Sustained Decline in Cigarette Consumption During COVID-19

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Article

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Title: Sustained Decline in Cigarette Consumption During COVID-19

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Abstract

Background: An estimated 8 million people die every year due to tobacco use. The COVID-19 pandemic has increased the health costs of smoking, which is a leading risk factor for more severe COVID-19 symptoms, hospitalization, and death. The pandemic has also led to reductions in physical activity, increases in stress and declines in mental well-being, all factors commonly associated with triggering higher tobacco.

Methods: Using a longitudinal data set of purchasing behavior from 2019-2020 among a national sample of the Danish population (n=4042), we estimate changes in tobacco use during the COVID-19 pandemic. Our analysis compares tobacco purchases prior to the pandemic to purchases during the pandemic, at the individual level. We also examine effects within subgroups based on smoking behavior in 2019 prior to the pandemic. We estimate effects for smokers and non-smokers. Within smokers, we separately estimate effects for occasional smokers and regular smokers.

Results: We find large, sustained, decreases in tobacco consumption during COVID-19. We estimate that, controlling for price, weekly tobacco purchase rates decline by 24 percent and average quantities decline by 12 percent during the period spanning the onset of the pandemic in March 2020 through the end of the year. The declines are driven by regular smokers with little change in behavior among non-smokers or occasional smokers. Among regular smokers, purchase rates decline by about 30 percent, tobacco consumption declines by about 20 percent and quitting rates increase by about 10 percentage points.

Conclusion: Our results are consistent with individuals responding to the increased health risks of smoking due to COVID-19 and suggest that the pandemic could lead to sustained reductions in tobacco consumption.

Plain language summary

The present study explores the effect of COVID-19 on smoking using systematically collected consumption data. Our longitudinal panel data allows us to examine the effects of the pandemic on subgroups defined by their pre-COVID-19 smoking behavior and also allows us to examine smoking behavior over the course of the pandemic. The data from our study and the existing evidence suggest that health shocks which make the risks of smoking more immediate (such as COVID-19) can lead to long term declines in tobacco consumption. A promising direction for future research is to design interventions that build off these findings to expand and sustain decreases in smoking beyond the COVID-19 pandemic.

Introduction

Tobacco consumption is one of the leading causes of death globally, and one of the most difficult health behaviors to change. An estimated 8 million people die every year due to tobacco use, which causes 17 percent of deaths in the U.S., 16 percent in Europe and 12 percent globally^{2,3}. Tobacco products are highly addictive with extremely low rates of cessation, particularly for sustained periods⁴. While tobacco use has declined in the last decade, about 20 percent of people around the world still smoke, including 14 percent in the U.S. and 28 percent in Europe^{3,5}. The economic costs of smoking – both health expenditures and productivity losses – are estimated at \$1.4 trillion per year globally, with estimates of \$300 billion per year in the U.S. and over \$600 billion per year in Europe^{6,7}.

The health costs of smoking have increased during the COVID-19 pandemic, which represents one of the greatest global shocks in modern history to both health and society. Researchers recognized early in the pandemic that tobacco smoking – which is long known to increase susceptibility to infection and activation of inflammation – is a leading risk factor for more severe COVID-19 symptoms, hospitalization, and death^{8,9}. The increased health risks were accompanied by unprecedented societal measures including lockdowns, social distancing, and remote working policies. There is evidence from prior work that both health shocks that increase personal risks from smoking (e.g., during pregnancy), as well as large societal shifts (e.g., smoking norms and restrictions) can drive sustained reductions in smoking^{10–12}. The COVID-19 pandemic might therefore have served as an accelerator to encourage tobacco cessation for consumers¹³, though it is not clear how quickly and

clearly information on increased risks of smoking spread to the public.¹ At the same time, recent studies demonstrate that the pandemic has led to reductions in physical activity, increases in stress and declines in mental well-being^{14,15}, all factors commonly associated with triggering higher tobacco use¹.

