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LUMINOUS INSIGHTS

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Research Article

Viral Viruses and Modified Mobility: Cyberspace Disease Salience Predicts Human Movement Patterns

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ABSTRACT
Humans have a motivational system that influences cognition and behavior to minimize the risk of contact with pathogens. This research examines the relationship between cyberspace disease salience and mobility behavior at the macro and micro levels. Across two studies, we predict and find that people adjust their mobility behavior to minimize the risk of close physical contact with strangers when cyberspace disease salience is high (vs. low). In Study 1, we analyze hourly sales data from five grocery stores and find that when cyberspace disease salience is high (vs. low), consumers spend 28% more money on each shopping trip and grocery stores sell 10% more items per hour despite 10% fewer shoppers per hour. Further, in Study 2, we test the generalizability of these results by analyzing the Google Community Mobility Reports. Here we find that high (vs. low) cyberspace disease salience is associated with an overall decrease in mobility in contexts where the risk of close contact with strangers is high—but not low. We discuss these findings in the context of sustainable consumer (mobility) behavior.

KEYWORDS
cyberspace, pathogens, disease, behavioral immune system, mobility, sustainable consumer behavior

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1. Introduction

Consumer behavior has been recognized in the Sustainable Development Goals formulated by the United Nations (UN, 2017). One group of such behaviors that are relevant in the context of sustainable development is consumer mobility. For example, someone who goes to the supermarket three times a week burns more fossil fuels related to their shopping behavior than someone who shops only once a week. Consumer mobility behavior is so critical to meeting the sustainable development agenda that car abandonment has been recognized as one of the most effective behavioral changes consumers can make to mitigate climate change (Wynes & Nicholas, 2017). Indeed, actions taken by many governments to slow the spread of the COVID-19 pandemic, which reduced human mobility, have resulted in improved water quality, cleaner air, and the reclamation of land for wildlife (Arora et al., 2020). Such disruptions in mobility patterns lead some consumers to change

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their mobility behavior over the long term, which has significant positive implications for sustainable transportation (Moser et al., 2018). The current research investigates how consumers' mobility patterns, and thus the environmental footprint associated with their shopping behavior, changed at times when shoppers were extensively informed about the spread of the pandemic.

The relevant marketing literature has previously focused on consumers' mobility characteristics, such as their supermarket shopping trips in relation to their choice of carrying equipment (Larsen et al., 2020), the influence of the physical distance of sales staff from consumers and their purchase responses (Otterbring et al., 2022), the relationship between in-store crowding and consumption-related outcomes (Aydinli et al., 2021; Blut & Iyer, 2020), and the effects of long-distance geographic mobility as well as mobility constraints on purchasing behavior (Andreasen, 1966; Lumpkin & Hunt, 1989). Less attention has been paid to predictors of consumer mobility behavior in the context of sustainability, although some notable exceptions exist. For example, consumers' intentions to use travel services to minimize the negative environmental footprint of their mobility are higher when they perceive such services as easier to use and useful (Mola et al., 2020). Consumers' concerns about the environmental footprint of their mobility choices are also positively related to their preference for green transportation alternatives; safety concerns and the desire for independence and flexibility in mobility choices are positively associated with some forms of green transportation (Herberz et al., 2020).

Notably, the COVID-19 pandemic has influenced consumers' mobility patterns. For example, Ma (2022) found that the level of concern about COVID-19, as reflected by the number of online searches for terms related to coronavirus, was positively related to the amount of time people spent at home (rather than outdoors). This effect was more pronounced in areas historically affected by infectious diseases (Ma, 2022). In China, the use of bike-sharing services increased after the pandemic outbreak, while the use of car hailing services decreased, such that consumers made more sustainable transportation choices during the pandemic than under normal conditions (Hu & Creutzig, 2022). Consumers who were asked to imagine traveling during the pandemic rated restaurants and travel activities more negatively under crowded conditions (i.e., when there are many visitors/guests) than under uncrowded conditions (i.e., when there are few/no visitors/guests; Park et al., 2021). Similarly, asking consumers to think about germs increased their preference for empty versus crowded stores and rooms (Wang & Ackerman, 2019).

All in all, it is plausible that the current pandemic and associated changes in mobility behaviors are related to consumers' sustainable mobility behaviors (e.g., less unnecessary shopping trips) and other daily activities. However, to our knowledge, there are no studies in the field of marketing that analyze changes in consumer mobility behavior at the micro and macro levels. In what follows, we develop a framework to examine how cyberspace disease salience relates to macro and micro-level mobility patterns among consumers. Most existing studies on related topics focus primarily on the relationship between mobility patterns, typically measured using cell phone data, and SARS-CoV-2 transmission and adherence to preventive measures to slow the spread of the virus (Levin et al., 2021; Nouvellet et al., 2021; Van Bavel et al., 2022). These data, often aggregated at the country level, are insufficient to examine people's mobility behavior at the micro-level. Other studies exploring how disease salience affects micro-level mobility show that disease salience is positively related to increased interpersonal and psychological distance preferences, understood as contact comfort, especially with strangers (Tybur et al., 2020; Welsch et al., 2021). However, these studies generally rely on self-reported tendencies without analyzing actual micro-level mobility behavior in particular locations, thus limiting the ecological validity of their findings (Dolinski, 2018; Nisbett & Wilson, 1977; Otterbring et al., 2020).

Building on the behavioral immune system framework (Murray & Schaller, 2016; Schaller & Park, 2011; Tybur & Lieberman, 2016), we propose that people extensively exposed to disease-related content in cyberspace adjust their mobility behavior to minimize the risk of close physical encounters with strangers. They should do this by limiting visits to places where proximity to strangers is relatively difficult to avoid but not to places where proximity to strangers is easy to avoid. For instance, grocery stores generally pose a high risk of close contact with others because they are designed so that most customer traffic occurs in a relatively small portion of the store's total space (Hui et al., 2009; Larsen et al., 2020; Larson et al., 2005; Sorensen et al., 2017). The greater the number of customers entering a store at a given time, the greater the risk.

Our work has three overarching goals: (a) to identify periods when disease salience is highest in cyberspace; (b) to examine micro-level mobility behavior in grocery stores when cyberspace disease salience is high compared to low; and (c) to examine macro-level mobility behavior in different locations when cyberspace disease salience is high compared to low.

