



UR

CANADIAN
JOURNAL
of UNDER
GRADUATE
RESEARCH

Microplastics on
the coast

“The widespread use of plastics, combined with degradation and distribution processes, has led to the widespread and global distribution of microplastics.” (p. 12)

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OCTOBER 2025 VOL 10(1)

Prejudice in care

“Deepening our understanding of the nuanced effects of race and gender would contribute to developing interventions and, ultimately, the goal of equitable pain care.” (p. 19)

Eating experiences

“People enjoy eating and each sense contributes to the enjoyment of food. Hence, sensory deficiencies and eating habits have important implications for quality of life.” (p. 39)

CANADIAN JOURNAL *of* UNDERGRADUATE RESEARCH

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

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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), Sk̓wx̓wú7mesh (Squamish), and səlilwətał (Tsleil-Waututh).

Letter from the editors-in-chief



It is our honour to present Volume 10, Issue 1 of the Canadian Journal of Undergraduate Research. This issue is representative of the hard work poured into research within fields such as medicine, sedimentology, psychology, and sensory science, and amid global concerns surrounding research funding and scientific credibility, we are immensely proud to continue to stand alongside Canadian and global academics.

The editorial team has been delighted to provide a platform to showcase the impressive work of undergraduate students across Canada. CJUR continues to receive manuscripts of the utmost quality from a variety of disciplines, and we are truly grateful to witness the fruits of inquisitive minds. As this publication marks the beginning of a new academic year, we are looking forward to even more manuscripts from course assignments, honours theses, and passion projects. We thank the authors for trusting our journal with their work, the supervisors for supporting students' academic goals, and the reviewers for their tremendous effort. This issue is a collaborative effort that would not be possible without each valuable contribution.

As the new editors-in-chief, we are excited for this opportunity to expand on the groundwork that has been set by the teams before us. Our editorial team has been working tirelessly on each submission, and their efforts are not going unnoticed – it has been a privilege to work with our seven editors, and we are excited to see how our journal will expand alongside the enthusiasm of our team. We would also like to acknowledge the continued support of our senior advisers for their insights, mentorship, and expertise in academic publishing.

Volume 10, Issue 1 is now available for the academic community to explore, and we are grateful for your support of research.

Yours sincerely,

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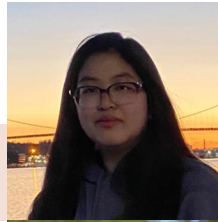
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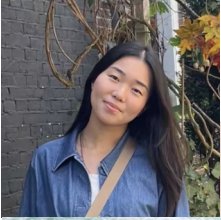
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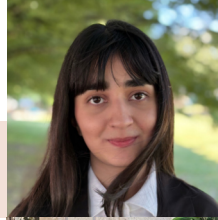
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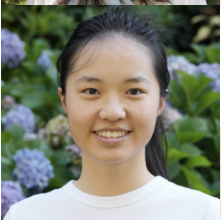
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A 'pandemic snapshot' of the health of Calgarians

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ABSTRACT In 2021, the McCaig Institute for Bone & Joint Health launched the "Mobility For Life" (M4L) Project during the COVID-19 pandemic with the objective of improving the mobility and wellness of Albertans. The objective of this cross-sectional study was to provide insight regarding the health of Albertans during the pandemic focusing on physical activity, sedentary behaviour, mood, pain and quality of life parameters, and to compare the differences between 'Lockdown' and 'Post-lockdown' groups. Between February and December 2021, 197 adults enrolled in the M4L cohort and completed an online intake questionnaire. In addition to demographics, the following validated questionnaires were used to characterize the cohort: the Self-Administered Comorbidity Questionnaire (SCQ), the International Physical Activity Questionnaire (IPAQ), The EuroQol Group 5 Dimension 5 Level (EQ-5D-5L), the Patient Health Questionnaire (PHQ-9), Generalized Anxiety Disorder Assessment (GAD-7), and Patient-Reported Outcomes Measurement Information System (PROMIS) for pain and physical function. Data were analyzed using SPSS statistics. Overall, participants spent 2.57 hours per day being active and 2.12 hours per day sitting, and rated their current health as 85 out of 100. The results also indicated that most participants experienced normal to mild levels of depression and minimal or mild anxiety based on PHQ-9 and GAD-7 results; however, 15.5% of respondents had moderate or severe depression, while 3.4% of respondents had moderate or severe anxiety. The cohort scored similar to the population average for the PROMIS questionnaires, indicating that even though participants were experiencing the effects of COVID-19 restrictions on daily life, their perception of pain and physical function was not very different from the population average. With the exception of ethnicity, there were no statistical differences between the 'Lockdown' and 'Post-lockdown' groups. Our results suggest most Albertans were not anxious or depressed and were meeting aerobic physical activity requirements during the pandemic.

INTRODUCTION

In March 2020, Canada introduced several public health and safety measures to help mitigate the spread of COVID-19. These involved closing down non-essential businesses (community recreation centers, sporting venues, gyms, swimming pools, even parks), and recommending to stay home to limit exposure (Lesser & Nienhuis, 2020). Varying degrees of lockdown were maintained throughout 2020 and 2021. In Alberta, restrictions on restaurants and recreational facilities were eased in June 2021; this relative easing of restrictions continued until December 2021 at which time the Omicron variant had become prevalent. Even prior to the COVID-19 pandemic, physical activity scores among Canadian adults were very low, with only 16% of adults accumulating the required 150 minutes of moderate to vigorous physical activity every week (Clarke et al., 2019). Prior to the emergence of COVID-19, one study showed that almost half of participants in a study of older Canadian adults experienced symptoms consistent with some form of mental illness (Reppas-Rindlisbacher et al., 2022). Existing data indicate that the lockdown did not improve the situation; one study found a significant increase in scores for depression, stress, fatigue and susceptibility to mental health issues (Terry et al., 2020). The implementation of lockdown procedures had a major effect on physical activity; one study showed that 40.5% and 22.4% of previously inactive and active individuals, respectively, were less active during lockdown, while 33% and 40.3% of inactive and active individuals, respectively were more active during lockdown, indicating that Canadians had a varied approach to staying active during the pandemic depending on baseline activity levels (Lesser & Nienhuis, 2020).

In 2021, the McCaig Institute for Bone & Joint Health at the University of Calgary launched the "Mobility For Life" (M4L) project, a prospective cohort study with the aim of assessing and improving the mobility and wellness of Albertans. Almost 200 healthy females and males aged 14 years and older were enrolled between February and December 2021 and, through an electronic survey, provided extensive data regarding physical activity, quality of life, and mental health. This presented a unique cross-sectional 'pandemic snapshot' of healthy Albertans during the height of the COVID-19 pandemic and lockdown. Furthermore, as enrolment spanned both the stringent lockdown period (i.e., February to June 2021) and a post-lockdown period during which restrictions were eased (i.e., July to December 2021),

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assessment of the M4L cohort provides an opportunity to compare physical activity and other important patient-reported outcomes during and after lockdown. In the present study, we aimed to characterize the physical activity of Albertans enrolled in the M4L cohort in 2021 and qualitatively compare physical activity parameters with other patient-reported outcomes. We also compared M4L participants recruited during the lockdown to those recruited post-lockdown period, to explore whether there were any differences in physical activity, quality of life, or mood. We hypothesized that the group recruited during lockdown would experience a decrease in physical activity levels, mood, and subjective quality of life while pain and anxiety levels would increase.

METHODS

This cross-sectional study utilized baseline data from all individuals who enrolled in the M4L study between February 2021 and December 2021. Participants were males and females from any ethnic background, 14 years of age or older. Participants completed a baseline survey at the time of enrollment; those enrolled between February and June 2021 completed the survey during a period of lockdown, while those enrolled between July and December 2021 completed the survey during a period when lockdown restrictions had been relaxed. This project received approval from the Calgary Health Research Ethics Board (REB19-0019).

Recruitment

Participants were recruited through a combination of community-based recruitment and online recruitment. Community-based recruitment involved public events organized by the McCaig Institute and the University of Calgary such as the Wood Forum, Cy Frank Legacy Lectureship, and Science in the Cinema, each with their own focus on raising awareness of various health topics. Online recruitment involved ongoing recruitment of participants through the M4L page on the McCaig Institute website, social media content, and the University of Calgary initiative, Participate in Research.

Data Collection

At the time of enrolment, study participants completed a self-administered electronic survey, which included a mixture of questions created specifically for the M4L project and questions from validated questionnaires. The survey addressed demographics, health history (Self-Administered Comorbidity Questionnaire, [SCQ]) (Sangha et al., 2003) physical activity (International Physical Activity Questionnaire, [IPAQ]) (Hagströmer et al., 2006), quality of life (EQ-5D-5L) (Fermont et al., 2017), mood (Patient Health Questionnaire, [PHQ-9]) (Kroenke et al., 2001; Martin et al., 2006), Generalized Anxiety Disorder Assessment (IGAD-7) (Löwe et al., 2008), and pain and physical function (Patient Reported Outcomes Measurement Information System [PROMIS Pain 6a & PROMIS Item Bank v2.0 – Physical Function]) (Amtmann et al., 2010; Cook et al., 2016; Rose et al., 2014).

Questionnaire analysis

Demographics were addressed by asking a variety of standard questions including age, sex (male, female), gender identification (man/boy, woman/girl, trans woman, trans man, non-binary, two-spirit, other, prefer not to answer), ethnicity (White, Black, East/

Southeast Asian, Indigenous, Latin, Middle Eastern, South Asian, I don't know, Other, prefer not to answer), education level (high school or secondary/post-secondary education), marital status (single, married, common-law, living with partner, separated, divorced, widowed), and employment (full-time, part-time, not working and on benefits, not working and no benefits, retired, homemaker, other). Lifestyle habits were also determined such as smoking (yes, no) and alcohol consumption over the last 30 days (yes, no).

The SCQ questionnaire is used to evaluate comorbid conditions in a population and is scored from 0 to a maximum score of 45 (long form), where the higher the score, the more susceptible an individual is to medical complications (Sangha et al., 2003).

Physical activity data was collected using the long version of the IPAQ questionnaire (International Physical Activity Questionnaire) (Hagströmer et al., 2006) which assessed physical activity levels during leisure, at-home, work and transport-related activities. Based on physical activity data, metabolic equivalents (METs) were calculated and each participant was categorized as having high, moderate or low physical activity. Participants also recorded how many minutes of vigorous, moderate, and walking physical activity they performed in the week; MET-minutes/week were calculated accordingly by multiplying a coefficient by the number of minutes and number of days/week performing the specific activity (Sjostrom et al., 2005). Participants fell into the 'high' category if they completed vigorous intensity exercise equating to a minimum of 1500 MET-minutes/week or any combination of exercise equating to at least 3000 MET-minutes/week. Participants fell into the moderate category if they completed any combination of exercises equating to a minimum of 600 MET-minutes/week. Participants fell into the low category if none of the previous physical activity thresholds were achieved.

The EQ-5D-5L questionnaire is a tool used to determine subjective quality of life where individuals score themselves on a scale from 0-100 where a low score represents poor health and a score of 100 represents the best possible health of the individual.

The PHQ-9 questionnaire result is determined by a sum of scores to determine the severity of depressive symptoms and are rated as normal (0-2), mild (3-5), moderate (6-8) or severe (9-12) (Kroenke et al., 2001; Martin et al., 2006).

The GAD-7 questionnaire result is determined by a sum of scores, rated as minimal (0-4), mild (5-9), moderate (10-14) or severe (>15) anxiety (Löwe et al., 2008).

The modified PROMIS questionnaire results are reported as median T-scores, with a T-score of 50 representing the population average (Cook et al., 2016). A higher score indicates a higher degree of the variable being surveyed, which could be positive or negative.

Data management and analysis

Questionnaire data was stored in a REDCap database (Harris et al., 2019). Data analysis was performed using SPSS (V. 26.0.0.0; Armonk, NY); descriptive statistics were utilized to present the findings. Continuous variables were reported as median and interquartile range (IQR) as the distribution was skewed while binary and categorical variables were reported as counts (n) and

proportions (%). Participants were categorized based on whether they were recruited between February and June 2021 (i.e., lockdown) or between July and December 2021 (i.e., post-lockdown). Survey responses were compared between these two groups using the Mann Whitney Wilcoxon test (non-parametric data) for continuous variables because we were comparing two small independent samples where the distribution was skewed; the Chi-squared test was utilized for binary and categorical variables. Extreme outliers were recognized using SPSS Statistics (V. 26.0.0.0; Armonk, NY), identified by an asterisk in our box plots (performed as part of the data cleaning and checking process). These extreme outliers represent data points that were either more than three IQRs below quartile one or more than three IQRs above quartile three.

For each variable, $p < 0.05$ indicated the results were statistically significant.

RESULTS

Table 1 lists the demographic information of the participants. The majority of participants in our study were female (75.6%), or white ethnicity (82.2%) and had secondary or post-secondary education (80.2%). Five individuals were removed from physical activity analyses due to reported values being severe outliers and implausible scores.

As shown in Table 1, 67.4% indicated that they had consumed alcohol within the past 30 days and 96.6% of participants did not smoke. The SCQ questionnaire revealed a median score of 4.0, where a score of 5.61 represented a population average (Sangha et al., 2003). Median scores for total physical activity time (hours/day) and total time spent sitting (hours/day) were 2.57 and 2.12 respectively. METs were calculated and each participant was categorized as having high (63.5%), moderate (26.9%) or low (7.1%) physical activity. Medians were calculated for each intensity; Vigorous MET-minutes/week (0), Moderate MET-minutes/week (1,595), Walking MET-minutes/week (1,287), Total PA MET-minutes/week (4,077). On a scale of 0-100, for the EQ-5D-5L, participant's subjective health score was a median of 85. The median score on the PHQ-9 (reflecting depression) was 2.0 and the median score on the GAD-7 (reflecting anxiety) was 1.5. Regarding the PHQ-9 questionnaire, 15.5% of respondents had moderate or severe depression; the GAD-7 questionnaire revealed that 3.4% of respondents had moderate or severe anxiety. Median T-scores for the modified PROMIS questionnaires for pain and physical function were 51.2 and 56.7 respectively, where a score of 50 represents the population average (Cook et al., 2016).

Table 2 shows the comparison between the two groups, 'Lockdown' and 'Post-lockdown'. The sample size in the lockdown group was significantly less than the post-lockdown group. For each variable, the corresponding p -value indicates

Table 1. Characteristics of individuals recruited to the Mobility For Life cohort in 2021.

| Variable | N | Median / Frequency | IQR / % |
|--------------------------------------|-----|--------------------|-------------|
| Recruitment period (post-lockdown)* | 179 | 124 | 69.3 |
| Sex (female)* | 193 | 146 | 75.6 |
| Gender (woman/girl)* | 193 | 146 | 75.6 |
| Age (years) | 193 | 65 | 50-69 |
| Height (cm) | 192 | 166 | 160-173 |
| Weight (kg) | 190 | 69.9 | 60-81 |
| BMI (kg/m ²) | 190 | 24.9 | 22-28 |
| Ethnicity (white)* | 197 | 162 | 82.2 |
| Education (> high school)* | 197 | 158 | 80.2 |
| Alcohol (yes)* | 175 | 118 | 67.4 |
| Smoking (no)* | 175 | 169 | 96.6 |
| EQ-5D-5L | 183 | 85.0 | 75-90 |
| PHQ-9 | 174 | 2.0 | 1-5 |
| GAD-7 | 174 | 1.5 | 0-3 |
| SCQ total score | 197 | 4.0 | 1-7 |
| PROMIS T-score (pain) | 181 | 51.2 | 41-56 |
| PROMIS T-score (physical function) | 174 | 56.7 | 44-57 |
| METs Vigorous | 192 | 0 | 0-1,440 |
| METs Moderate | 192 | 1,515 | 690-3,399 |
| METs Walking | 192 | 1,279 | 594-2,463 |
| Total physical activity METs | 192 | 4,052 | 2,124-7,192 |
| METs categorical score (high)* | 192 | 121 | 63.0 |
| Total time of PA (hours/day) | 192 | 2.57 | 1.3-4.2 |
| Total time spent sitting (hours/day) | 192 | 2.12 | 1.5-2.7 |

* Variables reported as Frequency and %

Abbreviations: N = Number of participants, BMI = Body Mass Index, EQ-5D-5L = Quality of Life Questionnaire, PHQ-9 = Mood Patient health Questionnaire, GAD-7 = Generalized Anxiety Disorder Assessment, SCQ = Self-Administered Comorbidity Questionnaire, PROMIS = Patient Reported Outcomes Measurement Information System, MET = Metabolic Equivalent, PA = Physical Activity

Table 2. Comparison of individuals recruited to the Mobility For Life cohort during lockdown and post-lockdown.

| Variable | N | Lockdown (Median / Frequency) | N | Post-lockdown (IQR / %) | p-value |
|--------------------------------------|----|-------------------------------|-----|-------------------------|---------|
| Sex (female)* | 55 | 39 (71) | 124 | 97 (78) | 0.29 |
| Gender (woman/girl)* | 55 | 39 (71) | 124 | 97 (78) | 0.29 |
| Age (years) | 55 | 66 (54–70) | 124 | 64 (45–69) | 0.31 |
| Height (cm) | 55 | 167.64 (160–173) | 124 | 166.37 (160–175) | 0.81 |
| Weight (kg) | 53 | 70.31 (61–80) | 124 | 69.85 (60–83) | 0.83 |
| BMI (kg/m ²) | 53 | 25.50 (22–27) | 124 | 24.41 (22–28) | 0.88 |
| Ethnicity (white)* | 55 | 37 (67) | 124 | 114 (92) | <0.001 |
| Education (> high school)* | 55 | 47 (85) | 124 | 100 (81) | 0.44 |
| Alcohol (yes)* | 55 | 34 (62) | 124 | 83 (70) | 0.26 |
| Smoking (no)* | 55 | 54 (98) | 124 | 114 (92) | 0.33 |
| EQ-5D-5L | 54 | 81.00 (75–90) | 116 | 85.00 (75–90) | 0.27 |
| PHQ-9 | 54 | 2.00 (1–5) | 116 | 2.00 (1–5) | 0.39 |
| GAD-7 | 54 | 1.00 (0–3) | 116 | 1.50 (0–3) | 0.56 |
| SCQ total score | 55 | 3.00 (1–7) | 124 | 4.00 (2–7) | 0.16 |
| PROMIS T-score (pain) | 54 | 52.30 (41–56) | 116 | 51.00 (41–56) | 0.53 |
| PROMIS T-score (physical function) | 54 | 52.35 (44–57) | 116 | 52.35 (44–57) | 0.89 |
| METs Vigorous | 54 | 0 (0–1,440) | 121 | 240 (0–1,440) | 0.17 |
| METs Moderate | 54 | 1,935 (803–4,678) | 121 | 1,595 (915–3,274) | 0.45 |
| METs Walking | 54 | 1,518 (780–2,302) | 121 | 1,287 (594–2,772) | 0.97 |
| Total PA METs | 54 | 4,771 (2,404–8,683) | 121 | 4,330 (2,459–7,543) | 0.87 |
| METs categorical score (high)* | 54 | 37 (69) | 121 | 82 (68) | 0.99 |
| Total time of PA (hours/day) | 54 | 2.96 (1.56–4.75) | 121 | 2.59 (1.43–4.22) | 0.51 |
| Total time spent sitting (hours/day) | 54 | 2.21 (1.71–2.79) | 121 | 2.14 (1.57–2.70) | 0.29 |

* Variables reported as Frequency and %.

p-values were calculated using Mann-Whitney-Wilcoxon test and Chi-squared test.

Abbreviations: N = Number of Participants, BMI = Body Mass Index, EQ-5D-5L = Quality of Life Questionnaire, PHQ-9 = Mood Patient Health Questionnaire, GAD-7 = Generalized Anxiety Disorder Assessment, SCQ = Self-Administered Comorbidity Questionnaire, PROMIS = Patient Reported Outcomes Measurement Information System, MET = Metabolic Equivalent, PA = Physical Activity

whether the results were statistically significant. *p*-values were > 0.05, for all variables except ethnicity (*p*<0.001).

DISCUSSION

The COVID-19 pandemic had an immense impact on physical activity, perceived quality of life, and mental health for Canadians. Findlay et al. (2020) found that just under half of the individuals in their cohort, which primarily included women, youth, and those with a physical health complication, experienced more stress and were more likely to report mental health challenges during the pandemic. Dunton et al. (2020) researched the effects of the pandemic on physical activity routines; it was found that there were general declines in the amount of vigorous, moderate, walking and step counts when they compared pre-pandemic data with that collected early in the COVID-19 era.

M4L participants, on the other hand, had high levels of physical activity, with no significant differences for those recruited during and post-lockdown. Data reported for self-perceived quality of life also showed high scores across both recruitment timeframes. This cross-sectional study revealed scores for the PROMIS questionnaire (pain and physical function) around the pre-pandemic population average; these outcomes are of interest considering the unprecedented restrictions that were imposed on the general public at the time the cohort was recruited.

Physical activity implications

A systematic review by Stockwell et al. (2021) investigated the comparison of physical activity levels and sedentary behaviour prior to and during the COVID-19 pandemic and found that in the majority of studies across many populations, physical activity levels decreased while sedentary behaviour increased. This study was a systematic review that involved multiple populations including children and individuals with medical conditions, which provides insight into the general trends of society but cannot be directly compared to our study which was made up of mostly healthy adults. Our study showed higher physical activity and lower sedentary behaviours compared to national recommendations (CSEP, 2021); there was a trend towards group differences where the post-lockdown group were less active, but spent less time sitting compared to the lockdown group, which could be attributed to returning to daily jobs and having less time to spend on personal fitness and downtime.

Previous literature has suggested that during the pandemic, physical activity levels went down substantially, however, Di Sebastiano et al. (2020) used fitness tracking applications to monitor physical activity levels in over 20,000 Canadians, of which over 2,000 individuals had complete data. This study found that 6 weeks after restrictions were introduced, moderate-vigorous activity returned to pre-COVID-19 levels; this may be one reason why our data shows high levels of physical activity.

Another possible reason for the physical activity levels reported in our study may be the overestimation of activity by participants. In a study conducted by Garriguet et al. (2015), where accelerometer data was compared to self-reported measures when trying to determine the percentage of participants meeting Canadian physical activity guidelines by self-report, 90% of individuals met the guidelines, however when compared to accelerometer data, this dropped to 29%. This indicates a large discrepancy between the two data collection methods and compromises the efficacy of self-reported measures when it is evident that people overestimated how much PA they actually performed. Finally, a study conducted by Lesser and Nienhuis (2020) found that individuals who were active prior to the pandemic tended to perform more physical activity while those who were inactive tended to perform less physical activity during the pandemic. The group of individuals who are likely to participate in a research study centred around mental and physical health outcomes, like M4L, may tend to be more active at baseline.

Mental health implications

A systematic review performed by Xiong et al. (2020) revealed that the COVID-19 pandemic not only had an impact on physical health but also compromised the mental well-being of individuals around the world. Their review identified high rates of depression, stress, post-traumatic stress disorder as well as anxiety in up to 50%. The study identified that one of the key risk factors was a younger population (<40) and females (Xiong et al., 2020). The present cross-sectional study population is predominantly female, and the median age is much higher (median=65), which may explain the difference in patient-reported outcomes; mood, anxiety and pain were all relatively low and perceived quality of life quite high (median=85.0) across participants. Nearchou et al. (2020) suggest that the restrictions imposed by the pandemic created additional barriers for youth to seek help to deal with mental health problems; not only are youth dealing with challenges associated with their development, but now a new social restriction is imposed. In addition, the nature of the pandemic brought unprecedented restrictions into everyone's lives, removing the possible exposure to protective mechanisms for young people against mental health challenges such as social gatherings, sporting events, and even learning environments (Nearchou et al., 2020). Older individuals may be more resilient to these challenges as they have already built a strong foundation in life regarding work-life balance.

Strengths and limitations

This study provided an opportunity to delve into the lives and routines of adults through a cross-sectional lens during the COVID-19 pandemic. We explored various parameters, including physical activity and patient-reported outcomes (pain, mood, anxiety, physical function) during unprecedented times. In contrast to other studies, we did not find the expected adverse effects of pandemic restrictions in our study cohort; a possible explanation could be the older age of our population. Additionally, healthy individuals may have been more likely to participate in mobility and joint-focused research during the pandemic. One major limitation of this study was that data was collected using subjective questionnaires which could have positively or negatively influenced results. Furthermore, we had questions where participants chose to not answer the question as well as five individuals who reported physical activity information that was not humanly possible and therefore their

responses to these questions were removed. Other possible limitations of the present study include the small sample size and the inability to compare participant data to the pre-pandemic era. As this was a cross-sectional study, it provided a 'snapshot' of the health of Calgarians during the pandemic but did not offer any comparison to the participant's daily routines without restrictions and lockdown measures.

Future studies should focus on obtaining a larger sample size that can be followed prospectively and record a baseline measurement for comparison. Researchers should also consider whether data collection, specifically for physical activity parameters, could be performed with more accurate methods such as accelerometers.

