ASIA MARKETING JOURNAL

Volume 24 | Issue 3 Article 2

October 2022

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## Recommended Citation

Jung, Hyunwoo; Li, Yiling; and Choi, Jeonghye (2022) "The Effect of Lockdown Repeal on Socialization: Bayesian Multilevel Difference-in-Differences Approach," *Asia Marketing Journal*: Vol. 24 : Iss. 3 , Article 2.
Available at: https://doi.org/10.53728/2765-6500.1592

# The Effect of Lockdown Repeal on Socialization: Bayesian Multilevel Difference-in-Differences Approach☆

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**Abstract**

**The COVID-19 lockdown has had an unprecedented impact on people in various ways. This study evaluates the effect of lockdown repeal from both marketing and public-policy perspectives. Combining the Bayesian multilevel model with the difference-in-differences design, we find that a lockdown repeal has had a negative impact on socialization. Furthermore, the results show that those who have a low level of risk perception are less affected by lockdown repeal. Also, the negative effect of lockdown repeal varies depending on past socialization behaviors; that is, the lockdown-repeal effect is attenuated for those who socialized more than others in the past. Our findings contribute to the intersection of public policy and marketing literature and provide both academic and practical implications.**

*Keywords:* Lockdown repeal, Public policy, Socialization, Bayesian multilevel model, Difference-in-differences

## 1. Introduction

Starting from the early phase of the COVID-19 pandemic, more than 90 countries around the world have implemented various non-pharmaceutical intervention policies to suppress the spread of COVID-19 (Di Domenico et al. 2020; Epicentre 2020; Glogowsky et al. 2020; UNESCO 2021). Lockdown has been one of the most widely implemented policies to restrict interpersonal contact and prevent transmission of the virus (Bottary 2022; Glogowsky et al. 2020). This unprecedented event constituted a significant change for people in various ways, including psychological aspects (Fields et al. 2021, pp. 1—9; Flint et al. 2020; Le and Nguyen 2021), physical activities (Ding et al. 2020; McCarthy et al. 2021; Rodríguez-Larrad et al. 2021), and daily infection cases (Cho 2020; Singh et al. 2021).

Though the lockdown succeeded in diminishing the transmission of the virus and saving lives (Arnon, Ricco and Smetters 2020), policy makers have had to weigh between disease control and adverse economic impact (Brzezinski et al. 2020; Glaseser et al. 2021; Nogueira et al. 2021). That is, lockdown incurs irreparable costs to the economy: sales reduction, loss in GDP, and destructive impact on relevant industries like travel and tourism (Allen 2022; Miles et al. 2021; Slater 2020; Škare et al. 2021). Therefore, some countries repealed the lockdown and relied on individuals' discretional social distancing (Fitzpatrick, Harris and Drawve 2020; Sheth 2020). While few studies have focused on the causal relationship between the effectiveness of lockdown repeal and the underlying mechanism in marketing context.

We examine the causal effect of lockdown repeal on socialization and discuss the mechanisms that drive the effect and heterogeneity across people. Specifically, we focus on the following three research questions: (1) Does lockdown repeal make people socialize as before? (2) If not, what is the underlying mechanism? (3) Does this effect influence all people equally? To study these issues, we use panel survey data of 510 participants in the U.S. This data is suitable for our study because the U.S.

☆ This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2020S1A3A2A02093277). This work was supported by Yonsei Signature Research Cluster (2022-22-0007).

Received 7 September 2022; accepted 20 September 2022.
Available online 13 October 2022

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*https://doi.org/10.53728/2765-6500.1592*

implemented a state-dependent lockdown policy, which allowed us to separate states into treatment and control groups within the country. To identify the causal effect of lockdown repeal, we construct a quasi-experimental setting comparing socialization time during and after the lockdown period. See Fig. 1 for the conceptual framework.

Our empirical findings show that lockdown repeal decreases socialization time by an average of 38.12%. Furthermore, such carry-over effect does not influence all people equally. We find significant heterogeneity in the treatment effect depending on the individual's risk perception and past socializing behavior. Specifically, the effect of lockdown repeal is attenuated for those who have a lower risk-perception of the pandemic than others and who socialized more than others in the past.

Therefore, our research makes several contributions. First, we fill the gap in the literature on the causal effect of public policy on socialization in the marketing context. Second, we document the importance of understanding heterogeneous characteristics of people when investigating the effect of policy repeal. Third, by examining the policy repeal's repercussions on socialization, our findings call for a tailored approach to designing effective public policies.

We organize the rest of this paper as follows. First, we discuss related research streams in the area of COVID-19 lockdown and develop hypotheses based on prior literature. We then describe the data and develop Bayesian multilevel difference-in-differences (DiD) models to assess the impact of lockdown repeal on socialization, followed by a discussion of our findings. We conclude the paper with discussions of the implications and limitations of our study and directions for future research.