In this study, we examine the impact of COVID-19 on tobacco consumption as measured by purchases among a national sample of the Danish population (N=4042). We take advantage of a longitudinal data set that tracks individual purchasing behavior prior to and during the pandemic from 2019 through 2020. The purchasing data come from the e-receipt system of widespread use in Denmark, which automatically collects all purchases from the most common supermarkets in the country using individual payment card data (see Materials and Methods for details of the data set).

Recent literature has used surveys to investigate self-reported consumption changes during the COVID-19 pandemic for diet and addictive substance use (i.e., alcohol, tobacco, drugs). The survey studies generally find that people report increased (expected) tobacco consumption during COVID-19^{16–19}, with the exception of²⁰, which finds declines in usage. Studies using US sales data report 13-14% increases in cigarette sales above expected sales²¹ and prior year sales during COVID-19²². The present study is the first to estimate the impact of COVID-19 tracking individuals over time using systematically

¹ For example, early in the pandemic there was media coverage suggesting that smoking may help protect against COVID-19³² as well as the reverse.

collected consumption data. This allows us to examine the effects of the pandemic separately by pre-pandemic smoking behavior.

Results

Figure 1 plots average cigarette purchase rates (Panel A) and quantities (Panel B) by week in 2019 and 2020 among smokers, who we define as those who buy at least one cigarette in 2019 (24,3% of our sample). The vertical dotted lines indicate the start of the strict lockdown in response to the onset of the COVID-19 pandemic in Denmark on March 11th, 2020, and the end of the lockdown on May 10th, 2020. During the lockdown (weeks 11-20), non-essential workers in the public sector were ordered to work from home, while in the private sector it was highly recommended; no more than ten people could assemble in public; all indoor public institutions and businesses with close contact were closed; restaurants were closed to in person dining and could only serve take-out. Stores where cigarettes can be purchased remained open with social distancing regulations in place, which lasted throughout the remainder of the year. After the lockdown ended, occupancy restrictions and social distancing measures remained in place for most businesses. A second, less comprehensive, lock-down was imposed from December 9th, 2020 (week 50) in 38 of the 98 Danish municipalities, including Copenhagen.

[Insert Figure 1]

Prior to the lockdown period (week 1-10), 2019 and 2020 purchasing habits are almost identical, with smokers buying on average 11.44 cigarettes per week in 2019 and 12.03 cigarettes per week in 2020 ($p=0,196$ from a rank-sum test of equality at the week level).

Purchase rates for smokers decline immediately after the lockdown begins, averaging 16.83% during the lockdown compared to 20.59% in the same period in 2019 ($p=0.002$). However, there is no impact on quantity during this period ($p=0.931$). After the lockdown ends in 2020, both purchase rates and quantities declined steadily throughout the spring and summer – a period when smoking usually increases – and then level off in the fall. In the post-lockdown period, purchase rates average 13.73% in 2020 compared to 20.68% in the same period in 2019 ($p<0.0001$), a 34% decline. Quantities over this period average 9.83 cigarettes per week, a 32% decline compared to the 2019 averages of 14.40 ($p<0.0001$).

Figure 2 plots seasonally-adjusted regression coefficients estimating the impact of the pandemic on purchases, pooling the lockdown and post-lockdown periods, weeks 11-52 (see Materials and Methods for details of the regression analysis). We present estimates for the full sample and for subgroups based on 2019 smoking behavior, both with and without price controls. The top panels show the estimated impact on weekly cigarette purchase rates (Panel A) and cigarette quantity (Panel B). The full regressions are presented in Appendix Tables S3 - S6.

For the full sample, we estimate that weekly purchase rates of cigarettes decreased by 1.2 - 1.6 percentage points ($p<0.001$ with and without controlling for price), a 24 - 33% decline compared to the same period in 2019. Weekly quantities drop by an estimated 0.4 - 1.0 cigarettes ($p=0.034$ and $p<0.001$ with and without controlling for price), a 12 - 28%

decline. The declines are driven entirely by smokers with no meaningful effects for non-smokers. That is, we find no evidence that the pandemic led non-smokers to begin smoking.