We address these objectives in three studies. In Study S1 (seeAppendix A), we use Google Trends to identify the periods with the highest and lowest disease salience in cyberspace in the first half of 2020, i.e., the periods with the highest and lowest presence and interest in content related to the coronavirus. In Study 1, we analyze hourly data from five grocery stores in Norway over these periods, including the value of the average shopping cart, the average number of items sold per hour, and the average number of shoppers per hour. In Study 2, we use the Google Community Mobility Reports (movement trends), which are based on cell phone location history, and analyze mobility in six types of locations in selected European countries during these periods.

We restrict our analysis to European countries for several reasons. We seek to make meaningful comparisons of mobility behavior at the macro and micro levels simultaneously during relatively high and low cyberspace disease salience. To this end, our micro-level mobility data (Study 1) should be temporally and spatially aligned with the macro-level mobility data (Study 2). The micro-level data came from grocery stores in Norway, and this country coordinated its response to the COVID-19 pandemic with many other European countries. In fact, the timing of specific pandemic containment measures—an indicator of cyberspace disease salience—was relatively uniform across Europe in the early stages of the COVID-19 outbreak, as the European Council and the World Health Organization (WHO) largely influenced national policies across the continent.

Our results show a consistent micro-level mobility pattern across five grocery stores: customers spend an average of 28% more money during a single shopping trip when cyberspace disease salience is high (vs. low), and stores sell 10% more items per hour even though the number of customers is 10% lower under these circumstances. This tendency among people to avoid close physical encounters with others during high (vs. low) disease salience can be generalized to macro-level mobility patterns across Europe, with mobility vastly decreasing under conditions of high (vs. low) cyberspace disease salience in all but residential areas, characterized by increasing mobility at that time. This finding suggests that when cyberspace disease salience is high (vs. low), people tend to avoid places where the risk of close contact with strangers is high (vs. low), but they compensate for this decrease in mobility by increasing their presence in places where the risk of such contact is low (vs. high).

Compared to existing studies, which often focus only on macro-level mobility behavior during the pandemic or on self-reported preferences for spatial proximity to others, we find similar mobility patterns at both levels of analysis. To our knowledge, this study is the first to examine hourly shopping data from brick-and-mortar grocery stores during the pandemic. Our study, inspired by research on the behavioral immune system (Murray & Schaller, 2016; Schaller & Park, 2011; Tybur & Lieberman, 2016), may partially explain why Americans increasingly preferred to live in larger homes farther from urban centers after the pandemic outbreak (Gómez, 2021). These results also contribute to research on food waste and sustainable travel behaviors and raise questions about how cyberspace content may affect the economic viability of retail stores during the spread of infectious diseases.

2. Theoretical Background

Mobility is an essential aspect of human behavior. Every day, billions of people around the world commute to their jobs, parks, and shopping malls. When commuting between locations, people choose the mode of transportation and the time when they travel. For example, those with flexible work schedules can choose to travel to the office before or during rush hour. Similarly, people can choose to visit grocery stores during rush hour and thus join the crowds or postpone their shopping to another day or time to avoid the crowds.

The COVID-19 pandemic has prompted governments around the world to impose lockdowns to contain the spread of the virus, leading to a macro-level decrease in overall mobility (Nouvellet et al., 2021). This decrease in mobility was particularly pronounced in areas historically affected by infectious diseases and was positively associated with online searches for pandemic-related content—an indicator of people's concerns about the disease (Ma, 2022). However, the decline in mobility was unequal depending on the type of mobility behavior. For example, Abu-Rayash and Dincer (2020) examined the change in mobility between the pre-pandemic period (December 2019) and during the first months of the pandemic (January 2020 to April 2020). They found that civilian and military mobility decreased by 20 to 76 percent after the pandemic outbreak. However, private and other mobility declined by only 6 percent, suggesting that people selectively adjusted their mobility patterns during the pandemic.

Apart from the obvious reasons for this decline, such as the need to work from home and partial lockdowns, fear of COVID-19 was also positively related to a macro-level decline in mobility, at least that captured by self-reported measures (Borkowski et al., 2021). Another line of research focuses on the impact of disease salience on micro-level aspects of mobility behavior, emphasizing changes in preferred interpersonal distances. Although these preferences are culturally determined and depend on demographic variables such as sex and age (Sorokowska et al., 2021, 2017), when people interact with strangers, they typically maintain between 75 to 125 centimeters of distance while preferring lower physical distances to acquaintances and even closer distances in intimate relationships. However, disease salience can also influence interpersonal distance preferences (Otterbring et al., 2021; Roggeveen & Sethuraman, 2020). Indeed, after the pandemic outbreak, people's preferred interpersonal distances swung with the number of infections but remained higher than pre-pandemic levels during periods of low infection rates (Welsch et al., 2021). This tendency to avoid close physical contact with people also applies to objects. For example, after the pandemic outbreak, people were less likely to touch fresh fruits and vegetables when shopping and showed a lower preference for cash payments, while the preference for contactless payment methods increased (Otterbring & Bhatnagar, 2022). All in all, as a result of the pandemic, consumers are likely to prefer a greater distance from service staff and other customers and expect people to respect their personal space (Otterbring, 2022).

3. Hypothesis Development

We propose that shifts in mobility patterns at both the micro and macro levels can be explained in part through the lens of the behavioral immune system (Murray & Schaller, 2016; Schaller & Park, 2011; Tybur & Lieberman, 2016). According to this framework, humans have a motivational immune system that influences their cognition and behavior to minimize the risk of contact with pathogens once environmental cues to those pathogens are present and recognized (Ackerman et al., 2018). Such avoidance of contact with pathogens, which can be achieved, for example, by avoiding physical proximity to others who appear to be infected, provides adaptive benefits because contact with pathogens is risky and requires activation of the somatic immune system that is energetically costly (Van Leeuwen & Petersen, 2018). Related research on the effects of (pathogen) disgust has been applied to various marketing domains, such as consumer food preferences (Siegrist & Hartmann, 2020), attitudes toward advertising (Dens et al., 2008), the effects of perceived product contagion on its evaluation (Morales & Fitzsimons, 2007), and the effect of fear appeals on message persuasion and compliance (Morales et al., 2012). In the context of the pandemic, research has shown that activation of the behavioral immune system is positively related to a preference for greater interpersonal distance and negative emotions toward strangers, as well as a lower frequency of interpersonal contact (Hromatko et al., 2021). Crucially, however, people's comfort with infection-risky contact with others depends on the value they place on a target. In the context of our research, it is important to note that people feel most comfortable with infection-risky contact with romantic partners, followed by friends, acquaintances, and strangers, respectively (Tybur et al., 2020).