## 2. Literature review and hypotheses

### 2.1. Related literature

In this section, we review prior literature on the impact of the COVID-19 pandemic on people. First, many studies have aimed to understand the effect of the COVID-19 lockdown on people's mental health. Le and Nguyen (2021) found that the lockdown is associated with a variety of negative psychological feelings like depression, worry, stress, and concern for public health. Other studies explored how these adverse psychological outcomes vary depending on age, gender, and social status (Fields et al. 2021, pp. 1–9; Flint et al. 2020). Second, studies also investigated how the lockdown impacted people's physical activity. For instance, Google searches related to physical activity increased dramatically at the beginning of the lockdown, suggesting increased public interest in physical activity during the lockdown (Ding et al. 2020). Yet, some studies found that physical activity dropped significantly during the lockdown (McCarthy et al. 2021; Rodríguez-Larrad et al. 2021).

In sum, prior studies have mainly focused on how the lockdown changed people's mental condition and physical activity. However, most studies make relatively few suggestions about the causality of lockdown repeal in the marketing context and the mechanisms underlying their findings. We differentiate our study from existing ones by focusing on causal relationships involving the impact of “lockdown repeal” in the marketing context. Specifically, we focus on socialization, which plays a pivotal role in marketing because it affects people's cognitive, affective, and behavioral attitudes (Toker-Yildiz et al. 2017; Wang et al. 2012; Wärneryd 1988, pp. 206–248). Moreover, policy makers wish to have a deeper understanding of the impact of policy on consumer behavior, values, and attitudes (Ekström 2006; Jo et al. 2020; Moschis and Churchill 1978). By studying the unprecedented impact of the lockdown on socialization, our study extends and complements previous research, as summarized in Table 1.

### 2.2. Hypotheses development

#### 2.2.1. Effect of lockdown repeal on socialization

In this section, we discuss how lockdown repeal could impact socialization in the treatment group compared to the control group. As we noted at the

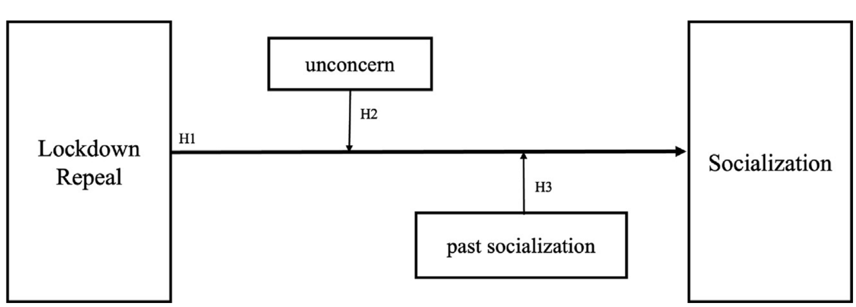


*Fig. 1. Conceptual framework.*

beginning of this article, policy makers should weigh the intention to minimize viral infection rates against the perceived economic cost before lifting the lockdown (Brzezinski et al. 2020; Glaseser 2021; Nogueira et al. 2021). The ideal scenario for policy makers is that people stay alert and reduce socialization voluntarily even after the lockdown is repealed, preventing viral transmission and alleviating economic costs at the same time. Some studies show this scenario at work in that physical activity and mobility continue to decrease after a lockdown repeal (Bu et al. 2021; McCarthy et al. 2021; Rodríguez-Larrad et al. 2021; Singh et al. 2021). A possible explanation for this is that people adopt preventive health habits as their fear of another outbreak increases (Poggi 2020), which would cause people to refrain from socializing after a lockdown repeal. In the same vein, we expect that people will socialize less after a lockdown repeal. Our formal hypothesis is as follows:

*H1. People will socialize less after a lockdown repeal than those who are still experiencing a lockdown.*

#### *2.2.2. The mechanism underlying the effect of lockdown repeal on socialization*

Several explanations can be proposed as providing theoretical evidence that a lockdown repeal decreases socialization. A possible driver proposed by research in health studies is that the risk perception of a hazard affects how individuals react to the hazard (Brewer et al. 2007; Champion and Skinner 2008; Floyd, Dunn and Rogers 2000). This risk perception can be divided into two main categories: susceptibility and severity (Brewer et al. 2007). “Susceptibility” refers to a belief about the chances of contracting a virus, and “severity” involves a belief about the seriousness of the symptoms. Heightened susceptibility or severity makes people adopt self-protective behavior to prevent infection (Champion and Skinner 2008; Lu et al. 2021). Repealing lockdown restrictions may heighten risk perception in that it can expose people to a more vulnerable environment of viral transmission (Anderson 2020; Fowler et al. 2020).

Protection Motivation Theory (PMT) is also well suited to our context. PMT suggests that health-threatening risks can make people more amenable to adopting a health authority's recommendations (Rogers and Prentice-Dunn 1997). Several studies document how heightened risk-perception alters an individual's intention to follow a health-communicator's recommendations (Copping 2022; Demirtaş-Madran and Andaç 2021; Håkansson and Claesdotter 2022). As social distancing is recommended even after the lockdown repeal (World Health Organization 2022), people will socialize less due to heightened risk-perception after lockdown repeal and be more inclined to follow the government's recommendation to stay at home.

