Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Short Communication

Was COVID-19 associated with increased cigarette purchasing, consumption, and smoking at home among US smokers in early 2020? Findings from the US arm of the International Tobacco Control (ITC) Four Country Smoking and Vaping Survey

Pete Driezen, Karin A. Kasza, Shannon Gravely, Mary E. Thompson, Geoffrey T. Fong, K. Michael Cummings, Andrew Hyland

A R T I C L E   I N F O

Keywords: COVID-19 United States Cigarettes Purchasing Smoking behaviors Smoke-free homes

A B S T R A C T

Evidence of the impact of COVID-19 and mandatory stay-at-home orders on cigarette smoking is mixed. In the United States, household tobacco purchases increased in early 2020, but it is unclear whether this was associated with increased smoking. Using individual-level, longitudinal data from a representative cohort of US smokers (n = 3046), this study tested whether (1) carton purchases of cigarettes increased in early 2020 relative to the same calendar period in 2018, (2) more smokers permitted smoking inside their homes, and (3) smokers increased the number of cigarettes they smoked per day. Weighted multivariable logistic regression tested whether trends in carton purchasing and smoke-free homes differed in 2020 compared to 2018 while weighted multivariable linear regression tested whether trends in cigarette consumption differed in 2020 compared to 2018. Overall, 24.0% of US smokers last purchased cigarettes by the carton in early 2018; this increased to 28.8% in early 2020 (p = 0.007). Average daily cigarette consumption and the percentage of smokers reporting that smoking was not allowed inside their homes did not differ between 2018 and 2020 (p = 0.92 and p = 0.054, respectively). Overall, these findings suggest that COVID-19 mitigation measures implemented in the spring of 2020 had limited impact on the smoking behavior of US adult smokers.

1. Introduction

In response to the initial spread of SARS-CoV-2, the novel coronavirus that causes COVID-19, in March of 2020, state and local governments in the United States (US) introduced stay-at-home orders intended to mitigate its spread. Mandatory stay-at-home orders requiring all residents to remain at home were enacted in 36 US states and the District of Columbia between March 19, 2020 and April 23, 2020. Four states retained mandatory orders after May 31, 2020 (California, Hawaii, Michigan, and New Jersey; Moreland et al., 2020). Mandatory orders were associated with decreased median population movement after such orders were implemented compared to the period preceding implementation (Moreland et al., 2020). However, evidence of the effect of COVID-19 and state-issued stay-at-home orders on smoking behavior is mixed.

Media reports have suggested that stay-at-home orders implemented to reduce the spread COVID-19 may have led smokers to smoke more if they were able to work remotely from home, either because of increased stress or because they could smoke more freely at home than at work (Geller & Cavale, 2020; Norton, 2020). In the US, total cigarette production decreased from 2015 to 2019 but remained stable from 2019 to 2020 (Alcohol and Tobacco Tax Trade Bureau, U.S. Department of the Treasury, 2021). US consumer purchasing data corroborate this trend: household tobacco purchases increased by 13% in early 2020 compared
to the same period in 2019 (Lee et al., 2021). However, Lee et al. (2021) could not disentangle increased household tobacco purchases from changes in individual tobacco use behaviors. Thus, the increase reported by Lee et al. (2021) may indicate that tobacco users were merely stockpiling tobacco products during this time. Indeed, other studies of consumer purchasing behavior suggested that people may have stockpiled household items in response to COVID-19 and the policies implemented to mitigate its spread (Micalizzi et al., 2021).

US studies of convenience samples of Amazon Mechanical Turk (MTurk) workers demonstrated that some smokers reported increased cigarette use due to COVID-19, others reported decreased use, but almost half reported no change in their cigarette use (Klemperer et al., 2020; White et al., 2021). Population studies of representative samples of US smokers report similar effects (Gravely et al., 2021; Kalkhoran et al., 2021). However, a repeat cross-sectional survey examining the effects of mandatory stay-at-home orders among smokers from California found that smokers surveyed after stay-at-home orders were implemented had higher cigarette consumption rates than those surveyed before such orders were implemented (Gonzalez et al., 2022). To date, no studies have compared population-level differences in cigarette purchasing and smoking behaviors during the initial outbreak of COVID-19 in the US against an earlier, but comparable, calendar period using longitudinal data.