Based on this framework, we draw two primary predictions. First, in times of high (vs. low) cyberspace disease salience, people should adjust their shopping behavior to minimize the risk of close contact with strangers so that they make more purchases during a single shopping trip and therefore visit grocery stores less frequently. Second, during periods of high (vs. low) cyberspace disease salience, people's mobility should vary in different areas depending on the risk of coming into close physical contact with strangers in those areas. For example, at bus stations or shopping malls, a person mainly encounters strangers. In residential areas, on the other hand, the same person interacts mainly with family, friends, and acquaintances. Therefore, we should observe a decrease in mobility in the former but not in the latter areas.

4. Study 1

In Study 1, we test the prediction that when cyberspace salience is high (vs. low), people adjust their mobility behavior to minimize the risk of close physical encounters with strangers. Studying consumer shopping behavior in grocery stores, where some degree of physical contact with strangers is inevitable due to the nature of their shared environment (many people touch products while selecting them, and aisles between shelves are sometimes narrow), provides a perfect opportunity to test our prediction under ecologically valid conditions. Therefore, in Study 1, we examine whether consumer shopping behavior changes when cyberspace disease salience is high (vs. low), such that the frequency of physical contact with strangers decreases, thus reducing the risk of pathogen exposure.

4.1. Method

Data: The data for Study 1 came from five grocery stores in Norway belonging to Coop Norge SA—one of the leading grocery retailers in the country. These stores were located in three municipalities that are in the northern part of Norway. None of these grocery stores were closed during the period studied herein. The units of analysis in Study 1 were 11,055 hourly sales data points that represented the following dependent variables: the average size of the shopping basket in Norwegian kroner (1 NOK = 0.11 USD), the average number of items sold per hour, and the average number of shoppers per hour. Additionally, we collected the following variables: store code (1–5), date (from January 2 to June 20, 2020), and time (stores were open between 7:00 and 23:00; sales data at, for example, 22:44 were coded as 22, so this variable ranged from 7 to 22). To remain consistent, we split these data in the same manner as in the study available in the Appendix, such that the high cyberspace disease salience period ranged from March 12 to May 6, 2020, whereas data before and after this period were coded as low in cyberspace disease salience (Boyle et al., 2022; Ma, 2022).

4.2. Results and Discussion

We fit linear mixed models to our data using the lme4 package for R (Bates et al., 2015) and obtained p-values with the lmerTest package (Kuznetsova et al., 2017). As a predictor (fixed effect), we added cyberspace disease salience to the model, coded as "high" (March 12–May 6, 2020) or "low" (February 15–March 11 and May 7–June 20, 2020). Considering that it was expected that shopping activities differed depending on the characteristics (e.g., size) of a given grocery store and date (e.g., a day preceding an important sports event), we allowed (random) intercepts to vary across stores (coded as 1–5) and dates (coded as date ranging from January 2 to June 20, 2020). The exclusion of outliers, defined as data points exceeding 1.5 $\times$ interquartile range above the third and below the first quartile (Van Den Bergh et al., 2008; Tybur & Lieberman, 2016), did not change the nature or significance of our results. Figure 1 shows hourly changes in shopping behavior during periods of high and low cyberspace disease salience, respectively, with data divided into peak hours (eight hours in the middle of the day with the highest sales) and off-peak hours (four first and four last opening hours) for illustrative purposes. According to the estimates of our model, the average basket size increased by NOK 78.59, or USD 8.75, when cyberspace disease salience was high relative to low (b = 78.59, SE = 7.76, t = 10.12, p < .001). Similarly, when cyberspace disease salience was high (vs. low), there were on average 78 more items sold per hour (b = 77.82, SE = 37.78, t = 2.06, p = .041). Finally, when cyberspace disease salience was high (vs. low), there were on average eight fewer shoppers in grocery stores per hour (b = -8.18, SE = 2.12, t = -3.85, p < .001).

We performed additional analyzes by including the average number of shoppers per hour (i.e., store crowding, which is a proxy measure for peak vs. off-peak shopping hours) in the interaction term with cyberspace disease salience. Below, we report standardized regression coefficients for readability. This analysis revealed a significant interaction between cyberspace disease salienc e and the number of hourly shoppers on the average basket size (β = .11, SE = .01, t = 9.75, p < .001), such that the slope of the number of hourly shoppers was steeper for high (vs. low) cyberspace disease salience (see Figure 2 , left panel). We decomposed this interaction to understand its nature using the package interactions for R (Long, 2019). Here we examined the conditional effects of cyberspace disease salience on the average basket size at the three levels of the moderator (the average number of shoppers per hour or store crowding), i.e., low (M -1 SD = 15 shoppers), medium (M = 73 shoppers), and high (M +1 SD = 131 shoppers). We found that the effects of cyberspace disease salience were significant at low (β = .46, SE = .05, 95% CI [.35, .56]), medium (β = .57, SE = .05, 95% CI [.47, .67]), and high (β = .68, SE = .05, 95% CI [.58, .79]) levels of the moderator. Importantly, the confidence intervals around the slopes of cyberspace disease salience