If this mechanism is at work, the effect of lockdown repeal should vary depending on the individual's risk perception. We use a summation of the unconcerned measures as a proxy for risk perception (i.e., how worried the respondent is about personal health, family and friends' health, community health, and public health) and add them to the interaction term to estimate the moderating effect of risk perception on lockdown repeal. We conjecture that the effect of lockdown repeal will be attenuated for those who have a lower risk-perception than others. Thus, we propose the following hypothesis:

*H2. The effect of lockdown repeal will be attenuated for those who have a lower risk-perception.*

#### *2.2.3. Heterogeneous effect of lockdown repeal on socialization*

In this section, we will discuss how the lockdown-repeal effect varies by individual characteristics. Studies have investigated how the effects of the

*Table 1. Related studies on the COVID-19 lockdown and their research focuses.*

| Study | Focus | Time Period | | Causal Inference | Check Mechanism |
|---|---|---|---|---|---|
| | | Lockdown | Repeal | | |
| Brezezinski, Kecht and Dijcke (2020) | Economical cost | ✓ | | ✓ | |
| Cho (2020) | Daily infection | ✓ | | ✓ | |
| Ding et al. (2020) | Physical activity | ✓ | | | |
| Flint et al. (2020) | Mental health | ✓ | | | |
| Glaeser et al. (2021) | Restaurant activity | | ✓ | | |
| Glogowsky, Hansen and Schachtele (2020) | Physical activity | ✓ | | ✓ | |
| Le and Nguyen (2021) | Mental health | ✓ | | ✓ | ✓ |
| McCarthy et al. (2021) | Physical activity | | ✓ | | |
| Rodríguez-Larrad et al. (2021) | Physical activity | ✓ | | | |
| Singh et al. (2021) | Daily infection | ✓ | ✓ | ✓ | ✓ |
| This study | Social activity | | ✓ | ✓ | ✓ |

COVID-19 pandemic vary depending on population characteristics like age (Fields et al. 2021, pp. 1–9; Flint et al. 2020), and some research explores how compliance with a lockdown differs by conspiratorial thinking and personality (Copping 2022; Presti et al. 2021).

We focus on the moderating effect of past socializing behavior. We expect that the more people are engaged into socialization, the less affected they will be by lockdown repeal. Reactance Theory (Clee and Wicklund 1980) gives a theoretical underpinning to our conjecture—that is, people tend to react adversely when they perceive a restriction on their freedoms. This results in attempts to reassert freedom in the form of psychological reactance (Brehm 1966; De Jonge et al. 2018), and the extent of this reactance depends on how important freedom is to the individual (Jo et al. 2020; Steward and Martin 1994). Accordingly, those who value their freedom more than others would react adversely when there are strict restrictions (Jo et al. 2020). In our context, we predict that the lockdown repeal effect will be attenuated for those who value socialization more than others in the past. Since socialization is impracticable during the lockdown period, those who value socialization more than others may have higher adverse psychological reactance, leading them to increase socialization after the lockdown repeal. As such, we hypothesize the following:

*H3. The effect of lockdown repeal will be attenuated for those who socialized more than others in the past.*

## 3. Research design

### 3.1. Data and variables

To understand the effect of lockdown repeal on socialization, we analyze a large set of open-access panel survey data exploring how the pandemic impacted people's mental health and sleep quality (Cunningham et al. 2021). The survey was conducted daily at the participants' discretion and spans 22 months, from March 2020 to December 2021.

The dataset includes three key pieces of information that are essential for our analysis. First, the survey data includes the daily activities of each participant (e.g., how much time they spent on socialization and how many people they met in person) so that we can extract the participants' daily socialization with others. Second, we have access to each participant's psychological status information (e.g., how concerned they are about and depressed they are from the pandemic). Third, the data includes demographics such as their age, gender, employment status, and the U.S. state in which they reside. This allows us to identify whether or not the participants are under lockdown at the time of the survey.

We include a subset of 510 participants in the U.S. to compare the socialization times between the treatment group and the control group. We set the treatment group as those who live in states in which the lockdown is repealed and the control group as those who are still under lockdown. Furthermore, we focus on the time period from March 23, 2020, to May 31, 2020, during which 39 states had repealed lockdown and the other 5 states had still been under lockdown. So, in our dataset, 381 participants are from states where the lockdown has been repealed, and 129 participants are from states where the lockdown has still been undergoing. Table 2 shows when the lockdown was initiated and repealed by the state. We aggregate the survey responses for each participant by week following recent studies on policy intervention (Jo et al. 2020; Jo et al. 2021). Table 3 provides detailed explanations of each variable used in our analysis.

*Dependent variable*. The dependent variable is the total socialization time (i.e., $\text{Socialization}_{it}$). "$\text{Socialization}_{it}$" is the daily average of socializing time participant $i$ spent during week $t$. To account for skewness in socialization minutes, we log-transformed the variable.