[Insert Figure 2]

Among smokers (who bought at least one cigarette in 2019), we estimate declines of 5.3 - 6.6 percentage points in weekly purchase rates ($p < 0.001$ with and without controlling for price) and 1.9 - 4.1 of cigarettes per week ($p = 0.013$ and $p < 0.001$ with and without controlling for price), 26 - 33% and 14 - 30% declines respectively. We further divide smokers into regular smokers (33%) and occasional smokers (67%), where we define regular smokers as those who purchase the equivalent of at least one cigarette per day in 2019²³. Among regular smokers, we estimate that weekly purchase rates decline by 14.9 - 18.3 percentage points, a 30 - 37% percent decline ($p < 0.001$). Average quantities drop by an estimated 7.4 - 13.4 cigarettes per week, a 20 - 35% decrease compared to 38.1 cigarettes per week in the same period in 2019 ($p < 0.001$). For occasional smokers – those who purchase at least one cigarette but less than one per day – we find small decreases in purchase rates ($p = 0.387$ and $p = 0.187$ with and without controlling for price); and small increases in purchase quantities ($p = 0.005$ and $p = 0.062$). That is, the reduction in cigarette consumption among all smokers is driven by changes in behavior among regular smokers, with little impact of the pandemic on occasional smokers. We find little evidence of significant heterogeneity across demographic subgroups, including gender, age, household type and employment status (Appendix Figure S1).

There may be concern that smokers substitute reduced tobacco use with increased alcohol consumption. The two bottom panels in Figure 2 present estimates for the impact of the pandemic on alcohol purchase rates (Panel C) and quantities (Panel D). We find suggestive evidence of increases in alcohol purchases during the pandemic. As we discuss in more detail in the Materials and Methods, the increase in alcohol purchases at grocery stores could partially be driven by reduced consumption at restaurants, which our data do not include. Importantly, we find no evidence of larger increases in alcohol consumption among regular smokers, who account for the full decrease in cigarette consumption.

Finally, we attempt to estimate quitting behavior among regular smokers in 2020 compared to regular smokers in 2019.² We define quitting as making no cigarette purchases for the remainder of the year. Figure 3 plots the difference by week in the cumulative proportion of quitters in 2020 compared to 2019 – i.e., the proportion who have made their final cigarette purchase of the year. Quitting rates are significantly higher throughout 2020 compared to 2019. If we consider those who quit for at least six months (i.e., make their final purchase prior to July 1st, week 27), we estimate that quitting rates increase by about 10 percentage points in 2020.

[Insert Figure 3]

Mechanisms

² We define regular smokers as buying on average at least one cigarette per day in the first ten weeks of the relevant year – i.e., prior to the start of the pandemic period in 2020.

We consider several potential mechanisms for the decline in tobacco purchases during COVID-19. It could be due to the increased risks from COVID-19 that smokers face, changes in social and work environments, or financial concerns.

Our findings do not provide strong evidence that the declines are driven by changes to social and work environments. We find smaller declines in purchases during the strict lockdown when there was the largest change to social and work environments, and the largest declines during the spring and summer when the economy reopened. We also do not find declines in tobacco consumption among occasional smokers who are likely to be those most sensitive to “social smoking.”

We find evidence that financial concerns may be partially driving the decline in tobacco use but do not fully explain it. Comparing estimates with and without controlling for price, we estimate that prices explain about 25% of the total decline in cigarette use during the pandemic. Using our data, we find evidence of price increases starting in week 27 of 2020 through the end of the year (see Appendix Figure S2). The increase is due to a national tax increase on cigarettes which came into effect on April 1st (week 14) but did not immediately affect prices due to retailers stocking up tobacco packages subject to the lower taxation rate²⁴. We estimate that prices increased by about 29% percent compared to the same period in 2019, and a price elasticity of 0.55 among regular smokers – which is in line with existing literature²⁵. We conduct a sensitivity analysis examining the effects of the pandemic prior to the price change in week 27 and find a similar impact of COVID-19 on cigarette consumption (Appendix S7).

To examine the net effect of price and quantity changes, we estimate the impact of the pandemic on money spent on cigarettes (Appendix Table S5). We find significant reductions in both the full population and all subgroups of smokers, with regular smokers spending an estimated \$3.15 less per week on cigarettes ($p < 0.001$), a 24% decrease compared to an average of \$12.87 during the same period in 2019. We conclude that price is partially driving the decrease in purchases but does not fully explain the decline.

