and translation elongation can be a benefit for those who are at risk for developing colorectal cancer (Faller et al., 2015). Further examination is needed to understand if APC targeting applies to all tumor sites experiencing APC deletion or suppression through HIF α .

Consequently, the inhibition of eEF2 by the increased presence of eEF2K causes low protein synthesis levels in the liver which can lead to hepatoma cell proliferation and increases cyclin D3 expression which has been connected to colorectal tumor initiation (Figure 3) (Liu & Proud, 2016). Cyclin D3 affects proliferation since it converts the cell from the G1 stage to the S stage in mitosis. This can be an important unfavourable prognostic biomarker that can be used to determine the malignancy of a tumor. The cyclin D3 expression level can be used to make better clinical diagnoses. Moreover, immunohistochemistry experiments have shown that eEF2 is overexpressed in many types of complex cancers. In a knockout experiment, eEF2 was knocked down by a short hairpin RNA. eEF2 knockdown significantly inhibited growth in eEF2 expressing fibrosarcoma, glioblastoma, lung, and pancreatic cancer (Oji et al., 2014). This indicates that eEF2 may play a significant role in cancer growth in hypoxic and normoxic conditions and its products may be a promising target for immunotherapy.

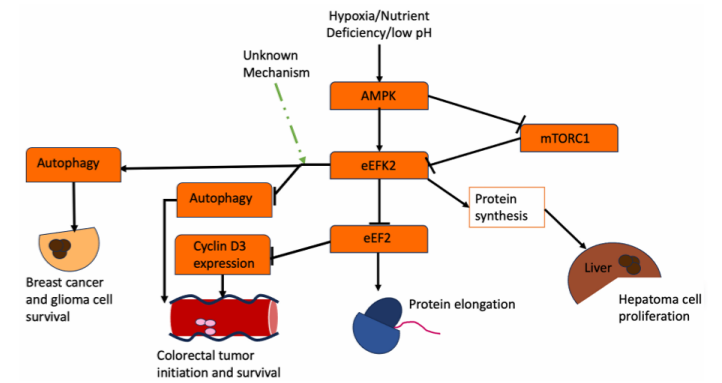


Figure 3. Effects of Hypoxia on eEF2. Cells under certain stresses like hypoxia, nutrient deficiency and low pH produce AMPK. AMPK inhibits mTORC1 and upregulates eEF2K. This diagram then shows both the positive and negative correlation of eEF2K with breast cancer, colorectal tumors, and hepatoma cell proliferation. The green arrow represents the unknown mechanism that upregulates autophagy in breast cancer and inhibits autophagy in colorectal tumors. It is unknown if this is the same or a different mechanism. Modified from (Liu & Proud, 2016).

Hypoxic Stress on the Endoplasmic Reticulum (ER)

Hypoxic chronic ER stress induces chemoresistance by affecting protein modifications by decreasing PHDs and other regulatory proteins, allows for an accumulation of misfolded proteins within the ER. This places stress on the structure and induces unfolded protein response (UPR) (P. Lee et al., 2020). A critical mechanism to promote the survival of malignant cells and creates resistance to hypoxia by decreasing protein synthesis and ER degradation. Chronic ER stress promotes UPR-induced apoptosis by the presumed positive feedback that stabilizes pro-apoptotic transcripts (P. Lee et al., 2020; R. Wang et al., 2022). However, ER stressed-induced apoptosis is regulated by protein sulfide isomerases (PDIs). PDIs are induced by hypoxia and, protect the ER from apoptosis by acting as a chaperone catalyzing disulphide bonds and inhibiting UPR-induced apoptosis. They also regulate cancer cell invasion by enhancing the secretion of matrix metalloproteinases (MMPs) through a dithiol-disulfide exchange. Dysregulation of PDI expression has been observed in many types of cancer and can be a new target for treatment (Samanta et al., 2017). One study found that inhibiting PDI in hepatocellular carcinoma (HCC) increases the efficacy of Sorafenib, a drug approved for HCC. Furthermore, PDI can be used as a biomarker to predict treatment resistance of HCC (Won et al., 2017). However, PDIs can interact negatively with the HIF pathway. Studies have shown that PDIs are essential to HIF1 α oxidation through these dithiol sulfide exchanges, and this decreases HIF1 α expression. Therefore, targeting PDI for treatment will have trade-offs (Kobayashi et al., 2021). Inhibition of PDI may decrease MMP secretion but could upregulate HIF1 α transcription. A better understanding of PDIs role in cancer progression and activation can improve current treatments.

