Better Late Than Never: Trends in COVID-19 Infection Rates, Risk Perceptions, and Behavioral Responses in the USA

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INTRODUCTION

In the USA, misinformation and inconsistent messaging surrounding coronavirus 2019 (COVID-19) may lead individuals to incorrectly assess transmission risk and undermine precautionary behaviors necessary to control the pandemic.[1] A key question is to what extent the new US presidential administration can change public behaviors by adopting consistent, science-based risk messaging or whether behavior change is unlikely. We help answer this question by characterizing how Americans have responded to changes in local COVID-19 risk throughout the pandemic. Specifically, we assessed state-level patterns and trends in risk perceptions and risk-mitigating behaviors in relation to reported COVID-19 case rates.

METHODS

We used data from a large, ongoing survey of Facebook users.[2] Since April 6, 2020, a geographically stratified random sample was invited daily to complete an externally hosted 5-min survey, covering COVID-19 symptoms, behaviors, and beliefs. Facebook had no access to individual survey responses. We analyzed risk perceptions, the percentage reporting being very worried that they or a relative would become seriously ill from COVID-19, and risk behaviors: the average number of contacts outside of household in the past 24 h; percentage avoiding others all/most of the time (collected prior to September 9); and percentage engaging in unmasked public activity in the past 24 h (collected after September 9). Results were weighted for nonresponse and to be representative of the US adult population. We obtained data on COVID-19 cases from the COVID Tracking Project.[3] We created time series plots of average weekly risk perceptions, behaviors, and cases per 100,000 for each state, grouped by Census regions, over the study period May 15 through November 22, 2020 (separating before September 7 and after September 13 to accommodate changes in the survey questionnaire). We examined peaks and troughs in our outcomes relative to those for case rates. We compared changes in outcomes across states with the 10 largest per capita spring, summer, and fall COVID-19 outbreaks using weighted linear regressions. Analyses were conducted using R 4.0.2. The research was deemed IRB exempt by the Harvard TH Chan School of Public Health (IRB20-0592).

RESULTS

Our sample included 9,667,400 respondents, of whom 53% were female and 21% over age 65 (weighted). During the summer surge, peak worry about COVID-19 illness coincided with the peak of detected cases per capita, and mitigating risk behaviors similarly rose and fell with case rates (Fig. 1). While worry increased nationally by 9 percentage points, behavior changes were most pronounced in states with largest summer per capita case rates. These included a decrease in average contacts of 2.3 (versus an increase of 0.3 spring peak states) and increase in avoiding others all or most of the time by 8 pp (versus a decrease of 5 pp) ($p < 0.001$ for comparisons).

Between September 14 and November 22, 2020, both case rates and risk-mitigating behaviors increased in every region (Fig. 2). The largest declines in unmasked public activity were in the Midwest (11 pp, to 23%), followed by the Northeast (8 pp, to 19%), and the West and South (6 pp, to 20%/25%). In the 10 highest fall incidence states, average contacts outside the home decreased by 3.3 (versus 2.0 in other states), and unmasked public activities by 12 pp (versus 7 pp) ($p < 0.001$ for comparisons). Improvements in risk-mitigating behaviors varied across states, with largest changes in states with high initial levels of risky behavior. For instance, unmasked public activity decreased in North Dakota from 46 to 26%, Montana