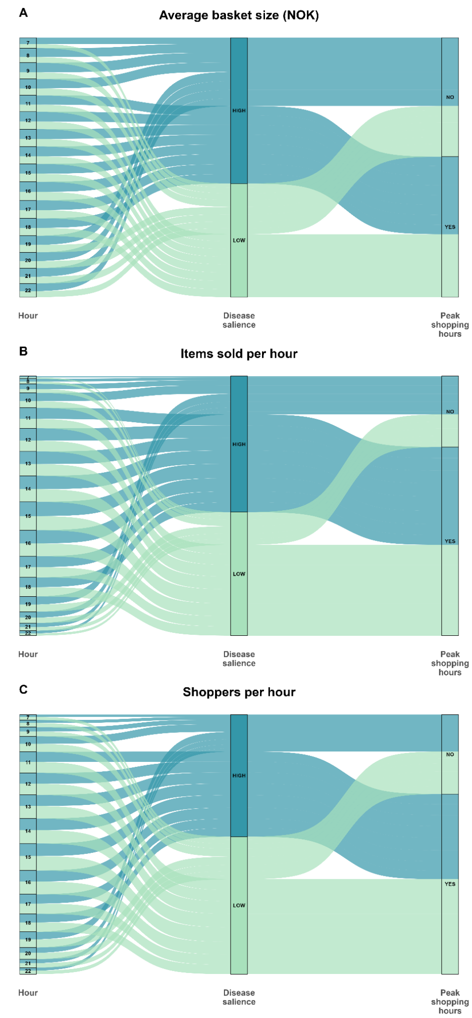

Figure 1. Shopping activities plotted by hour

Note. The alluvial plots show hourly shopping activities in five grocery stores in Norway in 2020, separately for the two periods coded as high (March 12–June 6) and low (January 2–March 11 and May 7–June 20) cyberspace disease salience. The eight hours with the highest average number of shoppers per hour were coded as peak (yes = 11:00–18:59), whereas the remaining eight hours were coded as off-peak hours (no = 07:00–10:59 and 19:00–22:59). The size of stack bars corresponds to the mean values belonging to each category. The size of the segments corresponds to the mean values belonging to the category matching these segments. For example, a higher "Disease salience" bar in the "A" panel indicates that the average basket size was higher during a high (vs. low) disease salience. Likewise, a higher bar in the "C" panel marked as "15" compared to the bar marked as "7" means that there were considerably more shoppers in the grocery stores per hour between 15:00–15:59 than between 7:00–7:59.

between the low and high levels of the moderator did not overlap, suggesting that our focal effect was stronger in highly crowded stores than in stores visited by relatively few customers per hour.

We repeated this analysis for the second dependent measure—the average number of items sold per hour—and again found a significant interaction (β = .24, SE = .01, t = 31.62, p < .001), indicating a steeper slope of the number of hourly shoppers on the average number of items sold per hour at high (vs. low) cyberspace disease salience. The conditional effects of cyberspace disease salience on the average number of items sold per hour were not significant at low values of the moderator (β = -.03, SE = .03, 95% CI [-.09, .03]) but were significant at medium (β = .21, SE = .03, 95% CI [.15, .26]) and high values (β = .44, SE = .03, 95% CI [.39, .50]). Again, the confidence intervals around the slopes of cyberspace disease salience between the medium and high levels of the moderator did not overlap, suggesting that the effect was stronger in highly crowded stores than in moderately crowded stores.

Finally, we investigated how many consumers per hour on average had to be present in stores for the effect of cyberspace disease salience to occur. We calculated Johnson-Neyman intervals and found that the effect of cyberspace disease salience on the average number of items sold per hour occurred only in moderately to heavily crowded stores when there were more than 36 shoppers per hour (-0.6 SD below the mean of the number of hourly shoppers; see Figure 2, right panel). Our results suggest that, on average, consumers bought more during a single shopping trip when cyberspace disease salience was high (vs. low), as indicated by the larger average basket size and the higher average number of items sold per hour. The opposite was true for the average number of shoppers—there were fewer shoppers per hour when cyberspace disease salience was high (vs. low). In addition, we found a significant interaction effect between cyberspace disease salience and the average number of shoppers per hour on the average size and the number of items sold per hour, as evidenced by steeper slopes in the high (vs. low) cyberspace disease salience period (see Figure 2). Specifically, when stores were more (vs. less) crowded, the effect of cyberspace disease salience on the average basket size and the average number of items sold per hour was stronger (vs. weaker). However, in terms of the average number of items sold per hour, the effect of cyberspace disease salience occurred only in moderately to heavily crowded stores that had more than 36 shoppers per hour on average. Together, these findings suggest that consumers purchased more in crowded stores to "buy their way out" of close physical contact with others, with this effect being particularly pronounced under conditions of cyberspace disease salience (cf. Otterbring et al., 2022 ; Otterbring et al., 2021).

Whereas Figure 1 may suggest relatively weak effect sizes, the average basket size was 28% larger during high (M = NOK 356, or USD 40) than during low cyberspace disease salience (M = NOK 278, or USD 31). We observed smaller differences in the average number of items sold per hour. The stores sold about 10% more items per hour during the high cyberspace disease salience period (M = 818) than during the low cyberspace disease salience period (M = 743). There were also 10% fewer shoppers per hour during high (M = 67) than during low (M = 75) cyberspace disease salience. Nevertheless, by multiplying our monetary results by the number of consumers in the stores during our studied periods, the managerial relevance of the current findings should become obvious (Funder & Ozer, 2019; Götz et al., 2022; Otterbring & Folwarczny, 2022; Otterbring et al., 2022). Together, our results support the notion that high (vs. low) cyberspace disease salience prompts people to minimize close physical contact with strangers.

5. Study 2

Although Study 1 shows that people exposed to high (vs. low) cyberspace disease salience adjust their mobility behaviors at the micro-level in a way that minimized the frequency of interpersonal contact, it is unknown whether these effects translate to macro-level mobility patterns. Additionally, it is unclear whether this effect occurs in all areas or only in areas with relatively high (vs. low) risk of close physical contact with strangers (vs. friends or acquaintances). Previous

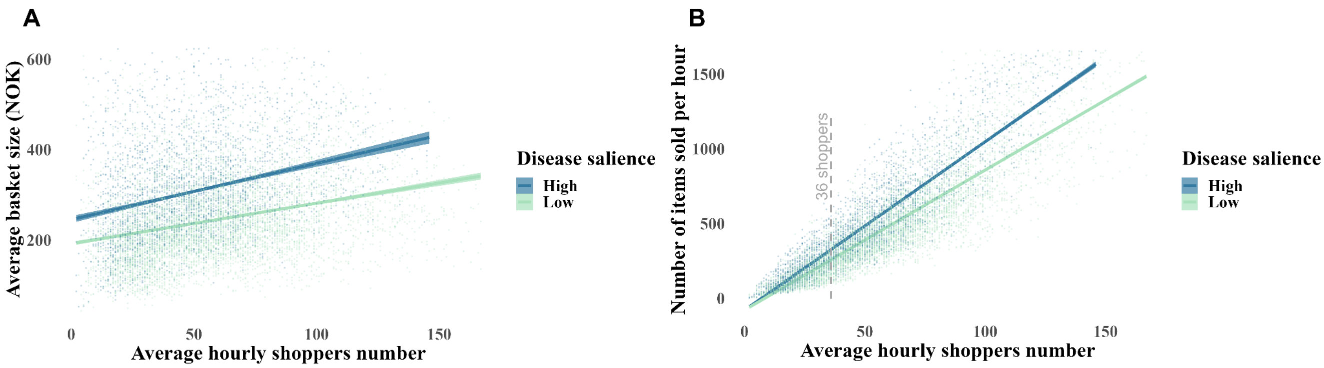

Figure 2. Interactional effect of cyberspace disease salience × the number of hourly shoppers on the two dependent measures

Note. The scatter plot excludes outliers, that is, data points exceeding 1.5 × interquartile range above the third and below the first quartile. The shaded areas around the regression slopes depict 95% confidence intervals.

research has shown that people are more likely to engage in infection-risky behavior when in contact with romantic partners, followed by friends, acquaintances, and strangers (Tybur et al., 2020). Therefore, it is plausible that in residential areas—where people interact predominantly with non-strangers—the effects of disease salience on mobility behavior will not occur or even become reversed. Study 2 examined this possibility.