CONCLUSION

Our cross-sectional study showed that people who enrolled in the M4L study between February and December 2021 had high self-reported physical activity and mental health both during and post-lockdown. This is an interesting finding as a literature search revealed that for many populations around the world, the COVID-19 pandemic had a negative effect on their well-being. Further research needs to be done to firstly determine whether subjective reporting is the best method to obtain accurate data and secondly to prospectively follow individuals to determine whether their behaviours changed throughout the course of the pandemic and during the post-COVID-19 era.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- [1] Amtmann, D., Cook, K. F., Jensen, M. P., Chen, W.-H., Choi, S., Revicki, D., Cella, D., Rothrock, N., Keefe, F., Callahan, L., & Lai, J.-S. (2010). Development of a PROMIS item bank to measure pain interference. *Pain, 150*(1), 173–182. <https://doi.org/10.1016/j.pain.2010.04.025>
- [2] Clarke, J., Colley, R., Janssen, I., & Tremblay, M. S. (2019). Accelerometer-measured moderate-to-vigorous physical activity of Canadian adults, 2007 to 2017. *Health Reports, 30*(8), 3–10. <https://doi.org/10.25318/82-003-X201900800001-ENG>
- [3] Cook, K. F., Jensen, S. E., Schalet, B. D., Beaumont, J. L., Amtmann, D., Czajkowski, S., Dewalt, D. A., Fries, J. F., Pilkonis, P. A., Reeve, B. B., Stone, A. A., Weinfurt, K. P., & Cella, D. (2016). PROMIS measures of pain, fatigue, negative affect, physical function, and social function demonstrated clinical validity across a range of chronic conditions. *Journal of Clinical Epidemiology, 73*, 89–102. <https://doi.org/10.1016/j.jclinepi.2015.08.038>
- [4] CSEP. (2021). *Adults 18-64 – 24-hour movement guidelines*. <https://csepguidelines.ca/guidelines/adults-18-64/>
- [5] Di Sebastiano, K. M., Chulak-Bozzer, T., Vanderloo, L. M., & Faulkner, G. (2020). Don't walk so close to me: Physical distancing and adult physical activity in Canada. *Frontiers in Psychology, 11*, 1895. <https://doi.org/10.3389/fpsyg.2020.01895>
- [6] Dunton, G. F., Wang, S. D., Do, B., & Courtney, J. (2020). Early effects of the COVID-19 pandemic on physical activity locations and behaviors in adults living in the United States. *Preventive Medicine Reports, 20*, 101241. <https://doi.org/10.1016/j.pmedr.2020.101241>
- [7] Fermont, J. M., Blazeby, J. M., Rogers, C. A., & Wordsworth, S. (2017). The EQ-5D-5L is a valid approach to measure health related quality of life in patients undergoing bariatric surgery. *PLoS ONE, 12*(12), e0189190. <https://doi.org/10.1371/journal.pone.0189190>

- [8] Findlay, L. C., Arim, R., & Kohen, D. (2020). Understanding the perceived mental health of Canadians during the COVID-19 pandemic. *Health Reports, 31*(4), 22–27. <https://doi.org/10.25318/82-003-X202000400003-ENG>
- [9] Garriguet, D., Tremblay, S., & Colley, R. C. (2015). Comparison of Physical Activity Adult Questionnaire results with accelerometer data. *Health Reports, 26*(7), 11–17. <https://pubmed.ncbi.nlm.nih.gov/26177042/>
- [10] Hagströmer, M., Oja, P., & Sjöström, M. (2006). The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nutrition, 9*(6), 755–762. <https://doi.org/10.1079/PHN2005898>
- [11] Harris, P. A., Taylor, R., Minor, B. L., Elliott, V., Fernandez, M., O'Neal, L., McLeod, L., Delacqua, G., Delacqua, F., Kirby, J., & Duda, S. N. (2019). The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics, 95*, 103208. <https://doi.org/10.1016/j.jbi.2019.103208>
- [12] Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9. *Journal of General Internal Medicine, 16*(9), 606–613. <https://doi.org/10.1046/j.1525-1497.2001.016009606.x>
- [13] Lesser, I. A., & Nienhuis, C. P. (2020). The impact of COVID-19 on physical activity behavior and well-being of Canadians. *International Journal of Environmental Research and Public Health, 17*(11), 3899. <https://doi.org/10.3390/ijerph17113899>
- [14] Löwe, B., Decker, O., Müller, S., Brähler, E., Schellberg, D., Herzog, W., & Herzberg, P. Y. (2008). Validation and standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the general population. *Medical Care, 46*(3), 266–274. <https://doi.org/10.1097/MLR.0b013e318160d093>
- [15] Martin, A., Rief, W., Klaiberg, A., & Braehler, E. (2006). Validity of the Brief Patient Health Questionnaire Mood Scale (PHQ-9) in the general population. *General Hospital Psychiatry, 28*(1), 71–77. <https://doi.org/10.1016/j.genhosppsych.2005.07.003>
- [16] Nearchou, F., Flinn, C., Niland, R., Subramaniam, S. S., & Hennessy, E. (2020). Exploring the impact of COVID-19 on mental health outcomes in children and adolescents: A systematic review. *International Journal of Environmental Research and Public Health, 17*(22), 8479. <https://doi.org/10.3390/IJERPH17228479>
- [17] Reppas-Rindlisbacher, C., Mahar, A., Siddhuria, S., Savage, R., Hallet, J., & Rochon, P. (2022). Gender differences in mental health symptoms among Canadian older adults during the COVID-19 pandemic: A cross-sectional survey. *Canadian Geriatrics Journal, 25*(1), 49–56. <https://doi.org/10.5770/cgj.25.532>
- [18] Rose, M., Bjorner, J. B., Gandek, B., Bruce, B., Fries, J. F., & Ware, J. E. (2014). The PROMIS Physical Function item bank was calibrated to a standardized metric and shown to improve measurement efficiency. *Journal of Clinical Epidemiology, 67*(5), 516–526. <https://doi.org/10.1016/j.jclinepi.2013.10.024>
- [19] Sangha, O., Stucki, G., Liang, M. H., Fossel, A. H., & Katz, J. N. (2003). The self-administered comorbidity questionnaire: A new method to assess comorbidity for clinical and health services research. *Arthritis & Rheumatism, 49*(2), 156–163. <https://doi.org/10.1002/art.10993>
- [20] Sjostrom, M., Ainsworth, B. E., Bauman, A., Bull, F. C., Hamilton-Craig, C. R., & Sallis, J. F. (2005). Guidelines for data processing analysis of the International Physical Activity Questionnaire (IPAQ) - Short and long forms. <https://api.semanticscholar.org/CorpusID:79242415>
- [21] Stockwell, S., Trott, M., Tully, M., Shin, J., Barnett, Y., Butler, L., McDermott, D., Schuch, F., & Smith, L. (2021). Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: a systematic review. *BMJ Open Sport & Exercise Medicine, 7*(1), e000960. <https://doi.org/10.1136/BMJSEM-2020-000960>
- [22] Terry, P. C., Parsons-Smith, R. L., & Terry, V. R. (2020). Mood responses associated with COVID-19 restrictions. *Frontiers in Psychology, 11*, 3090. <https://doi.org/10.3389/FPSYG.2020.589598/BIBTEX>
- [23] Xiong, J., Lipsitz, O., Nasri, F., Lui, L. M. W., Gill, H., Phan, L., Chen-Li, D., Iacobucci, M., Ho, R., Majeed, A., & McIntyre, R. S. (2020). Impact of COVID-19 pandemic on mental health in the general population: A systematic review. *Journal of Affective Disorders, 277*, 55–64. <https://doi.org/10.1016/j.jad.2020.08.001>

Microplastic abundances in Craig Bay, British Columbia

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ABSTRACT Microplastics are primarily produced from the fragmentation of larger plastic materials via physical, chemical, or biological means to eventually be carried by wind and water to marine environments, such as estuaries. As a result, in these microplastic sinks, the concentration of microplastics accumulated in sediments depends on grain size, such that microplastics are deposited with similarly sized grains. Ultimately, sampling in microplastic sinks provides information about microplastic retention. Samples were collected from Craig Bay, British Columbia, Canada, to determine if different energy levels within depositional environments affect the accumulation and retention of microplastics. Samples were split into three subsets: one subset was sifted through various sieves to determine grain size distributions and dominant grain size; a second subset was used to determine organic matter content; and, the third was used for microplastic extraction using density floatation and enzyme digestion. Although the study showed no relationship between grain size and microplastic concentration, samples closest to the tidal channel contained fewer microplastics, suggesting that higher energy environments may be less likely to retain microplastics. Although the sample size was insufficient to confirm whether a correlation between microplastics and sediment exists, this study evaluated two analytical methods and developed a workflow that can be applied to future sample sets. A larger sample size from various locations may provide insight into other factors that affect microplastic retention and quantity, such as energy levels and proximity to urban areas. This research is part of a new and emerging research area within sedimentology that focuses on the correlation between sediments and microplastics.

INTRODUCTION

Various plastics, each with unique qualities, have been developed for multiple purposes, such as polyester for clothing and polypropylene for children's toys. Unfortunately, improperly disposed plastic items, such as litter on a beach, degrade over time and fragment into microplastics (MPs)—plastic particles 5 mm or less—through physical, chemical, or biological processes (Firदाus et al., 2020; Garrido Gamarro et al., 2020; Perumal & Muthuramalingam, 2022). The widespread use of plastics, combined with degradation and distribution processes, has led to the widespread and global distribution of microplastics.

Although ubiquitous, research in different regions shows that MPs are unevenly distributed globally. For instance, sediment samples collected from three locations off the southwest coast of Vancouver Island, British Columbia, report a range of 0–877 particles/kg, while 15 sampling sites along the Western Pacific Ocean produced a range of 0–1,042 particles/kg (Morra, 2021; Zhang et al., 2020). The consequences of MP pollution include the potential risk of bioaccumulation of toxins in marine organisms that ingest MPs. Similarly, human consumption of aquatic organisms that do not require the removal of the digestive tract, such as bivalves, may result in the ingestion of large quantities of MPs, increasing potential health risks (Campanale et al., 2020; Garrido Gamarro et al., 2020; Lusher et al., 2017; Smith et al., 2018).

Rivers play a crucial role in transporting MPs to the ocean, as the shallow, typically low-energy environment at the river's mouth allows MPs to accumulate. Areas of MP deposition are known as "sinks," with an important MP sink being estuaries: transitional zones where freshwater rivers meet the ocean (Govender et al., 2020; Nayak, 2014; Peng et al., 2017; Phuong et al., 2021). Studies conducted in estuaries worldwide have found varying amounts of MPs; for example, two South Carolina estuaries had concentrations of 413.8 ± 76.7 particles/m² (Charleston Harbor) and 221.0 ± 25.6 particles/m² (Winyah Bay), compared to the mean concentration of 7.9 particles/kg d.w. in Canada's Cowichan-Koksilah Estuary and 121 ± 9 particles/kg d.w. in China's Changjiang Estuary (Alava et al., 2021; Gray et al., 2018; Peng et al., 2017). These differences highlight the need for further investigation regarding factors that influence MP deposition within coastal environments, as well as for standardization in units.

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Estuaries, while typically dominated by low-energy conditions, are dynamic and controlled by tidal and seasonal shifts that result in areas of higher and lower energy levels and therefore in fine, low-energy deposits and coarser, high-energy deposits. The process of winnowing sorts grains by their weight, leading to the expectation that sediment grains and MPs of similar weights would be deposited together. Thus, this reflects a possible influence of energy levels and reactivity of grains on the deposition and retention of MPs. However, studies are limited, and findings vary, as some studies reported positive correlations between grain size and MP abundance, while other studies have found no correlations (Alava et al., 2021; Alves & Figueiredo, 2019; Blair et al., 2019; Govender et al., 2020; Peng et al., 2017). To address this research gap, our study will focus on sediment samples from Craig Bay, which were used to evaluate two analytical methods and determine MP accumulation within sediments dominated by contrasting grain sizes.

We hypothesize that samples containing smaller grain sizes from lower energy environments within the estuary will have a greater abundance of microplastics. As more information regarding the harm MPs bring to the environment and fauna is discovered, understanding the various factors involved in MP deposition and retention must be considered. This study combines multiple factors (i.e., MP abundance, organic matter content, grain size, energy levels, and clay reactivity) to determine the relationship between these environmental factors and MP abundance.

METHODS

Sample collection

Surface sediment samples were taken from Craig Bay, British Columbia, in 2007 and stored in cloth bags. The sediment samples were taken from four locations along the estuary adjacent to a tidal channel (n=1 per site). Based on sediment descriptions taken during sampling, Sample 1 (S1) was composed of sandy mud, Samples 2 (S2) and 3 (S3) were sandy and contained minor mud, and Sample 4 (S4) comprised sandy mud taken from a muddy interdune (i.e., the space between two dunes) (Fig. 1).

Grain size distribution

A sieve analysis was performed to determine sediment grain size using standard sieves with 4000-, 2000-, 1000-, 500-, 250-, 125-, and 63- μm mesh, and a pan was used to collect grains smaller than 63 μm . Sieves were weighed before samples were added and re-

weighed between each sample. Samples 1 through 4 were subsampled (12.5 g) and poured through the stacked sieves, which were subsequently shaken manually for one minute. After shaking, the sediments were collected, weighed, and transferred into separate vials. The calculated sediment weight determined the grain size distribution.

A small portion of sediment from each vial was taken and analyzed under a stereomicroscope to visually determine if the grains are from local sources based on their mineral composition and angularity. Physical characteristics (i.e., colour, luster, cleavage planes, and fracture patterns) observed from the larger grains (4000–125 μm) were used to determine the overall mineral composition of each sample. Small portions from vials containing grains < 63 μm were placed on carbon paper and observed using a Hitachi TM-3000 scanning electron microscope to determine their angularity.

Organic matter content

Five-gram portions of sediment or ashed sand (as a blank) were added individually to pre-weighed crucibles. Samples were dried in a muffle furnace for two hours at 105°C, allowed to cool to room temperature, re-weighed, and returned to the muffle furnace for two hours at 360°C. The amount of organic matter in the samples was determined by percent loss-on-ignition (%LOI), calculated by subtracting the weight at 360°C from the weight determined at 105°C and dividing the value by the weight at 105°C.

Microplastic extraction

Microplastics were extracted from sediment samples using density floatation and enzymatic digestion in a custom-built extraction device (Fig. 2). Prior to extraction, each sample (25 g), including a blank of ashed sand, was weighed. Once weighed, sediments containing clumps were transferred to a mortar and gently crushed.

A K_2CO_3 solution with a density of 1.5 g/mL was used to extract microplastics from the sediment samples for density floatation. Samples were added to the bottom chamber while stirring at 300 RPM to avoid clumping. Additional K_2CO_3 was added until the top sight glass was one-half to two-thirds full. The apparatus was covered with aluminum foil and stirred for one hour at 300 RPM. Afterward, the solids were allowed to settle for 48 hours. Once the separation was complete, the butterfly valve was closed to isolate



Figure 1. Map of sample locations in Craig Bay, Vancouver Island, where S1: sandy mud; S2: sandy with minor mud; S3: sandy with minor mud; and, S4: sandy mud.

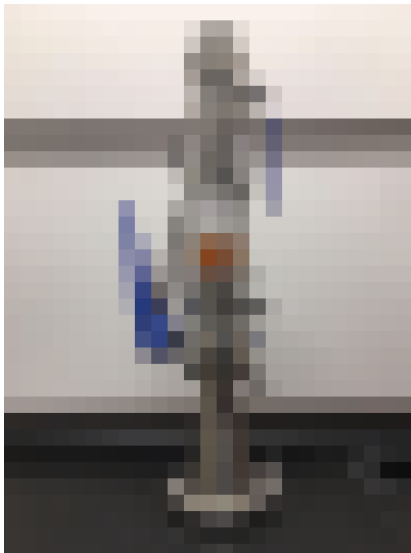


Figure 2. A custom-built microplastic extraction device consisting of, from top to bottom, a tri-clamp ball valve, a sight glass, a butterfly valve, and a sediment chamber. Each section is sealed together using clamps with silicon gaskets in between each section.

floating particles and removed from the apparatus with the sight glass.

A stainless-steel filter with a pore size of 10 μm , stainless-steel frit, and gasket were placed on top of the sight glass, followed by a closed tri-clamp ball valve. The setup was flipped over and attached to a vacuum manifold. The ball valve was opened, and the vacuum was turned on to drain the K_2CO_3 and retain particulates on the frit. Sequentially, filtered deionized water, and 70% ethanol in water were used to wash the interior of the sight glass. The ball valve was closed, and the setup was removed from the vacuum manifold.

To remove organic matter, a modification of the method developed by Lavoy and Crossman (2021) was used. With the ball valve closed, 100 mL of an 80 g/L Bio-Clean® septic enzyme suspension was added to the sight glass, and the top was covered and placed in an oven at 55°C for two days. Afterward, the enzyme solution was removed by vacuum filtration, and 25 mL of 35% H_2O_2 was added to chemically digest any residual enzymes or organic matter. The sight glass was returned to the oven at 65°C for 24 hours, after which the H_2O_2 was drained and the sight glass was washed with filtered deionized water and 70% ethanol in water.

All samples and the blank underwent a second density floatation due to a high amount of residual organic matter remaining on the sample filters. The sight glass where the MPs were initially collected was used as the sediment chamber, and a second sight glass was used to collect the floated material. The procedure was the same as the first floatation; however, samples were stirred for 15 minutes rather than an hour and left overnight to settle. Unlike other samples, Sample 1 continued to contain residual organic matter and underwent a second digestion using enzymes and H_2O_2 .

Nile red staining

Following MP extraction, all stainless-steel filters were transferred to Analyslide petri slides and stained with a few drops of 10 $\mu\text{g}/\text{mL}$ Nile red in methanol (Erni-Cassola et al., 2017). The petri slides were covered and placed in an oven for 10 minutes at 60°C and were then moved to a fume hood and left with their covers

slightly open for the remaining methanol to evaporate. Samples were observed under a stereomicroscope with fluorescence attachments. An external microscope light source with blue lights (460 nm) was used for excitation, and a Tiffen Orange 21 camera filter attached to the microscope objective was used as an emission filter to view fluorescing particles. Whole filter images were processed using the MP-VAT macro in ImageJ to obtain MP count and circularity (Prata et al., 2021). Circularity values were used to determine the morphology of the particles; fibers had a circularity of 0–0.3, and fragments were > 0.3. Large fluorescing particles were manually picked with tweezers, placed onto a transparent film with double-sided tape, circled, and numbered (Grbić et al., 2020).

Raman spectroscopy

All picked particles were analyzed using Raman spectroscopy to identify polymer composition. The camera attachment allowed for the visual determination of morphology, and sizes were determined using the ruler function in the LabSpec 6 software. Particles that were curved could not be measured. Raman analysis was done using a Horiba XploRA PLUS with the following acquisition parameters: a 750- cm^{-1} spectro, 50–2500 cm^{-1} range for the 785 nm laser, four-second acquisition and accumulation times, a 100- μm slit size, and a 300- μm hole size. A 785-nm laser at 25% power was used to minimize particle burning and fluorescence. A 50x or 100x objective lens was used depending on the particle size. The spectra obtained were analyzed using Wiley's Know-It-All spectra database (John Wiley and Sons, Inc., USA) and Open Specy (Cowger et al., 2021) spectral libraries to identify the polymer composition of the particles. Matches were determined by the hit quality value of at least 60% and by manually confirming matching peaks to the suggested results. Coloured particles not identified in either database were labeled “unknown anthropogenic.”

Contamination mitigation

All equipment used to extract microplastics were washed with 0.22- μm filtered Milli-Q water to prevent MP contamination and kept covered with a cleaned cap or aluminum foil when not in use to avoid airborne contamination. Procedures were performed in a laminar flow hood to prevent contamination, and samples were kept covered and only opened when needed for analysis. When undergoing Raman analysis, the instrument doors were kept closed unless the sample or the objective lens was being changed.

RESULTS

Sediment and organic matter

Samples S1 and S4 had a dominant grain size of silt and clay at 48.51% and 45.67%, respectively, while S2 and S3 were dominated by fine sand at 48.14% and 45.81%, respectively (Fig. 3). All samples contained angular grains of quartz, mica, and amphiboles, and S2 and S3 contained additional minerals such as feldspars, garnet, and epidote.

From the LOI analysis, S1 and S4 were determined to contain the most organic matter at 4.37% and 1.97%, respectively, while S2 and S3 consisted of 0.73% and 0.32% organic matter, respectively.

Concentrations and characteristics of microplastics

All samples collected across the four sites contained identifiable MPs. Based on the Nile red staining, the highest concentrations of MPs were found at site S4 (7,739 particles/kg), followed by S2

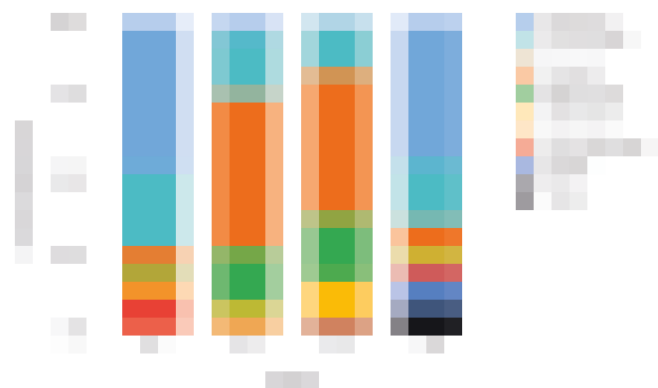


Figure 3. Distribution of each grain size by weight in each sample, where samples S1: sandy mud; S2: sandy with minor mud; S3: sandy with minor mud; S4: sandy mud. Grain sizes are ordered from smallest to largest.

(2,219 particles/kg), S3 (2,144 particles/kg), and S1 (541 particles/kg). Fragment-shaped MPs dominated all samples: S1 contained 10 fragments and 4 fibers, S2 had 57 fragments and 2 fibers, S3 had 56 fragments and no fibers, and S4 had 188 fragments and 3 fibers (Fig. 4). No films were identified in the samples.

The concentrations of the samples using the particle-picking method were 77 particles/kg for S1, 75 particles/kg for S2, 268 particles/kg for S3, and 203 particles/kg for S4. The average concentration across all sites was 156 particles/kg. Raman analysis identified these particles as polypropylene, polystyrene, and polyester (Table 1). Statistical analyses could not be performed due to the limited sample size (n=1) at each site.

Table 1. Distribution of particle types analyzed by Raman spectroscopy.

| | Morphology | Colour | Polymer |
|-------|----------------------|---|--|
| Blank | 2 fragment | 1 red 1 clear | 1 acrylonitrile butadiene styrene 1 polyester |
| S1 | 1 fragment 1 film | 1 clear 1 pink | 2 unknown anthropogenic |
| S2 | 1 film 1 fibre | 1 white 1 pink | 1 polypropylene 2 unknown anthropogenic |
| S3 | 2 film 5 fibre | 3 clear 1 white 1 purple 1 pink 1 mixed (black and white) | 1 polypropylene 1 polystyrene 3 polyester 2 unknown anthropogenic |
| S4 | 5 fibre | 4 clear 1 white | 3 polyester 2 unknown anthropogenic |

Fluorescence analysis under a microscope indicated that the blank contained 10 particles; however, only two were large enough to be picked. The unpicked fluorescing particles were fragments. Particles similar to those in the blank did not appear in the samples.

DISCUSSION

Microplastic analytical method comparison

Two methods were implemented to analyze the MPs found in Craig Bay: Nile red staining with automated quantification, and manual particle-picking of fluorescent particles followed by Raman spectroscopy. Of the two methods, fluorescence staining and automated quantification is ideal for rapid quantification of MPs in each sample; however, it is limited in other areas of analysis and has the potential for over-quantification. In particular, single fibers that have been partially stained could be mistaken as multiple fragments in ImageJ due to their appearance. Stanton et al. (2019) have also acknowledged that Nile red does not stain some MPs and will not uniformly stain coloured MPs. Furthermore, due to higher levels of organic matter in S1 and S4, residual organic matter was present following the digestion stage, leading to potential staining with Nile red and therefore over-quantification (Erni-Cassola et al., 2017; Shim et al., 2016). The percentage overestimation of organic matter could not be calculated because the ashed lab blank did not contain organic matter. Finally, samples in this study were contaminated with polytetrafluoroethylene (PTFE) from the stir bars, an issue that became apparent after PTFE was found while analyzing MPs directly on the stainless-steel filters with the Raman; Nile red may have also stained these particles, leading to further over-quantification of MPs. Unfortunately, the limited sample size prevented statistical analysis of the overestimation due to organic matter and PTFE, and in future studies, the equipment selection should be carefully made to avoid contamination of the samples.

While both methods can indicate the extent of MPs found in samples, particle-picking could further identify polymer type when combined with Raman spectroscopy. Although picking MPs from the filters and placing them onto tape mitigates the inclusion of organic matter, it is time-consuming because each particle must be tested to determine its material (i.e., plastic or otherwise). Furthermore, this method can only analyze particles that can be picked with tweezers, leaving behind smaller MPs (Blair et al., 2019). However, particle-picking results are the most reliable because quantification is least impacted by contaminants, unlike



Figure 4. Microplastic quantification using ImageJ representing total count and percent distribution, where samples S1: sandy mud; S2: sandy with minor mud; S3: sandy with minor mud; S4: sandy mud.

the case of fluorescence: organic matter could be excluded using visual confirmation under white light, and PTFE particles that were too small to be picked or be identified by Raman spectroscopy were excluded from the analyzed particles. Although the main concern with particle-picking was the polyester tape the particles were placed on, polyester particles were analyzed twice at different locations to ensure the accuracy of the results. Due to the potential over-quantification of MPs using the fluorescence staining method and the more reliable identification of plastic particles, we chose to compare MPs in the sediment samples using the results generated from the particle-picking method.

Microplastics in estuarine sediment

Microplastics were found in all samples, and fibers were found to be the dominant morphology. Although fragments were identified while picking particles from the filter, as a result of their small size, not all MP fragments could be collected and further analyzed. The particles analyzed for their polymer types by Raman spectroscopy indicate that polyester fibers were the most common. These fibers are produced in large quantities in washing machines and can bypass wastewater treatment due to their small size and eventually enter the ecosystem (Alves & Figueiredo, 2019). The French Creek Pollution Control Center, located northwest of Craig Bay, provides wastewater treatment services and is a potential source of polyester MPs, while the community adjacent to the estuary could be another.