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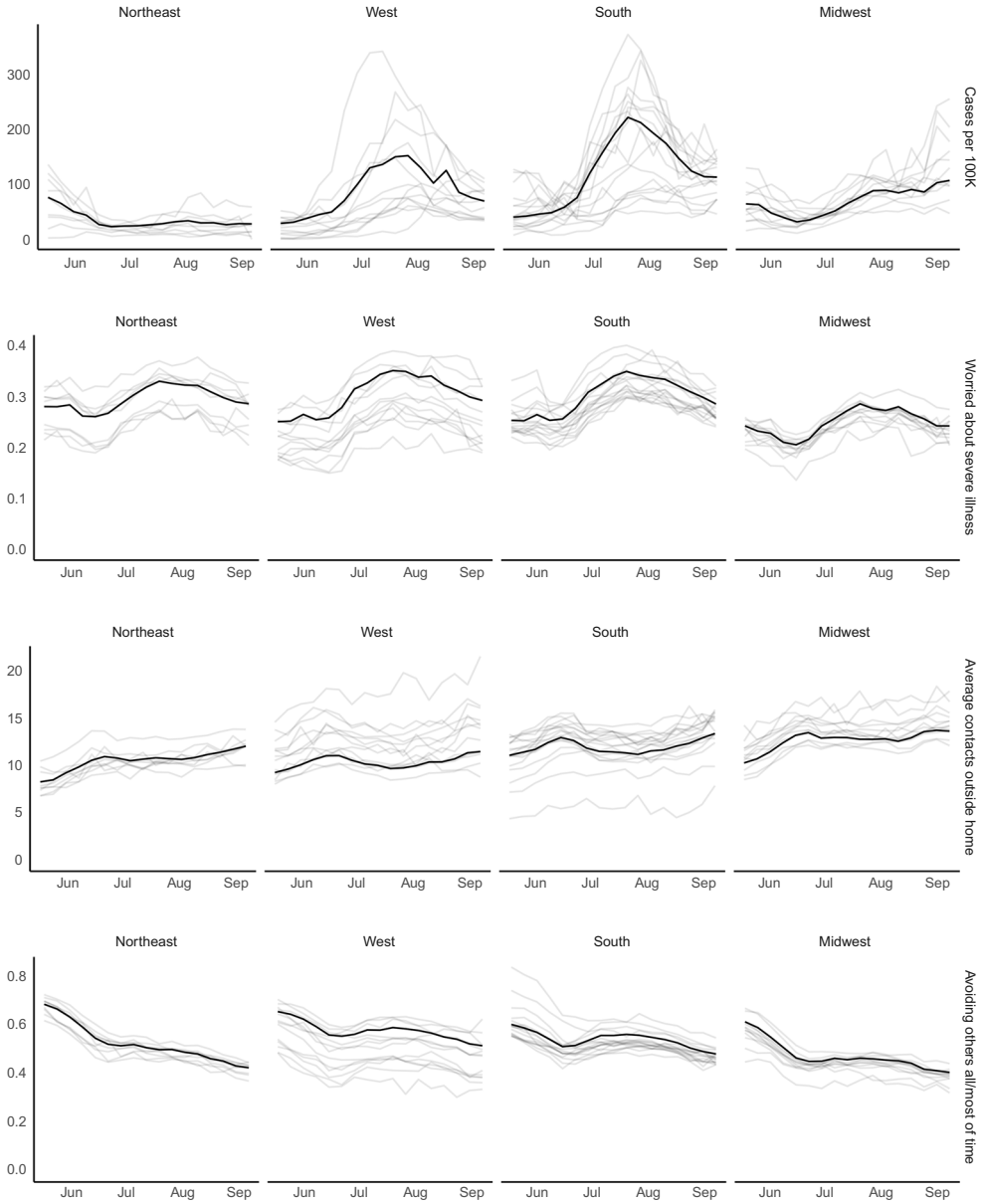

Fig. 1 Trends by region and state, May 15, 2020, to September 6, 2020. The black line reflects the region, while the gray lines are individual states. Note that *y*-axes differ across variables. Due to survey reordering and minor wording changes, survey result levels are not directly comparable between Figures 1 and 2.

from 40 to 26%, Utah from 39 to 23%, and Nebraska from 39 to 26%.[4]

DISCUSSION

Our analysis of a large national survey indicates strong correspondence between rising COVID-19 case reports and increases in individual risk perceptions and mitigating behaviors. Nevertheless, the temporal coincidence between surging cases and behavior changes suggests that this reactive dynamic is likely too late to prevent substantial outbreaks and associated morbidity and mortality.[5] With clear and consistent messaging and early warning signals, the new administration may be able to amplify and accelerate the public's responses to mitigate COVID-19 outbreaks.