5.1. Method

Data. We used the Google Community Mobility Reports as our primary data source in Study 2 (Sparks et al., 2022). These publicly available data, consisting of mobility patterns in most regions of the world, were collected from users who shared their location history with Google (for details, see https://www.google.com/covid19/mobility/). By default, Google grouped mobility patterns into six categories: retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential areas. Median daily traffic for the period January 3 to February 6, 2020, was used as the baseline. Thus, positive (negative) values, expressed as percentages, indicate a relative increase (decrease) in mobility in an area on a given day.

We divided the data into two time periods following criteria from the previous studies. The high cyberspace disease salience period for the selected European countries ranged from March 12 until May 6, 2020. From February 15 until March 11 (mobility data reported by Google for Norway begin on February 15, 2020) and from May 7 until June 20, 2020, data were coded as low cyberspace disease salience.

5.2. Results and Discussion

We followed a similar analytic approach as that of Study 1, except for random effects. Because the Google Community Mobility Reports data were nested within countries and we expected the effects of cyberspace disease salience to vary across countries, we added random intercepts for countries and by-country random slopes for the effects of cyberspace disease salience on the dependent variable.

As depicted in Figure 3, during high (vs. low) pathogens salience, mobility decreased in the following five areas: retail and recreation ($b = -43.30$, $SE = 2.10$, $t = -20.66$, $p < .001$), grocery and pharmacy ($b = -22.38$, $SE = 1.66$, $t = -13.50$, $p < .001$), parks ($b = -34.63$, $SE = 4.16$, $t = -8.33$, $p < .001$), transit stations ($b = -35.29$, $SE = 1.58$, $t = -22.34$, $p < .001$), and workplaces ($b = -28.96$, $SE = 1.31$, $t = -22.09$, $p < .001$). In contrast, we found increased mobility in residential areas ($b = 12.62$, $SE = 0.60$, $t = 31.09$, $p < .001$).

We performed similar analyses with simple linear models separately for Norway. Replicating the pattern of findings from other countries, during high (vs. low) pathogens salience, mobility in Norway decreased in retail and recreation ($b = -32.19$, $SE = 0.50$, $t = -64.10$, $p < .001$), grocery and pharmacy ($b = -15.31$, $SE = 0.63$, $t = -24.34$, $p < .001$), parks ($b = -12.97$, $SE = 2.82$, $t = -4.60$, $p < .001$), transit stations ($b = -27.91$, $SE = 0.53$, $t = -52.74$, $p < .001$), and workplaces ($b = -27.25$, $SE = 0.29$, $t = -92.91$, $p < .001$). However, mobility increased in residential areas ($b = 11.48$, $SE = 0.15$, $t = 77.51$, $p < .001$).

Consistent with our theorizing, the results of Study 2 suggest that high (vs. low) cyberspace disease salience is negatively associated with mobility in places where the risk of close physical contact with strangers is relatively high. However, high (vs. low) cyberspace disease salience is positively related to mobility in places where the risk of close physical contact with strangers is relatively low (i.e., residential areas). In other words, cyberspace disease salience appears to be negatively associated with preferences for places full of strangers, but not with places where one interacts primarily with familiar people. Remarkably, this pattern of results holds both for the European countries shown in Figure 3, and specifically for Norway, demonstrating a considerable generalizability of our findings.

6. General Discussion

Building on research on the behavioral immune system (Murray & Schaller, 2016; Schaller & Park, 2011; Tybur et al., 2020), we propose that people change their mobility behavior when cyberspace disease salience is high (vs. low) so that they minimize the likelihood of close physical contact with strangers. Analysis of hourly sales data from five grocery stores in Study 1 shows that mobility patterns change when cyberspace disease salience is high (vs. low): shopping trips result in a higher average basket size value, coupled with more items sold per hour. At the same time, the average number of shoppers per hour decreases. However, store crowding (i.e., the number of shoppers per hour) moderates the effect of cyberspace disease salience on the average basket size and the number of items sold per hour, such that it is stronger in the first case in crowded (vs. uncrowded) stores and occurs only in moderately to heavily crowded stores in the second case. Finally, analyzing the Google Community Mobility Reports in Study 2, we find that mobility decreases in areas where close contact with strangers is difficult to avoid under high (vs. low) cyberspace disease salience conditions. In contrast, mobility increases during this period in areas where close physical encounters with strangers are easier to avoid. Taken together, our results show broadly consistent mobility patterns under conditions of high (vs. low) cyberspace disease salience at both the micro and macro levels.

The results we obtained with respect to the average number of items sold per hour in moderately and highly crowded stores suggest that people adjust their mobility behavior at the micro-level only when physical encounters with strangers are relatively difficult to avoid. Therefore, it is plausible that people "buy their way out" of personal space violations when cyberspace disease salience is high more than when cyberspace disease salience is low, suggesting that customer personal space violations lead to paradoxical effects in which consumers spend more money despite feeling psychologically uncomfortable (Otterbring et al., 2022).

There is surprisingly little marketing literature on the effects of consumer density or crowding on sales, presumably because it is difficult to obtain sales data for academic purposes. In one of the few related studies, Levav and Zhu (2009) predicted and found, based on reactance research, that spatial crowding, such as that caused by crowding in stores, prompts consumers to seek more variety, so they choose more diverse and unique products, presumably as compensation for the violation of their personal space. Our findings from retail store sales data, showing that the average shopping basket was larger and more items were sold per hour when stores were very crowded (but not when stores were less crowded), are consistent with these earlier findings. However, we found that this effect was stronger when cyberspace disease salience was high (vs. low). Thus, we contribute to the study of the effects of crowding on sales by highlighting that disease salience may be an overlooked moderator of the above effects.