Hypoxia Mediated Immune Response

Hypoxia also induces changes in the cytokine secretion of macrophages, including the release pro-angiogenic and inflammatory chemokines/cytokines *in vitro* and *in vivo* models, specifically the tissue culture of *Drosophila* legs (Lewis et al., 1999). Inflammation and hypoxia have processes that cross over and reinforce each other. Mediated by toll-like receptors, tumors cells activate and recruit leukocytes through the release of cytokines. A group of molecules derived by necrotic tumors called endogenous

ligands stimulate leukocytes like macrophages to release endothelial growth factors and contribute to anomalies in vascular networks in ways that comprise oxygen delivery (Eltzschig & Carmeliet, 2011). These cytokines are produced by macrophages, and these can become tumor-associated macrophages (TAMs). Their behaviour aid tumors progression by signalling wound healing which interferes with treatment. Blocking recruitment or inhibiting the function of TAMs can increase efficacy of treatment. In breast cancer, macrophage migration is directed by two chemokines/cytokines Eotaxin and Oncostatin (Tripathi et al., 2014). Novel therapy can target these two cytokines and increase efficacy of cancer treatment.

Immune cells and tumor cells compete for nutrients leading to a metabolic battle in the TME. Tumor cells reprogram themselves to have a metabolic advantage over immune cells, weakening immunosurveillance. This is due to the Warburg Effect, which sees an increase in glycolysis and a preference of producing lactate over pyruvate, a key intermediate in aerobic respiration (Bartrons & Caro, 2007). Arginase, which produces ornithine and urea from arginine, can be found in tumors and sites of inflammation (Lewis et al., 1999). Ornithine can be used to produce proline and other polyamines. Subsequently draining arginine from the extracellular area limits neighboring cells proliferation and survival (Lewis et al., 1999). Competing for arginine is the enzyme nitric oxide synthase (NOS), which converts arginine to nitric oxide (NO). NO mediates the tumoricidal properties of macrophages (Biswas, S. K., Sodhi, A., & Paul, 2021). Therefore, arginase is a factor in regulating NO production. Re-oxygenation may be required for optimal NO levels for macrophages. Oxygenating hypoxic tumor cells can improve natural antitumoral properties and in turn improve therapy efficacy. However, it is difficult to provide oxygen due to tumor cell's distance from vasculature networks. Advances in treatments like nanoparticles which have been fabricated into oxygen-binding materials can transfer oxygen rich sources to hypoxic tumors (H. Wang et al., 2020). While this is an encouraging strategy, more research is needed to understand the effectiveness of this treatment approach.

CONCLUSIONS

There are several approaches to improving the efficacy of cancer treatment (Ferrara et al., 2022; Papież & Krzyściak, 2021). By understanding and managing hypoxic tumors, anti-tumorigenic properties can be exploited and inactivate pro-tumorigenic properties. Therapeutics targeting *HIF1a* (Bui, Nguyen, Lee, & Cho, 2022; Prabhakar & Semenza, 2015; Turgu et al., 2021; Xin Zhang et al., 2021 ATF4 (Feng et al., 2021; Y. Wang et al., 2013), and other downstream products can increase tumor breakage. A wide range of *HIF1a* targeting compounds are under investigation, such as kamebakaurin (K. S. Wang et al., 2016) and imperatorin (Mi et al., 2017). While other medications like PX-478, KF58333, and Geldanamycin are in clinical trial (Powis & Kirkpatrick, 2004). However, there are still unknown mechanisms like eEFK2's role in autophagy that make treatment unpredictable. Further understanding in the manipulating of HIF pathway, eEFK2, PDIs and NO levels through knockout or nanoparticle treatment can at the least, increase the synergistic qualities of other cancer treatments (H. Wang et al., 2020).