Craig Bay is a wide-mouthed estuary with a relatively high-energy environment. Sediments primarily contained minerals such as obsidian, indicating volcanoclastic sediments, and micas (Table 2), which are a group of silicate minerals that are easily worn down due to their soft nature and do not appear in sediments that have traveled long distances (Blakemore, 2016). The angular grains in the current study also indicate a nearby source because they are less worn down by transportation. Furthermore, the estuary sites provided two dominant sediment types (Table 2) with differences in organic matter content, such that low-energy sites (S1 and S4) deposited muddy sediments that contained more organic matter. The coarser grains indicate a higher energy area (i.e., comparably wave-winnowed) than those with finer grains, as more energy is needed to transport them.

Comparing the microplastic abundances amongst sites, S1 and S2 have fewer MPs than S3 and S4. The sites S1 and S2 are closer to a tidal channel (Fig. 1) and lower in the intertidal zone; they may be more persistently influenced by tidal advection during falling and rising tides. The increased tidal reworking carries away lighter

MPs, hence the lack of films and fibers and the presence of fragments. Conversely, S3 and S4 are topographically higher in the flats, leading to shorter durations of tidal reworking and more drainage through the sediment during falling tides. The shorter durations of tidal reworkings lead to sieving and allow for the accumulation of films and fibers. In addition, S4 is located furthest from the tidal channel and has a higher clay content than S2 and S3. MPs typically float due to their low density, but a recent study has determined that clays will adhere to MPs, causing an increase in their overall mass and therefore resulting in sinking and deposition; this may be enhanced during falling and low tide as particles are trapped on the surface (Sutherland et al., 2023). S1, also with a high clay content, is closer to the channel, where higher energy levels may result in these dense MP-clay agglomerations being carried out to a more distal location before being deposited.

Grain size and organic matter fraction may also be important parameters influencing microplastic abundances in sediments. The fine sand samples contained less organic matter (0.32% and 0.73%) and were likely more porous than the silt and clay-rich samples, where organic matter-bound aggregate silt and clay grains have less pore space for MP deposition. Some studies have also observed a higher MP abundance in coarse sediment, other studies have found the opposite, where MPs were more abundant in fine sediments with high amounts of organic matter, and further studies have found no correlations (Alava et al., 2021; Alves & Figueiredo, 2019; Blair et al., 2019; Govender et al., 2020; Peng et al., 2017). The lack of consensus clearly supports the need for more research, particularly as few studies have taken the approach to link depositional environments and energies to MP deposition.

The limited sample size prevented statistical analysis of the concentrations between sites or the correlation between grain size and MP. Despite this, MP concentrations determined in this study resemble those found in other parts of the world. The picked particle concentrations of S3 (268 particles/kg) and S4 (203 particles/kg) are similar to those of Robert Point (355 ± 119 particles/kg), Grice Bay (298 ± 141 particles/kg), and Kennedy Cove (213 ± 96 particles/kg) on Vancouver Island (Morra, 2021). The concentrations from all the sites are also within the range found in the sediments of the Changjiang Estuary, China (20–340 items/kg) (Peng et al., 2017). In contrast to these locations with similar concentrations, a study performed in the Western Pacific Ocean (WPO) has found upwards of 1,042 items/kg in their samples (Zhang et al., 2020). One reason for the difference between the Craig Bay and WPO sites may be their proximity to the Western Garbage Patch: the WPO sites are in the Pacific Ocean, south of the garbage patch, increasing the amount of MPs in their

Table 2. Summary of results.

| | S1 | S2 | S3 | S4 |
|-----------------------------|--|--|--|-----------------------------|
| Dominant grain size | Silt and clay | Fine sand | Fine sand | Silt and clay |
| Minerals | Quartz Mica Amphibole Plagioclase | Quartz Mica Amphibole Garnet Epidote Feldspar | Quartz Mica Amphibole Garnet Epidote Feldspar Obsidian | Quartz Mica Amphibole |
| Organic matter content | 4.37% | 0.73% | 0.32% | 1.97% |
| MP count (fluorescence) | 541 particles/kg | 2,219 particles/kg | 2,144 particles/kg | 7,739 particles/kg |
| MP count (particle picking) | 77 particles/kg | 75 particles/kg | 268 particles/kg | 203 particles/kg |

samples. While currents from the Pacific Ocean feed into Craig Bay, channels are narrow and restrict large influxes of water, resulting in little sediment transfer into Craig Bay and more localized sources of MPs.

CONCLUSION

Samples showed two opposing dominant grain sizes and organic matter levels: fine sand samples with less organic matter (0.32% and 0.73%) and silt and clay samples with more organic matter (1.97% and 4.37%). The particle-picking method resulted in a range of 75–268 particles/kg, consistent with MP abundances in other estuarine sediments. No relationship between grain size and MP concentration could be determined. However, the results show that the samples closest to the tidal channel contained fewer MPs. This suggests that higher energy environments with consistent current or wave action may be less likely to retain MPs. The porosity of the samples also affects MP deposition, as organic matter-bound grains are less porous and contained fewer MPs. By understanding the factors influencing MP deposition (e.g., organic matter content, grain size and porosity, depositional environment), regions of potentially high microplastic abundances can be identified, which will better help to identify potentially at-risk populations, such as bivalves that reside in high densities in estuaries, as well as focus mitigation efforts. Predictions of MP accumulation and the risks posed to organisms that reside in these “sinks” can be made using MP deposition mechanisms.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- [1] Alava, J. J., Kazmiruk, T. N., Douglas, T., Schuerholz, G., Heath, B., Flemming, S. A., Bendell, L., & Drever, M. C. (2021). Occurrence and size distribution of microplastics in mudflat sediments of the Cowichan-Koksilah Estuary, Canada: A baseline for plastic particles contamination in an anthropogenic-influenced estuary. *Marine Pollution Bulletin*, 173, 113033. <https://doi.org/10.1016/j.marpolbul.2021.113033>
- [2] Alves, V. E. N., & Figueiredo, G. M. (2019). Microplastic in the sediments of a highly eutrophic tropical estuary. *Marine Pollution Bulletin*, 146, 326–335. <https://doi.org/10.1016/j.marpolbul.2019.06.042>
- [3] Blair, R. M., Waldron, S., Phoenix, V. R., & Gauchotte-Lindsay, C. (2019). Microscopy and elemental analysis characterisation of microplastics in sediment of a freshwater urban river in Scotland, UK. *Environmental Science and Pollution Research*, 26(12), 12491–12504. <https://doi.org/10.1007/s11356-019-04678-1>
- [4] Blakemore, D. (2016, February 18). *Mineral spotlight: Mica minerals*. Calvin University Chimes. Retrieved August 1, 2025, from <https://calvinchimes.org/2016/02/18/mineral-spotlight-mica-minerals/>
- [5] Campanale, C., Massarelli, C., Savino, I., Locaputo, V., & Uricchio, V. F. (2020). A detailed review study on potential effects of microplastics and additives of concern on human health. *International Journal of Environmental Research and Public Health*, 17(4), 1212. <https://doi.org/10.3390/ijerph17041212>
- [6] Cowger, W., Steinmetz, Z., Gray, A., Munno, K., Lynch, J., Hapich, H., Pimpke, S., De Frond, H., Rochman, C., & Herodotou, O. (2021). Microplastic spectral classification needs an open source community: Open Specy to the rescue! *Analytical Chemistry*, 93(21), 7543–7548. <https://doi.org/10.1021/acs.analchem.1c00123>
- [7] Erni-Cassola, G., Gibson, M. I., Thompson, R. C., & Christie-Oleza, J. A. (2017). Lost, but found with Nile red: A novel method for detecting and quantifying small microplastics (1 mm to 20 µm) in environmental samples. *Environmental Science & Technology*, 51(23), 13641–13648. <https://doi.org/10.1021/acs.est.7b04512>
- [8] Firdaus, M., Trihadiningrum, Y., & Lestari, P. (2020). Microplastic pollution in the sediment of Jagir Estuary, Surabaya City, Indonesia. *Marine Pollution Bulletin*, 150, 110790. <https://doi.org/10.1016/j.marpolbul.2019.110790>
- [9] Garrido Gamarro, E., Ryder, J., Elvevoll, E. O., & Olsen, R. L. (2020). Microplastics in fish and shellfish – A threat to seafood safety? *Journal of Aquatic Food Product Technology*, 29(4), 417–425. <https://doi.org/10.1080/10498850.2020.1739793>
- [10] Govender, J., Naidoo, T., Rajkaran, A., Cebekhulu, S., Bhugeloo, A., & Sershen, (2020). Towards characterising microplastic abundance, typology and retention in mangrove-dominated estuaries. *Water*, 12(10), 2802. <https://doi.org/10.3390/w12102802>
- [11] Gray, A. D., Wertz, H., Leads, R. R., & Weinstein, J. E. (2018). Microplastic in two South Carolina estuaries: Occurrence, distribution, and composition. *Marine Pollution Bulletin*, 128, 223–233. <https://doi.org/10.1016/j.marpolbul.2018.01.030>
- [12] Grbić, J., Helm, P., Athey, S., & Rochman, C. M. (2020). Microplastics entering northwestern Lake Ontario are diverse and linked to urban sources. *Water Research*, 174, 115623. <https://doi.org/10.1016/j.watres.2020.115623>
- [13] Hanvey, J. S., Lewis, P. J., Lavers, J. L., Crosbie, N. D., Pozo, K., & Clarke, B. O. (2017). A review of analytical techniques for quantifying microplastics in sediments. *Analytical Methods*, 9(9), 1369–1383. <https://doi.org/10.1039/C6AY02707E>
- [14] Lavoy, M., & Crossman, J. (2021). A novel method for organic matter removal from samples containing microplastics. *Environmental Pollution*, 286, 117357. <https://doi.org/10.1016/j.envpol.2021.117357>
- [15] Lusher, A., Hollman, P. C. H., & Mendoza-Hill, J. (2017). *Microplastics in fisheries and aquaculture: Status of knowledge on their occurrence and implications for aquatic organisms and food safety* (Publication No. 615). Food and Agriculture Organization of the United Nations. https://www.researchgate.net/publication/319644050_Microplastics_in_fisheries_and_aquaculture_Status_of_knowledge_on_their_occurrence_and_implications_for_aquatic_organisms_and_food_safety
- [16] Morra, J. (2021, August 25). *Characterizing microplastic pollution in aquatic sediments from southwestern British Columbia, Canada*. Simon Fraser University. <https://doi.org/10.1016/j.etd.21.1667.pdf>
- [17] Nayak, G. (2014). Estuary as a sedimentary depositional environment – A review. *Gondwana Geological Magazine, Special 15*, 121–132. https://www.researchgate.net/publication/268780696_Estuary_as_a_sedimentary_depositional_environment_-_A_review
- [18] Peng, G., Zhu, B., Yang, D., Su, L., Shi, H., & Li, D. (2017). Microplastics in sediments of the Changjiang Estuary, China. *Environmental Pollution*, 225, 283–290. <https://doi.org/10.1016/j.envpol.2016.12.064>
- [19] Perumal, K., & Muthuramalingam, S. (2022). Global sources, abundance, size, and distribution of microplastics in marine sediments—A critical review. *Estuarine, Coastal and Shelf Science*, 264, 107702. <https://doi.org/10.1016/j.ecss.2021.107702>
- [20] Phuong, N. N., Fauvelle, V., Grenz, C., Ourgaud, M., Schmidt, N., Strady, E., & Sempéré, R. (2021). Highlights from a review of microplastics in marine sediments. *Science of The Total Environment*, 777, 146225. <https://doi.org/10.1016/j.scitotenv.2021.146225>
- [21] Prata, J. C., da Costa, J. P., Fernandes, A. J. S., da Costa, F. M., Duarte, A. C., & Rocha-Santos, T. (2021). Selection of microplastics by Nile red staining increases environmental sample throughput by micro-

- Raman spectroscopy. *Science of The Total Environment*, 783, 146979. <https://doi.org/10.1016/j.scitotenv.2021.146979>
- [22] Shim, W. J., Song, Y. K., Hong, S. H., & Jang, M. (2016). Identification and quantification of microplastics using Nile red staining. *Marine Pollution Bulletin*, 113(1), 469–476. <https://doi.org/10.1016/j.marpolbul.2016.10.049>
- [23] Smith, M., Love, D. C., Rochman, C. M., & Neff, R. A. (2018). Microplastics in seafood and the implications for human health. *Current Environmental Health Reports*, 5(3), 375–386. <https://doi.org/10.1007/s40572-018-0206-z>
- [24] Stanton, T., Johnson, M., Nathanail, P., Gomes, R. L., Needham, T., & Burson, A. (2019). Exploring the efficacy of Nile red in microplastic quantification: A costaining approach. *Environmental Science & Technology Letters*, 6(10), 606–611. <https://doi.org/10.1021/acs.estlett.9b00499>
- [25] Sutherland, B. R., Dhaliwal, M. S., Thai, D., Li, Y., Gingras, M., & Konhauser, K. (2023). Suspended clay and surfactants enhance buoyant microplastic settling. *Communications Earth & Environment*, 4(1), Article 1. <https://doi.org/10.1038/s43247-023-01055-2>
- [26] Zhang, D., Liu, X., Huang, W., Li, J., Wang, C., Zhang, D., & Zhang, C. (2020). Microplastic pollution in deep-sea sediments and organisms of the Western Pacific Ocean. *Environmental Pollution*, 259, 113948. <https://doi.org/10.1016/j.envpol.2020.113948>

Painfully prejudiced? Racial stereotypicality and gender in pain perception, treatment, and empathy

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ABSTRACT Black and female individuals are systemically undertreated for pain. While studies on racial biases in pain care have predominantly focused on the effects of between-race differences, few have considered the potential role of racial stereotypicality (how closely an individual resembles “typical” features of their race). Past research demonstrates that Black individuals perceived to be higher in racial stereotypicality face significant disadvantages in various domains, such as criminal justice and education, due to stronger associations with negative racial stereotypes. Findings suggest that stereotypicality may also have implications for healthcare. Therefore, the present study used a 2 (Racial Stereotypicality: Less Stereotypically Black vs. More Stereotypically Black) × 2 (Gender: Male vs. Female) between-subjects design to investigate how targets’ racial stereotypicality and gender influence lay perceivers’ pain perception, empathy, and treatment decisions. Furthermore, this study examined the relationships between perceivers’ perceptions of targets’ trustworthiness and attractiveness and their empathy toward targets. In an online experiment on Qualtrics, participants (N = 233) were randomly assigned to view one of four medical vignettes, each containing a photo insurance card, medical chart, and pain rating. Participants then rated the target’s pain, indicated how likely they would be to recommend a series of treatments for the target, completed a measure of empathic concern toward the target, and rated the target’s trustworthiness and attractiveness. Racial stereotypicality and gender did not significantly affect perceived pain, empathy, and most treatment decisions. However, perceivers’ empathy was positively correlated with targets’ perceived trustworthiness and attractiveness. This study provides a valuable starting point for further investigation into the role of racial stereotypicality and gender in pain care. Future research with working clinicians and advanced analyses are essential to deepening our understanding of the complexities of pain care disparities, and ultimately, achieving equitable pain care.

INTRODUCTION

Significant race and gender disparities exist in pain care, with Black and female individuals often being undertreated compared to White and male individuals (Meghani et al., 2012; Thurston et al., 2022). Cisgender female (vs. male) patients in pain face undertreatment and increased stigmatization from healthcare professionals (Chen et al., 2008; Hayes et al., 2023; Hoffmann & Tarzian, 2001; Lloyd et al., 2020; Samulowitz et al., 2018; Wimbish et al., 2022). Similarly, Black (vs. White) patients are 29–34% less likely to receive pain relief treatment (Drwecki, 2018; Lee et al., 2019; Meghani et al., 2012; Morales & Yong, 2021; Trawalter & Hoffman, 2015). Such disparities span various types of pain, including acute (Lee et al., 2019), cancer (Anderson et al., 2009), labour (Mathur et al., 2020), postpartum (Johnson et al., 2019), and chronic pain (Morales & Yong, 2021). Furthermore, not only can undertreating pain cause serious harm, such as increased depression and anxiety, sleep problems, and lower quality of life (Herr & Garand, 2001; Sinatra, 2010), but Black people and females also exhibit lower pain tolerance and a greater prevalence of pain conditions (Drwecki, 2018; Fillingim, 2017; Kim et al., 2017). Chronic experiences of injustice and institutionalized social exclusion likely contribute to higher pain among Black people, while an interaction of biological and psychosocial factors may account for higher pain among females (Drwecki, 2018; Fillingim, 2017; Hoffmann et al., 2022). While most studies on race and gender disparities in pain care are based in the United States, evidence suggests that similar disparities may be found in Canada (Kaseweter et al., 2012; Mahabir et al., 2021; The Canadian Pain Task Force, 2020). Therefore, it is critical to study factors associated with racial and gender disparities in pain care in a Canadian context. Based on past research with US samples, two potential mechanisms that have been identified are healthcare providers’ perception of patients’ pain and their empathy toward patients.

Empathy has been theorized to partially mediate racial biases in pain care (Drwecki, 2018; Tait & Chibnall, 2014). In general, studies have demonstrated a robust racial ingroup bias in empathy (Han, 2015, 2018), wherein people empathize less with other-race targets’ pain compared to same-race targets. Furthermore, the underrepresentation of racial minorities in the Canadian medical field suggests that patients from minority backgrounds are more often treated by other-race providers (Khan et al., 2020). Preliminary support for the role of

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providers' empathy in racial disparities in pain care comes from both experimental studies (e.g., Kaseweter et al., 2012) and studies that have successfully used empathy interventions to reduce biased treatment in laboratory settings (Drwecki et al., 2011; Hirsh et al., 2019). For example, Kaseweter et al. (2012) found that racial biases in empathy correlated with pain treatment biases and also mediated the relationship between patient race and pain treatment. Notably, pro-White empathy biases were highly predictive of pro-White treatment biases. Collectively, these findings underscore the potential value of examining empathy in pain treatment disparities.

Additionally, perceptual mechanisms may play a role, in that medical providers may undertreat Black patients' pain partly because they misjudge its severity (Anderson et al., 2009; Tait & Chibnall, 2014). Studies show that White laypeople and medical professionals rapidly and automatically underestimate pain in Black targets (Hoffman et al., 2016; Mende-Siedlecki et al., 2019, 2022; Trawalter et al., 2012; Trawalter & Hoffman, 2015). Furthermore, these biased judgments may be rooted in stereotypes that Black people feel less pain, which have historically been used to justify the mistreatment of Black people (Drwecki, 2018; Hoffman et al., 2016; Morning, 2011; Trawalter & Hoffman, 2015; Waytz et al., 2015). For instance, Hoffman et al. (2016) found that endorsement of such stereotypes among White laypeople and medical residents and students positively correlated with racial bias in pain ratings and treatment. Thus, preliminary evidence suggests racial stereotypes may contribute to pain care disparities.

If stereotypes about racial differences in pain sensitivity affect pain perception and treatment, patients who look more (vs. less) stereotypically Black may be at higher risk for undertreatment. Perceived racial stereotypicality refers to how closely a person's physical features resemble those perceived as "typical" of their race or ethnicity. For example, more stereotypically Black (i.e., Afrocentric) features include full lips, dark skin tone, and a broad nose (Osborne et al., 2017). Although emerging research highlights the significance of stereotypicality in various domains (e.g., criminal justice, education; Maddox & Perry, 2018; Osborne et al., 2017; Williams et al., 2019), to our knowledge, few studies have directly investigated patients' perceived racial stereotypicality in pain treatment, whether from the perspective of the general public or healthcare providers. However, past findings suggest that Afrocentric features may have implications for healthcare in general, correlating with worse health outcomes, such as depression and hypertension (Hagiwara et al., 2013; Monk, 2015), and leading to judgments of lower sensitivity to social pain ("responses to aversive interpersonal experiences"; Deska et al., 2020, p. 1). Given past findings implicating racial stereotypes in pain care disparities, we aimed to examine how targets' Black phenotypic stereotypicality influences laypeople's pain perception, treatment, and empathy for targets. Additionally, limited research has examined the interaction between racial stereotypicality and gender in the context of health. However, given evidence to suggest that Black females are uniquely discriminated against in pain care (Mathur et al., 2020), we also sought to examine how racial stereotypicality and gender interact to impact pain perception, treatment, and empathy.

The present study used a 2 (Patient Racial Stereotypicality: More Stereotypically Black [MSB] vs. Less Stereotypically Black [LSB]) × 2 (Patient Gender: Male vs. Female) between-subjects factorial

design to examine the effects of patients' phenotypic racial stereotypicality and gender on perceived pain, treatment, and empathy in a convenience sample of undergraduate students at a Canadian university. After viewing one of four vignettes, which depicted an individual with lower back pain, participants estimated the patient's pain, indicated their likelihood of making a series of treatment recommendations, and self-reported state empathy. We hypothesized main effects for, and an interaction effect between, racial stereotypicality and gender, such that participants would favour male and LSB patients.

Additionally, past research suggests that lay perceivers' and healthcare professionals' evaluations of targets' trustworthiness and attractiveness may also influence how they perceive and empathize with targets' pain (Ashton-James & Nicholas, 2016; Jankowiak-Siuda et al., 2015; LaChapelle et al., 2014; Sessa & Meconi, 2015; Yang et al., 2022). In clinical contexts, judgments of trustworthiness carry significant implications for providers' empathy and treatment of patients' pain, given salient concerns over malingering, defined as the exaggeration or falsification of symptoms for external gains such as money or drugs (Ashton-James & Nicholas, 2016; Buchman et al., 2016). Similarly, judgments of targets' physical attractiveness may influence lay perceivers' empathy for targets' pain. Consistent with research on the "what is beautiful is good" stereotype, studies on pain empathy show that targets' physical attractiveness facilitates perceivers' empathy for pain (Balconi et al., 2022; Meng et al., 2020; Zhu et al., 2022). Therefore, a secondary aim was to examine the relationships between perceivers' empathy and targets' perceived trustworthiness and attractiveness to determine whether our findings would replicate past research. We hypothesized that targets' perceived trustworthiness and attractiveness would correlate positively with perceivers' empathy for targets' pain. Lastly, we explored the relationships between racial stereotypicality and trustworthiness, attractiveness, and empathy.

METHODS

Positionality Statement

The first author is a Hong Kong–Chinese immigrant whose lived experience as a visible minority informs their perspective on racial and gender biases. At the same time, they acknowledge that being Asian carries certain privileges that members of the Black community are not afforded, and that their experiences as a minority cannot be equated to those of the Black community. The second author, as a first-generation university student from rural regions of Canada, has encountered unique challenges such as limited access to healthcare and resources which have shaped their approach to psychological science, particularly in chronic pain and pain management. The third author is a researcher trained in Health Psychology with a focus on pain research in the remote northern region of British Columbia. Their dual roles as a patient and healthcare worker uniquely influence their perspective on pain management and healthcare access in remote areas. The last author is a social psychologist with over two decades of expertise in intergroup relations, stereotypes, prejudice, and discrimination.

The authors acknowledge that their diverse ethn racial, professional, academic, and personal backgrounds may influence their assumptions and understandings of minoritized experiences, chronic pain, patient experiences, access to care, and the generalizability of research findings across different contexts. To

challenge and mitigate potential bias from these varied standpoints, the authors collaborated with colleagues from diverse backgrounds throughout the research. During manuscript preparation, the authors were careful to be mindful of potential biases in how they interpreted the findings. Together, the authors share a firm commitment to transparency and hope that disclosing their positionality and engaging in continuous reflexivity makes their research more inclusive, scientifically rigorous, and credible.

Participants

Data were collected from October 2022 to December 2022. Participants ($N = 233$) were undergraduate psychology students aged 17 to 38 years ($M = 20.3$, $SD = 2.4$) who were enrolled at the University of British Columbia, Okanagan (UBCO). Participants were recruited through UBCO's online psychology participant pool, SONA, and recruitment took place throughout the data collection period. Based on the sample size guidelines outlined by Field (2017), it was decided a priori that a sample size of at least 200 would provide a high level of power (80%; Cohen, 1988) for detecting a moderate effect size.

We adopted a convenience sampling method and recruited undergraduate psychology students. We chose psychology students because past findings have demonstrated (a) racial and gender biases in pain perception and treatment among the general population (e.g., Hoffman et al., 2016; Kissi et al., 2022; Trawalter et al., 2012) and (b) race and gender stereotypes related to pain, such as the belief that women exaggerate their pain and that Black individuals are less sensitive to pain, among both laypeople and medical professionals (e.g., Drwecki et al., 2011; Hoffman et al., 2016; Hollingshead et al., 2016; Zhang et al., 2021). Most relevant to the current study, Deska et al. (2020) found a consistent effect of targets' racial stereotypicality in judgments of social pain among undergraduate samples. Furthermore, if we found evidence of racial and gender biases regarding pain perception, treatment, and empathy in undergraduate students, this could suggest that such biases extend beyond the medical field, thus carrying significant implications for our understanding of how everyday individuals respond to the pain of more stereotypically Black and female individuals. These biases in response to targets' pain are far from inconsequential in everyday life; laypeople regularly encounter individuals that are different to them in race and gender, and such biases may influence situations in which Black and female

individuals are in pain and in need of help from others. Thus, the possible implications of racial and gender biases in laypeople underlaid our rationale for utilizing a convenience sample.