Finally, several studies report growing awareness and fear of the increased risks of COVID-19 among smokers ^{26,27}. Beginning in March 2020, local media repeatedly highlighted the correlation between smoking and more severe COVID-19 infections, though as noted above there was some contradictory coverage early in the pandemic. We also find evidence, based on Google searches, of increased interest in the relationship between smoking and COVID-19 during this period. See Appendix Table S8 and Figure S3 for a summary of the most relevant media publications in Denmark and a time trend of Google searches of related terms, respectively.

Discussion & Conclusions

We document sustained declines in cigarette consumption throughout the pandemic. Our estimated purchase rate declines of about 25% in the full population and about 30% among regular smokers are large relative to policy interventions to reduce smoking. A review of these interventions -- including informational campaigns, price increases and smoking bans -- estimates a 7-8% reduction in cigarette demand, compared to our estimates of about

12%; and 3-4 percentage point increases in smoking cessation compared to about a 10 percentage point increase in quitting behavior during the pandemic ²⁸. One potential reason for the large impact of COVID-19 relative to other policy interventions is that – similar to smoking during pregnancy – COVID-19 makes the health risks of smoking more immediate. This may help some smokers overcome a key barrier to quitting – that the enjoyment of smoking is felt in the present and the health costs are usually felt in the future.

Whether smoking returns to pre-pandemic levels is an open question. Studies of health shocks, such as pregnancy, demonstrate large rebound effects after the temporary shock fades away: e.g. 23% had ceased smoking during pregnancy but only 8% had quit smoking after pregnancy in ¹². At the same time, the pandemic has shifted some lifestyle habits in ways that people expect to persist ²⁹. If the health risk perception related to COVID-19 and smoking lasts long enough, the quitting behavior might also persist, loosening the addictive habit. Recent work estimates that decreasing longer-term smoking rates by 8 percent leads to a 6 percent reduction in mortality ³⁰. If the decline in smoking we document persists, it could both help decrease the risks from COVID-19 as new variants emerge and have longer-term benefits to societal health.

Materials and Methods

The sample of this study is composed of 4042 users of two smartphone apps developed by *Spenderlog*, a Danish fintech company. The anonymous consumption data was purchased from the private company partner following the European GDPR regulation in force at the time of the study. The dataset is composed by 4042 users who have data for both 2019 and

2020 (Stata/MP 16.1 was used for data analysis). The apps provide an overview of either spending or the environmental impact of users' grocery purchases (of the 69.4% of respondents we have data on app usage: 48.5% used the spending app, 40.9% used the environmental impact app and 10.6% used both).

App-users can activate a profile that includes optional demographic questions and connect the app to an e-receipt system of widespread use in Denmark. The e-receipt system collects data from the most common supermarkets in the country using individual payment card data and registers all food purchases at the individual level without the need for any manual entries. It also provides historic data on grocery purchases prior to the download, allowing us to track purchases within an individual user over time.

A subsample of our participants self-reported demographic characteristics via the app during the sign-up process: gender (68% report), age (68.5% report), employment status (70.4% report), and household type (71.5% report). As shown in Appendix Table S1, compared to the overall population, our participants are on average more likely to be female, to cover younger age groups, to have a higher income, to have children in the household and to be more heavily drawn from the capital region (Copenhagen).

Our analysis focuses on cigarette purchases, which account for 98.67% of tobacco purchases. Including purchases of rolling tobacco does not affect the results (Appendix Table S2). We characterize each individual based on smoking behavior in 2019 prior to the COVID-19 pandemic: non-smokers who purchased no cigarettes in 2019 (76.7% of our

sample) and smokers who purchased at least one cigarette in 2019 (24.3%). Among smokers, we also characterize regular smokers as those who purchased the equivalent of at least one cigarette per day in 2019 (33% of smokers, 8% of our sample) and occasional smokers who purchased at least one cigarette in 2019 but less than the equivalent of one cigarette per day (66.9% of smokers, 16.3% of our sample).³ Smoking behavior observed in our sample is lower than the same habit in the Danish population: an estimated 17% of Danes smoke daily ³¹. The differences between our sample and the Danish population may be in part due to individuals purchasing cigarettes at outlets other than grocery stores that are not captured in our data, such as convenience stores and corner shops. Therefore, our estimates of cigarette purchases may be an underestimate of total quantity.⁴

We also examine alcohol purchases, which may serve as a substitute (or complement) for cigarettes. We are not able to estimate whether smokers substitute to e-cigarettes, cigarette smoking cessation products, prescription medication or illegal drugs because we do not observe consumption of these products in our dataset.