*Independent variables*. The term "$\text{DiD}_{it}$" is an indicator variable that takes the value 1 if participant $i$ is subject to state $s$ in which lockdown is repealed at week $t$ (treatment group) and 0 otherwise (control group). Moreover, we operationalize the moderator for "$\text{Unconcern}_{it}$" by summing the responses to all unconcern questions on individual health, family and friend's health, community health, and public health during the past week to establish causality following Jo et al. (2021). "$\text{PastSocialization}_{it}$" represents the average of socializing minutes participant $i$ spent for the two weeks before week $t$. We use the average of two weeks to reduce Nickell bias—that is, the bias due to the correlation between the lagged dependent variable and the error term (Nickell 1981). We impute part of the missing data in our dataset using linear interpolation (see also Choi et al. 2010).

*Control variables*. We add participants' demographics like age, status, and gender as control variables. We also control for how much time had elapsed for the participant since the lockdown had been implemented or repealed. Finally, we control for the weekly average of COVID-19 cases per 1000 people by state.

*Table 2. Statewide lockdown period.*

| States | Lockdown started | Lockdown repealed | States | Lockdown started | Lockdown repealed |
|---|---|---|---|---|---|
| Alabama | April 4 | April 30 | Montana | March 28 | April 26 |
| Alaska | March 28 | April 24 | Nebraska | – | – |
| Arizona | March 31 | May 8 | Nevada | April 1 | May 9 |
| Arkansas | March 24 | May 6 | New Hampshire | March 27 | June 11 |
| California | March 19 | May 18 | New Jersey | March 21 | June 9 |
| Colorado | March 26 | April 26 | New Mexico | March 24 | May 16 |
| Connecticut | March 23 | May 20 | New York | March 22 | May 29 |
| Delaware | March 24 | June 1 | North Carolina | March 30 | May 5 |
| Florida | April 2 | May 4 | North Dakota | – | – |
| Georgia | April 3 | April 30 | Ohio | March 23 | May 15 |
| Hawaii | March 25 | May 7 | Oklahoma | April 2 | April 22 |
| Idaho | March 25 | April 30 | Oregon | March 23 | May 15 |
| Illinois | March 21 | May 30 | Pennsylvania | April 1 | May 01 |
| Indiana | March 25 | May 1 | Rhode Island | March 28 | May 08 |
| Iowa | – | – | South Carolina | April 7 | May 04 |
| Kansas | March 30 | May 4 | South Dakota | – | – |
| Kentucky | March 26 | May 20 | Tennessee | April 2 | April 30 |
| Louisiana | March 23 | May 15 | Texas | April 2 | April 30 |
| Maine | April 2 | April 30 | Utah | – | – |
| Maryland | March 30 | May 15 | Vermont | March 25 | May 15 |
| Massachusetts | March 24 | May 18 | Virginia | March 30 | May 15 |
| Michigan | March 24 | June 2 | Washington | March 30 | June 8 |
| Minnesota | March 27 | May 18 | West Virginia | March 23 | May 04 |
| Mississippi | April 3 | April 27 | Wisconsin | March 25 | May 13 |
| Missouri | April 6 | May 3 | Wyoming | – | – |

Note: Six states (i.e., Iowa, Nebraska, North Dakota, South Dakota, Utah, and Wyoming) did not implement the lockdown.

*Table 3. Variable operationalization.*

| Variables | Operationalization |
|---|---|
| **Dependent variable** | |
| $\text{Socialization}_{it}$ | Log of daily average of socializing minutes participant *i* spent during week *t* |
| **Independent variables** | |
| $\text{DiD}_{it}$ | Equals 1 if participant *i* is subject to state *s* where lockdown is repealed at week *t* |
| $\text{Unconcern}_{it}$ | Degree of unconcern toward the pandemic that participant *i* feels at week *t-1* |
| $\text{PastSocialization}_{it}$ | Log of daily average of socializing minutes participant *i* spent for the two weeks before week *t* |
| **Control variables** | |
| $\text{Age}_{i}$ | Age of citizen *i* |
| $\text{Student}_{i}$ | Equals 1 if participant *i* is a student, 0 otherwise |
| $\text{Employed}_{i}$ | Equals 1 if participant *i* is employed, 0 otherwise |
| $\text{Gender}_{i}$ | Equals 1 if participant *i* is female, 0 otherwise |
| $\text{LockdownWeek}_{it}$ | Number of weeks since the lockdown had started in state *s* in which participant *i* lives at week *t* |
| $\text{RepealWeek}_{it}$ | Number of weeks since the lockdown was repealed in state *s* in which participant *i* lives at week *t* |
| COVID-19 $\text{Cases}_{st}$ | Average COVID-19 cases per 1000 people in state *s* at week *t* |

### *3.2. Descriptive statistics*

Table 4 presents the descriptive statistics of the variables used in our model. On average, people spent 48 minutes socializing (Mean = 3.04 min, SD = 1.59 in log form) and 40 minutes socializing for the previous two weeks (Mean = 2.56 min, SD = 1.59 in log form). "$\text{Unconcern}_{it}$", the sum of five unconcern questions on a 7-points Likert scale, is 14.64, slightly lower than 20, the degree to which the average people are concerned about their health. The participants in our data are 41 years old on average, 21% are students, 58% are employed, and 83% are female. They had experienced lockdown for about 5 weeks and repeal for about 1 week on average, and an average of 5.12 COVID-19 cases occurred per 1000 people.