Eligibility criteria included fluency in reading and writing in English and normal or corrected vision. Exclusion criteria included any history of a pain-related disorder (e.g., chronic pain), as past research has shown that patients with pain-related disorders perceive and empathize with others' pain differently (e.g., Borg et al., 2014; Sohn et al., 2016; Zhao et al., 2022). Participants participated in exchange for extra course credit toward an eligible psychology course of their choice. Ethical approval for this study was obtained from the Behavioural Research Ethics Board of The University of British Columbia Okanagan (H22-02673).

Materials

Each vignette contained a photo health insurance card, medical chart, self-reported pain level, and patient narrative. Vignettes across all four conditions were identical except for the patient's photo, reported sex, and gender identifiers. Patients' medical charts, pain reports, and narratives were adapted from a similar study that examined factors contributing to differential treatment among First Nations and White patients (Johnson-Jennings, 2010). To increase participants' understanding, we simplified the language and content of the vignettes. Patients' health insurance cards were created by Author KK.

Figure 1 displays the patient images that were used for each condition, Figure 2 shows an example of a patient health insurance card, and Figure 3 shows an example medical chart and pain rating. Patient photos for the vignettes were selected from the Chicago Face Database (Ma et al., 2015). The database contains standardized untouched photographs (i.e., all wearing the same clothing, against the same background, in the same lighting, with the same neutral facial expression) of individuals of various ethnicities, including Black individuals. Each model has an assortment of subjective norming data (e.g., ratings for age, attractiveness, dominance) provided by a sample of over 1,000 independent raters. Photos were selected in the following manner. First, models must have self-identified as Black. We then used normed ratings of prototypicality (i.e., stereotypicality) from the database to select MSB and LSB photos. Prototypicality ratings



Figure 1. Patient photos used in vignettes. Top left: Less stereotypically Black (LSB) male. Top right: More stereotypically Black (MSB) male. Bottom left: LSB female. Bottom right: MSB male.

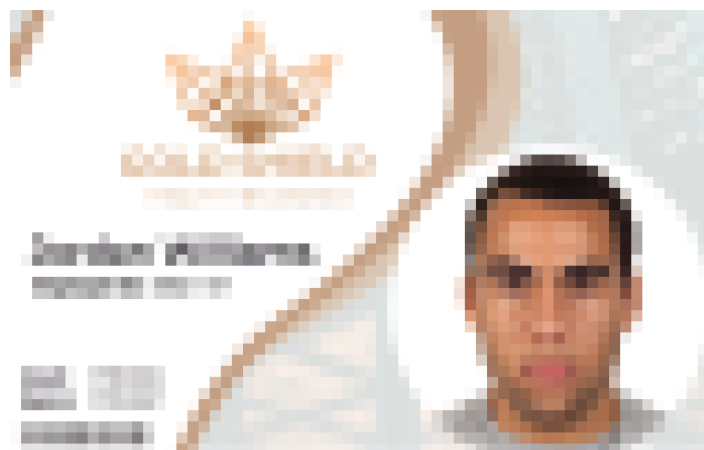


Figure 2. Example of a Patient Health Insurance card.

were on a 5-point scale. The rating cutoff was 4 or higher for MSB targets and 2 or lower for LSB targets. To strengthen the stereotypicality manipulation and ensure that it was not confounded with race, we chose models who also had a high probability (at least 60%; Kunst et al., 2022) of being categorized as Black by raters. Lastly, we chose models who were rated similarly on age, given previous findings suggesting that age influences pain perception and treatment (Ogasawara et al., 2010; Stutts et al., 2010; Wandner et al., 2014).

Measures

Pain perception

A visual analogue scale (VAS) was used to measure participants' perceptions of the patient's pain level. Participants were asked to answer the question, "How much pain do you believe this patient is currently experiencing?" (0 = No Pain; 100 = Worst Pain Possible). To increase clarity, the word "pain" was formatted in bold. Additionally, to ensure participants understood that the study was asking for their subjective estimates and not their ability to recall details from the medical chart, the words "do you believe" were italicized and underlined.

Treatment recommendations

Using a VAS ranging from 0% (Extremely Unlikely) to 100% (Extremely Likely), participants were asked to indicate how likely

they would be to diagnose the patient with chronic lower back pain and to recommend each of the following: (a) refer for medical imaging, (b) at-home self-management, (c) over-the-counter pain relievers, (d) opioid pain medication, (e) psychological treatment, (f) further assessment for malingering, and (g) no intervention. We selected the treatment options from a questionnaire previously used in a similar study of healthcare disparities between First Nations and White patients, which pilot tested the questionnaire with a panel of medical experts (Johnson-Jennings, 2010). As our participants were undergraduate psychology students, we sought to increase their understanding of the treatment recommendations by simplifying the language from the original questionnaire and providing examples of each recommendation. Past studies have successfully assessed pain treatment disparities among laypeople in a similar manner (i.e., using specific treatment options; Drwecki et al., 2011; Kaseweter et al., 2012). While our undergraduate participants may have lacked knowledge regarding pain diagnostic procedures, the inclusion of this item aimed to measure participants' willingness to help targets, rather than their expertise in formal pain assessment.

Empathy

Participants' empathic reactions toward the patient were measured using the Empathic Concern Scale (ECS; Batson et al., 1997; Drwecki et al., 2011). As opposed to commonly used measures of dispositional empathy, the ECS is a measure of state empathy and was therefore more suited to measuring participants' empathic reactions to the patients. After viewing the vignette, participants indicated the extent to which they felt "tender," "softhearted," "warm," "compassionate," "moved," "concerned," and "sympathetic" for the patient, using Likert-type scales ranging from 1 (Not at All) to 7 (Extremely). Each participant received a composite empathy score, which was calculated by averaging across responses to the seven items. The ECS has previously been used in Canadian undergraduate samples and studies of bias in pain care (Drwecki et al., 2011; Kaseweter et al., 2012). In the present study, the ECS demonstrated high internal reliability ($\alpha = .89$).

Perceptions of trustworthiness and attractiveness

Participants indicated their perceptions of the patient's trustworthiness and attractiveness using two VASs ranging from 0% to 100%. Specifically, participants were asked to answer the questions, "How trustworthy do you find this patient?" (0% = Extremely Untrustworthy; 100% = Extremely Trustworthy) and "How physically attractive do you find this patient?" (0% = Extremely Unattractive; 100% = Extremely Attractive). To make the questions clearer, the words "trustworthy" and "physically attractive" were formatted in bold, and the words "do you find" were italicized.

Attention checks

Attention checks were used to confirm whether participants thoroughly attended to the patient's reported pain in the vignette. Using separate open-ended responses, participants were asked to provide a numerical answer to each of the two questions: "How much pain did the patient report currently experiencing in the medical chart?" and "How much pain did the patient report experiencing on average in the medical chart?". The words "currently experiencing" and "on average" were formatted in bold, italicized, and coloured red to



Figure 3. Example medical chart and pain rating.

distinguish the two questions from each other. To pass the attention checks, participants must have answered “9” and “5” to the first and second questions, respectively. Data from participants who did not answer these questions with the exact numbers were removed from the final analyses.

Demographics

The demographics questionnaire asked participants about their gender, age, cultural background (e.g., European, South Asian, African), racial identity, and education. Participants' demographics are shown in Table 1.

Procedure

Participants self-selected into the study through the UBCO psychology SONA system after reading the title and a brief description of the study. Participants completed the study online using the survey platform Qualtrics (<https://www.qualtrics.com/>) from a location and device of their choice. From SONA, participants were provided with a hyperlink to access the study. Upon opening the hyperlink, participants were presented with an informed consent form, which provided a description of the study, including the purpose, risks, and benefits of their participation, and the confidential collection and storage of data. To minimize socially desirable responding and increase the validity of the findings, the hypotheses and specific research questions of the study (i.e., the focus on racial stereotypicality and gender biases) were masked, and participants were informed that their data would be anonymized. In compliance with ethics approval, participants were instead informed that the study aimed to explore medical assessment and decision-making in response to patients' medical information. Additionally, by using scales that have been validated in similar samples, we hoped to have minimized any effect of social desirability in responses. Participants were also informed that their involvement was voluntary, and that they were free to withdraw from the study at any time without penalty.

After providing informed consent, participants were presented with the instructions for the study, which informed them that they will be asked to review a patient's chart and symptoms, and then use this information to assess and provide treatment recommendations for the patient. Participants were asked to imagine themselves as a doctor at a walk-in clinic and to treat the target as their patient. Additionally, to increase participants' attentiveness to the study, participants were informed that they would be asked about the contents of the chart and would need to read it carefully as they would not be able to return to the previous page. Participants were given as much time as they would like to read the instructions. However, to ensure that participants read the instructions carefully, they were restricted from proceeding to the next page until after 30 seconds had passed. Participants were not restricted from taking notes or photos to aid in recall if they chose to. After reading the instructions, the Qualtrics platform randomly assigned participants evenly to one of the four vignette conditions (i.e., More Stereotypically Black Male; Less Stereotypically Black Male; More Stereotypically Black Female; Less Stereotypically Black Female). The patient's health insurance card, medical chart, and pain rating and description were presented on separate pages. While participants were permitted to view each page for as long as they liked, a minimum viewing time was set to ensure that participants viewed the vignette thoroughly. Participants were only permitted to navigate to the next page after

the minimum viewing time had passed. We first presented the patient's health insurance card, followed by a medical chart, and finally the patient's rating and description of their pain. The minimum viewing times were 15, 30, and 20 seconds, respectively. Throughout the entire study, participants were not permitted to return to previous pages.

After reading the vignette, participants provided their pain rating and treatment recommendations. They then completed the measures of empathy, perceived trustworthiness and attractiveness, and the attention checks. Finally, participants completed the demographics questionnaire. After completing the demographics questionnaire, participants were directed to a debriefing form which revealed to participants our interest in the effects of racial stereotypicality and gender, explained the use of deception and experimental manipulations in the study, and reminded participants of how they could withdraw their data if they no longer consented. The study took approximately 20 minutes to complete. Upon completion of the study, participants were awarded a 0.5 class credit.

Data Analysis

Data analyses were performed using IBM SPSS Statistics (Version 29). To examine the effects of racial stereotypicality and gender on pain perception and empathy, we performed two separate 2 (Patient Racial Stereotypicality) \times 2 (Patient Gender) between-subject factorial analyses of variance (ANOVAs). To examine the effects of racial stereotypicality and gender on treatment decisions, we performed a series of 2 (Patient Racial Stereotypicality) \times 2 (Patient Gender) between-subjects factorial ANOVAs with each treatment recommendation as an outcome variable. Due to implications associated with specific treatment recommendations, which may have been masked by analyzing treatment recommendations as an aggregate variable, each recommendation was analyzed as a separate outcome variable. For example, racial stereotypes may be more strongly associated with opioid treatments compared to psychological treatments (Burgess et al., 2014; Hirsh et al., 2020). To test our hypotheses regarding empathy and perceptions of trustworthiness and attractiveness, we conducted two one-tailed null hypothesis significance tests of the Pearson correlation between (a) perceived trustworthiness and empathy and (b) perceived attractiveness and empathy. Finally, to explore the relationships between racial stereotypicality, empathy, and perceived trustworthiness and attractiveness, we compared the bivariate correlations between (a) empathy and perceived trustworthiness and (b) empathy and perceived attractiveness in the LSB and MSB conditions.

RESULTS

Participant flow

Figure 4 illustrates the study's participant flow. A total of 300 participants enrolled in the study through the SONA system. After data exclusions due to incomplete responses or failed attention checks, the final sample was 233 participants. Most participants identified as female and European/White. Table 1 shows the detailed demographics of the final sample.

Descriptive statistics

Table 2 shows the descriptive statistics for the full sample and by experimental condition.



Figure 4. Flowchart of study participants.

Pain perception

A 2 (Racial Stereotypicality) \times 2 (Gender) factorial ANOVA found no significant main effect of racial stereotypicality ($F[3, 229] = 0.02$, $p = .89$, $\eta^2 < .001$) or gender ($F[3, 229] = 0.00$, $p = .97$, $\eta^2 < .001$) on pain ratings. Participants rated pain similarly for the LSB ($M = 78.63$, $SD = 1.17$) and MSB patients ($M = 78.86$, $SD = 1.15$) as well as the male ($M = 78.72$, $SD = 1.15$) and female patients ($M = 78.78$, $SD = 1.17$). There was no statistically significant interaction between racial stereotypicality and gender on ratings of pain, $F(3, 229) = 1.14$, $p = .29$, $\eta^2 = .005$. Figure 5 illustrates mean pain ratings in each condition.

Empathy

A 2 (Racial Stereotypicality) \times 2 (Gender) factorial ANOVA found no significant main effects of racial stereotypicality ($F[3, 229] = 0.75$, $p = .39$, $\eta^2 = .003$) or gender ($F[3, 229] = 0.02$, $p = .90$, $\eta^2 < .001$) on participants' empathy. Participants reported similar levels of empathy for the LSB ($M = 4.4$, $SD = 0.1$) and MSB patients ($M = 4.6$, $SD = 0.1$) as well as the male ($M = 4.5$, $SD = 0.1$) and female patients ($M = 4.5$, $SD = 0.1$). There was no statistically significant interaction between racial stereotypicality and gender on empathy, $F(3, 229) = 0.29$, $p = .59$, $\eta^2 = .001$. Figure 6 illustrates mean empathy scores in each condition.

Treatment recommendations

There were no statistically significant main effects of racial stereotypicality on all treatments (Table 3). For most treatment decisions, there were no statistically significant main effects of gender. There was a statistically significant small main effect of gender on the likelihood of making medical imaging referrals, $F(3, 229) = 4.83$, $p = .03$, $\eta^2 = .02$. Participants were significantly more likely to refer female ($M = 85.45$, $SD = 2.24$) over male patients ($M = 78.56$, $SD = 2.19$) for medical imaging. For most treatment decisions, there were no statistically significant interaction effects between racial stereotypicality and gender. There was a statistically significant small interaction effect between racial stereotypicality and gender on decisions to assess malingering, $F(3, 229) = 9.43$, $p = .002$, $\eta^2 = .04$. Figure 7 illustrates this interaction effect. Among LSB patients, participants were

Table 1. Participant Demographics. $N = 233$. Participants were on average 20.3 years old ($SD = 2.4$). Percentages total to more than 100% as participants were able to select multiple options.

| Characteristic | n (%) |
|----------------------------|------------|
| Gender | |
| Female | 175 (75.1) |
| Male | 55 (23.6) |
| Non-binary | 2 (0.9) |
| Cultural Background | |
| European | 145 (62.2) |
| South Asian | 38 (16.3) |
| East Asian | 25 (10.7) |
| South East Asian | 16 (6.9) |
| Indigenous | 12 (5.2) |
| Middle Eastern | 7 (3.0) |
| Hispanic | 4 (1.7) |
| African | 2 (0.9) |
| Race | |
| European/White | 151 (64.8) |
| Asian | 79 (33.9) |
| Indigenous | 10 (4.3) |
| Black | 5 (2.1) |
| Hispanic | 4 (1.7) |

significantly more likely to assess malingering for male (vs. female) patients, while this was reversed among MSB patients.

Trustworthiness, attractiveness, and empathy

There were statistically significant associations between empathy and perceived attractiveness and trustworthiness in both racial stereotypicality conditions (Table 4). For LSB patients, empathy was significantly and positively correlated with perceived trustworthiness ($r[112] = .31$, $p < .001$, 95% CI [.16, 1.00]) and attractiveness ($r[112] = .25$, $p = .003$, CI [.10, 1.00]). Similarly, for MSB patients, empathy was significantly and positively correlated with perceived trustworthiness ($r[117] = .35$, $p < .001$, CI [.21, 1.00]) and attractiveness ($r[117] = .19$, $p = 0.02$, CI [.04, 1.00]). Empathy correlated more strongly with perceived trustworthiness for MSB (vs. LSB) patients, whereas the correlation between empathy and perceived attractiveness was stronger for LSB (vs. MSB) patients. This suggests that perceived trustworthiness may be more predictive of empathy for MSB patients, whereas perceived attractiveness may be more predictive for LSB patients. However, this was not formally tested using inferential tests as it was outside the scope of the present study.

DISCUSSION

This study's primary aim was to examine how patients' racial stereotypicality and gender impact lay perceivers' perception of

Table 2. Descriptive statistics for full sample and by experimental condition. *N* = 233. LSB = Less Stereotypically Black; MSB = More Stereotypically Black.
^a Empathy scores were calculated by averaging across responses to each scale item, with possible scores ranging from 1 to 7.

| Variable | Full sample | | LSB Male | | MSB Male | | LSB Female | | MSB Female | |
|--|-------------|-------|----------|-------|----------|-------|------------|-------|------------|-------|
| | M | SD | M | SD | M | SD | M | SD | M | SD |
| Pain perception | 78.75 | 12.46 | 77.72 | 13.36 | 79.7 | 13.84 | 79.54 | 11.86 | 78.02 | 10.61 |
| Empathy a | 4.5 | 1.2 | 4.4 | 1.2 | 4.6 | 1.1 | 4.5 | 1.2 | 4.5 | 1.1 |
| Perceived trustworthiness | 79.97 | 17.04 | 80.84 | 16.6 | 83.57 | 15.9 | 79.39 | 18.61 | 75.88 | 16.56 |
| Perceived attractiveness | 38.67 | 25.71 | 39.17 | 27.73 | 35.88 | 21.58 | 47.14 | 27.48 | 32.91 | 24.3 |
| Treatment recommendations | | | | | | | | | | |
| Diagnose with chronic, lower back pain | 71.66 | 25.51 | 65.1 | 28.61 | 72.06 | 23.18 | 76.04 | 22.38 | 73.57 | 26.72 |
| Refer for medical imaging | 81.9 | 24.09 | 78.74 | 25.86 | 78.49 | 27.21 | 88.68 | 19.27 | 82.22 | 22.08 |
| At-home self-management | 72.7 | 30.28 | 72.41 | 31.35 | 73.54 | 30.6 | 72.89 | 28.05 | 71.9 | 31.65 |
| Over the counter pain relievers | 63.77 | 29.48 | 69.84 | 26.65 | 59.21 | 31.13 | 61.3 | 30.99 | 64.88 | 28.51 |
| Opioid pain medication | 33.88 | 29.09 | 33.96 | 28.72 | 34.38 | 31.62 | 29.55 | 25.31 | 37.46 | 30.26 |
| Psychological treatment | 22.01 | 25.8 | 18.26 | 23.79 | 19.46 | 24.77 | 20.88 | 26.55 | 29.55 | 27.14 |
| Further assessments for malingering | 26.63 | 30.34 | 32.71 | 34.75 | 22.97 | 26.69 | 18.21 | 23.71 | 32.53 | 32.99 |
| No intervention and advise to wait | 5.15 | 10.67 | 3.9 | 9.71 | 5.43 | 11.15 | 4.98 | 9.72 | 6.28 | 11.99 |

patients' pain, treatment recommendations for the patient, and empathy toward the patient. Results did not fully support our hypotheses; there were no main nor interaction effects of racial stereotypicality and gender on pain ratings, empathy, and most treatment decisions. However, participants were more likely to refer female (vs. male) patients for medical imaging. Furthermore, participants were also more likely to assess malingering for male (vs. female) patients when they were LSB but less likely to do so for male (vs. female) MSB patients. Our secondary aim was to examine empathy in relation to perceived trustworthiness and attractiveness. Results supported our final hypothesis, as greater empathy was associated with higher attractiveness and trustworthiness. Furthermore, this association held for both LSB and MSB patients.

Pain perception and treatment

Considerable evidence indicates pro-White and pro-male biases in pain perception and treatment (Drwecki, 2018; Hoffmann & Tarzian, 2001; Lee et al., 2019; Morales & Yong, 2021; Zhang et al., 2021), yet neither racial stereotypicality nor gender affected these outcomes in our study. Several factors may explain these discrepancies. First, participants were currently enrolled in a psychology course. Thus, despite efforts to conceal our hypotheses, participants may have been more skeptical of experimental manipulations and/or aware of social issues, possibly leading to socially desirable responses. Notably, a post-hoc analysis found that many participants believed our study was about race and bias. Relatedly, participants' limited exposure to

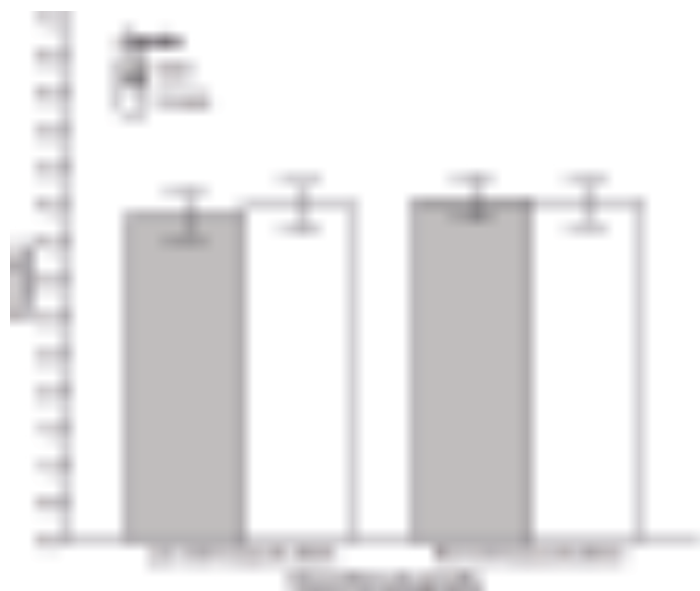
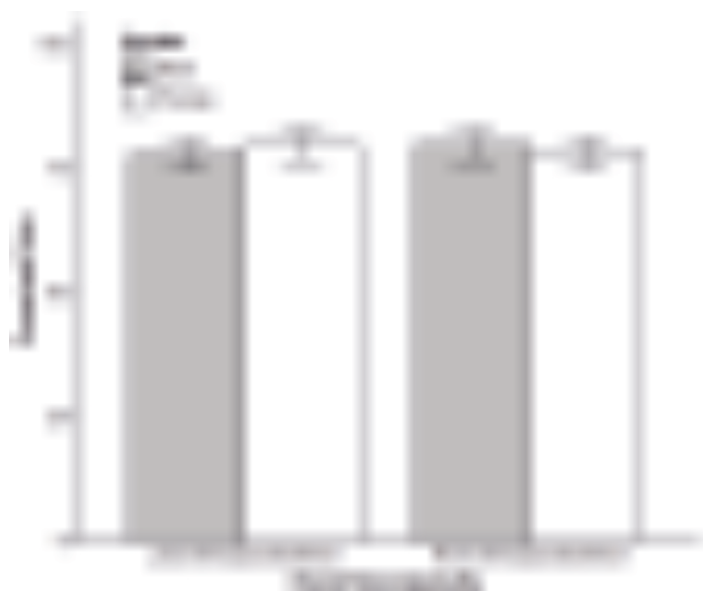


Figure 5. Mean pain ratings by racial stereotypicality and gender. Error bars represent 95% confidence intervals.

Figure 6. Mean empathy scores by racial stereotypicality and gender. Scores were out of 7. Error bars represent 95% confidence intervals.

Table 3. Two-way ANOVA statistics for treatment recommendations. *df* = 3299 for all tests.

| Treatment Recommendation | Racial Stereotypicality | | | Gender | | | Racial Stereotypicality x Gender | | |
|--|-------------------------|------|----------|--------|------|----------|----------------------------------|-------|----------|
| | F | p | η^2 | F | p | η^2 | F | p | η^2 |
| Diagnose with chronic, lower back pain | 0.46 | 0.5 | 0.002 | 3.5 | 0.06 | 0.02 | 2.01 | 0.16 | 0.009 |
| Refer for medical imaging | 1.11 | 0.29 | 0.005 | 4.83 | 0.03 | 0.02 | 1.01 | 0.32 | 0.004 |
| At-home self-management | 0 | 0.99 | <.001 | 0.02 | 0.88 | <.001 | 0.07 | 0.79 | <.001 |
| Over the counter pain relievers | 0.84 | 0.36 | 0.004 | 0.14 | 0.71 | 0.001 | 3.4 | 0.07 | 0.02 |
| Opioid pain medication | 1.19 | 0.28 | 0.005 | 0.03 | 0.86 | <.001 | 0.96 | 0.33 | 0.004 |
| Psychological treatment | 2.17 | 0.14 | 0.009 | 3.59 | 0.06 | 0.02 | 1.24 | 0.27 | 0.005 |
| Further assessments for malingering | 0.34 | 0.56 | 0.001 | 0.4 | 0.53 | 0.002 | 9.43 | 0.002 | 0.04 |
| No intervention and advise to wait | 1.01 | 0.32 | 0.004 | 0.48 | 0.49 | 0.002 | 0.01 | 0.93 | <.001 |

medical racism may have also influenced responses. Second, the lack of stereotypicality effects on pain perception may stem from using explicit over implicit priming, as past research suggests that racial bias may be more unconscious (Mathur et al., 2014). The present study used explicit priming by allowing participants an unlimited amount of time to examine targets' faces. However, in an experimental study, Mathur et al. (2014) found that participants who were shown static images of targets for seven seconds (explicit prime) displayed pro-Black biases in pain ratings, whereas participants who were rapidly shown targets for 30 ms (implicit prime) displayed pro-White biases. To explore this possibility, future studies on racial stereotypicality biases could examine how the method of stimuli presentation (explicit/static vs. implicit/rapid) moderates the relationship between racial stereotypicality and pain perception. Third, using neutral expressions in our stimuli may have reduced the perceived magnitude of the patient's reported pain, leading to lower pain ratings overall. Future studies could compare pain ratings evoked by neutral versus painful facial expressions.