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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A Comparative Analysis of Kombucha pH for Food Safety by Tea Type

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ABSTRACT Kombucha is a fermented beverage originating from China over 2000 years ago. It has gained global popularity due to its potential health advantages. Currently, there is limited research on the food safety of kombucha fermented by various tea types. This study aimed to investigate the influence of tea types on the pH levels of kombucha, focusing particularly on blue tea (Butterfly Pea Flower), which is a relatively less investigated variety. An experiment was conducted in 2024 with 6 replicates each for black, green, red, and blue tea bases. The pH measurements were collected on the 2nd, 7th, and 14th day during a 2-week fermentation period. The study indicates a consistent decrease in pH levels across all tea types, with blue tea kombucha exhibiting the lowest pH value. Despite some statistically significant differences, all tea types remained within the food-safe pH range throughout fermentation. These findings may provide valuable insights for consumers, producers, and regulators regarding the food safety of blue tea kombucha.

INTRODUCTION

Kombucha is a traditional and ancient beverage with a mild sweetness and acidity, due to the fermentation of sugar, tea, and the pellicles – “the symbiotic culture of bacteria and yeast (SCOBY)” (Abaci et al., 2022). Originating from China over 2000 years ago, it has gained global popularity because of its potentially healthful advantages (Miranda et al., 2022; Watawana et al., 2015). Kombucha boasts a wealth of B vitamins, deoxycholic acid, and glutamate, contributing to its potential benefits for mental well-being (Villarreal-Soto et al., 2020). Meanwhile, the fermented kombucha also contains other necessary nutrient substances of amino acids, proteins, and minerals for the human body (Abaci et al., 2022). The microbes from *Acetobacteraceae* family are mainly responsible for this fermenting process, including *Komagataeibacter*, *Acetobacter*, and *Gluconobacter* (Abaci et al., 2022; Miranda et al., 2022). During the fermentation process, the sucrose in the mixture is converted into glucose and fructose by the yeast cells. They subsequently experience a transformation into ethanol and carbon dioxide with the metabolism of yeast. Finally, ethanol is converted into acetic acid and acetaldehyde during the metabolism process of acetic acid bacteria (AAB). The AAB also metabolized glucose into gluconic and glucuronic acids (Jakubczyk et al., 2022; Wang et al., 2022).

Blue tea is also known as butterfly pea flower, obtaining the bright blue color from its high anthocyanin concentration. This plant is widely used as a coloring agent in food production, with anti-inflammatory and antioxidant properties (Aksornsri et al., 2023). These potential health benefits make it a good candidate for kombucha production. The more recent popularity of kombucha has led to other less traditional ingredients, which include raw materials, such as milk, soy, fruit juice, and blue tea (Miranda et al., 2022; Sintyadewi et al., 2021). Yet the effects of those new ingredients on fermented kombucha still need to be tested for food safety. While blue tea for making kombucha has not been extensively investigated, studies have shown that kombucha made from black tea, green tea, red tea, white tea (*Camelia sinensis*), and oolong tea (*Camelia sinensis*) is considered safe for consumption (Jakubczyk et al., 2020; Kitwetcharoen et al., 2023). Despite some current studies focusing on black and green tea bases, red and blue tea have received relatively less attention (Jakubczyk et al., 2020). The determination of the relationship between tea type and food safety is essential due to possible variations in consumers' tea preferences when consuming kombucha beverages for health and personal habit considerations. Therefore, the primary focus of this experiment was on examining the correlation between the pH levels of kombucha produced from blue tea (*Clitoria ternatea*) and those from the other three tea types: black tea (*Camelia sinensis*), green tea (*Camelia sinensis*), and red tea (*Aspalathus linearis*).

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METHODS

This project used descriptive and chemical analysis to investigate the relationship between four varieties of tea and the pH levels of the resulting kombucha, including black tea (Tetley Orange Pekoe Tea), green tea (Uncle Lee's Organic Green Tea), red tea (Numi Organic Rooibos Tea), and blue tea (O5 Tea) *in situ* at The University of British Columbia, with pH levels being indicative of food safety. Blue tea is still considered a specialty tea and cannot be found in most supermarkets. The blue tea for this experiment was obtained from O5 Tea in Vancouver, British Columbia. The blue tea (Dok Anchan) was grown at 16°58'N 99°42'E in Sukhothai, Thailand. Twenty-four sample jars were sanitized using a dishwasher on a high-temperature setting to ensure they were adequately cleaned and sanitized before the kombucha fermentation process. The jars were then distributed, with six jars allocated to each of the four tea types. Subsequently, the jars were filled with tea brewed by boiling 1 L of water and adding 8 g of tea per jar, after which 50 g of white sugar (Kirkland Signature Organic Sugar, Brazil) were dissolved in each jar. Once the liquid in all jars had cooled to room temperature, each sample was inoculated by adding 1 piece of SCOBY (see Figure 1) and 125 mL of starter liquid. The original kombucha SCOBY and starter liquid were provided by a faculty member at The University of British Columbia. The SCOBY originates from a long-established fermentation lineage that has been maintained in Vancouver for over 10 years. Each sample jar was covered with one paper coffee filter affixed with a rubber band to ensure consistency, followed by a 2-week period. The data was collected on the 2nd, 7th, and 14th day after fermentation by measuring the pH of the kombucha samples with a digital pH meter (Dr.meter-PH838, Dr.meter, Canada) to ensure accuracy. These methods were adapted from Gaggia et al. (2018).