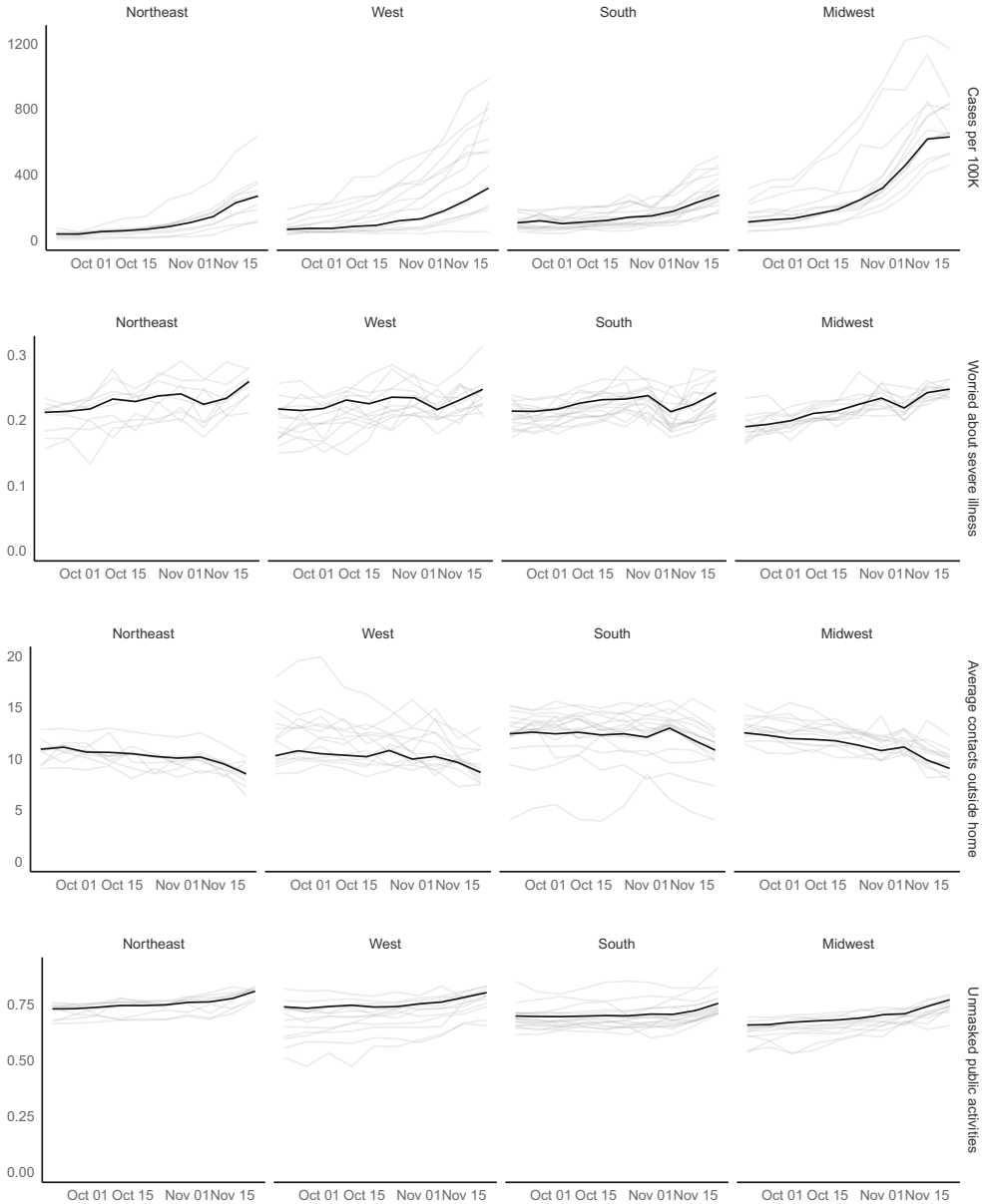

Fig. 2 Trends by region and state from September 14, 2020, through November 22, 2020. The black line reflects the region, while the gray lines are individual states. Note that *y*-axes differ across variables. Due to survey reordering and minor wording changes, survey result levels are not directly comparable between Figures 1 and 2.

Limitations in this study include use of self-reported data and a sample of social media users, who may not be representative of the general population even on a highly used platform like Facebook. Further investigation of the dynamic relationship between infection risk, perceptions, behaviors, and heterogeneity by socioeconomic characteristics is warranted.[6]

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Data Availability: *Aggregated data and code are publicly available on GitHub: https://github.com/abilinski/COVID19RiskResponse.*

Declarations:

Conflict of Interest: *The authors declare that they do not have a conflict of interest.*

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APPENDIX

Trends in Risk Perceptions, Behavioral Responses, and COVID-19 Rates in the US

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SURVEY ITEMS

This research is based on survey results from Carnegie Mellon University's Delphi Research Group.