### *3.3. Empirical model*

Our goals are twofold. First, we attempt to estimate the effect of the lockdown repeal on socialization. Second, we aim to highlight the moderating role of two variables: the degree of unconcern toward the

*Table 4. Descriptive statistics and correlation matrix.*

| Variable | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. $Socialization_{it}^{a}$ | 3.04 | 1.59 | 1.00 | | | | | | | | | |
| 2. $Unconcern_{it}$ | 14.64 | 8.96 | 0.00 | 1.00 | | | | | | | | |
| 3. $PastSocialization_{it}^{a}$ | 2.56 | 1.59 | 0.33 | 0.40 | 1.00 | | | | | | | |
| 4. $Age_{i}$ | 41.07 | 17.97 | 0.07 | 0.08 | 0.05 | 1.00 | | | | | | |
| 5. $Student_{i}$ | 0.21 | 0.40 | 0.01 | −0.02 | 0.01 | −0.45 | 1.00 | | | | | |
| 6. $Employed_{i}$ | 0.58 | 0.49 | −0.07 | −0.04 | −0.06 | −0.08 | −0.62 | 1.00 | | | | |
| 7. $Gender_{i}$ | 0.83 | 0.37 | 0.06 | −0.02 | −0.04 | 0.00 | −0.03 | −0.02 | 1.00 | | | |
| 8. $LockdownWeek_{it}$ | 5.14 | 2.24 | −0.12 | 0.23 | 0.33 | 0.03 | −0.04 | 0.02 | 0.00 | 1.00 | | |
| 9. $RepealWeek_{it}$ | 0.65 | 1.21 | −0.17 | 0.12 | 0.12 | −0.00 | 0.02 | −0.04 | −0.03 | 0.06 | 1.00 | |
| 10. COVID-19 $Cases_{st}$ | 5.12 | 4.59 | −0.05 | 0.12 | 0.24 | 0.13 | −0.02 | −0.03 | 0.06 | 0.69 | 0.03 | 1.00 |

Note: [a] These variables are log-transformed.
N = 3700.

pandemic and past socialization behavior. By doing so, we demonstrate that lockdown repeal has a heterogeneous effect on socialization. To capture the causal effect of lockdown repeal on socialization and the abovementioned heterogeneous effects, we use the Bayesian multilevel DiD model.

The Bayesian multilevel DiD model is well suited for our study for the following reasons. First, DiD is one of the most popular procedures used to estimate the causal effect of policy intervention or new-technology adoption (Datta, Knox and Bronnenberg 2018; Jung et al. 2022; Jo et al. 2020; Palazzolo and Pattabhiramaiah 2021; Sant'Anna and Zhao 2020). DiD provides important advantages in situations like the COVID-19 lockdown in which interventions have not been randomized (Goodman-Bacon and Marcus 2020). Second, Bayesian multilevel DiD is apposite to address data that cannot be matched at the most granular level (Normington 2019). Since our data is based on a discretional survey, extending the classical DiD model to the multilevel context is desirable. Finally, a multilevel structure provides a consistent model that incorporates both individual- and group-level information simultaneously (Gelman and Hill 2006). We adopt the multilevel structure in our model to handle both individual- and state-level information because lockdown in the U.S. was state-dependent and there were appreciable differences between states in how they handled the pandemic (Choi et al. 2020; Jeff 2020; Painter and Qui 2020; Pew Research Center 2020).

We build Model (1) to investigate the effect of lockdown repeal on socialization:

$$\log(Socialization_{it}) \sim N\left(\mu_{it}, \sigma_e^2\right)$$

$$\mu_{it} = \beta_0 + \beta_1\, DiD_{it} + \boldsymbol{\theta} \boldsymbol{Z}_{it} + participant_i + week_t + state_s + \varepsilon_{it} \qquad (1)$$

where log(Socialization_it) is the log of the daily average of socializing minutes participant $i$ spent during week $t$. $\beta_1$ captures the average effect of lockdown repeal on the treatment group, relevant to H1. If negative and significant, $\beta_1$ implies that lockdown repeal decreases the average socialization time of the treatment group. $\boldsymbol{Z}_{it}$ denotes a vector of observable characteristics at the participant level, and $\boldsymbol{\theta}$ is the corresponding vector of parameter estimates. Finally, varying intercepts for the participant, week, and state are included to explain any permanent heterogeneity at the participant-, week- and state-levels. To incorporate participant- and state-level information, we specify multilevel Gaussian prior on our varying intercepts. We use Gaussian prior for all other variance parameters as well. We additionally employ an MCMC (Markov chain Monte Carlo) procedure to sample from the posterior distribution.