Figure 1. Photograph of Symbiotic Culture of Bacteria and Yeast (SCOBY).

The collected data was used to determine the average pH of each tea type at various time intervals. Based on these averages, a single-factor Analysis of Variance (ANOVA) was performed using Microsoft Excel to detect significant differences in the pH measurements across the twenty-four samples. When the p value was less than 0.05, the differences were regarded as significant.

RESULTS

This experiment used pH as the main indicator for food safety. If the mean pH fell within the established safe range of 2.5 - 4.2 (Miranda et al., 2022), it could be deemed safe for consumption. Assuming that the pH value of a fermenting sample does not reach lower than 4.2 before the 7th day, the sample is considered to be potentially polluted, and fermentation needs to be terminated. A pH value under 2.5 is an indication of the possible need to add more tea to balance the level out (Nummer, 2013).

Figure 2 shows four completed kombucha samples by tea type. Several observations were made during the fermentation process. Gas bubbles which formed on the inside of the jars were similar to those observed by Miranda et al. (2022) at the end of fermentation. The kombucha samples darkened in color and also developed a strong odor characteristic of the fermentation process. These observations then indicate that fermentation was actively occurring.



Figure 2. Four Kombucha Samples by Tea Type.

Figure 3 illustrates the trends of the average pH value of 24 kombucha samples fermented by four tea types (black, blue, green, red) during the two weeks after the samples were created. As can be seen in Figure 3, the pH levels of fermented kombucha showed a consistent decrease over time across all tea types. On the 7th day of the fermentation, the pH of kombucha decreased to the range of 3.17-3.39 from 2.93-3.19 on the 2nd day. Compared to black, green, and red tea bases, blue tea kombucha demonstrated the lowest pH value (2.69), experiencing a relatively substantial decrease of approximately 0.6 over the two-week period.

Results of this study found that even though the black and green tea kombucha registered similar averages, the green tea base exhibits a more centralized pH value to the average. The red tea shows the closest overall pH value compared to the average value, while the blue tea experiences the lowest pH average across all tea types.

An ANOVA analysis was performed to determine if there was a statistically significant pH difference based on tea type. The pH of kombucha varied significantly depending on the "starter" tea type ($p < 0.01$, $N = 6$, Table 1). The extremely low p-value observed in this analysis indicates a high likelihood that the association is not

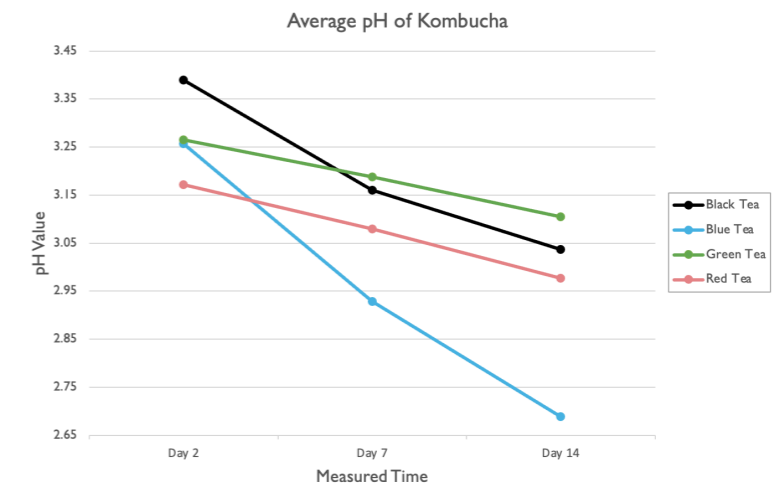


Figure 3. Average pH of Kombucha by Tea Type Over Time

Table 1. Analysis of Variance (ANOVA)

Source of Variation	SS	df	MS	F	P-Value	F crit
Between Groups	0.2237	3	0.074567	12.81418	6.76415E-05	3.098391
Within Groups	0.116381	20	0.005819			
Total	0.340081	23				

attributable to random chance. Although we found statistical significance, practical significance is more relevant, given that the pH is within the range of 2.5-4.5 (Miranda et al., 2022). This indicates that all four tea types can produce kombucha beverages within the food-safe pH range throughout the fermentation period (Kim & Adhikari, 2020).