RISK PERCEPTIONS

Worry

- **C9 (Before September 8).** How do you feel about the possibility that you or someone in your immediate family might become ill from COVID-19 (coronavirus disease)?
- **C9 (From September 8).** How worried do you feel that you or someone in your immediate family might become seriously ill from COVID-19 (coronavirus disease)?
- **Responses.** "Very worried", "Somewhat worried", "Not too worried", "Not worried at all"
- **Coding.** We identified individuals who selected "Very worried."

RISK BEHAVIORS

Average contacts

- **C10.** In the past 24 hours, with how many people have you had direct contact, outside of your household? Your best estimate is fine. ["Direct contact" means: a conversation lasting more than 5 minutes with a person who is closer than 6 feet away from you, or physical contact like hand-shaking, hugging, or kissing.]
- **Responses.** Readers filled in numbers corresponding to "At work", "Shopping for groceries and other essentials", "In social gatherings" and "Other"
- **Coding.** We added the number provided in each category. We included a response if an individual filled a number in at least one category.

Avoiding others

- **C7. (Before September 8)** To what extent are you intentionally avoiding contact with other people?
- **Options.** "All of the time", "Most of the time; I only leave my house to buy food or other essentials", "Some of the time; I have reduced the amount of times I am in public spaces, social gatherings, or at work"; "None of the time"
- **Coding.** We identified individuals who selected "All of the time" or "Most of the time; I only leave my house to buy food or other essentials."

Unmasked public activity

- **C13 (From September 8).** In the last 24 hours, have you done any of the following? Please select all that apply.

[1] Aggregated data and code are publicly available on GitHub (link).

- **Options.** "Gone to work or school outside the place where you are currently staying", "Gone to a market, grocery store, or pharmacy", "Gone to a bar, restaurant, or cafe", "Spent time with someone who isn't currently staying with you", "Attended an event with more than 10 people, Used public transit"

- **C13a (From September 8).** During which activities in the past 24 hours did you wear a mask? Please select all that apply

- **Options.** Activities the respondent had selected for C13.

- **Coding.** We first identified individuals who engaged in no public activities, selected "None of the above" for C13, OR who reported in C13a wearing a mask for all activities selected in C13. We allowed a possible exception of not reporting wearing a mask while having "Gone to a bar, restaurant, or cafe", due to ambiguity around wearing a mask during eating. The outcome "unmasked public activities" was 1 minus this composite.

Data Cleaning and Weights

Of 10,842,811 responses completed fromm May 15, 2020 to November 22, 2020 (inclusive), we removed 936,700 (9%) for poor data quality (e.g., more than 30 people in a household, reporting having experienced all symptoms, body temperature above 104, profane or political responses in "other symptoms", contacts greater than 100) and 238,711 (2%) that were missing a valid zip code linking to a state or that lived outside the United States, with 9,667,400 (89%) included in the final sample. Weights are explained in this paper. Comparisons of weighted and unweighted demographic characteristics and missingness are provided below. For simplicity, for each outcome reported, we omitted responses with missing data. With the exception of the September survey change, when missingness in average contacts increased from 16% to 21%, missing data patterns were fairly stable over time.

Table 1: Weighted demographic questions and missing data

Variable	April 6-September 6	September 14-November 1
% female	0.52	0.53
% missing age	0.11	0.12
% missing avoiding others	0.06	NA
% missing contacts (all)	0.16	0.22
% missing contacts (other)	0.49	0.58
% missing contacts (shopping)	0.32	0.42
% missing contacts (social)	0.29	0.39
% missing contacts (work)	0.33	0.40
% missing gender	0.11	0.12
% missing public activities	NA	0.05
% missing worry about illness	0.10	0.12
% over 65	0.21	0.22

Table 2: Unweighted demographic questions and missing data

Variable	April 6-September 6	September 14-November 1
% female	0.66	0.66
% missing age	0.00	0.00
% missing avoiding others	0.06	NA
% missing contacts (all)	0.15	0.22
% missing contacts (other)	0.47	0.57
% missing contacts (shopping)	0.30	0.42
% missing contacts (social)	0.28	0.39
% missing contacts (work)	0.32	0.41
% missing gender	0.10	0.11
% missing public activities	NA	0.04
% missing worry about illness	0.09	0.10
% over 65	0.10	0.11