Racial stereotypicality and gender did not affect most treatment decisions. However, participants were more likely to refer female

patients for medical imaging, which aligns with a retrospective study in which female (vs. male) patients in pain were more likely to have imaging tests ordered but less likely to be treated (Taylor et al., 2005). This finding could reflect a gender bias in the perceived trustworthiness of female versus male patients, as physicians may order more tests to prove the legitimacy of female patients' physical pain. Supporting this possibility, a review of gendered norms in healthcare found that providers often diminish and psychologize women's pain (Samulowitz et al., 2018). However, this is merely speculative and future studies are required to substantiate this claim about providers' intentions. In the current study, participants were more likely to prescribe psychological treatment to female patients, although this was marginally significant. Nevertheless, given existing evidence for gender disparities and stereotypes in pain care (e.g., Clar us & Renstr m, 2019; Guzikovits et al., 2024; Lloyd et al., 2020; Samulowitz et al., 2018), future studies could examine how gender and trustworthiness impact pain treatment.

Interestingly, racial stereotypicality and gender interactively affected malingering assessments. Participants were more likely to assess malingering for the MSB female patient compared to the LSB female patient. This aligns with much evidence for how racism and sexism doubly impact the medical treatment of Black (vs. White) women, partly due to the compounding effects of racial and gender stereotypes (Mathur et al., 2020, p. 202; Okoro et al., 2022; Wang et al., 2021; Weber & Parra-Medina, 2003). However, the finding that LSB males were more likely to be assessed for malingering compared to LSB females and MSB males was unexpected, as prior research shows that pain care favours White males. It is possible that unique characteristics of the LSB male contributed to this finding, which we discuss further in Limitations and future directions.

Table 4. Intercorrelations for trustworthiness, attractiveness, and empathy disaggregated by racial stereotypicality. Results for the More Stereotypically Black condition (*n* = 119) are shown above the diagonal. Results for the Less Stereotypically Black condition (*n* = 114) are shown below the diagonal.

| Variable | 1 | 2 | 3 |
|------------------------------|--------|--------|------|
| 1. Empathy | - | .35*** | .19* |
| 2. Perceived trustworthiness | .31*** | - | .17* |
| 3. Perceived attractiveness | .25** | .18* | - |

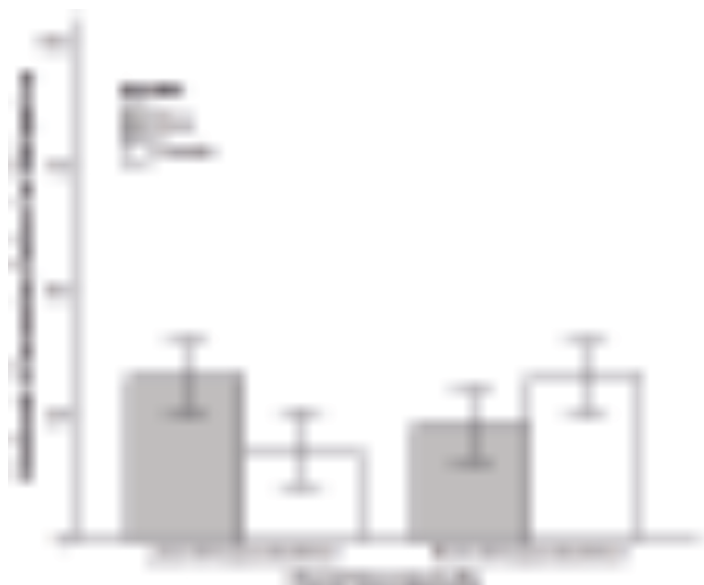


Figure 7. Mean likelihood of conducting further assessments for malingering by racial stereotypicality and gender. Error bars represent 95% confidence intervals.

Empathy, trustworthiness, and attractiveness

Our findings on racial stereotypicality and empathy diverge from past research demonstrating racial biases in empathy, as targets' racial stereotypicality did not affect perceivers' empathy in our study. Like pain perception, racial bias in empathy may be more implicit, suggesting our use of self-report may not have been a valid measure of empathy. Despite masking the hypotheses of the study and anonymizing the data, social desirability may have led participants to report higher empathy. For example, research shows that explicit empathy measures are more prone to mixed findings, while neuroimaging techniques have consistently found racial biases in neural empathic responses (Han, 2018). As such, future research could use both implicit and explicit measures to disentangle racial stereotypicality's role in empathy.

The finding that empathy was significantly associated with perceived attractiveness and trustworthiness bolsters past research implicating such perceptions in pain empathy. Additionally, the relations between these factors varied between LSB and MSB patients. Specifically, the correlation between empathy and perceived trustworthiness was stronger for MSB than LSB patients, whereas the correlation between empathy and perceived attractiveness was stronger for LSB than MSB patients. This suggests differential pathways to pain empathy depending on stereotypicality. Supporting the possibility that racial stereotypicality influences both empathy and perceptions of attractiveness, Yang et al. (2022) found that dark-skinned targets who were judged to be more attractive were also judged to be in less pain and received less empathy. However, this pattern contradicts our finding that attractiveness and empathy were more strongly correlated for less stereotypically Black targets. As well, Yang et al. only examined attractiveness judgments, while our study measured judgments of attractiveness and trustworthiness. Thus, exactly how racial stereotypicality affects the relations between trustworthiness, attractiveness, and pain empathy remains an open question for future research.

Limitations and future directions

We note that the effect sizes and correlations we found were small to modest in magnitude. While some of the effects—namely, the effect of gender on medical imaging decisions, the interaction effect of racial stereotypicality and gender on malingering assessments, and the correlations between perceived trustworthiness and attractiveness—were statistically significant, these small effect sizes may suggest that the strength of these relationships is limited. Nevertheless, given that the role of racial stereotypicality and gender in responses to pain have received less attention in past research, it would be valuable for future research to consider larger sample sizes to detect more robust effects and more meaningful relationships.

Additionally, this study was limited by the lack of a manipulation check to confirm whether the racial stereotypicality and gender manipulations were successful. Though we strived to maximize differences in perceived stereotypicality using the Chicago Face Database's ratings, a manipulation check could have improved internal validity by revealing any failed manipulations and allowing us to adjust the data analyses accordingly. Another limitation was using single targets per condition, making it possible that idiosyncrasies in patients' appearance, rather than racial stereotypicality and/or gender, influenced outcomes. As discussed earlier, for example, specific features of the LSB male

patient may have affected malingering assessments. Past research has indicated the importance of using multiple targets to represent a category in social psychological research (Wells & Windschitl, 1999). Therefore, to reduce idiosyncratic influences, future studies could use multiple targets per condition or employ graphics software to manipulate specific physical features, thereby enhancing experimental control. The latter method is often used in studies of racial stereotypicality in other contexts, such as organizational behaviour (Kahn et al., 2015) and eyewitness identification (Kahn & Davies, 2011).

Our use of a student sample limits the generalizability of our findings to medical professionals. However, empathy and pain perception are also fundamental in shaping everyday social interactions between individuals of different backgrounds. Thus, the implications of examining perceived racial stereotypicality and gender among laypeople extend beyond the medical domain. Furthermore, in light of limited research on how racial stereotypicality and gender impact pain perception, treatment, and empathy, this study provides a valuable starting point for further inquiry in this area. As discussed earlier, racial stereotypicality and gender biases were largely absent in our findings, contradicting past studies which have found racial and gender biases in healthcare professionals. This raises interesting questions regarding the causes of such biases in healthcare, especially when considering the deep-rooted nature of medical racism (Ortega & Achu, 2021). Therefore, future research could compare the effects of racial stereotypicality on pain perception, treatment, and empathy in medical professionals and laypeople.

CONCLUSION

This study is one of the first to examine the roles of patient racial stereotypicality and gender in pain perception, treatment, and empathy. While we did not find evidence that racial stereotypicality and gender significantly biased perceived pain, empathy, and most treatment decisions, this study's limitations offer important insights for future research in this area. Given limited research on stereotypicality biases in healthcare, alongside vast disparities in pain care, further research is needed to shed light on the roles of racial stereotypicality and gender in responses to pain. Deepening our understanding of the nuanced effects of race and gender would contribute to developing interventions and, ultimately, the goal of equitable pain care.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- [1] Anderson, K. O., Green, C. R., & Payne, R. (2009). Racial and ethnic disparities in pain: Causes and consequences of unequal care. *The Journal of Pain*, 10(12), 1187–1204. <https://doi.org/10.1016/j.jpain.2009.10.002>
- [2] Ashton-James, C. E., & Nicholas, M. K. (2016). Appearance of trustworthiness: An implicit source of bias in judgments of patients' pain. *Pain*, 157(8), 1583–1585. <https://doi.org/10.1097/j.pain.0000000000000595>
- [3] Balconi, M., Kapiś-Posiej, N., Venturella, I., Zabielska-Mendyk, E., Augustynowicz, P., & Angioletti, L. (2022). The effect of cognitive strategies and facial attractiveness on empathic neural responses. *International Journal of Environmental Research and Public Health*, 19(21), Article 21. <https://doi.org/10.3390/ijerph192114617>
- [4] Batson, C. D., Early, S., & Salvarani, G. (1997). Perspective taking: Imagining how another feels versus imagining how you would feel. *Personality and Social Psychology Bulletin*, 23(7), 751–758. <https://doi.org/10.1177/0146167297237008>
- [5] Borg, C., Padovan, C., Thomas-Antérion, C., Chaniel, C., Sanchez, A., Godot, M., Peyron, Laurent, B., & de Parisot, O. (2014). Pain-related mood influences pain perception differently in fibromyalgia and multiple sclerosis. *Journal of Pain Research*, 7, 81–87. <https://doi.org/10.2147/JPR.S49236>
- [6] Buchman, D. Z., Ho, A., & Illes, J. (2016). You present like a drug addict: Patient and clinician perspectives on trust and trustworthiness in chronic pain management. *Pain Medicine*, 17(8), 1394–1406. <https://doi.org/10.1093/pm/pnv083>
- [7] Burgess, D. J., Phelan, S., Workman, M., Hagel, E., Nelson, D. B., Fu, S. S., Widome, R., & van Ryn, M. (2014). The effect of cognitive load and patient race on physicians' decisions to prescribe opioids for chronic low back pain: A randomized trial. *Pain Medicine*, 15(6), 965–974. <https://doi.org/10.1111/pme.12378>
- [8] Chen, E. H., Shofer, F. S., Dean, A. J., Hollander, J. E., Baxt, W. G., Robey, J. L., Sease, K. L., & Mills, A. M. (2008). Gender disparity in analgesic treatment of emergency department patients with acute abdominal pain. *Academic Emergency Medicine*, 15(5), 414–418. <https://doi.org/10.1111/j.1553-2712.2008.00100.x>
- [9] Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge. <https://doi.org/10.4324/9780203771587>
- [10] Deska, J. C., Kunstman, J. W., Bernstein, M. J., Ogungbadero, T., & Hugenberg, K. (2020). Black racial phenotypicality shapes social pain and support judgments. *Journal of Experimental Social Psychology*, 90, 103998. <https://doi.org/10.1016/j.jesp.2020.103998>
- [11] Drwecki, B. B. (2018). Race and pain: A dual injustice. In T. Vervoort, K. Karos, Z. Trost, & K. M. Prkachin (Eds.), *Social and interpersonal dynamics in pain: We don't suffer alone* (pp. 455–480). Springer International Publishing. https://doi.org/10.1007/978-3-319-78340-6_21
- [12] Drwecki, B. B., Moore, C. F., Ward, S. E., & Prkachin, K. M. (2011). Reducing racial disparities in pain treatment: The role of empathy and perspective-taking. *Pain*, 152(5), 1001–1006. <https://doi.org/10.1016/j.pain.2010.12.005>
- [13] Field, A. (2017). *Discovering statistics using IBM SPSS statistics* (5th edition). SAGE Publications.
- [14] Fillingim, R. B. (2017). Sex, gender, and pain. In *Principles of Gender-Specific Medicine* (pp. 481–496). Elsevier. <https://doi.org/10.1016/B978-0-12-803506-1.00038-3>
- [15] Hagiwara, N., Penner, L. A., Gonzalez, R., & Albrecht, T. L. (2013). Within-group health disparities among Blacks: The effects of Afrocentric features and unfair treatment. *Cultural Diversity and Ethnic Minority Psychology*, 19(4), 477–480. <https://doi.org/10.1037/a0032566>
- [16] Han, S. (2015). Intergroup relationship and empathy for others' pain: A social neuroscience approach. In J. E. Warnick & D. Landis (Eds.), *Neuroscience in Intercultural Contexts* (pp. 31–47). Springer New York. https://doi.org/10.1007/978-1-4939-2260-4_2
- [17] Han, S. (2018). Neurocognitive basis of racial ingroup bias in empathy. *Trends in Cognitive Sciences*, 22(5), 400–421. <https://doi.org/10.1016/j.tics.2018.02.013>
- [18] Hayes, M., Hutchinson, A., & Kerr, D. (2023). Gender-based differences in assessment and management of acute abdominal pain in the emergency department: A retrospective audit. *Australasian Emergency Care*, 26(4), 290–295. <https://doi.org/10.1016/j.auec.2023.03.001>
- [19] Herr, K. A., & Garand, L. (2001). Assessment and measurement of pain in older adults. *Clinics in Geriatric Medicine*, 17(3), 457–478. [https://doi.org/10.1016/S0749-0690\(05\)70080-X](https://doi.org/10.1016/S0749-0690(05)70080-X)
- [20] Hirsh, A. T., Anastas, T. M., Miller, M. M., Quinn, P. D., & Kroenke, K. (2020). Patient race and opioid misuse history influence provider risk perceptions for future opioid-related problems. *American Psychologist*, 75(6), 784–795. <https://doi.org/10.1037/amp0000636>
- [21] Hirsh, A. T., Miller, M. M., Hollingshead, N. A., Anastas, T., Carnell, S. T., Lok, B. C., Chu, C., Zhang, Y., Robinson, M. E., Kroenke, K., & Ashburn-Nardo, L. (2019). A randomized controlled trial testing a virtual perspective-taking intervention to reduce race and socioeconomic status disparities in pain care. *Pain*, 160(10), 2229–2240. <https://doi.org/10.1097/j.pain.0000000000001634>
- [22] Hoffman, K. M., Trawalter, S., Axt, J. R., & Oliver, M. N. (2016). Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between Blacks and Whites. *Proceedings of the National Academy of Sciences of the United States of America*, 113(16), 4296–4301. <https://doi.org/10.1073/pnas.1516047113>
- [23] Hoffmann, D. E., Fillingim, R. B., & Veasley, C. (2022). The woman who cried pain: Do sex-based disparities still exist in the experience and treatment of pain? *Journal of Law, Medicine & Ethics*, 50(3), 519–541. <https://doi.org/10.1017/jme.2022.91>
- [24] Hoffmann, D. E., & Tarzian, A. J. (2001). The girl who cried pain: A bias against women in the treatment of pain. *Journal of Law, Medicine & Ethics*, 29(1), 13–27. <https://doi.org/10.1111/j.1748-720X.2001.tb00037.x>
- [25] Hollingshead, N. A., Meints, S. M., Miller, M. M., Robinson, M. E., & Hirsh, A. T. (2016). A comparison of race-related pain stereotypes held by White and Black individuals. *Journal of Applied Social Psychology*, 46(12), 718–723. <https://doi.org/10.1111/jasp.12415>
- [26] Jankowiak-Siuda, K., Rymarczyk, K., Żurawski, Ł., Jednoróg, K., & Marchewka, A. (2015). Physical attractiveness and sex as modulatory factors of empathic brain responses to pain. *Frontiers in Behavioral Neuroscience*, 9, 236. <https://doi.org/10.3389/fnbeh.2015.00236>
- [27] Johnson, J. D., Asiodu, I. V., McKenzie, C. P., Tucker, C., Tully, K. P., Bryant, K., Verbiest, S., & Stuebe, A. M. (2019). Racial and ethnic inequities in postpartum pain evaluation and management. *Obstetrics & Gynecology*, 134(6), 1155–1162. <https://doi.org/10.1097/AOG.0000000000003505>
- [28] Johnson-Jennings, M. (2010). *Factors influencing healthcare providers' chronic pain assessment and treatment decision-making among American Indian populations: Does racial concordance or ethnic salience matter?* [Unpublished doctoral dissertation]. The University of Wisconsin-Madison.
- [29] Kahn, K. B., & Davies, P. G. (2011). Differentially dangerous? Phenotypic racial stereotypicality increases implicit bias among ingroup and outgroup members. *Group Processes & Intergroup Relations*, 14(4), 569–580. <https://doi.org/10.1177/1368430210374609>
- [30] Kahn, K. B., Unzueta, M. M., Davies, P. G., Alston, A. T., & Lee, J. K. (2015). Will you value me and do I value you? The effect of phenotypic racial stereotypicality on organizational evaluations. *Journal of Experimental Social Psychology*, 59, 130–138. <https://doi.org/10.1016/j.jesp.2015.03.008>
- [31] Kaseweter, K. A., Drwecki, B. B., & Prkachin, K. M. (2012). Racial differences in pain treatment and empathy in a Canadian sample. *Pain Research and Management*, 17(6), 381–384. <https://doi.org/10.1155/2012/803474>
- [32] Khan, R., Apramian, T., Kang, J. H., Gustafson, J., & Sibbald, S. (2020). Demographic and socioeconomic characteristics of Canadian medical students: A cross-sectional study. *BMC Medical Education*, 20(1), 151. <https://doi.org/10.1186/s12909-020-02056-x>
- [33] Kim, H. J., Yang, G. S., Greenspan, J. D., Downton, K. D., Griffith, K. A., Renn, C. L., Johantgen, M., & Dorsey, S. G. (2017). Racial and ethnic differences in experimental pain sensitivity: Systematic review and

- meta-analysis. *Pain*, 158(2), 194–211. <https://doi.org/10.1097/j.pain.0000000000000731>
- [34] Kissi, A., Van Ryckeghem, D. M. L., Mende-Siedlecki, P., Hirsh, A., & Vervoort, T. (2022). Racial disparities in observers' attention to and estimations of others' pain. *Pain*, 163(4), 745–752. <https://doi.org/10.1097/j.pain.0000000000002419>
- [35] LaChapelle, D. L., Lavoie, S., Higgins, N. C., & Hadjistavropoulos, T. (2014). Attractiveness, diagnostic ambiguity, and disability cues impact perceptions of women with pain. *Rehabilitation Psychology*, 59, 162–170. <https://doi.org/10.1037/a0035894>
- [36] Lee, P., Le Saux, M., Siegel, R., Goyal, M., Chen, C., Ma, Y., & Meltzer, A. C. (2019). Racial and ethnic disparities in the management of acute pain in US emergency departments: Meta-analysis and systematic review. *The American Journal of Emergency Medicine*, 37(9), 1770–1777. <https://doi.org/10.1016/j.ajem.2019.06.014>
- [37] Lloyd, E. P., Paganini, G. A., & ten Brinke, L. (2020). Gender stereotypes explain disparities in pain care and inform equitable policies. *Policy Insights from the Behavioral and Brain Sciences*, 7(2), 198–204. <https://doi.org/10.1177/2372732220942894>
- [38] Ma, D. S., Correll, J., & Wittenbrink, B. (2015). The Chicago face database: A free stimulus set of faces and norming data. *Behavior Research Methods*, 47(4), 1122–1135. <https://doi.org/10.3758/s13428-014-0532-5>
- [39] Maddox, K. B., & Perry, J. M. (2018). Racial appearance bias: Improving evidence-based policies to address racial disparities. *Policy Insights from the Behavioral and Brain Sciences*, 5(1), 57–65. <https://doi.org/10.1177/2372732217747086>
- [40] Mahabir, D. F., O'Campo, P., Lofters, A., Shankardass, K., Salmon, C., & Muntaner, C. (2021). Experiences of everyday racism in Toronto's health care system: A concept mapping study. *International Journal for Equity in Health*, 20(1), 74. <https://doi.org/10.1186/s12939-021-01410-9>
- [41] Mathur, V. A., Morris, T., & McNamara, K. (2020). Cultural conceptions of women's labor pain and labor pain management: A mixed-method analysis. *Social Science & Medicine*, 261, 113240. <https://doi.org/10.1016/j.socscimed.2020.113240>
- [42] Mathur, V. A., Richeson, J. A., Paice, J. A., Muzyka, M., & Chiao, J. Y. (2014). Racial bias in pain perception and response: Experimental examination of automatic and deliberate processes. *The Journal of Pain*, 15(5), 476–484. <https://doi.org/10.1016/j.jpain.2014.01.488>
- [43] Meghani, S. H., Byun, E., & Gallagher, R. M. (2012). Time to take stock: A meta-analysis and systematic review of analgesic treatment disparities for pain in the United States. *Pain Medicine*, 13(2), 150–174. <https://doi.org/10.1111/j.1526-4637.2011.01310.x>
- [44] Mende-Siedlecki, P., Goharadz, A., Tuerxuntuoheti, A., Reyes, P. G. M., Lin, J., & Drain, A. (2022). Assessing the speed and spontaneity of racial bias in pain perception. *Journal of Experimental Social Psychology*, 101, 104315. <https://doi.org/10.1016/j.jesp.2022.104315>
- [45] Mende-Siedlecki, P., Qu-Lee, J., Backer, R., & Van Bavel, J. J. (2019). Perceptual contributions to racial bias in pain recognition. *Journal of Experimental Psychology: General*, 148(5), 863–889. <https://doi.org/10.1037/xge0000600>
- [46] Meng, J., Li, X., Peng, W., Li, Z., & Shen, L. (2020). The interaction between pain and attractiveness perception in others. *Scientific Reports*, 10(1), Article 1. <https://doi.org/10.1038/s41598-020-62478-x>
- [47] Monk, E. P. (2015). The cost of color: Skin color, discrimination, and health among African-Americans. *American Journal of Sociology*, 121(2), 396–444. <https://doi.org/10.1086/682162>
- [48] Morales, M. E., & Yong, R. J. (2021). Racial and ethnic disparities in the treatment of chronic pain. *Pain Medicine*, 22(1), 75–90. <https://doi.org/10.1093/pm/pnaa427>
- [49] Morning, A. (2011). *The nature of race: How scientists think and teach about human difference*. University of California Press. <https://doi.org/10.1525/9780520950146>
- [50] Ogasawara, M., Tamura, N., Onuma, S., Kusaoi, M., Sekiya, F., Matsudaira, R., Kempe, K., Yamaji, K., & Takasaki, Y. (2010). Observational cross-sectional study revealing less aggressive treatment in Japanese elderly than nonelderly patients with rheumatoid arthritis. *JCR: Journal of Clinical Rheumatology*, 16(8), 370. <https://doi.org/10.1097/RHU.0b013e3181fe8b37>
- [51] Okoro, O. N., Hillman, L. A., & Cernasev, A. (2022). Intersectional invisibility experiences of low-income African-American women in healthcare encounters. *Ethnicity & Health*, 27(6), 1290–1309. <https://doi.org/10.1080/13557858.2021.1899138>
- [52] Ortega, R., & Achu, R. A. (2021). On anesthesia and race. *Journal of the National Medical Association*, 113(5), 541–545. <https://doi.org/10.1016/j.jnma.2021.05.007>
- [53] Osborne, D., Davies, P. G., & Hutchinson, S. (2017). Stereotypicality biases and the criminal justice system. In *The Cambridge handbook of the psychology of prejudice* (pp. 542–558). Cambridge University Press. <https://doi.org/10.1017/9781316161579.024>
- [54] Samulowitz, A., Gremyr, I., Eriksson, E., & Hensing, G. (2018). "Brave men" and "emotional women": A theory-guided literature review on gender bias in health care and gendered norms towards patients with chronic pain. *Pain Research & Management*, 2018, 6358624. <https://doi.org/10.1155/2018/6358624>
- [55] Sessa, P., & Meconi, F. (2015). Perceived trustworthiness shapes neural empathic responses toward others' pain. *Neuropsychologia*, 79, 97–105. <https://doi.org/10.1016/j.neuropsychologia.2015.10.028>
- [56] Sinatra, R. (2010). Causes and consequences of inadequate management of acute pain. *Pain Medicine*, 11(12), 1859–1871. <https://doi.org/10.1111/j.1526-4637.2010.00983.x>
- [57] Sohn, H.-S., Lee, D.-H., Lee, K.-J., Noh, E. C., Choi, S.-H., Jang, J. H., Kim, Y. C., & Kang, D.-H. (2016). Impaired empathic abilities among patients with complex regional pain syndrome (type I). *Psychiatry Investigation*, 13(1), 34. <https://doi.org/10.4306/pi.2016.13.1.34>
- [58] Stutts, L. A., Hirsh, A. T., George, S. Z., & Robinson, M. E. (2010). Investigating patient characteristics on pain assessment using virtual human technology. *European Journal of Pain*, 14(10), 1040–1045. <https://doi.org/10.1016/j.ejpain.2010.04.003>
- [59] Tait, R. C., & Chibnall, J. T. (2014). Racial/ethnic disparities in the assessment and treatment of pain: Psychosocial perspectives. *American Psychologist*, 69(2), 131–141. <https://doi.org/10.1037/a0035204>
- [60] Taylor, B. A., Casas-Ganem, J., Vaccaro, A. R., Hilibrand, A. S., Hanscom, B. S., & Albert, T. J. (2005). Differences in the work-up and treatment of conditions associated with low back pain by patient gender and ethnic background. *Spine*, 30(3), 359–364. <https://doi.org/10.1097/01.brs.0000152115.79236.6e>
- [61] The Canadian Pain Task Force. (2020). *Working together to better understand, prevent, and manage chronic pain: What we heard*. Health Canada. <https://www.canada.ca/en/health-canada/corporate/about-health-canada/public-engagement/external-advisory-bodies/canadian-pain-task-force/report-2020.html>
- [62] Thurston, K. L., Zhang, S. J., Wilbanks, B. A., Billings, R., & Aroke, E. N. (2022). A systematic review of race, sex, and socioeconomic status differences in postoperative pain and pain management. *Journal of PeriAnesthesia Nursing*, 38(3), 504–515. <https://doi.org/10.1016/j.jpnan.2022.09.004>
- [63] Trawalter, S., & Hoffman, K. M. (2015). Got pain? Racial bias in perceptions of pain. *Social and Personality Psychology Compass*, 9(3), 146–157. <https://doi.org/10.1111/spc3.12161>
- [64] Trawalter, S., Hoffman, K. M., & Waytz, A. (2012). Racial bias in perceptions of others' pain. *PLoS ONE*, 7(11), e48546. <https://doi.org/10.1371/journal.pone.0048546>
- [65] Wandner, L. D., Heft, M. W., Lok, B. C., Hirsh, A. T., George, S. Z., Horgas, A. L., Atchison, J. W., Torres, C. A., & Robinson, M. E. (2014). The impact of patients' gender, race, and age on health care professionals' pain management decisions: An online survey using virtual human technology. *International Journal of Nursing Studies*, 51(5), 726–733. <https://doi.org/10.1016/j.ijnurstu.2013.09.011>
- [66] Wang, E., Glazer, K. B., Sofaer, S., Balbierz, A., & Howell, E. A. (2021). Racial and ethnic disparities in severe maternal morbidity: A qualitative study of women's experiences of peripartum care. *Women's Health Issues*, 31(1), 75–81. <https://doi.org/10.1016/j.whi.2020.09.002>
- [67] Waytz, A., Hoffman, K. M., & Trawalter, S. (2015). A superhumanization bias in Whites' perceptions of Blacks. *Social Psychological and Personality Science*, 6(3), 352–359. <https://doi.org/10.1177/1948550614553642>