DISCUSSION

The primary aim of this study was to investigate whether the choice of tea type influences the food-safe pH range of kombucha, determining whether kombucha made from blue tea could be safely consumed compared to three other tea types (black tea, green tea, and red tea). This experiment sought to address the hypothesis of there being a substantial relationship between tea type and pH values by observing the pH of the four tea type bases fermented over 14 days.

During fermentation, the production of carbon dioxide resulted in observed gas bubbles. According to Miranda et al. (2020), carbon dioxide is produced as one of the final products. Due to the process of chemical oxidation, alterations in the tea leaves impact the distinctive qualities of kombucha, such as its darkened and yellowish color and its smell. The color of kombucha is a result of a complex interplay between the initial tea base, fermentation processes, microbial activity, and any added ingredients.

The pH of all examined samples decreased consistently over time during the analysis. One potential explanation for this finding could be attributed to the metabolic activities of the symbiotic culture of bacteria and yeast (SCOBY) involved in fermentation. Mousavi et al. (2020) explained that the substances in tea and sugar are processed by these microorganisms, resulting in the production of organic acids such as acetic acid, gluconic acid, and

glucuronic acid. Therefore, this process can contribute to the increasing concentration of acetic acid during fermentation and the observed safe decline in pH levels over time during kombucha fermentation. The results of this fermentation align with the finding from Jakubczyk et al. (2020), which demonstrated a substantial decrease in pH levels during kombucha fermentation of white, green, black, and red tea in their experiments. It's noted that the pH of their kombucha decreased from the range of 5.34-6.53 before fermentation to 2.31-2.53 after 7 days of fermentation, indicating a substantial shift toward acidity (Jakubczyk et al., 2020). These findings demonstrate the crucial role of a safe fermentation process in pH reduction across various tea types.

Similarly, the indication of this study that blue tea reached the lowest pH after fermentation can also be supported by other research. Sintyadewi et al. (2021) revealed that increasing the content of Butterfly Pea Flower (blue tea) when producing kombucha with black tea results in lower pH levels of the kombucha. The pH of kombucha was found to significantly decrease during the fermentation process, with the lowest pH (3.0) observed on the 8th day of fermentation. This data is similar to the measurement of a 2.93 pH value for blue tea observed in this experiment. Meanwhile, the pH level of pure blue tea kombucha was lower than that of kombucha brewed with both black tea and blue tea, consistent with the findings of Sintyadewi et al. (2021). These comparisons underscore the general trends of kombucha fermentation and the reproducibility and reliability of this experiment. According to Zhang et al. (2024), butterfly pea flower has the highest total polysaccharides (TPS) compared to other tea types. These polysaccharides provide an additional nutrient source for the yeast in kombucha, promoting more vigorous growth and increased acid production. As a result, kombucha made with blue tea tends to have a lower pH than that made with other tea types.

However, these findings are subject to some limitations. The generalizability of findings could be restricted by the variations *in situ* environmental conditions which could also influence the fermentation process and collected data. This research emphasizes the reliability and safety of the fermentation process in producing consumable kombucha beverages. These limitations might be addressed by future studies to optimize the fermenting process.