In summary, our findings add to the growing body of research that applies the behavioral immune system

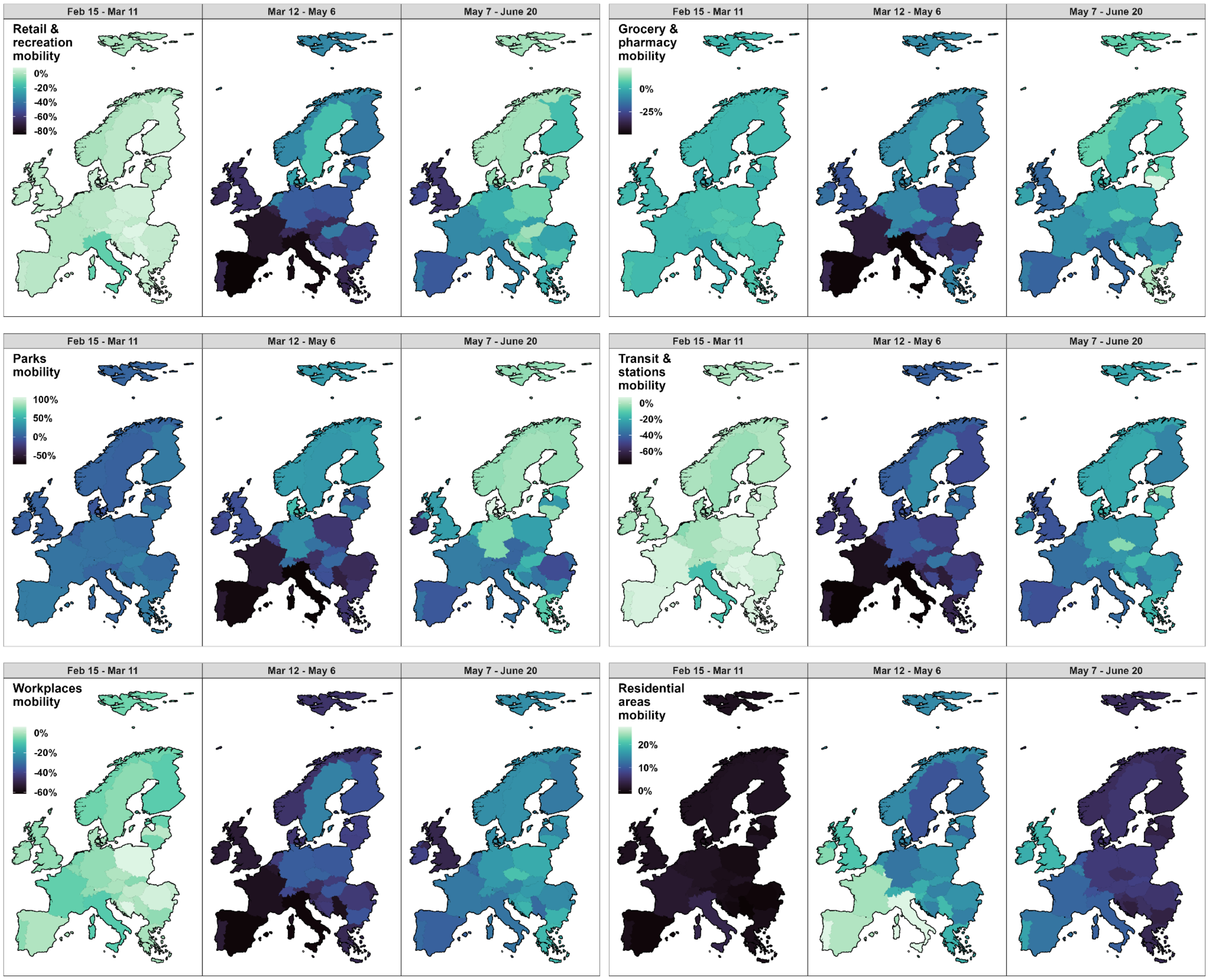

Figure 3. Mobility patterns across the included European countries in 2020

framework to understand the effects of the pandemic on human behavior (Hromatko et al., 2021). Although numerous studies show the impact of the pandemic on macro-level mobility behavior (Abu-Rayash & Dincer, 2020; Ma, 2022; Nouvellet et al., 2021), to our knowledge, our work is the first to examine the relationship between cyberspace disease salience with micro-level mobility patterns using a unique and ecologically valid dataset from five grocery stores. With the health of the planet in mind, this study adds to the growing literature on how consumer (mobility) behavior—which plays a critical role in shaping a sustainable economy (Alden, 2021; Folwarczny et al., 2023)—changed during the pandemic (Büyükayman et al., 2022).

Unlike aggregate data extensively used in previous research, our hourly sales data allow us to examine by-hour mobility patterns in grocery stores. Earlier choice experiments have shown that in situations where COVID-19 is increasingly prevalent, consumers are generally less likely to buy food in brick-and-mortar grocery stores (Grashuis et al., 2020). Similarly, and in line with our findings, studies relying on self-reports show that consumers reduced the frequency of their grocery shopping during the pandemic, but also that they purchased more products than they normally would when they went grocery shopping (Schmidt et al., 2021; Wang et al., 2020). In addition, during the pandemic outbreak, self-report data show that many consumers began shopping in the morning rather than at times when more people were in the store (Wang et al., 2020). These effects were related to negative perceptions of in-store safety measures, as well as high levels of the perceived threat from the COVID-19 and high levels of media exposure (Schmidt et al., 2021; Wang et al., 2020). Although these earlier findings from consumer self-reports are consistent with our results, our behavioral data in the form of hourly shopping metrics provide a much more nuanced and more objective representation of consumer in-store behavior during high and low disease salience. Specifically, across studies, we find that people act to minimize the risk of close physical encounters with strangers when cyberspace disease salience is high (vs. low). This finding has practical implications for retailers and policymakers, as more efforts should be made to encourage consumers to do more of their shopping during off-peak hours.