$$participant_i \sim N\left(state_{s[i]}, \sigma_i^2\right)$$

$$week_t \sim N\left(0, \sigma_t^2\right)$$

$$state_s \sim N\left(0, \sigma_s^2\right)$$

To estimate the heterogeneous effects of lockdown repeal, we add the interaction terms $DiD_{it} \times Unconcern_{it}$, $DiD_{it} \times PastSocialization_{it}$ into the equation to investigate the effectiveness of the lockdown repeal at different levels of unconcern degree and past socialization behavior, relevant to H2 and H3. Thus, Model (2) is as follows.

$$\log(Socialization_{it}) \sim N\left(\mu_{it}, \sigma_e^2\right)$$

$$\mu_{it} = \beta_0 + \beta_1\, DiD_{it} + \beta_2\, DiD_{it} \times Unconcern_{it} + \beta_3 DiD_{it} \times PastSocialization_{it} + \boldsymbol{\theta} \boldsymbol{Z}_{it} + participant_i + week_t + state_s + \varepsilon_{it} \qquad (2)$$

The term $\beta_2$ measures the moderating effect of risk perception on socialization. If positive and significant, $\beta_2$ implies that the effect of lockdown repeal will be attenuated for those who are unconcerned toward pandemic. $\beta_3$ captures the effect of past socialization behavior on socialization. If positive and significant, $\beta_3$ implies that the effect of lockdown repeal will be attenuated for those who socialize more than others. All varying intercepts for participant, week, and state and control variables remain the same as those of Model (1).

### 3.4. Identification strategy

In this section, we discuss how we address identification challenges. We add observed control variables and varying intercepts by the participant, week, and state in our model. By doing so, our model can account for both observed and unobserved heterogeneity across participants, weeks, and states. However, we cannot ensure that our model is free from endogeneity because unobservable differences between participants may remain. Thus, to further control for potential endogeneity, we use inverse probability treatment weighting (IPTW), a widely used approach in observational studies, to create a synthetic sample in which assignment to the treatment group is independent of covariates (Austin and Stuart 2015). Moreover, IPTW allows us to obtain unbiased estimates of average treatment effects while preserving all observations from our sample (Austin and Stuart 2015; King and Nielsen 2019). To be specific, we use individual covariates to calculate the IPTW for each participant and employ it as a weight in our model. Using IPTW is not only in line with recent studies in the literature (Atefi et al. 2018; Zhang et al. 2021) but also enables us to separate the unobserved endogeneity from the error term, which can solve the endogeneity problem.

## 4. Results

### 4.1. Effect of lockdown repeal on socialization

Table 5 presents the estimation results of the models. As explained above, Model (1) is used in testing H1, and Model (2) is used in testing H2 and H3. To ensure the robustness of our findings, we conduct a series of analyses with different approaches. We begin with basic analyses with no controls in columns (1) and (2), add observed controls in column (3), control for unobserved heterogeneity in column (4), and finally address the endogeneity issue in column (5).

As for the effect of lockdown repeal, the coefficient of the $DiD_{it}$ ($\beta_1$) is negative and significant ($\beta_1 = -0.77$, significant at the 95% level). This result is consistent across all of the models, ranging from $-2.53$ to $-0.48$. This indicates that the lockdown repeal decreases socialization by 38.12% on average among the treatment group compared with the control group.[1] This supports the idea that lockdown repeal does not signal to people that going outside is safe but rather increases their fear of another outbreak, thus reducing their socialization after the lockdown repeal. Therefore, our results support H1.

### 4.2. Underlying mechanism of the effect of lockdown repeal

In this subsection, we examine the underlying mechanism of the effect of lockdown repeal. Our discussion of the results hereinafter centers on the model estimates in column (5). Interesting findings emerge when we focus on the moderating effect of risk perception. First, the effect of lockdown repeal ($\beta_1$) remains negative, and the interaction term of unconcern measure ($\beta_2$) yields a positive and significant estimate ($\beta_2 = 0.01$, significant at the 95% level). That is, the lockdown-repeal effect is attenuated for those who have a lower risk-perception toward the pandemic. This result provides evidence for PMT. Specifically, those who are unconcerned toward the pandemic will underestimate the hazard of the virus, leading them to act with less caution than others. Therefore, H2 is supported.

In Fig. 2, Panel A shows the expected changes in socialization with varying degrees of unconcern measure. We plot the expected lockdown-repeal effect at the 5th, 25th, 50th, 75th, and 95th quantile values of the unconcern measure. Panel A suggests that the lockdown-repeal effect is attenuated for those who worry less about the pandemic and their health conditions.

### 4.3. Heterogeneous effects of lockdown repeal

Further insight comes from examining how the lockdown-repeal effect varies according to the past behavior of the individual. The interaction term of past socialization behavior ($\beta_3$) yields a positive and significant estimate ($\beta_3 = 0.07$, significant at the 95% level). That is, those who socialized more than others in the past would be less affected by a

[1] We compute the effect of lockdown repeal on socialization by using $(Exp(DiD_{it}) - 1) \times 100$ based on column (5).