CONCLUSIONS

In conclusion, this study indicates that the safe pH values of kombucha products may not be significantly affected by the various tea types, even though blue tea showed statistically significant differences among them. Kombucha produced from blue tea was considered food-safe due to its appropriate pH level. Thus, this experiment can contribute to the exploration of factors influencing kombucha fermentation and provide direction for future research.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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Born in the wrong era: How *Stranger Things* and Netflix's binge-watching model evoke vicarious nostalgia in Generation Z viewers

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ABSTRACT *Stranger Things* (Duffer et al., 2016-present) is an ongoing Netflix original series that has gained significant popularity since it first aired in 2016. The show draws inspiration from classic science fiction films and manufactures a romanticized version of the 1980s, thereby evoking nostalgia in viewers who have and have not lived through the decade. This paper focuses on the vicarious nostalgia instilled by the show in its Generation Z viewers through its “authentic” recreation of the 1980s. This paper also considers how Netflix’s binge-watching model amplifies the transportive impact of *Stranger Things* by encouraging viewers to watch more episodes in individual sittings, thereby establishing a state of immersion which takes them further from the real world. Through this research, I argue that the enveloping and alluring environment produced by the show and its suggested method of consumption causes Generation Z viewers to experience vicarious nostalgia and a yearning for the 1980s. I conclude this article by recommending further avenues for research within the domain of vicarious nostalgia.

INTRODUCTION

Stranger Things (Duffer et al., 2016-present), a Netflix original sci-fi horror series about a group of adolescents in 1980s Indiana, has received considerable public acclaim ever since it first aired in 2016. Given the show’s TV-14 rating (i.e., unsuitable for children aged 14 and below due to coarse language, violence, and sexual content), *Stranger Things* is targeted primarily towards teenagers and young adults, who make up majority of the show’s viewership and are a part of Generation Z, which, as defined in this paper, consists of individuals born between the years of 1996 and 2010. With the show’s references to 1980s media and pop culture, *Stranger Things* has been successful in instilling feelings of yearning and nostalgia for the era for many people, particularly those who lived through it, as well as among the Generation Z demographic, despite them not having experienced the time. Nostalgia for a time period one hasn’t endured has been labelled as vicarious nostalgia. This may be induced through films, TV shows, or even personal anecdotes from people who lived through the period in question (Goulding, 2002).

Through this paper, I aim to explore Generation Z’s experience of vicarious nostalgia and its evocation by *Stranger Things* and Netflix’s binge-watching model. Nostalgia has been found to be triggered by the experience of distress and/or dissatisfaction in present circumstances (Batcho, 2013). Those belonging to Generation Z have come of age in the era of social media, and while this exposure allows for easy and convenient communication, excessive use of social media platforms has been linked to increased anxiety and loneliness (Caballero, 2020). Social media has also allowed Generation Z to access a wide variety of content, including media from previous generations (Caballero, 2020). I argue that the digital age and the isolation and turbulent emotions succeeding it have led to Generation Z’s yearning for simpler, idealized eras of the past, which are easily accessible to them through social media and content on streaming services like Netflix, Amazon Prime, and Disney+.

In my research, I also consider how Netflix’s binge-watching model led to *Stranger Things*’ becoming a transportive experience for its viewers. Anghelcev et al. (2021) found that for their sample of college students, binge-watching was an immersive, transformative experience, and participants who experienced higher levels of transportation while watching a show were more likely to binge-watch frequently. By looking comprehensively at the reconstruction of the 1980s by *Stranger Things* and Netflix’s promotion of binge-watching, I investigate the elicitation of vicarious nostalgia by the show and its streaming service.

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VICARIOUS NOSTALGIA AND GENERATION Z

Batcho (2013) described nostalgia as an affective state associated with the bittersweet “longing for one’s past.” Nostalgia for a particular period of time can be acquired through socialization, especially during early childhood years (Goulding, 2002). Agents of socialization can include parents, peers, and family members, who, through their recollections of bygone eras, can paint a romanticized image of the past, thereby reinforcing the prevalence of nostalgic feelings (Goulding, 2002). By selectively recalling affirmative events and facets of their pasts, these agents of socialization alter those time periods with their own fantasies (Boym, 2001). Nostalgia is also often used as a coping mechanism for dealing with discontinuity and upheaval in life, such that present stressors, loneliness, and sadness are shown to increase likelihood of experiencing nostalgia (Davis, 1979, as cited in Batcho, 2013; Madoglou et al., 2017). The therapeutic benefits of nostalgia include enhancement and solidification of individual identity, increase in the feeling of “belongingness,” psychological well-being, and stress reduction (Madoglou et al., 2017).