The purpose of this pre-post study, therefore, was to examine the effect of stay-at-home orders (implemented to mitigate the spread of COVID-19) on cigarette purchasing and smoking behaviors in the US using individual-level data from a longitudinal, representative sample of US adult smokers. We tested whether carton purchases (i.e., bulk purchasing) increased in 2020 compared to 2018, whether more smokers permitted smoking inside their homes in 2020 compared to 2018, and whether mean daily cigarette consumption increased in 2020 compared to 2018.

2. Materials & methods

Data came from a longitudinal cohort of 3046 at least monthly smokers participating in the 2018 and/or 2020 waves of the US arm of the International Tobacco Control (ITC) Four Country Smoking and Vaping Survey (ITC 4CV Survey, Thompson et al., 2019). Only respondents who reported smoking at least once a month in either wave were included; the majority reported smoking every day (81% in 2018 and 80% in 2020, unweighted). Of these 3046 smokers, 1229 (40%) participated only in the 2018 wave, 980 (32%) participated only in the 2020 wave, and 837 (28%) participated in both the 2018 and 2020 waves. All respondents provided informed consent. Survey protocols and questionnaires received ethical approval from the Office of Research Ethics, University of Waterloo, Canada (ORE#20803/30570, ORE#21609/30878) and the Medical University of South Carolina, US (waived due to minimal risk).

The ITC 4CV Survey is an ongoing cohort survey of people who currently use combustible cigarettes, e-cigarettes, and/or heated tobacco products. The survey instruments contain more than 600 items (per wave) measuring the use of these tobacco products; sociodemographic measures; and policy-specific measures such as price, health warnings, and packaging. A complete description of the survey instruments is available elsewhere (Thompson et al., 2019; International Tobacco Control Policy Evaluation Project, 2020a; International Tobacco Control Policy Evaluation Project, 2020b). Data for all survey waves were collected via computer-assisted web interviewing. Thompson et al. (2019) describe the methods of the ITC 4CV Survey in more detail.

Data for each year were classified into three survey periods according to respondent interview date: (1) before March 19, (2) March 19–April 23, and (3) after April 23. The March 19–April 23 period in 2020 corresponded to state-issued stay-at-home orders intended to mitigate the spread of COVID-19 (Moreland et al., 2020). California issued the first mandatory order on March 19, 2020; Alaska was the first state to rescind or allow an order to expire on April 24, 2020 (Moreland et al., 2020). These cut points were chosen to represent a time when most states had mandatory stay-at-home orders in place in early 2020. It is important to note, however, that the timing of these orders varied across US states.

An additional sensitivity analysis was conducted to assess the robustness of results to different assumptions regarding the state-specific implementation of stay-at-home orders using publicly available data from “Ballotpedia” (Ballotpedia, 2021). That is, based on respondents’ state of residence, three periods were coded for each respondent in each survey year according to the timing of state-specific stay-at-home orders implemented in early 2020 (Supplementary Table S1). For example, respondents from Florida were classified into three calendar periods for each survey year: (1) prior to implementation of stay-at-home orders (before April 2), (2) the period when stay-at-home orders were in effect (April 2 to May 4), and (3) the period after stay-at-home orders were eased or rescinded. Respondents from states where orders remained in effect after the end of data collection in 2020 were only classified into two periods for the sensitivity analysis while respondents from states that did not implement stay-at-home orders according to “Ballotpedia” were coded into a single “states not implementing stay-at-home orders” category.