*Table 5. Estimation results.*

| Model | Treatment Only | Adding interaction | Controlling observed heterogeneity | Controlling unobserved heterogeneity | Inverse probability treatment weighting |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $\mathrm{DiD}_{it}$ ($\beta_1$) | −0.77* | −2.53* | −1.71* | −0.48* | −0.48* |
| | (−0.87, −0.67) | (−2.82, −2.25) | (−2.04, −1.38) | (−0.78, −0.18) | (−0.77, −0.19) |
| $\mathrm{DiD}_{it} \times \mathrm{Unconcern}_{it}$ ($\beta_2$) | | 0.04* | 0.03* | 0.01* | 0.01* |
| | | (0.02, 0.05) | (0.02, 0.05) | (0.00, 0.02) | (0.00, 0.02) |
| $\mathrm{DiD}_{it} \times \mathrm{PastSocialization}_{it}$ ($\beta_3$) | | 0.40* | 0.32* | 0.10* | 0.07* |
| | | (0.33, 0.47) | (0.25, 0.39) | (0.03, 0.16) | (0.00, 0.13) |
| Intercept | 2.52* | 2.77* | 3.53* | 3.97* | 3.98* |
| | (2.42, 2.63) | (2.66, 2.88) | (3.23, 3.83) | (3.35, 4.61) | (3.35, 4.61) |
| $\mathrm{Unconcern}_{it}$ | −0.02* | −0.03* | −0.02* | 0.00 | 0.00 |
| | (−0.03, −0.02) | (−0.03, −0.02) | (−0.03, −0.02) | (−0.01, 0.01) | (−0.01, 0.00) |
| $\mathrm{PastSocialization}_{it}$ | 0.43* | 0.35* | 0.41* | 0.07* | 0.10* |
| | (0.40, 0.46) | (0.31, 0.39) | (0.38, 0.45) | (0.03, 0.16) | (0.05, 0.14) |
| $\mathrm{Age}_i$ | | | 0.00* | 0.01* | 0.00* |
| | | | (0.00, 0.01) | (0.00, 0.01) | (0.00, 0.01) |
| $\mathrm{Student}_i$ | | | −0.04 | −0.05 | −0.06 |
| | | | (−0.22, 0.14) | (−0.44, 0.35) | (−0.45, 0.34) |
| $\mathrm{Employed}_i$ | | | −0.17* | −0.25 | −0.24 |
| | | | (−0.31, −0.04) | (−0.54, 0.05) | (−0.53, 0.06) |
| $\mathrm{Gender}_i$ | | | −0.19* | −0.26 | −0.25 |
| | | | (−0.31, −0.07) | (−0.53, 0.01) | (−0.50, 0.01) |
| $\mathrm{LockdownWeek}_{it}$ | | | −0.18* | −0.18* | −0.19* |
| | | | (−0.21, −0.15) | (−0.22, −0.13) | (−0.22, −0.14) |
| $\mathrm{RepealWeek}_{it}$ | | | −0.18* | −0.18* | −0.17* |
| | | | (−0.25, −0.11) | (−0.24, −0.11) | (−0.23, −0.10) |
| COVID-19 $\mathrm{Cases}_{st}$ | | | 0.01* | 0.02* | 0.02* |
| | | | (0.00, 0.03) | (0.00, 0.04) | (0.00, 0.04) |
| Multilevel random intercept (participant, state, week) | False | False | False | True | True |
| IPTW | False | False | False | False | True |

Note: The values with * are estimates whose 95% credible intervals do not include zero. The values with parentheses indicate 95% credible intervals.

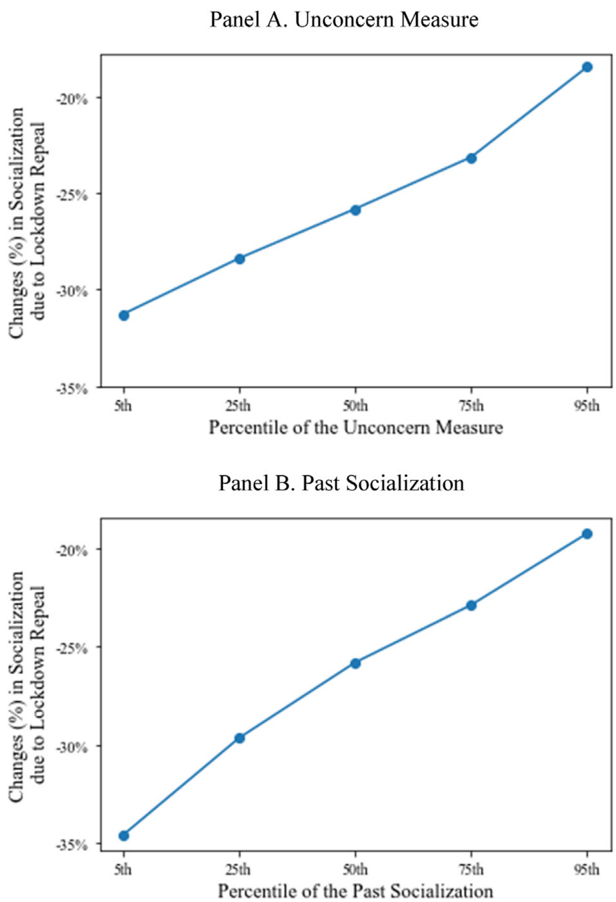


*Fig. 2. Moderating effect of lockdown repeal. Panel A. Unconcern measure. Panel B. Past socialization.*

lockdown repeal. A possible explanation for this is that those who enjoy socializing more than others will exert more psychological reactance because the extent of an individual's reactance depends on how important freedom is to the individual (Brehm 1966; Jo et al. 2020). Thus, the lockdown-repeal effect will be attenuated by the past socialization behavior, supporting H3.