Academics have speculated whether people can experience nostalgia for a time they have not lived through. Stern (1992, as cited in Batcho, 2013) distinguished between personal nostalgia and historical nostalgia. While personal nostalgia reflects a longing for one’s own past, historical nostalgia refers to yearning for a historical period that is perceived as being superior to the present. Vicarious nostalgia, a construct similar to historical nostalgia, has gained traction in the recent past. Baker and Kennedy (1994, as cited in Goulding, 2002) defined vicarious or simulated nostalgia as a form of nostalgia that arises in response to the longing for an era experienced indirectly through stories, images, and possessions. Goulding (2002) found that vicarious nostalgia can be observed in a variety of cognitions and behaviours including preference for the artefacts, music, and fashion of previous eras, not being able to relate to one’s own peer group, and the feeling of being born in the “wrong” generation. Because of easier access to media content of past eras (i.e., television shows, movies, music) in today’s digital age, vulnerability to vicarious nostalgia among younger generations has the potential to increase.

Generation Z’s experience of vicarious nostalgia could be accounted for by a variety of factors. Being the first “authentically digital” generation, Generation Z has grown up with advanced technology and a multitude of social media platforms that ensure constant virtual connection with the rest of the world and constant access to information on a myriad of topics.

Despite its benefits, social media can bring harm to its users. Many studies have linked higher internet and social media usage to increased rates of chronic stress, anxiety, and depression among Generation Z (Caballero, 2020). Furthermore, according to the American Psychological Association (2019), Generation Z participants reported levels of stress significantly higher than their Millennial, Generation X, and Baby Boomer predecessors. A large portion of the Generation Z demographic have now entered university and/or early adulthood, which are both associated with a variety of pressures and stressors. In fact, academic and financial pressures, post-graduation plans, and loneliness have been found to contribute to depression, anxiety, and stress experienced by college students (Beiter et al., 2015).

In contrast to these troublesome experiences and emotions, the past and “retro aesthetic” offer solace. For Generation Z, the past provides a path of escapism and represents an unknown world filled with exciting discoveries (Holotová et al., 2020). Generation Z’s engagement and fascination with the past can be witnessed in some of their consumer choices. For example, following the success of Netflix’s *Stranger Things*, music, fashion, and products associated with the 1980s, such as bomber jackets, mullets, and scrunchies, started regaining popularity among Generation Z consumers. A prime instance of this occurred when the song “Running Up That Hill” by Kate Bush premiered on *Stranger Things*’ “Chapter Four: Dear Billy” in 2022 and rose to No. 3 on the Billboard Hot 100 list after its original release in 1985. *Stranger Things*’ popularity among teenagers and young adults is an indicator of its evocation of vicarious nostalgia among its target audience.

VICARIOUS NOSTALGIA EVOCATION BY STRANGER THINGS AND NETFLIX’S BINGE-WATCHING MODEL

Stranger Things follows a group of adolescents as they navigate and try to make sense of their encounters with supernatural forces and an alternate dimension known as the Upside Down. One of the defining features of the show is its homage to classic 1980s sci-fi thriller movies, such as *E.T. the Extra-Terrestrial*, *The Goonies*, and *Poltergeist*. Through its references to the aesthetics and pop culture of the 1980s, *Stranger Things* has successfully induced feelings of nostalgia amongst those who have lived through the decade, as well as those who didn’t.

The vicarious nostalgia elicited among Generation Z viewers by *Stranger Things* could be attributed to a number of factors. Most of the show’s protagonists are adolescents, who, along with their supernatural adventures, face challenges typically associated with the teenage experience. Nostalgia is often evoked when viewers or audience members feel an empathetic connection with on-screen characters (Sirianni, 2019); thus, emotional experiences in the show reminiscent of adolescence, such as the middle school dances, Mike and Eleven’s first kiss in “Chapter Eight: The Upside Down” (Ditcher et al., 2016), or the protagonists playing *Dungeons & Dragons* in “Chapter One: The Vanishing of Will Byers” (Nickson-Lopez et al., 2016), have the potential to evoke similar personal memories of a time associated with less stress (Sirianni, 2019). In fact, according to a survey administered by Mascio (2021) to participants aged 20-25, while *Stranger Things* is set in a distant period, certain events in the show are reflective of the personal life and childhood experiences of Generation Z viewers.