- [68] Weber, L., & Parra-Medina, D. (2003). Intersectionality and women's health: Charting a path to eliminating health disparities. In *Advances in Gender Research* (Vol. 7, pp. 181–230). Emerald (MCB UP). [https://doi.org/10.1016/S1529-2126\(03\)07006-1](https://doi.org/10.1016/S1529-2126(03)07006-1)
- [69] Wells, G. L., & Windschitl, P. D. (1999). Stimulus sampling and social psychological experimentation. *Personality and Social Psychology Bulletin*, 25(9), 1115–1125. <https://doi.org/10.1177/01461672992512005>
- [70] Williams, M. J., George-Jones, J., & Hebl, M. (2019). The face of STEM: Racial phenotypic stereotypicality predicts STEM persistence by—and ability attributions about—students of color. *Journal of Personality and Social Psychology*, 116(3), 416–443. <https://doi.org/10.1037/pspi0000153>
- [71] Wimbish, L. A., Simpson, J. R., Gilbert, L. R., Blackwood, A., & Grant, E. A. (2022). Examining racial, ethnic, and gender disparities in the treatment of pain and injury emergencies. *HCA Healthcare Journal of Medicine*, 3(3). <https://doi.org/10.36518/2689-0216.1425>
- [72] Yang, D., Li, X., Zhang, Y., Li, Z., & Meng, J. (2022). Skin color and attractiveness modulate empathy for pain: An event-related potential study. *Frontiers in Psychology*, 12, 780633. <https://doi.org/10.3389/fpsyg.2021.780633>
- [73] Zhang, L., Losin, E. A. R., Ashar, Y. K., Koban, L., & Wager, T. D. (2021). Gender biases in estimation of others' pain. *The Journal of Pain*, 22(9), 1048–1059. <https://doi.org/10.1016/j.jpain.2021.03.001>
- [74] Zhao, R., Ji, Y., Li, J., Li, X., Wu, T., Wu, H., & Liu, C. (2022). Pain empathy and its association with the clinical pain in knee osteoarthritis patients. *Journal of Pain Research*, 15, 4017–4027. <https://doi.org/10.2147/JPR.S379305>
- [75] Zhu, J., Yang, Z., Ma, R., Yin, L., & Hu, X. (2022). Face beauty or soul beauty? The influence of facial attractiveness and moral judgment on pain empathy. *Frontiers in Psychology*, 13, 990637. <https://doi.org/10.3389/fpsyg.2022.990637>

Cognitive behavioural therapy as an evidence-based treatment for bulimia nervosa

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ABSTRACT Bulimia nervosa (BN) presents significant psychological, behavioural, and physical challenges, often co-occurring with psychiatric conditions such as depression, PTSD, and ADHD, which can worsen prognosis and psychosocial functioning. This narrative review explores the efficacy of cognitive-behavioural therapy for bulimia nervosa (CBT-BN) as an evidence-based treatment, contrasting its rapid symptom improvement with traditional approaches like psychoanalytic psychotherapy. Studies consistently show that CBT-BN offers substantial reductions in binge eating and purging within a short treatment duration, making it an efficient and effective intervention. Key to its success is the structured targeting of dietary restraint and cognitive distortions that drive the binge-purge cycle. Group CBT also emerges as a promising, cost-effective alternative with comparable efficacy to individual CBT, suggesting potential for broader accessibility. Despite the positive outcomes, access to specialized CBT-BN practitioners remains limited, underscoring the need for scalable models such as group therapy. This review highlights CBT-BN's potential as a comprehensive, impactful approach that addresses primary and secondary symptoms of BN and offers enduring benefits for affected individuals.

INTRODUCTION

Bulimia nervosa (BN) is a severe psychiatric disorder with a prevalence of approximately 1%-2% among young women in Canada, though it can affect individuals of all genders (Hudson et al., 2007). BN is most commonly diagnosed in late adolescence and early adulthood, with increasing rates observed in recent years, likely due to growing awareness and changing diagnostic criteria (Smink et al., 2014). The disorder is marked by recurrent episodes of binge eating followed by inappropriate compensatory behaviours such as vomiting, excessive exercise, or laxative misuse (Anderson & Maloney, 2001; Lampard & Sharbanaee, 2015). These behaviours often stem from a pervasive preoccupation with body shape and weight, contributing to cycles of restrictive eating, bingeing, and purging (Murphy et al., 2010).

BN presents a complex array of challenges at the intersection of psychological, behavioural, and physical domains. Beyond the typical symptoms of disordered eating, individuals with BN often grapple not only with psychological symptoms like clinical perfectionism and low self-esteem, but also with a constellation of psychiatric comorbidities, including major depression (50%), specific phobia (50%), post-traumatic stress disorder (PTSD) (45%), or neurodivergence like attention-deficit hyperactivity disorder (ADHD) (35%) (Murphy et al., 2010; Patel et al., 2018). These add to the multifaceted nature of the disorder and inevitably contribute to a poorer prognosis. The disorder also profoundly impacts psychosocial functioning, impairing social relationships, academic performance, and occupational responsibilities (Bohn et al., 2008). These psychosocial difficulties are worsened by the aforementioned comorbidities (Yao et al., 2016). In recognizing these intricate challenges posed by BN, the need for effective evidence-based psychotherapeutic treatment approaches becomes evident.

Understanding the cognitions and behaviours that maintain BN is crucial to the design and delivery of successful interventions. The cognitive-behavioural model of BN is an etiological framework that delineates the core clinical features and mechanisms of maintenance in BN, through a dysfunctional system of self-evaluation (Fairburn et al., 1986). It suggests that the primary criterion for self-evaluation in BN is the perceived control over weight, shape, or eating. Over-evaluating the significance of these factors initiates a cycle of dietary restraint, characterized by the cognitive control of eating through strict and inflexible dietary rules. The model suggests that the rigidity of dietary rules plays a pivotal role in sustaining binge eating (Lampard & Sharbanaee, 2015; Polivy & Herman, 1985). First, efforts to maintain self-control make one susceptible to uncontrolled eating during moments of disrupted control, like heightened emotional states. Additionally, physiological hunger can override cognitive

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control, resulting in poor self-control during eating. Lastly, deviations from strict rules can trigger the “abstinence violation” effect, wherein eating is perceived as a catastrophic loss of self-control, resulting in unrestricted thoughts about continued overeating (Fairburn et al., 1986). Thus, the inflexibility of dietary rules sets the stage for an all-or-nothing reaction, where even minor transgressions lead to the abandonment of all attempts to control eating, culminating in binge episodes, and in turn contributing to the perpetuation of the binge-eating cycle (Byrne & McLean, 2002; Fairburn et al., 1986).

Cognitive-behavioural therapy for BN (CBT-BN) has emerged as a leading evidence-based intervention in recent years (Monteleone et al., 2022). CBT-BN was specifically developed to address binge-purge behaviours and the dysfunctional thought patterns that maintain these behaviours in BN (Fairburn, 1981; Lampard & Sharbanee, 2015). This paper will review CBT-BN as an evidence-based treatment for BN, examining its efficacy, applicability, and key therapeutic mechanisms.

METHODS

Although this is a narrative review, a structured search strategy was employed to ensure a comprehensive analysis of the literature. Articles were retrieved from PsycINFO, PubMed, and Google Scholar using search terms such as “CBT for bulimia nervosa,” “cognitive-behavioural therapy BN efficacy,” and “group CBT-BN.” Studies included in this review met the following criteria: (1) empirical research on CBT-BN, (2) published in peer-reviewed journals, and (3) focused on treatment efficacy, mechanisms of change, or accessibility. The exact number of articles screened and selected varied, but a representative set of key studies was chosen based on relevance and methodological rigour.

DISCUSSION

CBT-BN: Treatment Principles and Phases

In CBT, psychopathology is believed to stem from distorted information processing, originating in flawed cognitive schemas, and ultimately resulting in maladaptive behaviours. The goal of CBT is to identify and modify these dysfunctional thought patterns, facilitating a positive shift in the cognitive system and promoting healthier behavioural responses (Beck, 2020). CBT-BN assumes dietary restraint to be a key precipitant in BN and operates in three distinct treatment phases — Phase 1 targets the reduction and elimination of excessive dietary restriction, Phase 2 focuses on the alteration of dysfunctional beliefs about body shape and weight, and the final Phase 3 is dedicated to maintaining treatment gains and developing relapse prevention and intervention plans (Fairburn et al., 1993; Spangler et al., 2004).

Throughout all phases, the CBT-BN protocol integrates relational elements like collaboration, empathy, involvement, and feedback, alongside structural elements such as agenda-setting, homework assignments, paced sessions, and summarization (Spangler et al., 2004). This creates a balanced setting of trust and psychological safety wherein the client feels comfortable, secure, and supported while navigating this highly structured, goal-oriented treatment program.

Efficacy of CBT-BN Compared to Other Treatments

CBT-BN involves a structured approach to ameliorate BN symptomatology, with a synergistic blend of cognitive and behavioural strategies (Fairburn et al., 1993). This integrative nature of CBT helps target both dysfunctional cognitions and maladaptive coping behaviours in BN. Importantly, it has shown a unique capacity to deliver substantial and enduring symptom improvements within a relatively short timeframe of 5 months (Murphy et al., 2010). This is a significant advantage since some of the prior ubiquitous treatments, like psychoanalytic psychotherapy, generally involve 1-2 years of treatment for BN (Hagan & Walsh, 2021; Murphy et al., 2010). A two-year randomized controlled trial directly compared the efficacy of CBT-BN with a psychoanalytic psychotherapeutic (PPT) treatment for BN (Poulsen et al., 2014). CBT-BN followed the clinical standard of 20 sessions over 5 months but was enhanced by a heightened emphasis on client engagement and coping skills. As per clinical practice standards, PPT involved weekly sessions over 2 years, with a focus on increasing the recognition of and tolerance towards negative affect experiences (Poulsen et al., 2014). Both treatments were delivered in outpatient settings, with treatment outcomes being measured at baseline, 5 months (CBT-endpoint), and 24 months (PPT-endpoint). A total of 70 individuals who met the DSM-IV diagnosis criteria for BN were recruited and randomly assigned to either CBT-BN or PPT (Poulsen et al., 2014).

Both CBT-BN and PPT demonstrated significant improvements in BN symptoms; however, the distinctive impact of CBT-BN was notably evident. Within just 5 months, a substantial 42% of individuals undergoing CBT-BN had ceased binge eating and purging, a stark contrast to the 6% in the PPT group. This trend persisted at the 2-year mark, with 44% in the CBT-BN group and 15% in the PPT group having successfully ceased bingeing and purging behaviours. Despite having far fewer treatment sessions and a shorter overall duration, CBT-BN significantly outperformed PPT. These results are corroborated in the broader literature (Russell et al., 2023). These findings underscore the superior efficacy, fast-acting nature, and enduring impact of CBT-BN in ameliorating BN symptoms (Poulsen et al., 2014).

CBT-BN: Access and Cost-effectiveness

It is important to note that accessing effective care for individuals with BN is challenging due to the limited availability of specialized interventions like CBT-BN (Zerwas et al., 2016). Well-trained CBT therapists specializing in BN may be scarce, and their one-to-one service may be expensive (Mussell et al., 2000; Zerwas et al., 2016). Group CBT may be a potential cost-effective solution to these challenges (Chen et al., 2003). A randomized controlled trial rigorously investigated the effects of group versus individual CBT-BN on several primary and secondary symptoms of BN—including binge eating and purging behaviours, weight and shape attitudes, social adjustment, self-esteem, and general psychopathology (Chen et al., 2003). 60 female patients who met DSM-IV criteria for BN were recruited and, using a randomized block design, were randomly allocated to either group (GCBT) or individual (ICBT) treatment groups. ICBT followed the standard program of 19, 50-minute sessions over 4.5 months, with access provided to the CBT-BN self-help handout by Fairburn (1995). The GCBT treatment was adapted from the Oxford manual for CBT-BN and was identical to ICBT in terms of handouts, number of sessions, and content (Fairburn et al., 1993). GCBT involved 90-minute sessions with 6 participants per group (Chen et al., 2003).

Both treatments were conducted in outpatient settings, and outcomes were measured at pretreatment, posttreatment, and 3- and 6-month follow-up. Their findings showed that both GCBT and ICBT proved effective in improving the primary and secondary symptoms of BN. The improvements were not only rapid but also sustained at the 6-month follow-up in both groups. Notably, ICBT initially demonstrated significantly greater abstinence from bingeing and vomiting behaviours at posttreatment compared to GCBT, but this difference was not sustained at 3- and 6-month follow-ups. Further, the dropout rates and overall treatment satisfaction were similar in both groups, indicating equal patient preference (Chen et al., 2003). These results underscore the potential of GCBT as an accessible, cost-effective, efficacious and scalable intervention for BN. Moreover, they affirm the broader efficacy of CBT-BN as a clinical treatment capable of improving several different primary and secondary symptoms of BN.

SYNTHESIS AND FUTURE DIRECTIONS

This review reinforces CBT-BN as a robust, evidence-based treatment that effectively reduces binge-purge behaviours while addressing underlying cognitive and emotional disturbances. CBT-BN has demonstrated superior efficacy compared to other therapeutic approaches, underscoring its ability to drive rapid and sustained improvements in symptomatology. Additionally, group CBT-BN has emerged as a viable and scalable alternative, highlighting its potential to bridge the treatment gap for individuals with limited access to specialized one-on-one care.

Despite these promising findings, several limitations exist in the current literature. First, the overwhelming focus on female participants in BN studies limits the generalizability of findings to other gender groups. As research increasingly acknowledges that BN affects men and non-binary individuals, future studies must examine whether CBT-BN is equally effective across diverse gender identities. Additionally, the role of cultural and socioeconomic factors in BN treatment remains understudied. The accessibility, acceptability, and effectiveness of CBT-BN across different cultural backgrounds warrant further exploration, particularly in populations where disordered eating may be underdiagnosed due to stigma or differing symptom presentations.

Another critical avenue for research is the adaptation of CBT-BN to digital and hybrid formats. With advancements in teletherapy, online CBT interventions hold promise in improving accessibility, particularly for individuals in remote areas or those facing logistical barriers to in-person therapy (Zerwas et al., 2016). Future studies should assess the efficacy of digital CBT-BN, explore engagement strategies for online therapy, and determine how virtual interventions compare to traditional face-to-face treatments.

Finally, longitudinal research is needed to assess the long-term sustainability of CBT-BN outcomes. Many existing studies have short follow-up periods, making it difficult to determine whether treatment effects persist over extended periods. Investigating relapse rates and identifying factors that contribute to long-term recovery will be crucial for refining intervention strategies and ensuring lasting benefits for individuals with BN.

CONCLUSION

In summary, the literature supports the notion that CBT-BN is a well-established, effective treatment for BN, offering rapid symptom relief and sustained improvements. Group-based CBT represents a promising avenue for increasing accessibility and affordability, though further research is needed to explore CBT-BN's long-term efficacy across diverse populations. Addressing existing research gaps will be crucial in optimizing BN treatment and ensuring equitable access to care.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

REFERENCES

- [1] Anderson, D. A., & Maloney, K. C. (2001). The efficacy of cognitive-behavioral therapy on the core symptoms of bulimia nervosa. *Clinical Psychology Review*, 21(7), 971–988. [https://doi.org/10.1016/S0272-7358\(00\)00076-3](https://doi.org/10.1016/S0272-7358(00)00076-3)
- [2] Beck, J. S. (2020). *Cognitive Behavior Therapy, Third Edition: Basics and Beyond*. Guilford Publications.
- [3] Bohn, K., Doll, H. A., Cooper, Z., O'Connor, M., Palmer, R. L., & Fairburn, C. G. (2008). The measurement of impairment due to eating disorder psychopathology. *Behaviour Research and Therapy*, 46(10), 1105–1110. <https://doi.org/10.1016/j.brat.2008.06.012>
- [4] Byrne, S. M., & McLean, N. J. (2002). The cognitive-behavioral model of bulimia nervosa: A direct evaluation. *International Journal of Eating Disorders*, 31(1), 17–31. <https://doi.org/10.1002/eat.10002>
- [5] Chen, E., Touyz, S. W., Beumont, P. J. V., Fairburn, C. G., Griffiths, R., Butow, P., Russell, J., Schotte, D. E., Gertler, R., & Basten, C. (2003). Comparison of group and individual cognitive-behavioral therapy for patients with bulimia nervosa. *The International Journal of Eating Disorders*, 33(3), 241–254; discussion 255–256. <https://doi.org/10.1002/eat.10137>
- [6] Fairburn, C. G. (1981). A cognitive behavioural approach to the treatment of bulimia. *Psychological Medicine*, 11(4), 707–711. <https://doi.org/10.1017/S0033291700041209>
- [7] Fairburn, C. G. (1995). *Overcoming binge eating*. Guilford Press.
- [8] Fairburn, C. G., Cooper, Z., & Cooper, P. J. (1986). The clinical features and maintenance of bulimia nervosa. *Handbook of Eating Disorders: Physiology, Psychology and Treatment of Obesity, Anorexia and Bulimia*, 389, 404.
- [9] Fairburn, C. G., Marcus, M. D., & Wilson, G. T. (1993). Cognitive-behavioral therapy for binge eating and bulimia nervosa: A comprehensive treatment manual. In *Binge eating: Nature, assessment, and treatment* (pp. 361–404). Guilford Press.
- [10] Hagan, K. E., & Walsh, B. T. (2021). State of the Art: The therapeutic approaches to bulimia nervosa. *Clinical Therapeutics*, 43(1), 40–49. <https://doi.org/10.1016/j.clinthera.2020.10.012>
- [11] Hudson, J. I., Hiripi, E., Pope, H. G., Jr, & Kessler, R. C. (2007). The prevalence and correlates of eating disorders in the National

- Comorbidity Survey Replication. *Biological Psychiatry*, 61(3), 348–358. <https://doi.org/10.1016/j.biopsych.2006.03.040>
- [12] Lampard, A. M., & Sharbanee, J. M. (2015). The cognitive-behavioural theory and treatment of bulimia nervosa: An examination of treatment mechanisms and future directions. *Australian Psychologist*, 50(1), 6–13. <https://doi.org/10.1111/ap.12078>
- [13] Monteleone, A. M., Pellegrino, F., Croatto, G., Carfagno, M., Hilbert, A., Treasure, J., Wade, T., Bulik, C., Zipfel, S., Hay, P., Schmidt, U., Castellini, G., Favaro, A., Fernandez-Aranda, F., Il Shin, J., Voderholzer, U., Ricca, V., Moretti, D., Busatta, D., ... Solmi, M. (2022). Treatment of Eating Disorders: A systematic meta-review of meta-analyses and network meta-analyses. *Neuroscience and Biobehavioral Reviews*, 142, 104857. <https://doi.org/10.1016/j.neubiorev.2022.104857>
- [14] Murphy, R., Straebl, S., Cooper, Z., & Fairburn, C. G. (2010). Cognitive behavioral therapy for eating disorders. *The Psychiatric Clinics of North America*, 33(3), 611–627. <https://doi.org/10.1016/j.psc.2010.04.004>
- [15] Mussell, M. P., Crosby, R. D., Crow, S. J., Knopke, A. J., Peterson, C. B., Wonderlich, S. A., & Mitchell, J. E. (2000). Utilization of empirically supported psychotherapy treatments for individuals with eating disorders: A survey of psychologists. *The International Journal of Eating Disorders*, 27(2), 230–237. [https://doi.org/10.1002/\(sici\)1098-108x\(200003\)27:2<230::aid-eat11>3.0.co;2-0](https://doi.org/10.1002/(sici)1098-108x(200003)27:2<230::aid-eat11>3.0.co;2-0)
- [16] Patel, R. S., Olten, B., Patel, P., Shah, K., & Mansuri, Z. (2018). Hospitalization outcomes and comorbidities of bulimia nervosa: A nationwide inpatient study. *Cureus*, 10(5), e2583. <https://doi.org/10.7759/cureus.2583>
- [17] Polivy, J., & Herman, C. P. (1985). Dieting and bingeing: A causal analysis. *American Psychologist*, 40(2), 193–201. <https://doi.org/10.1037/0003-066X.40.2.193>
- [18] Poulsen, S., Lunn, S., Daniel, S. I. F., Folke, S., Mathiesen, B. B., Katznelson, H., & Fairburn, C. G. (2014). A randomized controlled trial of psychoanalytic psychotherapy or cognitive-behavioral therapy for bulimia nervosa. *American Journal of Psychiatry*, 171(1), 109–116. <https://doi.org/10.1176/appi.ajp.2013.12121511>
- [19] Rotenberg, K. J., Bharathi, C., Davies, H., & Finch, T. (2013). Bulimic symptoms and the social withdrawal syndrome. *Eating Behaviors*, 14(3), 281–284. <https://doi.org/10.1016/j.eatbeh.2013.05.003>
- [20] Russell, H., Aouad, P., Le, A., Marks, P., Maloney, D., Aouad, P., Barakat, S., Boakes, R., Brennan, L., Bryant, E., Byrne, S., Caldwell, B., Calvert, S., Carroll, B., Castle, D., Caterson, I., Chelius, B., Chiem, L., Clarke, S., ... National Eating Disorder Research Consortium. (2023). Psychotherapies for eating disorders: Findings from a rapid review. *Journal of Eating Disorders*, 11(1), 175. <https://doi.org/10.1186/s40337-023-00886-w>
- [21] Smink, F. R., van Hoeken, D., Oldehinkel, A. J., & Hoek, H. W. (2014). Prevalence and severity of DSM-5 eating disorders in a community cohort of adolescents. *The International Journal of Eating Disorders*, 47(6), 610–619. <https://doi.org/10.1002/eat.22316>
- [22] Spangler, D. L., Baldwin, S. A., & Agras, W. S. (2004). An examination of the mechanisms of action in cognitive behavioral therapy for bulimia nervosa. *Behavior Therapy*, 35(3), 537–560. [https://doi.org/10.1016/S0005-7894\(04\)80031-5](https://doi.org/10.1016/S0005-7894(04)80031-5)
- [23] Wilson, G. T., Fairburn, C. C., Agras, W. S., Walsh, B. T., & Kraemer, H. (2002). Cognitive-behavioral therapy for bulimia nervosa: Time course and mechanisms of change. *Journal of Consulting and Clinical Psychology*, 70(2), 267–274. <https://doi.org/10.1037/0022-006X.70.2.267>
- [24] Yao, S., Kujala, R., Thornton, L. M., Runfola, C. D., D'Onofrio, B. M., Almqvist, C., Lichtenstein, P., Sjölander, A., Larsson, H., & Bulik, C. M. (2016). Familial liability for eating disorders and suicide attempts: Evidence from a population registry in Sweden. *JAMA Psychiatry*, 73(3), 284–291. <https://doi.org/10.1001/jamapsychiatry.2015.2737>
- [25] Zerwas, S. C., Watson, H. J., Hofmeier, S. M., Levine, M. D., Hamer, R. M., Crosby, R. D., Runfola, C. D., Peat, C. M., Shapiro, J. R., Zimmer, B., Moessner, M., Kordy, H., Marcus, M. D., & Bulik, C. M. (2016). CBT4BN: A randomized controlled trial of online chat and face-to-face group therapy for bulimia nervosa. *Psychotherapy and Psychosomatics*, 86(1), 47–53. <https://doi.org/10.1159/000449025>

End-of-life care perspectives of South Asian older adults with chronic illnesses

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ABSTRACT The focus of this article is to understand the social perspectives of end-of-life care within the South Asian community in Western countries such as the UK, through the influence of spiritual and faith-based approaches, cultural norms, family relationships, and community experiences in healthcare settings. In this paper, South Asian's perspectives of end-of-life care will be conceptualized using Corr's (1992) task-based approach to coping with dying (Copp, 1998). This approach helps understand how coping with dying takes various forms and outcomes, going beyond understanding the experiences of a dying person as well as the effects on family and carers (Copp, 1998). This model's consideration for family and carers is important, especially when understanding their involvement in decision-making during end-of-life care for older adults. The aspects of this approach that will be utilized are the four primary areas of coping with dying: physical, psychological, social, and spiritual (Copp, 1998). Each area of this model can be applied to the ways that the South Asian community perceives end-of-life care and is inclusive of all the different challenges that may be faced during this phase.