Respondents reported how they purchased cigarettes the last time they bought cigarettes. For this measure, respondents could report they last purchased cigarettes by the carton, in packs, or as single (loose) cigarettes. Responses were dichotomized into carton purchases vs. packs/bags/loose. Respondents also reported whether they allowed smoking inside their homes (never allowed anywhere vs. allowed anywhere/something in between), and number of cigarettes smoked/day. Logistic regression was used to estimate average marginal effects, or the adjusted percentage of smokers who last purchased cigarettes by the carton, and who never allowed smoking inside their homes. Linear regression was used to estimate adjusted mean cigarettes smoked/day. These adjusted estimates, or average marginal effects, account for differences in covariate distributions across survey periods (Grubard & Korn, 1999; Muller & MacLeod, 2014). Covariates used in all regression models were US census division (New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific), sex, age (18–24, 25–39, 40–54, 55+), race/ethnicity (white, black, Hispanic, other/mixed race), respondent type (new recruit, re-contact), income (< $30,000, $30,000 to < $60,000, ≥ $60,000), education (< high school, some college/Associate degree, ≥ Bachelor’s degree), employment status (employed, otherwise), living with children under 18 (any, none/no children), e-cigarette use (at least weekly, < weekly, not at all), and smoking status (daily, non-daily). A period-by-year interaction term tested whether overall and period-specific trends differed between years. These multi-variable models were fit using generalized estimating equations in SAS-callable SUDAAN (Version 11.0.3) to account for the stratified sampling design, sampling weights, and within-subject correlation arising from respondents completing both the 2018 and 2020 surveys.

3. Results

Controlling for all sociodemographic factors, e-cigarette use, and daily/non-daily smoking status, an estimated 24.6% of US smokers last purchased cigarettes by the carton at the time of the 2018 survey. This increased to 28.8% in 2020 (p = 0.007, Table 1). During the period when most US states had enacted mandatory stay-at-home orders (March 19, 2020 – April 23, 2020), 32.3% of US smokers reported they last purchased cigarettes by the carton, compared to 26.2% during the same calendar period in 2018 (p = 0.025). The percentage of smokers reporting they last purchased cigarettes by the carton after April 23 was not significantly higher in 2020 than in 2018 (p = 0.12).

Overall, there was a small, but non-significant, increase in the
The findings of this study suggest that stay-at-home orders implemented to mitigate the spread of COVID-19 influenced smokers’ purchasing practices but did not influence their smoking behaviors. Household tobacco purchases during the initial outbreak of COVID-19 in the US may partially be explained by increased carton purchasing, corroborating findings by Lee et al. (2021). However, average daily cigarette consumption did not differ in 2018 and 2020 among US smokers.

In contrast to reports in the popular media (Geller & Cavale, 2020; Norton, 2020), this study found that COVID-19 mitigation measures implemented in the spring of 2020 had limited impact on the smoking behavior of US adult smokers. Future research should explore whether smoking behaviors changed among adolescents as a result of the COVID-19 pandemic or associated mitigation measures and whether e-cigarette use may have changed among adolescent and adult populations.

### 4. Discussion

The findings of this study suggest that stay-at-home orders implemented to mitigate the spread of COVID-19 influenced smokers’ purchasing practices but did not influence their smoking behaviors. Household tobacco purchases during the initial outbreak of COVID-19 in the US may partially be explained by increased carton purchasing, corroborating findings by Lee et al. (2021). However, average daily cigarette consumption did not differ in 2018 and 2020 among US smokers. Further, in each of the three periods, there was a slight, but non-significant, increase from 2018 to 2020 in the percentage of smokers reporting that smoking was never allowed inside their homes, suggesting that stay-at-home orders did not increase smoking inside the home.

### 4.1. Strengths and limitations

The primary strength of this study was that it used longitudinal data from a representative sample of US adult smokers to compare changes in cigarette purchasing, smoke-free homes, and daily cigarette consumption that could be attributable to state-issued stay-at-home orders designed to mitigate the spread of COVID-19. Changes were estimated in the same calendar periods in 2018 and 2020 and estimated differences controlled for multiple comparisons using the Bonferroni correction (FDR adjustment, e.g., 20.8% of smokers surveyed before March 19, 2020 last purchased cigarettes by the carton vs. 32.3% of smokers surveyed from March 19–April 23, 2020; FDR p < 0.05). All tests (within and between years) were adjusted using the false-discovery rate adjustment (ten tests per model). Estimated regression parameters from the GEE models are presented in Supplementary Table S3.