The show’s evocation of vicarious nostalgia for the 1980s could also be accredited to its “authentic” recreation of decade. The soundtrack, the wardrobe of the characters, and the décor and props used are implicative of the 1980s and contribute to the establishment of the show’s scenic realism, or the accuracy of its depiction of the era (Sirianni, 2019). In contrast, however, a crucial element in *Stranger Things*’ depiction of the ‘80s is its “romanticization” of the era, which is accomplished through the omission of some hardships that defined it, such as the AIDS epidemic, and its emphasis on the relatively positive themes of childhood friendship, middle school, and sibling and familial relationships. This fastidious and specific recollection of the 1980s by the show has led to the era’s fantasization and subsequent

remembrance by younger generations (Boym, 2007), as by its very definition, nostalgia implies the romanticization of a forepassed era (Mukhopadhyay, 2024). For Generation Z, the show’s “1980s aesthetic” allows for a transportive experience, as well as a connection with the fictional characters and the fantasy world (Mascio, 2021). As mentioned, social media platforms, while useful, contribute to isolation, anxiety, and depression, and *Stranger Things*’ depiction of a pre-tech era, simplistic lifestyle could also be a reason for Generation Z’s fascination with the show and the 1980s.

The transportive impact of *Stranger Things* is made more significant through Netflix’s binge-watching model, which includes the practices of releasing all episodes of a season at once, designing storylines that continue through multiple episodes or seasons, ensuring that episodes end with cliff-hangers, and playing episodes continuously (Anghelcev et al., 2021). This model has reinforced the need for instant gratification prevalent in media content consumers, which further encourages them to indulge in binge-watching, defined in this paper as watching three or more episodes of a television show in a single sitting. Anghelcev et al. (2021) studied the binge-watching behaviours of a sample of US college students and their correlation to experiential aspects of immersion within shows, transportation to the show’s worlds, and the formation of parasocial relationships with characters. Their results revealed that the participants who engaged in binge-watching behaviours more frequently and for longer durations experienced higher levels of transportation and facilitation of parasocial relationships with the characters. Frequent binge-watching was also found to be linked positively to enjoyment of the shows (Anghelcev et al., 2021). Erickson et al. (2019) conducted a study with university students comparing behaviours as a result of binge-watching (i.e., watch three episodes of the same show over a short period of time), and traditional television viewing (i.e., watching one episode per week). They unearthed that the participants who engaged in binge-watching experienced higher levels of transportation into the narrative of the show and had more solidified parasocial relationships with the characters compared to the traditional TV viewing group. The need for escapism is one of strongest predictors of binge-watching tendencies, and identification with TV show characters acts as a mediator (Gabbadini et al., 2021).

A focus group study with university students in the US, conducted by Rubenking et al. (2018), found that emotionally intense, captivating, mystery-thriller television shows, such as *Breaking Bad*, *Game of Thrones*, and *Stranger Things*, were more likely to be binge-watched. This study also showed that the desire for mood regulation, relaxation, and escape from the mundane realities of everyday life were strong predictors and motivators of binge-watching. The participants in this study reported that binge-watching media content allowed for the satisfaction of crucial social needs, such as the formation of interpersonal, parasocial connections with the characters, as well as the facilitation of discussions and conversations with other people who had consumed the same content (Rubenking et al., 2018). Netflix’s release of *Stranger Things* in accordance with its binge-watching model, along with the show’s genuine recreation of the pop-cultural atmosphere of the 1980s, can therefore attest to the show’s successful evocation of vicarious nostalgia within its target audience, Generation Z. Further, it can be said that transportive

binge-watching and escapism act as catalysts and facilitators for *Stranger Things*’ vicarious nostalgia elicitation.

CONCLUSION

This paper explores some of the reasons behind Generation Z’s experience of vicarious nostalgia and its induction by Netflix’s *Stranger Things* and the binge-watching model. By taking into account the show’s manufacturing of the retro ‘80s aesthetic, Netflix’s method of releasing the show to encourage binge-watching, and the need for escapism fulfilled by binge-watching behaviour, it is concluded that these factors seem to collectively evoke vicarious nostalgia among Generation Z viewers.

Research within the domain of vicarious nostalgia is fairly limited. Proper conceptualization and refinement of the determinants of vicarious nostalgia is critical. Future investigation could also consider the psychological effects of vicarious nostalgia. In the context of Generation Z, media and content consumption patterns as impacted by vicarious nostalgia could also be inspected. Detailed study of specific elements of TV shows and films based on past eras, such as the soundtrack, fashion, and product placement, and their elicitation of vicarious nostalgia must also be pursued.

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CONFLICT OF INTEREST

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