INTRODUCTION

Studies have shown that in comparison to other ethnic groups, South Asian migrants are at a higher risk of chronic and life-threatening diseases (Shabnam et al., 2020). Studies have also shown that South Asians constitute the single largest ethnic minority group in the UK, yet gaps remain in the literature regarding this community's perspectives on death and dying and experiences of end-of-life care (Venkatasalu et al., 2013). There is even less literature addressing the specific needs for end-of-life care among South Asian immigrants (Weerasinghe & Maddalena, 2016). When considering the higher risk of chronic diseases for South Asian migrants, it is crucial to understand the perspectives of end-of-life care for South Asians— especially in diasporic communities as they make up a large portion of the overall older adult population in Western countries, particularly, the US and Canada (Weerasinghe, 2023).

It is important to consider the South Asian community's perspectives of end-of-life care because in addition to dealing with chronic diseases, unique social challenges exist in end-of-life care. These challenges include accessibility and language barriers, cultural differences, discrimination, and inadequate care due to the lack of awareness surrounding specific South Asian end-of-life beliefs and practices (Weerasinghe, 2023). For example, instances of physician-directed care often interfere with spiritual and religious beliefs of South Asians in the process of dying, making it harder for the overall population and those involved to be satisfied with their care (Khosla et al., 2016). Considering these factors, understanding the South Asian community's perspectives is crucial to the study of end-of-life care. For physicians, this begins with addressing unconscious bias, culturally insensitive practices, and discriminatory attitudes towards the religious beliefs and teachings of patients (Khan, 2024).

LITERATURE REVIEW

Spiritual approaches to end-of-life care

Spiritual beliefs have a significant role when considering the factors that shape the South Asian community's perceptions of end-of-life care (Samanta et al., 2018). More specifically, philosophical, moral, and spiritual considerations at the end of life are engaged with to make sense of dying (Samanta et al., 2018). Spirituality may be used as a personal search for answers regarding phases in a person's life and is associated with sacred beliefs, values, and behaviours (Damianakis & Marziali, 2012). In a study that explored end-of-life care for South Asian immigrants in Canada from the perspectives of family caregivers, participants took a faith-based approach to make sense of their chronic illness (Weerasinghe & Maddalena, 2016).

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For example, Hindu participants in this study perceived cancer diagnoses as a result of bad “karma,” meaning a result of consequences for their actions (Weerasinghe & Maddalena, 2016). Similarly, Catholic participants viewed cancer diagnoses as being “divinely determined actions” (Weerasinghe & Maddalena, 2016). In this sense, chronic illnesses are understood through spiritual beliefs to comprehend disease causation.

In Corr’s task-based approach to coping with dying, one of the primary tasks is spiritual and is concerned with the need to identify, develop, and reaffirm sources of spiritual energy, as well as foster hope (Copp, 1998). Making sense of one’s situation spiritually rather than medically may lead to the acceptance of approaching the end-of-life for older adults and their families. Sharma et al. (2012) looked at the end-of-life perspectives of older Indian adults in the US and found that Hindu participants pointed towards concepts of reincarnation along with karma as a basis for their attitude towards death and dying. Some participants argued that treatment at the end-of-life may interfere with religious beliefs and what is intended for them based on their karma, while others argued that there is a limit to how much religious beliefs should interfere with treatment and suffering (Sharma et al., 2012). Similarly, a study that focused on perceptions of palliative care among South Asian participants ages 50 to 80 in Canada, suggested that 44% of participants believed that palliative care treatment was against their religious beliefs and values (Dosani et al., 2020). Additionally, Khosla et al. (2016) looked at the perspectives of health care providers in the US on South Asian attitudes towards pain management and suggested that Muslim participants did not feel comfortable with taking pain medications as it’s considered sinful. Identifying with the end-of-life both religiously and spiritually is important to South Asians but can be difficult when medical treatment is involved as it influences decisions on pain management, hospice utilization, and withdrawal of life-sustaining treatments in Western medical care (Khan, 2024).

Additionally, Corr also speaks to how caregivers are impacted in how they deal with the challenges that arise with end-of-life caregiving (Copp, 1998). Shabnam et al. (2020) describe love, respect, and religious reward as motivators for caregivers, helping them overcome various challenges associated with caring for an older adult at the end of life. Therefore, spiritual teachings can be used to motivate and encourage caregivers in overcoming challenges that arise in the course of their caregiving duties.

Family relationships and end-of life care

For most South Asian families, it is customary that children look after their parents or grandparents at the end of life. Many older South Asian adults prefer to live in multi-generational households so that responsibilities of care are distributed among all family members (Dosani, 2020). In a systematic review of South Asian perspectives of palliative care, a total of 30 articles identified that the involvement of family members in palliative care decision-making improves the overall satisfaction of services (Shabnam et al., 2020). Having family members make decisions on behalf of older adults in their family requires substantial trust. An example of this sense of trust is presented in a study on the perspectives of older South Asian adults living in East London, where one of the participants—a 72-year-old Punjabi woman—indicated that she was leaving the place of her death entirely up to her daughter (Venkatasalu et al., 2013). Similarly, spouses are also expected to

be fully present in the decision-making and care of their terminally ill partners. In a study on the perspectives of end-of-life care for South Asians living in Canada, the caregiver wife of a terminally ill husband was injured after bypass surgery but refused to leave him alone until the hospital reassured her of their reunification (Weerasinghe & Maddalena, 2016). Family members taking on decision-making roles on behalf of older adults is common in many South Asian households.

Corr describes one of the main areas of task work as social, involving the enhancement of interpersonal attachments of significance to the person and addressing the social implications of dying (Copp, 1998). It is understood that close-knit family relationships are considered a cultural norm for many South Asians. Older adults hold lots of trust, attachment, and dependence on their children or spouse. This relates to the idea that family relationships, which are of importance to many older South Asian adults, are being sustained and enhanced via the role and presence of caregivers, the decision-making done on behalf of older adults, and being present at the end of a family member’s life. The responsibility of children and spouses caring for their loved ones is often learned and passed down through generations of caregiving (Sharma et al., 2012). Although preferences differ based on the individual’s needs, it is evident that the challenges faced by South Asians at the end of life are often approached and dealt with as a family, rather than independently.

Cultural norms and discussing end-of-life care

When understanding how cultural norms shape the perspectives of end-of-life care for South Asians, avoiding important discussions about death and dying is understood as a common factor. Venkatasalu et al. (2013) show that there is a clear absence of discussion in the South Asian community about end-of-life care which contributes to a lack of preparation and advance care planning. This is to avoid feelings of distress and to maintain a positive attitude towards life (Venkatasalu et al., 2013). Venkatasalu et al. (2013) further illustrate this with the account of an older South Asian woman who avoided thinking about and discussing death because “you get very sick”. For many in the South Asian community, mental, emotional, spiritual, and physical health are all connected. Therefore, it is believed that if an individual is suffering mentally at the end of life, it can worsen their physical health. Similarly, Corr’s task-based approach consists of physical, psychological, social, and spiritual dimensions, all of which consider the idea that there is more than one way to cope with dying (Copp, 1998). In this model, the idea of dying is difficult to cope with and is believed to cause physical distress (Copp, 1998).

Although it is a cultural norm for families to use positive talk to avoid the discussion of death to protect the feelings of older adults, the lack of discussion about death in the South Asian community could lead to family members being burdened with difficult decisions and stress associated with last-minute planning (Khan, 2024). Relatedly, it is found that discussing and planning for death in advance allows for the dying person to have control over how they would like to die and their funeral arrangements (Clarke et al., 2012). Although South Asian families insist on taking this responsibility on behalf of older adults out of good intentions, specific rituals in the process of dying should be discussed between children and their parents or grandparents. For example, one of the Hindu rituals of passing away involves the eldest child

lighting the fire during the cremation ceremony (Sharma et al., 2012). This is an important tradition for many Hindu and Buddhist South Asians that is often passed down through generations (Sharma et al., 2012). The significance of this ritual should be discussed with the eldest child prior to death, to ensure the wishes of loved ones are being met. By having more discussions pertaining to end-of-life decisions, older adults and their preferences are more likely to be considered and followed.

Concerns in healthcare settings

There are many factors that make the experiences of end-of-life care for South Asian older adults uniquely challenging. For example, poor health literacy, language barriers, and the inaccessibility of palliative care contribute to these challenges (Yarnell et al., 2020). Yarnell et al. (2020) looked at the associations between South Asian and Chinese immigrants in end-of-life care and found that both communities were more likely to receive aggressive end-of-life care and to die in healthcare settings than those of the general population. This observation was based on patient-provider ethnicity discordance, decreased resources due to low socioeconomic status, and instances of discrimination (Yarnell et al., 2020). Similarly, another study focused on the observations of health care providers of South Asian patients in end-of-life care in the US and found a lack of understanding regarding the different cultural practices and beliefs of this community (Khosla et al., 2016). Considering the traditional expectations of South Asians and the involvement of family members in decision-making, it is common that ideologies between patients and their providers may clash (Khosla et al., 2016). Western health care practices have shown to lack culturally sensitive care and compassion, both of which are important to diverse patient populations (Singh et al., 2020).

In Corr's task-based approach to coping with dying, challenges are equally faced by family, caregivers, and dying patients (Copp, 1998). There is a need for clinician-patient-family interactions to be a collaborative process whereby knowledge is shared and obtained equally from each other (Khosla et al., 2016). This should be done through the allowance and acceptance of values and preferences from both patients and their families, as well as a deeper understanding of the resources available to help with language translation, incorporating religious practices in health care settings, and education about common South Asian cultural beliefs towards end-of-life care (Khosla et al., 2016). Furthermore, palliative care is defined as providing supportive physical, psychological, social, and spiritual care to individuals suffering from life-threatening diseases beginning from diagnosis to bereavement (Weerasinghe & Maddalena, 2016). All aspects of palliative care should be considered and carried out even after the individual has passed away and the family is affected.

CONCLUSION

This article discussed the factors that shape the perceptions of end-of-life care for South Asians. Through understanding the importance of spiritual approaches to end-of-life care in this community, it was found that religious beliefs help to make sense of the diagnosis of chronic diseases. There is also a concern and debate within the South Asian community about whether medical treatment at the end of life interferes with religious beliefs. In terms of family relationships and end-of-life care, it is considered common for families to be involved in the decision-making

process and caregiving responsibilities for older adults. When considering the cultural norms that shape perceptions of end-of-life care, discussions regarding death and dying are often avoided to protect older adults from mental distress, which is believed to worsen physical health. However, it is also important for South Asian family members and caregivers to plan end-of-life rituals and duties in advance to avoid the risk of not knowing the preferences of loved ones when they pass away. Finally, there are several factors that could contribute to a poor experience for South Asians in end-of-life care due to the differences between Western medical practices and South Asian practices. More knowledge about South Asian experiences of end-of-life care will help to understand the changes that need to be made to normalize these discussions, and improvements that need to be made to create a culturally sensitive environment in healthcare settings.

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REFERENCES

- Clarke, L. H., Korotchenko, A., & Bundon, A. (2012). 'The calendar is just about up': older adults with multiple chronic conditions reflect on death and dying. *Ageing and Society*, 32(8), 1399–1417. <https://doi.org/10.1017/S0144686X11001061>
- Copp, G. (1998). A review of current theories of death and dying. *Journal of Advanced Nursing*, 28(2), 382–390. <https://doi.org/10.1046/j.1365-2648.1998.00794.x>
- Damianakis, T., & Marzali, E. (2012). Older adults' response to the loss of a spouse: The function of spirituality in understanding the grieving process. *Aging & Mental Health*, 16(1), 57–66. <https://doi.org/10.1080/13607863.2011.609531>
- Dosani, N (2020). Perceptions of palliative care in a South Asian community: findings from an observational study. *BMC Palliat Care*, 19, 141. <https://doi.org/10.1186/s12904-020-00646-6>
- Khan, N. (2024). *Barriers to access palliative care for ethnic minorities, particularly south asians in the UK: A systematic review* [Masters dissertation, University of Wales Trinity Saint David]. Research Repository. <https://repository.uwtd.ac.uk/id/eprint/3275>
- Khosla, N., Washington, K. T., & Regunath, H. (2016). Perspectives of health care providers on US south asians' attitudes toward pain management at end of life. *American Journal of Hospice & Palliative Medicine*, 33(9), 849–857. <https://doi.org/10.1177/1049909115593063>
- Samanta, J., Samanta, A., & Madhloom, O. (2018). A rights-based proposal for managing faith-based values and expectations of migrants at end-of-life illustrated by an empirical study involving south asians in the UK. *Bioethics*, 32(6), 368–377. <https://doi.org/10.1111/bioe.12447>
- Shabnam, J., Timm, H., Nielsen, D. S., & Raunkiaer, M. (2020). Palliative care for older south asian migrants: A systematic review. *Palliative & Supportive Care*, 18(3), 346–358. <https://doi.org/10.1017/S1478951519000397>
- Sharma, R. K., Khosla, N., Tulsy, J. A., Carrese, J. A. (2012). Traditional expectations versus US realities: First- and second-generation asian indian perspectives on end-of-life care. *Journal of General Internal Medicine*, 27, 311–317. <https://doi.org/10.1007/s11606-011-1890-7>

- [10] Singh, P., King-Shier, K., & Sinclair, S. (2020). South Asian patients' perceptions and experiences of compassion in healthcare. *Ethnicity & Health, 25*(4), 606–624. <https://doi.org/10.1080/13557858.2020.1722068>
- [11] Venkatasalu, M. R., Arthur, A., & Seymour, J. (2013). Talking about end-of-life care: the perspectives of older south asians living in east london. *Journal of Research in Nursing, 18*(5), 394-406. <https://doi.org/10.1177/1744987113490712>
- [12] Weerasinghe S. (2023). Inpatient end-of-life care delivery: discordance and concordance analysis of Canadian palliative care professionals' and South Asian family caregivers' perspectives. *Palliative Care and Social Practice, 17*, 1-17. <https://doi.org/10.1177/26323524221145953>
- [13] Weerasinghe, S., & Maddalena, V. (2016). Negotiation, mediation and communication between cultures: End-of-life care for south asian immigrants in canada from the perspective of family caregivers. *Social Work in Public Health, 31*(7), 665–677. <https://doi.org/10.1080/19371918.2015.1137521>
- [14] Yarnell, C. J., Fu, L., Bonares, M. J., Nayfeh, A., & Fowler, R. A. (2020). Association between chinese or south asian ethnicity and end-of-life care in Ontario, Canada. *Canadian Medical Association Journal (CMAJ), 192*(11), E266–E274. <https://doi.org/10.1503/cmaj.190655>

Beyond taste: Multisensory aspects to food enjoyment

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ABSTRACT Our experience with food extends beyond taste alone. All our senses play a part in the enjoyment and perception of food. This narrative review aims to discuss the contributions of orthonasal olfaction, audition, haptics, thermoception, and vision to the multisensory perceptions and enjoyment of food. Smells impact food enjoyment by enhancing specific flavours and triggering appetite. Ambient sounds, as well as sounds made during food consumption, affect the experience and enjoyment of eating. The feeling of food in the mouth, including its spice, contributes to the enhancement of the eating experience. Visual cues such as food arrangement and colour, as well as ambiance, make an important contribution to the aesthetic satisfaction, food preferences, and enjoyment. These senses also interact with each other to create new expectations. For example, scents are perceived more intensely if a beverage is coloured, which in turn affects the perceived intensity of taste. Understanding how senses interact to influence the eating experiences provides valuable insights into what affects food enjoyment.

INTRODUCTION

Food consumption extends far beyond the basic needs of nourishment and satiating hunger. Auditory, olfactory, haptic, and visual cues – stemming from the food itself and from the ambient environment – shape our taste and perception of food through various mechanisms (Figure 1). Here, we review and synthesize insights into the interplay between the multisensory cues of the food experience to highlight how various senses sculpt people's eating behaviours and, ultimately, their culinary satisfaction.

We review how factors other than taste itself affect people's food experience and food choices to gain insight into what impacts food enjoyment and why. Understanding non-taste food enjoyment has the potential to help people who have strict dietary needs, taste deficiencies or psychological challenges around eating.

LITERATURE REVIEW

Olfaction

It is well established that flavour perception involves retronasal and orthonasal olfaction in addition to the true taste sensed by the tongue (Small et al., 2005; Goldberg et al., 2018). Here, we explore how orthonasal cues from both food and the environment contribute to flavour perception.

Odours smelled only through the nose (orthonasally) can affect taste when presented simultaneously with or just prior to consumption (Biswas et al., 2021; Djordjevic et al., 2004; Sakai et al., 2001). Sniffing the smell of strawberries amplifies the perceived sweetness of a sucrose solution (Djordjevic et al., 2004), and the smell of vanilla enhances the sweetness ratings of the artificial sweetener aspartame (Sakai et al., 2001). Exposure to the smell of soy sauce, on the other hand, amplifies the perceived saltiness of the solution, but not its sweetness (Djordjevic et al., 2004). These studies have demonstrated what is known as the amplification effect – congruent smells intensify tastes. The smell-taste alignment can be explained by the close link between olfaction and taste processing in the brain. Olfaction and taste perceptions converge in the orbitofrontal cortex where neurons responding to odours are influenced by previous taste associations (Rolls, 2001). More recently, convergence between olfaction and taste has been found even earlier in processing. Neurons in the primary olfactory cortex respond selectively to taste, which may contribute to the taste qualities associated with smells (Small et al., 2013).

Ambient smells can also lead to sensory-specific appetite, which is a primed desirability of particular foods (Boesveldt & de Graaf, 2017). Participants who were primed for the sweet-

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Figure 1. Multisensory cues affecting taste. Auditory, visual, haptic, and olfactory cues (symbolized by icons) can stem from the environment and the food itself, each influencing the enjoyment of food.

fatty smell of ‘pain au chocolat’ more frequently chose higher-energy desserts such as waffles over low-energy desserts like applesauce (Chambaron et al., 2015). People who smelled savoury odours had an increased appetite for all savoury foods but decreased appetite for sweet foods (Ramaekers et al., 2014). The increase in appetite for particular foods may be the result of smell acting as an early cue for preparing the body for food consumption. Ramaekers et al. (2014) hypothesized that the body prepares to eat certain foods after smelling them while making other foods less appealing. This preparation and expectation for certain flavours may also contribute to the impact on flavour perception.

However, a field study found that participants bought less unhealthy food when they were exposed to scents of indulgent food (cookies) over non-indulgent food (strawberries) for over two minutes (Biswas & Szocs, 2019). These findings suggest that the duration of exposure to the scent is an important factor for sensory-specific appetite. Short-term exposure may amplify desire for certain foods, while prolonged exposure might reduce impulsive food choices, as the smell can satisfy the reward circuitry in the brain (Biswas & Szocs, 2019).

Audition

Similar to olfaction, hearing interacts with taste in two ways: sounds made when consuming food and ambient sounds. The sounds made when consuming food include those from within the mouth when biting and chewing, while ambient sounds include music or other noise from the environment.

Crisp eating sounds can enhance the perceived crispness and freshness of food (Zampini & Spence, 2004). Similarly, loud sounds made when biting apples make them seem crisper (Demattè et al., 2014). Elderly participants rated soft foods as more pleasant and satisfying when they heard crunchier chewing sounds instead of their own soft chewing sounds (Endo et al., 2016). Expectations play a significant role in these effects of sound

on food evaluations (Spence & Shankar, 2010). For example, participants who heard crunchier sounds while eating soft food expected more variety in ingredients, likely contributing to higher ratings for the food (Endo et al., 2016).

Expectations are also created through sounds in the environment. Certain sounds and music are consistently associated with particular tastes, such as sweet and sour for higher-pitched sounds and bitterness for lower-pitched sounds (Table 1) (Crisinel & Spence, 2009; Guedes et al., 2023). Instrumental tones such as brass instruments are associated with a bitter taste and piano instruments with sweet tastes (Guedes et al., 2023). When listening to a bitter soundtrack, participants rated coffee to taste more bitter than when hearing a sweet soundtrack (Crisinel et al., 2012). Creamy music, music with longer flute notes, caused chocolate to taste creamier (Reinoso Carvalho et al., 2017). Ambient noise aside from music or musical tones also affects the taste perception such that expected noise enhances the experience. Chocolate gelato tastes sweeter when accompanied by park or café noise, but more bitter with fast food, bar, or food court noises (Lin et al., 2019). When eating a salad box, the eating experience was rated as more pleasant when the background noise was rated as appropriate, such as hearing cafeteria noise or fast music as opposed to silence or slow music (Mathiesen et al., 2022). Finally, music played just after eating does not affect taste perception, indicating that the sound-taste interaction is likely based on expectation rather than retrospective interpretations (Wang et al., 2020).

Another possible mechanism linking audition with eating experiences is its effect on emotional responses. Pleasurable music may lead to approach behaviours and halo effects on food perception. In support of this notion, neutral and liked songs were related to perceived sweetness, whereas disliked songs were related to bitterness (Kantono et al., 2016). However, contradicting results have also been found, where song preference had no significant interaction effect on perceived sweetness (Reinoso Carvalho et al., 2017).

Moreover, the volume of ambient sound is also important. Loud sounds can make food taste less intense, as participants rate coffee to be less bitter and intense, whereas quieter settings can enhance enjoyment (Bravo-Moncayo et al., 2020). In general, increased sound levels lower the liking for food (Alamir & Hansen, 2021). Loud sounds are believed to lower taste intensity due to its distracting effects (Bravo-Moncayo et al., 2020). However, in direct contradiction, loud sounds have been shown to enhance umami flavours (Yan & Dando, 2015). There may be other mechanisms at play, such as the masking effects of ambient sounds on the sounds made during consumption. Further research is needed to elucidate the mediators between audition and taste.

Haptics and Thermoception

Physical sensations play an important role in the perceived enjoyment and rejection of food. Physical sensations range from the feeling of the food or vessel in one’s hands, to the texture, heat and spice felt in the mouth. In a study with 473 U.S. participants, 94% of individuals reported rejecting a food item due to its texture, a rate comparable to rejection based on flavour (Pellegrino & Luckett, 2020). Common texture-related complaints are related to viscosity (e.g., “slimy”) and hardness (e.g., “mushy”).

Table 1. Flavours and their associated sounds summarized from Guedes et al. (2023) and Reinoso Carvalho et al. (2017).

| Basic Tastes and Select Flavours | Associated Sounds |
|----------------------------------|----------------------------------|
| Sweet | Higher-pitched, Piano |
| Sour | Higher-pitched |
| Salty | Mixed results |
| Umami | Lower-pitched |
| Bitter | Lower-pitched, Brass instruments |
| Creamy | Longer notes, Flute |

Despite high sensitivities to texture, many seek out mild pain sensations when eating. People sometimes eat spicy curry above the pain threshold or sip coffee that is excessively hot. These thermal and irritant qualities originating in the mouth are conveyed to the brain through the trigeminal pathway (Carstens et al., 2002; Spencer & Dalton, 2020), the pain pathway which is typically aversive to humans. Nonetheless, some people develop a preference for spicy food (Spencer & Dalton, 2020). Similarly, the initial aversiveness of carbonated drinks, caused by carbonic acid stimulating trigeminal receptors, can counterintuitively lead to enjoyment once the sensation becomes familiar (Carstens et al., 2002). Further, there are some who enjoy the isolated burning sensation elicited by spice even without the taste (Rozin et al., 1982; Spencer & Dalton, 2020).

While the exact mechanism linking pain to food enjoyment is still unknown, learned associations seem to be a key factor. Indeed, the preference for spicy food is not innate but rather gradually acquired from as young as age of two to nine for children exposed to spices (Rozin & Schiller, 1980). Aside from associating spice with otherwise tasty food, people may be learning the association of chemical irritants like chili peppers to the increased release of endorphins (Spencer & Dalton, 2020). Others also argue that people enjoy the thrilling sensation of constrained risks that come with trigeminally irritating ingredients (Spencer & Dalton, 2020).

However, it is important to note that there are significant individual differences in spice tolerance and surpassing one's threshold is aversive. Supertasters, often known for their higher-than-normal sensitivity toward the taste of food, are more sensitive to irritants, such as spicy or acidic foods such as capsaicin or ethanol. As such, they are less likely to enjoy the sensation (Prescott & Swain-Campbell, 2000).

Finally, the tactile experience of packaging or containers, such as cup material can also affect the enjoyment of a drink (Schifferstein, 2009). Cups that feel strong and pleasant enhance the enjoyment of the drink inside them (Schifferstein, 2009). Cups judged as more pleasurable or soft led to rating the drink as more pleasurable as well, likely due to associations between the vessel and drink. Thus, the haptic properties of food containers play a major role in the evaluation of the food that they contain.

Vision

Visual cues significantly influence taste perception. People quickly recognize food and its visual presentation activates the lateral orbitofrontal cortex, the lateral occipital complex and the middle insular cortex (van der Laan et al., 2011). These brain regions are involved in representing rewards in decision-making, visual

recognition, and food craving (Rolls & Grabenhorst, 2008; van der Laan et al., 2011). The lateral orbitofrontal cortex is directly linked to how pleasant we find food, activating not only during tasting and smelling but also during anticipation (van der Laan et al., 2011).