Percentage of smokers who reported they never allowed smoking inside their homes from 2018 (48.6%) to 2020 (53.5%, p = 0.054). Similar increases were observed in each of the three calendar periods. There was no difference in average daily cigarette consumption in 2018 and 2020 (p = 0.92). Average differences in period-specific cigarette consumption between 2018 and 2020 were small, ranging from −0.06 cigarettes/day (p = 0.95) to 0.17 cigarettes per day (p = 0.92).

Results from the sensitivity analysis using the state-specific timing of stay-at-home orders (Supplementary Table S2) were consistent with those from the main analysis (Table 1). Specifically, overall estimates and trends from both models were essentially the same. In addition, in the sensitivity analysis, the percentage of smokers last purchasing cigarettes by the carton remained significantly higher during the state-specific stay-at-home period in 2020 than the percentage in the corresponding calendar period in 2018. As in the main analysis, there was no significant difference in the percentage of smokers not allowing smoking inside their homes during the stay-at-home period in 2020 compared to the same calendar period in 2018, nor was there a significant difference in the average number of cigarettes smoked per day.

### 5. Conclusions

In contrast to reports in the popular media (Geller & Cavale, 2020; Norton, 2020), this study found that COVID-19 mitigation measures implemented in the spring of 2020 had limited impact on the smoking behavior of US adult smokers. Future research should explore whether smoking behaviors changed among adolescents as a result of the COVID-19 pandemic or associated mitigation measures and whether e-cigarette use may have changed among adolescent and adult populations.

### 6. Ethics approvals

Survey protocols and questionnaires received ethical approval from the Office of Research Ethics, University of Waterloo, Canada (ORE#20803/30570, ORE#21609/30878) and the Medical University of South Carolina, US (waived due to minimal risk).

### Funding sources

This study was supported by grants from the US National Cancer
Institute (P01 CA200512) and the Canadian Institutes of Health Research (FDN-148477). GTF was also supported by the Ontario Institute for Cancer Research Senior Investigator Grant (IA-004), and the Canadian Cancer Society O. Harold Warwick Prize. None of the funders had any role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit the paper for publication.

CRediT authorship contribution statement

Pete Driezen: Conceptualization, Methodology, Formal analysis, Validation, Writing – original draft, Writing – review & editing. Karin A. Kasza: Conceptualization, Methodology, Formal analysis, Writing – review & editing. Shannon Gravely: Writing – review & editing. Mary E. Thompson: Funding acquisition, Conceptualization, Methodology, Writing – review & editing, Supervision. Geoffrey T. Fong: Funding acquisition, Resources, Writing – review & editing, Supervision. K. Michael Cummings: Funding acquisition, Writing – review & editing, Supervision. Andrew Hyland: Conceptualization, Writing – review & editing, Supervision.

Declaration of Competing Interest

Geoffrey T. Fong has served as an expert witness on behalf of governments in litigation involving the tobacco industry. K. Michael Cummings has served as a paid expert witness in litigation filed against the cigarette industry. All other authors have no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2022.107276.

References

Alcohol and Tobacco Tax Trade Bureau, U.S. Department of the Treasury. (2021). Tobacco Statistics: Yearly Tobacco Statistics. [https://www.ittb.gov/tobacco/tobacco -statistics].

Ballotpedia. (2021). States that issued lockdown and stay-at-home orders in response to the coronavirus (COVID-19) pandemic, 2020. [Available from https://ballotpedia. org/States_that_issued_lockdown_and_stay-at-home_orders_in_response_to_the_coronavirus_(COVID-19)_pandemic,_2020]. Accessed November 26, 2021.

Geller, M., & Cavale, S. (2020, November 19). Big Tobacco gets a pandemic pick-me-up. [https://www.reuters.com/article/us-health-coronavirus-smoking-insight idUSKBN27721Z].

Gonzalez, M., Epperson, A. E., Halpern-Feldsher, B., Halliday, D. M., & Song, A. V. (2021). Smokers are more likely to smoke more after the covid-19 california lockdown order. International Journal of Environmental Research and Public Health, 18(5), 1–9. [https://doi.org/10.3390/ijerph18052082].

Graubard, B. I., & Korn, E. L. (1999). Predictive margins with survey data. Biometrics, 55, 652–659. [https://doi.org/10.1111/j.0006-341X.1999.00652.x].