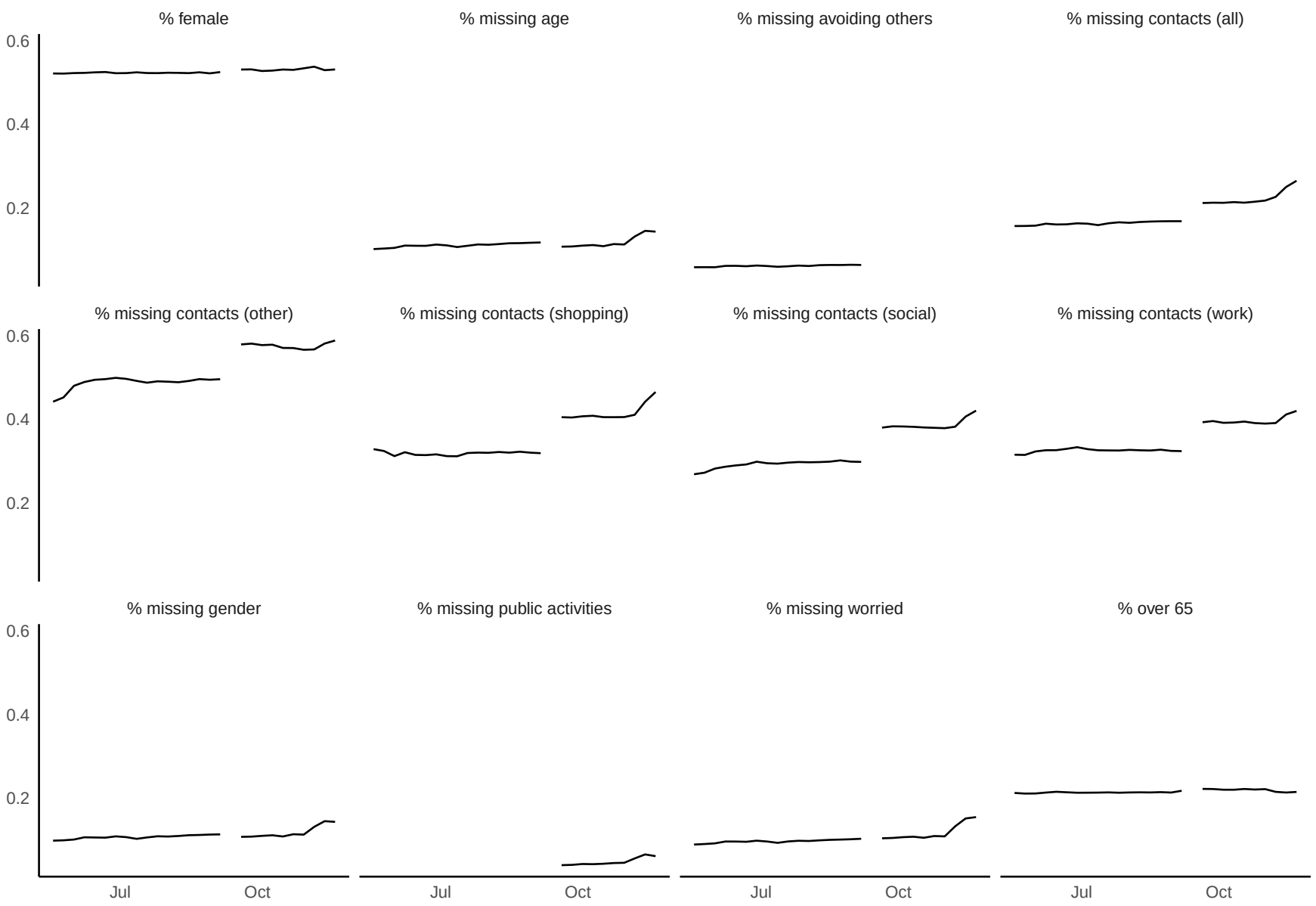

Figure 1: Demographics and missingness over time