In Fig. 2, Panel B presents the expected changes in socialization with varying degrees of past-socialization quantile. We plot the expected lockdown-repeal effect at the 5th, 25th, 50th, 75th, and 95th quantile values of the past socialization. Panel B suggests that the lockdown-repeal effect is attenuated for those who socialized a lot in the past.

## 5. Discussion

In many countries, strict lockdowns have impacted people in various ways. Previous studies have focused on this effect of lockdown, including negative psychological feelings, physical activities, and daily infection cases (Cho 2020; Ding et al. 2020; Fields et al. 2021, pp. 1–9; Flint et al. 2020; Le and Nguyen 2021; McCarthy et al. 2021; Singh et al. 2021). Though some studies have investigated the effect of lockdown repeal, the magnitude and direction of the lockdown-repeal effect have remained unclear and mixed. Several studies report that people's activity soared back after the lockdown repeal (Glaeser et al. (2021); Franks et al. 2020; Petherick et al. 2021; Tsai et al. 2021), while other studies report the opposite (McCarthy et al. 2021; Singh et al. 2021). To fill this research gap, we focus on the lockdown repeal in the U.S., in which the policy varied by state. In this context, we conduct a quasi-experiment to estimate the causal effect of lockdown repeal on socialization. Below, we discuss our empirical results and possible mechanisms for our findings, implications for policy makers and academia, and limitations of the study.

### 5.1. Discussion on the empirical results

In this section, we sum up our findings and some theoretical underpinnings that may drive our results. Our empirical results suggest that lockdown repeal decreases socialization compared to those who are still experiencing lockdown. To test the mechanism behind this finding, we use the individual's unconcern measure as a proxy for risk perception. We observe that lower risk-perception could attenuate the effect of lockdown repeal, and we attribute PMT as the theoretical underpinning of our findings. That is, those who have high risk-perception of the pandemic will be more amenable to the government's recommendation to stay at home.

We further examine when and how lockdown repeal effects are moderated by the characteristics of individuals, and we find that the effect of lockdown repeal is attenuated for those who were socially active because heightened psychological reactance results in increased socialization. By doing so, our study contributes to the current knowledge on how lockdown repeal impacts socialization.

### 5.2. Implications for academia

Our study presents several contributions to the growing literature on the intersection of public policy and marketing. First and foremost, our findings that socialization times tend to decrease more after a lockdown repeal add empirical evidence to the marketing literature that investigates the causal effect of public policies (Jo et al. 2020; Jo, Nam and Choi 2022; Palazzolo and Pattabhiramaiah 2021) and carry-over effect on socialization (Wang et al. 2016). Our findings call for the causal-inference approach in marketing research.

Second, by testing the moderating effects of personal character and past behavior, our work deepens the understanding of the mechanisms and heterogeneous effects of lockdown repeal. We find that heightened risk-perception strengthens the effect of lockdown repeal, which leads people to follow the government's recommendation. Also, those who socialized more than others tend to be less affected by the lockdown repeal. Investigating heterogeneity among people deepens our understanding of how people behave differently according to their characteristics (Kim et al. 2022; Kim et al. 2021).

### 5.3. Implications for policy makers and industry

Our study furthers our understanding of policy repeal's repercussions on socialization. Specifically, we show that lockdown repeal has negative repercussions on socialization, indicating that people do not always behave as before after the regulation repeal, and such a reduction in socialization may lead to reduced sales for industry and, consequently, negative economic impact. These findings call for a more tailored approach to policy design and the need to prepare a strategic plan to handle the unanticipated consequence of policy.

### 5.4. Limitations and directions for future research

Despite its potentially beneficial implications, our study is subject to the following caveats and limitations, which could suggest areas for future research. First, the granular level of our data does not match entirely. That is, since the daily survey was totally dependent on discretional will, time points across responses are not completely consistent. Although we adopt the Bayesian multilevel DiD method and aggregate responses at the week level to address the problem, future research can obtain more robust results if the data is matched at all granular levels. Second, the data-collecting process might be biased. People who are more inclined to participate in surveys diligently might have some unobservable characteristics affecting the dependent variable. Also, most of the participants are white, college graduates. If a more balanced and unbiased dataset were available, more robust results could be drawn. We acknowledge these limitations and hope future research will explore these opportunities further.

## Conflict of interest

The authors declare that there is no conflict of interest.

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