Prior to the pandemic, consumers in many countries increasingly preferred shorter (vs. longer) shopping trips with relatively few items purchased (Larsen et al., 2020; Sorensen et al., 2017). These short trips led many shoppers to forgo any equipment to carry the selected items to the checkout (Larsen et al., 2017). In contrast to this trend, our results show that during the period of high cyberspace disease salience associated with the pandemic outbreak, this trend reversed, at least temporarily, and shopping baskets became larger, which may indicate a greater need for shopping cart capacity. The dilemma in times of high disease salience is that shopping cart handles, as well as hand-held baskets, can be hidden reservoirs of pathogens (Gerba & Maxwell, 2012; Irshaid et al., 2014; Mizumachi et al., 2011). Although infection risk from contact with contaminated surfaces or items is generally considered low (CDC, 2021), fear of infection and lack of knowledge may lead consumers to avoid shopping carts altogether. Studies show a positive correlation between a shopping cart and the number of items purchased (Larsen et al., 2020). Therefore, it is crucial that in-store hygiene routines are visible to consumers and that retailers participate in community education to promote hand hygiene (Larsen & Sigurdsson, 2019). A practical idea would be to have a greeter at the entrance of a retail store to welcome each shopper and make sure to guide consumers to properly clean shopping baskets and carts so that consumers do not abandon a cart when they need it.

Given that some interventions alter mobility patterns over the long term (Skarin et al., 2017), including those developed during the pandemic (Kang et al., 2020), retailers should consider strategies to lower the risk of infection by reducing the density of customers on the most-traveled path of their stores by separating the path of customers with relatively low demand (who come only to buy a few items) from other customers. One strategy might be to serve the low-demand customers closer to the entrance and exit; that is, to get this segment in and out as quickly as possible without forcing them to walk through the entire store to find what they are looking for. Such a strategy requires retailers to identify the categories and items that low-demand customers are most likely to buy and then use that knowledge in managing customer flow. For example, retailers could use dedicated shelves near the entrance and checkout for products that are frequently purchased by this customer segment (Larsen et al., 2020; Sorensen et al., 2017). They should also make it easier for these shoppers to take shortcuts from the entrance to the checkout area (Larsen et al., 2020). This can shorten walking distances within the store and disrupt the path of many shoppers with little needs. It could also reduce the average shopping time for this customer segment, resulting in fewer customers in the store at a given time. Consequently, it would be easier for the other customers in the store to maintain social distancing. Better serving customers with few needs who buy only a few items go hand in hand with infection management at the retail store level.

Retailers can better prepare for future pandemics by considering the micro- and macro-level shifts in shopping and mobility behavior described herein. In addition to the strategies suggested above, retailers should consider extending grocery store hours at times when society is aware of pandemics so that consumers can shop in less crowded stores, which should be more convenient for them because they have larger average shopping baskets at such times. This idea is supported by the fact that high (vs. low) cyberspace disease salience was associated with more (vs. fewer) items sold per hour in crowded (vs. less crowded) stores, which may suggest that store logistics were under increased and unnecessary pressure at these times.

7. Limitations and Future Research

Some limitations of our work can serve as fruitful avenues for future research First, our dataset does not include information about which products were purchased or how consumers behaved in the store. Because our results show that, on average, consumers bought more when disease salience was high (vs. low), it is possible that they bought relatively more hedonic products such as sweets (Otterbring, 2019), which are often more expensive than utilitarian products such as fresh vegetables. More accurate sales data, including the use of observational technology and retail analytics (Larsen et al., 2017) or consumer receipts, are needed to test this possibility, which could have public health implications.

Second, people had more reasons to go to grocery stores to buy food (they had more needs) when cyberspace disease salience was high (vs. low). Restaurants and cafeterias were closed, leading to more food being prepared at home. At the same time, more people worked from home and therefore ate lunch at home instead of eating in the office cafeteria. Similar effects have been observed in other countries (Vazquez-Martinez et al., 2021; Young et al., 2022). More reasons to go shopping should normally lead to more trips to the grocery store. Instead, the average number of shoppers per hour decreased by 10 percent. Thus, we suspect that disease salience might have had a larger negative impact on shopping trips frequency than our results suggest because more reasons to go may have attenuated the effect of disease salience on the average number of shoppers per hour. On the other hand, researchers in many countries report an increase in online grocery shopping, including home delivery, as a result of the COVID-19 pandemic (Guzman et al., 2021), which tends to reduce reasons to go to a physical grocery store. However, online grocery retailing is not yet very developed in the regions where the stores in this study are located. Therefore, we suggest further research to examine this impact on consumer travel behavior to grocery stores and in-store behavior in areas where online retailing is well developed.

Third, our data do not allow us to make clear conclusions about the causality of the relationship between cyberspace disease salience and grocery store mobility behavior. It is imperative to conduct field experiments in which cyberspace disease salience is manipulated to establish such a causal relationship. This is particularly important because it is possible that many consumers used their own bags when shopping to minimize the risk of contact with pathogens when cyberspace disease salience was high (vs. low), with the choice of carrying equipment influencing shopping behavior (Larsen et al., 2020). Thus, our results may have been influenced in part by the specific carrying equipment used by customers.

Relatedly, the lack of casual links established by experimental manipulations under controlled conditions limits the scope of the implications that can be derived from our results. We were only able to demonstrate associations between the average size of shopping baskets and the number of items sold and the periods when society was fully informed about the pandemic and searched online for information about the coronavirus. Thus, consumers' mobility patterns likely changed due to external circumstances rather than their own deliberations. Despite this critical weakness in our research design, it is nevertheless plausible that at least some consumers changed their shopping habits over the long term. This is consistent with research on post-purchase dissonance reduction (Oshikawa, 1969; see also Moser et al. (2018), 2018, who show that interrupting mobility behavior for two weeks produces lasting changes in habitual associations with mobility options in different contexts).

Fourth, we divided the data into periods of high and low cyberspace disease salience based in part on the presence of COVID-19-related content in cyberspace. Indeed, many studies have found an association between exposure to visual cues in cyberspace and subsequent preferences for products sold in grocery stores. However, we did not collect data on perceptions of the COVID-19 threat over the analyzed period. Therefore, our results do not account for variability in the perceived threat of the coronavirus, which could be the psychological mechanism driving our mobility effects. Future research should address this possibility.

Finally, although our findings can be understood through the lens of the behavioral immune system framework (Murray & Schaller, 2016; Schaller & Park, 2011; Tybur & Lieberman, 2016) and are consistent with previous studies showing that consumers prefer less (vs. more) crowded places and activities with fewer other individuals when thinking about germs and the pandemic (Park et al., 2021; Wang & Ackerman, 2019), we cannot conclude that consumers changed their in-store shopping behavior solely in response to the threat of pathogens. Further studies, preferably under more controlled conditions, should at least test whether searching for pandemic-related content is positively related to perceived threat of pathogens and, consequently, to preference for less frequent grocery shopping, at least in physical (vs. online) grocery stores.