Two visual factors that impact the evaluation of food are arrangement and colour. The sight of food itself, its immediate surroundings, such as the plate and packaging, and environmental aesthetics all impact food perceptions (Paakki et al., 2019; Ryu & Jang, 2007; Sugimori & Kawasaki, 2022). People perceive neater (Campo et al., 2017; Zellner et al., 2011), art-inspired (Michel et al., 2014, 2015), and visually "more attractive" (Zellner et al., 2014) food as more favourable and enjoyable to consume. This was seen in Michel and et al. (2014) study, where participants rated the artistically presented food as tastier (Figure 2), suggesting that aesthetic presentations of food can enhance not only the overall dining experience but also the perceived flavour of the dish. Preference for certain food arrangements may stem from the perception that neatly arranged food is treated with more care and is, therefore, tastier and less risky to eat (Zellner et al., 2011).

Cultural differences also affect preferences for food presentation. U.S. participants tend to perceive classical plating to be tastier due to the orderliness, while Chinese participants favour expressive plating (see Figure 3) (Liu et al., 2023). In another cross-cultural study, participants in Italy and the US preferred disorganized plating over organized plating (neat and geometric) and casual plating over figurative plating (placed in the shape of a heart or smile), whereas participants in Japan showed no preference (Zampollo, Wansink, et al., 2012). These variations in preferences for food presentation may be due to cultural values and aesthetic principles as the preferences for the US and Italy may reflect a greater appreciation for natural, effortless presentations that align with the cultural ideal of authenticity and informality in dining experiences.

Perceived graspability and proximity of food can also affect our liking due to the embodied mental simulation of eating (Spence et al., 2022). Enhancing graspability refers to displaying food in a way that makes it easier for us to grasp. For example, a sandwich oriented to the right enables right-handed viewers to grasp it with one hand with less effort, which leads to an increased rating of the sandwich due to convenience (Elder & Krishna, 2012). Bringing food closer to the viewer can also make it easier to simulate eating and increase consumers' liking for the food (Chu et al., 2021).



Figure 2. Stimulus used in Michel et al. (2014): (A) Kandinsky painting used as inspiration; (B) Kandinsky-inspired arrangement of a salad; (C) conventional presentation; (D) neat presentation.

Colourfulness, vibrancy, and hue all have effects on food preference. Colourful foods are often preferred for meals. When participants were presented with blurred images of food with varying colours, 90% selected the most colourful or bright dish as the most preferred (Paakki et al., 2019). They frequently attributed their preference to colour rather than the assumed type of food. Adults typically prefer three to four colours per dish, while children preferred six colours (Zampollo, Kniffin, et al., 2012). Furthermore, adults preferred plates with a colour that contrasted with the vegetable item on the plate (Schifferstein et al., 2017), substantiating their preference for vibrant food. Colour impacts food experience by setting expectations for the taste, quality, safety, familiarity, and freshness of food (Paakki et al., 2019). Colour and vibrancy are particularly important for vegetables, as they indicate freshness and quality (Paakki et al., 2019).

However, the effect of colours is more nuanced than vibrancy alone; expectations are also set with surrounding colour. For instance, a dark brown cake on a black plate is perceived as tastier than that on a white plate (Piqueras-Fiszman et al., 2013). Lighter-coloured cakes were generally preferred when presented on white plates. Similarly, bitter chocolate wrapped in black is perceived as more bitter than the same chocolate wrapped in pink (Sugimori & Kawasaki, 2022). Motoki et al. (2021) observed that customers expected a sweet coffee flavour when coffee shops had a reddish and light theme, whereas coffee shops with a greenish and dark theme prompted customers to expect a sour, bitter, or more robust flavour. These examples illustrate that factors such as colour-flavour associations are involved. For instance, black may evoke the idea of intense chocolate, which pairs well with cake.

The aesthetics of the visual environment can also influence the enjoyment and desire for food (Ryu & Han, 2010; Ryu & Jang, 2007; Wu et al., 2022). Elements such as the restaurant's colour scheme, floral arrangements, lighting, music, and plate colour play a crucial role in shaping the enjoyment and desire for the dish. Wu et al. (2022) found that eating in aesthetically pleasing settings boosts satisfaction and enhances our perception of taste and smell. The effects of arrangement and colours on taste perception may arise from the aesthetic satisfaction of the arrangement (Paakki et al., 2019). Wu et al. (2022) specifically demonstrated that emotion acts as a mediator between environmental aesthetics and enjoyment. The combination of environment, plating and food characteristics influences overall enjoyment by shaping the perception of flavour and taste intensity.

Interaction of Sensory Cues

Sensory cues do not affect taste and food preferences in isolation. Different combinations can interact to result in different effects. For instance, smells are affected by visual information. Zellner and Kautz (1990) highlighted this interaction by demonstrating that participants rate the smell of coloured beverages as more intense than the smell of colourless beverages. Another study found that participants used red wine aroma descriptors when evaluating a white wine that was artificially coloured red (Spence, 2015). Furthermore, seeing the food before smelling leads to a more positive experience, including expected and perceived taste, than smelling before seeing the item (Biswas et al., 2021). These findings suggest that smells and visual cues can amplify the perceived smell and subsequently make the taste more enjoyable. This effect is thought to occur because visual cues set expectations that



Figure 3. Different styles of plating food in classical or expressive aesthetic. Stimuli from Liu et al. (2023).

influence sensory processing. When people see food, the brain anticipates its taste and smell, activating neural pathways linked to flavour perception. The combination of vision and smell works together to enhance the sensory richness of food, aligning expectations with reality (Spence, 2015).

Ambient music and visual settings are often combined to create an environmental aesthetic that can influence their impact on food enjoyment. Wansink and van Ittersum (2012) found that bright lights and loud pop music made customers eat faster in a fast food setting and soft lights and quiet jazz caused participants to eat more slowly and less food overall. They also rated the food as more enjoyable. Similarly, Spence et al. (2014) found that different lighting and music influence the taste of wine. Participants consistently reported the highest liking for wine when it was tasted under red lighting accompanied by sweet music, despite rating the wine as more fresh when under green lighting and sour music (Spence et al., 2014). These studies show the importance of the overall environment during consumption in shaping the quality of customers' gastronomic experiences.

CONCLUSION

Olfactory, auditory, haptic, and visual cues influence food enjoyment through various psychological mechanisms. Olfaction significantly influences taste perception, as scents can whet the appetite for congruent foods and impact food choices along with perceived taste. Sounds associated with eating can alter perceptions of texture and flavour, whereas ambient sounds can influence meal enjoyment. Haptic sensations also contribute to food experience as mouthfeel is a primary factor involved in food aversion. Visual cues play an important role in shaping food expectations and preferences. Furthermore, the interplay between lighting and music emerges as a powerful influencer, affecting not only the pace of eating but also the perceived enjoyment of food.

Food enjoyment is important to overall quality of life (Vaudin et al., 2024). Enjoying food can increase quality of life (Vaudin et al., 2024), while diets consisting solely of soft, uniform foods can negatively impact it (Swan et al., 2015). There are also many food-related disorders and health conditions, such as binge eating, extreme dieting, and obesity associated with low quality of life (Kolotkin & Andersen, 2017; Mitchison et al., 2012). While each condition is nuanced, food enjoyment is often associated with healthy eating (Bédard et al., 2020).

Understanding how individuals perceive and enjoy meals can promote healthy relationships with food and is important for

raising overall quality of life. Given the impact of all senses on eating experiences, any deficits or differences in perception are bound to affect food perception. To compensate for this diminished experience, individuals may resort to adding seasoning like salt or sugar to intensify the flavour. In a society facing challenges in promoting healthy eating, it is crucial to explore alternative ways to enhance perceived flavour. For instance, eating in quieter environments or using colours for the packaging or plating that promote the intended flavour can enhance the perceived taste without the need to add sugar or salt.

In conclusion, the research reviewed here underscores the crucial role of multisensory perception in shaping food enjoyment and experience. Every sense contributes to creating cohesive expectations, intensifying flavours, and enhancing the dining experience. The aesthetics of the environment and the food itself strongly influence eating satisfaction. These findings have implications for nutritionists, marketers, and designers who aim to influence food choices and preferences. Future studies on food enjoyment and the associated quality of life should investigate and test solutions to improve individuals' relationships with eating, especially in the context of sensory deficits.

CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

REFERENCES

- [1] Alamir, M. A., & Hansen, K. (2021). The effect of type and level of background noise on food liking: A laboratory non-focused listening test. *Applied Acoustics*, 172, 107600. <https://doi.org/10.1016/j.apacoust.2020.107600>
- [2] Bédard, A., Lamarche, P.-O., Grégoire, L.-M., Trudel-Guy, C., Provencher, V., Desroches, S., & Lemieux, S. (2020). Can eating pleasure be a lever for healthy eating? A systematic scoping review of eating pleasure and its links with dietary behaviors and health. *PLoS ONE*, 15(12), e0244292. <https://doi.org/10.1371/journal.pone.0244292>
- [3] Biswas, D., Labrecque, L. I., & Lehmann, D. R. (2021). Effects of sequential sensory cues on food taste perception: Cross-modal interplay between visual and olfactory stimuli. *Journal of Consumer Psychology*, 31(4), 746–764. <https://doi.org/10.1002/jcpsy.1231>
- [4] Biswas, D., & Szocs, C. (2019). The smell of healthy choices: Cross-modal sensory compensation effects of ambient scent on food purchases. *Journal of Marketing Research*, 56(1), 123–141. <https://doi.org/10.1177/0022243718820585>
- [5] Boesveldt, S., & de Graaf, K. (2017). The differential role of smell and taste for eating behavior. *Perception*, 46(3–4), 307–319. <https://doi.org/10.1177/0301006616685576>
- [6] Bravo-Moncayo, L., Reinoso-Carvalho, F., & Velasco, C. (2020). The effects of noise control in coffee tasting experiences. *Food Quality and Preference*, 86, 104020. <https://doi.org/10.1016/j.foodqual.2020.104020>
- [7] Campo, R., Loporcaro, G., & Baldassarre, F. (2017). The effects of food aesthetics on consumers. Visual stimuli and food marketing. *DIEM: Dubrovnik International Economic Meeting*, 3(1), 553–565.
- [8] Carstens, E., Iodi Carstens, M., Dessirier, J.-M., O'Mahony, M., Simons, C. T., Sudo, M., & Sudo, S. (2002). It hurts so good: Oral irritation by spices and carbonated drinks and the underlying neural mechanisms. *Food Quality and Preference*, 13(7), 431–443. [https://doi.org/10.1016/S0950-3293\(01\)00067-2](https://doi.org/10.1016/S0950-3293(01)00067-2)
- [9] Chambaron, S., Chisin, Q., Chabanet, C., Issanchou, S., & Brand, G. (2015). Impact of olfactory and auditory priming on the attraction to foods with high energy density. *Appetite*, 95, 74–80. <https://doi.org/10.1016/j.appet.2015.06.012>
- [10] Chu, X.-Y. (Marcos), Chang, C.-T., & Lee, A. Y. (2021). Values created from far and near: Influence of spatial distance on brand evaluation. *Journal of Marketing*, 85(6), 162–175. <https://doi.org/10.1177/00222429211000706>
- [11] Crisinel, A.-S., Cosser, S., King, S., Jones, R., Petrie, J., & Spence, C. (2012). A bittersweet symphony: Systematically modulating the taste of food by changing the sonic properties of the soundtrack playing in the background. *Food Quality and Preference*, 24(1), 201–204. <https://doi.org/10.1016/j.foodqual.2011.08.009>
- [12] Crisinel, A.-S., & Spence, C. (2009). Implicit association between basic tastes and pitch. *Neuroscience Letters*, 464(1), 39–42. <https://doi.org/10.1016/j.neulet.2009.08.016>
- [13] Demattè, M. L., Pojer, N., Endrizzi, I., Corollaro, M. L., Betta, E., Aprea, E., Charles, M., Biasioli, F., Zampini, M., & Gasperi, F. (2014). Effects of the sound of the bite on apple perceived crispness and hardness. *Food Quality and Preference*, 38, 58–64. <https://doi.org/10.1016/j.foodqual.2014.05.009>
- [14] Djordjevic, J., Zatorre, R. J., & Jones-Gotman, M. (2004). Odor-induced changes in taste perception. *Experimental Brain Research*, 159(3), 405–408. <https://doi.org/10.1007/s00221-004-2103-y>
- [15] Elder, R. S., & Krishna, A. (2012). The “visual depiction effect” in advertising: Facilitating embodied mental simulation through product orientation. *Journal of Consumer Research*, 38(6), 988–1003. <https://doi.org/10.1086/661531>
- [16] Endo, H., Ino, S., & Fujisaki, W. (2016). The effect of a crunchy pseudo-chewing sound on perceived texture of softened foods. *Physiology & Behavior*, 167, 324–331. <https://doi.org/10.1016/j.physbeh.2016.10.001>
- [17] Goldberg, E. M., Wang, K., Goldberg, J., & Aliani, M. (2018). Factors affecting the ortho- and retronasal perception of flavors: A review. *Critical Reviews in Food Science and Nutrition*, 58(6), 913–923. <https://doi.org/10.1080/10408398.2016.1231167>
- [18] Guedes, D., Vaz Garrido, M., Lamy, E., Pereira Cavalheiro, B., & Prada, M. (2023). Crossmodal interactions between audition and taste: A systematic review and narrative synthesis. *Food Quality and Preference*, 107, 104856. <https://doi.org/10.1016/j.foodqual.2023.104856>
- [19] Kantono, K., Hamid, N., Shepherd, D., Yoo, M. J. Y., Grazioli, G., & Carr, B. T. (2016). Listening to music can influence hedonic and sensory perceptions of gelati. *Appetite*, 100, 244–255. <https://doi.org/10.1016/j.appet.2016.02.143>
- [20] Kolotkin, R. L., & Andersen, J. R. (2017). A systematic review of reviews: Exploring the relationship between obesity, weight loss and health-related quality of life. *Clinical Obesity*, 7(5), 273–289. <https://doi.org/10.1111/cob.12203>
- [21] Lin, Y. H. T., Hamid, N., Shepherd, D., Kantono, K., & Spence, C. (2019). Environmental sounds influence the multisensory perception of chocolate gelati. *Foods*, 8(4), Article 4. <https://doi.org/10.3390/foods8040124>
- [22] Liu, M., Ji, S., Jiang, B., & Huang, J. (2023). Plating for health: A cross-cultural study of the influence of aesthetics characteristics on food evaluation. *International Journal of Gastronomy and Food Science*, 33, 100785. <https://doi.org/10.1016/j.ijgfs.2023.100785>
- [23] Mathiesen, S. L., Hopia, A., Ojansivu, P., Byrne, D. V., & Wang, Q. J. (2022). The sound of silence: Presence and absence of sound affects meal duration and hedonic eating experience. *Appetite*, 174, 106011. <https://doi.org/10.1016/j.appet.2022.106011>
- [24] Michel, C., Velasco, C., Fraemohs, P., & Spence, C. (2015). Studying the impact of plating on ratings of the food served in a naturalistic dining context. *Appetite*, 90, 45–50. <https://doi.org/10.1016/j.appet.2015.02.030>
- [25] Michel, C., Velasco, C., Gatti, E., & Spence, C. (2014). A taste of Kandinsky: Assessing the influence of the artistic visual presentation of food on the dining experience. *Flavour*, 3(1), 7. <https://doi.org/10.1186/2044-7248-3-7>
- [26] Mitchison, D., Hay, P., Slewa-Younan, S., & Mond, J. (2012). Time trends in population prevalence of eating disorder behaviors and their relationship to quality of life. *PLoS ONE*, 7(11), e48450. <https://doi.org/10.1371/journal.pone.0048450>

- 10.1371/journal.pone.0048450
- [27] Motoki, K., Takahashi, A., & Spence, C. (2021). Tasting atmospherics: Taste associations with colour parameters of coffee shop interiors. *Food Quality and Preference*, *94*, 104315. <https://doi.org/10.1016/j.foodqual.2021.104315>
- [28] Paakki, M., Aaltojärvi, I., Sandell, M., & Hopia, A. (2019). The importance of the visual aesthetics of colours in food at a workday lunch. *International Journal of Gastronomy and Food Science*, *16*, 100131. <https://doi.org/10.1016/j.ijgfs.2018.12.001>
- [29] Pellegrino, R., & Luckett, C. R. (2020). Aversive textures and their role in food rejection. *Journal of Texture Studies*, *51*(5), 733–741. <https://doi.org/10.1111/jtxs.12543>
- [30] Piqueras-Fiszman, B., Giboreau, A., & Spence, C. (2013). Assessing the influence of the color of the plate on the perception of a complex food in a restaurant setting. *Flavour*, *2*(1), 24. <https://doi.org/10.1186/2044-7248-2-24>
- [31] Prescott, J., & Swain-Campbell, N. (2000). Responses to repeated oral irritation by capsaicin, cinnamaldehyde and ethanol in PROP tasters and non-tasters. *Chemical Senses*, *25*(3), 239–246. <https://doi.org/10.1093/chemse/25.3.239>
- [32] Ramaekers, M. G., Boesveldt, S., Lakemond, C. M. M., van Boekel, M. a. J. S., & Luning, P. A. (2014). Odors: Appetizing or satiating? Development of appetite during odor exposure over time. *International Journal of Obesity*, *38*(5), Article 5. <https://doi.org/10.1038/ijo.2013.143>
- [33] Reinoso Carvalho, F., Wang, Q. (Janice), van Ee, R., Persoone, D., & Spence, C. (2017). "Smooth operator": Music modulates the perceived creaminess, sweetness, and bitterness of chocolate. *Appetite*, *108*, 383–390. <https://doi.org/10.1016/j.appet.2016.10.026>
- [34] Rolls, E. T. (2001). The rules of formation of the olfactory representations found in the orbitofrontal cortex olfactory areas in primates. *Chemical Senses*, *26*(5), 595–604. <https://doi.org/10.1093/chemse/26.5.595>
- [35] Rolls, E. T., & Grabenhorst, F. (2008). The orbitofrontal cortex and beyond: From affect to decision-making. *Progress in Neurobiology*, *86*(3), 216–244. <https://doi.org/10.1016/j.pneurobio.2008.09.001>
- [36] Rozin, P., Ebert, L., & Schull, J. (1982). Some like it hot: A temporal analysis of hedonic responses to chili pepper. *Appetite*, *3*(1), 13–22. [https://doi.org/10.1016/S0195-6663\(82\)80033-0](https://doi.org/10.1016/S0195-6663(82)80033-0)
- [37] Rozin, P., & Schiller, D. (1980). The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion*, *4*(1), 77–101. <https://doi.org/10.1007/BF00995932>
- [38] Ryu, K., & Han, H. (2010). Influence of the quality of food, service, and physical environment on customer satisfaction and behavioral intention in quick-casual restaurants: Moderating role of perceived price. *Journal of Hospitality & Tourism Research*, *34*(3), 310–329. <https://doi.org/10.1177/1096348009350624>
- [39] Ryu, K., & Jang, S. S. (2007). The effect of environmental perceptions on behavioral intentions through emotions: The case of upscale restaurants. *Journal of Hospitality & Tourism Research*, *31*(1), 56–72. <https://doi.org/10.1177/1096348006295506>
- [40] Sakai, N., Kobayakawa, T., Gotow, N., Saito, S., & Imada, S. (2001). Enhancement of sweetness ratings of aspartame by a vanilla odor presented either by orthonasal or retronasal routes. *Perceptual and Motor Skills*, *92*(3_suppl), 1002–1008. <https://doi.org/10.2466/pms.2001.92.3c.1002>
- [41] Schifferstein, H. N. J. (2009). The drinking experience: Cup or content? *Food Quality and Preference*, *20*(3), 268–276. <https://doi.org/10.1016/j.foodqual.2008.11.003>
- [42] Schifferstein, H. N. J., Howell, B. F., & Pont, S. C. (2017). Colored backgrounds affect the attractiveness of fresh produce, but not its perceived color. *Food Quality and Preference*, *56*, 173–180. <https://doi.org/10.1016/j.foodqual.2016.10.011>
- [43] Small, D. M., Gerber, J. C., Mak, Y. E., & Hummel, T. (2005). Differential neural responses evoked by orthonasal versus retronasal odorant perception in humans. *Neuron*, *47*(4), 593–605. <https://doi.org/10.1016/j.neuron.2005.07.022>
- [44] Small, D. M., Veldhuizen, M. G., & Green, B. (2013). Sensory neuroscience: Taste responses in primary olfactory cortex. *Current Biology*, *23*(4), R157–R159. <https://doi.org/10.1016/j.cub.2012.12.036>
- [45] Spence, C. (2015). On the psychological impact of food colour. *Flavour*, *4*(1), 21. <https://doi.org/10.1186/s13411-015-0031-3>
- [46] Spence, C., Motoki, K., & Petit, O. (2022). Factors influencing the visual deliciousness / eye-appeal of food. *Food Quality and Preference*, *102*, 104672. <https://doi.org/10.1016/j.foodqual.2022.104672>
- [47] Spence, C., & Shankar, M. U. (2010). The influence of auditory cues on the perception of, and responses to, food and drink. *Journal of Sensory Studies*, *25*(3), 406–430. <https://doi.org/10.1111/j.1745-459x.2009.00267.x>
- [48] Spence, C., Velasco, C., & Knoeferle, K. (2014). A large sample study on the influence of the multisensory environment on the wine drinking experience. *Flavour*, *3*(1), 8. <https://doi.org/10.1186/2044-7248-3-8>
- [49] Spencer, M., & Dalton, P. (2020). The third dimension of flavor: A chemesthetic approach to healthier eating (a review). *Journal of Sensory Studies*, *35*(2), e12551. <https://doi.org/10.1111/joss.12551>
- [50] Sugimori, E., & Kawasaki, Y. (2022). Cross-modal correspondence between visual information and taste perception of bitter foods and drinks. *Food Quality and Preference*, *98*, 104539-. <https://doi.org/10.1016/j.foodqual.2022.104539>
- [51] Swan, K., Speyer, R., Heijnen, B. J., Wagg, B., & Cordier, R. (2015). Living with oropharyngeal dysphagia: Effects of bolus modification on health-related quality of life—a systematic review. *Quality of Life Research*, *24*(10), 2447–2456. <https://doi.org/10.1007/s11136-015-0990-y>
- [52] van der Laan, L. N., de Ridder, D. T. D., Viergever, M. A., & Smeets, P. A. M. (2011). The first taste is always with the eyes: A meta-analysis on the neural correlates of processing visual food cues. *NeuroImage (Orlando, Fla.)*, *55*(1), 296–303. <https://doi.org/10.1016/j.neuroimage.2010.11.055>
- [53] Vaudin, A., Dean, W., & Sahyoun, N. (2024). Quality of Life and the Role of Food and Eating as Described by Community-Dwelling Older Adults. *Journal of Nutrition in Gerontology and Geriatrics*, *43*(1), 14–35. <https://doi.org/10.1080/21551197.2023.2269118>
- [54] Wang, Q. J., Spence, C., & Knoeferle, K. (2020). Timing is everything: Onset timing moderates the crossmodal influence of background sound on taste perception. *Journal of Experimental Psychology: Human Perception and Performance*, *46*(10), 1118–1126. <https://doi.org/10.1037/xhp0000820>
- [55] Wansink, B., & van Ittersum, K. (2012). Fast food restaurant lighting and music can reduce calorie intake and increase satisfaction. *Psychological Reports*, *111*(1), 228–232. <https://doi.org/10.2466/01.PRO.111.4.228-232>
- [56] Wu, C., Zhu, H., Huang, C., Liang, X., Zhao, K., Zhang, S., He, M., Zhang, W., & He, X. (2022). Does a beautiful environment make food better—The effect of environmental aesthetics on food perception and eating intention. *Appetite*, *175*, 106076–106076. <https://doi.org/10.1016/j.appet.2022.106076>
- [57] Yan, K. S., & Dando, R. (2015). A crossmodal role for audition in taste perception. *Journal of Experimental Psychology: Human Perception and Performance*, *41*(3), 590–596. <https://doi.org/10.1037/xhp0000044>
- [58] Zampini, M., & Spence, C. (2004). The role of auditory cues in modulating the perceived crispness and staleness of potato chips. *Journal of Sensory Studies*, *19*(5), 347–363. <https://doi.org/10.1111/j.1745-459x.2004.080403.x>
- [59] Zampollo, F., Kniffin, K. M., Wansink, B., & Shimizu, M. (2012). Food plating preferences of children: The importance of presentation on desire for diversity. *Acta Paediatrica*, *101*(1), 61–66. <https://doi.org/10.1111/j.1651-2227.2011.02409.x>
- [60] Zampollo, F., Wansink, B., Kniffin, K. M., Shimizu, M., & Omori, A. (2012). Looks good enough to eat: How food plating preferences differ across cultures and continents. *Cross-Cultural Research*, *46*(1), 31–49. <https://doi.org/10.1177/1069397111418428>
- [61] Zellner, D. A., & Kautz, M. A. (1990). Color affects perceived odor intensity. *Journal of Experimental Psychology: Human Perception and Performance*, *16*(2), 391–397. <https://doi.org/10.1037/0096-1523.16.2.391>
- [62] Zellner, D. A., Loss, C. R., Zearfoss, J., & Remolina, S. (2014). It tastes as good as it looks! The effect of food presentation on liking for the flavor of food. *Appetite*, *77*, 31–35. <https://doi.org/10.1016/>

j.appet.2014.02.009

- [63] Zellner, D. A., Siemers, E., Teran, V., Conroy, R., Lankford, M., Agraftotis, A., Ambrose, L., & Locher, P. (2011). Neatness counts. How plating affects liking for the taste of food. *Appetite*, 57(3), 642–648. <https://doi.org/10.1016/j.appet.2011.08.004>