Gravely, S., Craig, L. V., Cummings, K. M., Ouimet, J., Loeven, R., Martin, N., Chung-Hall, J., Driezen, P., Hitchman, S. C., McNeil, A., Hyland, A., Quah, A. C. K., O’Connor, R. J., Borland, R., Thompson, M. E., Boudreau, C., & Fong, G. T. (2021). Smokers’ cognitive and behavioural reactions during the early phase of the COVID-19 pandemic: Findings from the 2020 ITC Four Country Smoking and Vaping Survey. PLoS ONE, 16(6), 1–23. [https://doi.org/10.1371/journal.pone.0254247].

International Tobacco Control Policy Evaluation Project. (2020a). 4-Country Smoking & Vaping W2, Recontact/Replenishment. Available from [https://itcproject.s3.amazonaws.com/uploads/documents/ITC_4CV2_Recontact-Replenishment_web_Eng_13April2020.pdf]. Accessed November 26, 2021.

International Tobacco Control Policy Evaluation Project. (2020b). 4-Country Smoking & Vaping W3, Recontact/Replenishment. Available from [https://itcproject.s3.amazonaws.com/uploads/documents/ITC_4CV3_Recontact-Replenishment_web_Eng_16Sep2020_1016.pdf]. Accessed November 26, 2021.

Kalkhoran, S., Levy, D. E., & Rigotti, N. A. (2021). Smoking and vaping among a national sample of U.S. adults during the COVID-19 pandemic. medRxiv, preprint. [https://doi.org/10.1101/2021.03.18.21259902].

Klemperer, E. M., West, J. C., Peasley-Miklus, C., & Villanti, A. C. (2020). Change in tobacco and electronic cigarette use and motivation to quit in response to COVID-19. Nicotine & Tobacco Research, 22(9), 1662–1663. [https://doi.org/10.1093/ntt/ntaa072].

Lee, B. P., Dodge, J. L., Leventhal, A., & Terrault, N. A. (2021). Retail alcohol and tobacco sales during COVID-19. Annals of Internal Medicine, Published Online First: 2 March 2021. [https://doi.org/10.7326/M20-7271].

Micalizzi, L., Zambrotta, N. S., & Bernstein, M. H. (2021). Stockpiling in the time of COVID-19. British Journal of Health Psychology, 26(2), 535–543. [https://doi. org/10.1111/bjhp.12480].

Moreland, A., Herliby, C., Tynan, M. A., Sunshine, G., McCord, R. F., Hilton, C., Baldwin, G. (2020). Timing of state and territorial COVID-19 stay-at-home orders and changes in population movement—United States, March 1-May 31, 2020. Morbidity and Mortality Weekly Report, 69(35), 1198–1203. [https://doi.org/10.15585/mmwr.mm6935e2].

Muller, C. J., & Maclehose, R. F. (2014). Estimating predicted probabilities from logistic regression: Different methods correspond to different target populations. International Journal of Epidemiology, 43, 962–970. [https://doi.org/10.1093/ije/dyu029].

Norton, C. (2020, July 6). Why cigarette sales are outperforming expectations despite a pandemic. Forbes. [https://www.forbes.com/sites/charlesnorton/2020/07/06/why-cigarette-sales-are-outperforming-expectations-despite-a-pandemic/?sh=7779864d46c6].

Thompson, M. E., Fong, G. T., Boudreau, C., Driezen, P., Li, G., Gravely, S., … Quah, A. C. K. (2019). Methods of the ITC Four Country Smoking and Vaping Survey, Wave 1 (2016). Addic tion, 114(51), 6–14. [https://doi.org/10.1111/add.14528].

White, A. M., Li, D., Smoll, L. M., O’Connor, R., Hoetger, C., Croft, D., … Osip, D. J. (2021). Perceptions of Tobacco Product-Specific COVID-19 Risk and Changes in Tobacco Use Behaviors Among Smokers, E-Cigarette Users, and Dual Users. Nicotine & Tobacco Research, 23(9), 1617–1622. [https://doi.org/10.1093/ntt/ntab053].