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Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Appendix A. Study S1

We conducted Study S1 to identify the periods of highest and lowest disease salience in cyberspace in the first half of 2020. We chose this time period because the data used in Study 1—obtained from Norwegian retailers—ranged from January 2 to June 20, 2020. We further tested whether critical announcements of pandemic containment measures corresponded with disease salience in cyberspace.

Method

Data. We took several steps to ensure that the division of the periods into high and low cyberspace disease salience was justified. First, we sought to maintain consistent periods across studies. Because we use sales data from Norway in Study 1, we rely on dates of specific COVID-19-related announcements by the Norwegian government; however, the periods of many pandemic containment measures were similar in most European countries in 2020. The first case of COVID-19 infection in Norway was reported on February 26, and the first patient was hospitalized on March 6, 2020. The government announced a partial lockdown on March 12, which went into effect on March 16. The country's policymakers announced a gradual easing of restrictions on May 7, 2020 (The Norwegian Government, 2022).

We analyzed Google Trends data that show the relative frequencies of web searches for specific keywords. Here we compared the total number of web searches for the terms "covid" and "coronavirus" (other pandemic-related words were relatively rarely searched on Google) in the world and specifically in Norway. These data are publicly available at htt ps://trends.google.com/trends/. As the second piece of evidence behind the adequacy of our division of time periods, we analyzed the numbers of daily SARS-CoV-2 infections and associated deaths in Norway as reported by the World Health Organization (WHO). These data can be accessed at https://covid19.who.int/region/euro/country/no.

Results and Discussion

The relative frequencies of web searches for the two terms related to the pandemic were highly correlated in Norway and in the world ($r = .50$ and $r = .68$, respectively); hence, we averaged them to create an index of cyberspace disease salience. We then divided the time periods into three categories: before the (partial) lockdowns in Norway, that is, from January 1 to March 11, during the lockdowns from March 12 to May 6, and after the lockdowns from May 7 to June 20, 2020.

First, we analyzed data from Norway. A one-way ANOVA revealed significant differences in web searches of the COVID-19-related terms between these three time periods, $F(2, 169) = 33.01$, $p < .001$, $\eta_p^2 = .28$. A post-hoc analysis with Tukey adjustment revealed that searches for terms related to the pandemic were more frequent between March 12 and May 6 than in the periods before and after (both $ps < .001$), which did not differ significantly from one another ($p = .177$). We repeated these analyzes using the combined worldwide data. Again, we found differences in web searches for terms related to the pandemic between the time periods, $F(2, 169) = 208.39$, $p < .001$, $\eta_p^2 = .71$. A similar post-hoc analysis found that searches for terms related to the pandemic were more frequent between March 12 and May 6 than in the other two time periods (both $ps < .001$), which again did not differ significantly from one another ($p = .482$). Next, we analyzed WHO data. We found a significant difference in daily new infections across the three time periods in Norway (WHO data cover the period from January 3, 2020), $F(2, 167) = 84.92$, $p < .001$, $\eta_p^2 = .50$. A post-hoc analysis with Tukey adjustment revealed that there were more new COVID-19 cases daily between March 12 and May 6 than in the periods before and after (both $ps < .001$), but again, these two periods were not significantly different from one another ($p = .834$). Similarly, we found a difference in daily deaths across the three periods, $F(2, 167) = 40.57$, $p < .001$, $\eta_p^2 = .33$. A post-hoc analysis revealed that there were more new COVID-19-related deaths between March 12 and May 6 than in the periods before and after (both $ps < .001$), with the latter two periods not significantly different from one another ($p = .201$). Figure A.1 depicts these findings.

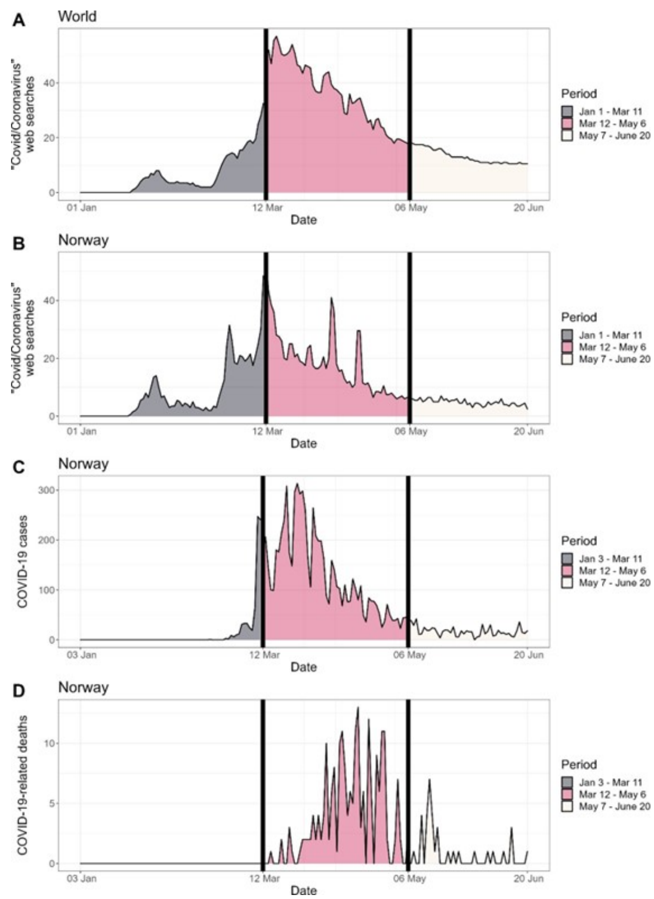

Figure A.1. Public interest in disease-related topics and the effects of the pandemic on public health in 2020

The results of Study S1 show that public interest in the pandemic-related terms in cyberspace was higher during the period referred to as "high cyberspace disease salience" (March 12–May 6, 2020) than during the period referred to as "low cyberspace disease salience" (January 1–March 11 and May 7–June 20, 2020) in the world and in Norway, where there were significantly more COVID-19 infections and deaths during this period than during the periods before and after, which we merge to facilitate parsimonious analysis and refer to as "low cyberspace disease salience" in the remainder of this article.

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