Our primary analysis examines weekly purchases from 2019 through 2020. We focus on the following periods of interest: weeks 1-10 of 2020 prior to the pandemic, weeks 11-20 (March 11th to May 10th, 2020) at the onset of the pandemic during the strict lockdown in Denmark, and the remainder of the year, weeks 21-52. We compare the pandemic period

³ According to the National Institute for Health Education Risk Prevention (INPES), a regular smoker is somebody who admits to smoking at least one cigarette (or equivalent) per day ²³.

⁴ Purchases may also reflect household rather than individual tobacco usage and so may be an overestimate of individual consumption. We may also overestimate consumption if people store the cigarettes they buy for long periods. In our data, most consumers buy cigarettes in small quantities suggesting they are not stocking up.

in 2020 to the same period in 2019 using a within subject comparison. We estimate changes in purchases during COVID-19 using the following fixed effects regression:

$$y_{it} = \beta_0 + \beta_1\sigma + \beta_2\gamma + \beta_3\gamma\sigma + \beta_4\log(\varpi_t) + \beta_5x_1 + \beta_6x_2 + \beta_7x_3 + \varepsilon_{it}$$

where the dependent variable y_{it} is the outcome of interest for individual i at the weekly level t ; the dummy σ which is an indicator for the year 2020 (vs. 2019); the dummy γ is the time indicator for COVID-19 period (i.e. from week 11 onwards), three covariates x_k control for seasonal fixed effect – where $k=1$ corresponds to spring (week 12 – week 25), $k=2$ to summer (week 26 – week 38) and $k=3$ to fall (week 39 – week 52). Our coefficient of interest is the term interacting the indicator for 2020 with the indicator for the COVID-19 period. We include the logarithmic function of ϖ_t to control for average weekly price as measured in our data²⁵; finally, ε_{it} is the residual term. We cluster standard errors at the individual level. We also separately estimate the impact of COVID-19 during the strict lockdown period and the post-lockdown period through the end of the year (Appendix Table S6). Because of the structure of the days in a week in 2019 and 2020, week 53 exists only for 2020 and is excluded from the analysis.

Because our data include grocery store purchases, there may be concern that our difference-in-differences estimates could partially reflect changes in where people make purchases. For example, there may be concern that changes in food or alcohol purchases partially reflect a shift towards buying a larger share of food and alcohol at grocery stores during the pandemic because public health measures may have reduced consumption from

restaurants. As noted in the main text, restaurants were closed for in person dining during the strict lockdown and were under occupancy restrictions for the remainder of the year. Shifting consumption patterns are less of a concern for cigarette purchases than for other grocery items because lockdown and social distancing measures did not differentially affect where people could buy tobacco: both convenience shops and supermarkets remained open throughout the pandemic.

Data and materials availability statement:

Data is not publicly available as dictated by contractual agreement between the University of Copenhagen and the data collecting partner company. Requests for data, with justification, should be sent to TF.

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Figures

Figure 1. Weekly Cigarette Purchases in 2019 vs. 2020.

Panel A –Smokers’ weekly average purchase rate by year; Panel B – Smokers’ weekly average purchase of cigarettes by year. The two red lines indicate the lockdown period. Smokers are defined as purchasing at least one cigarette in 2019.

Figure 2. Estimated Effects of COVID-19 on Cigarette Purchases for Smokers and Non-Smokers.

Panel A – Estimated impact of COVID-19 on weekly purchase rates of cigarettes; Panel B – Estimated impact of COVID-19 on weekly consumption of cigarettes; Panel C – Estimated impact of COVID-19 on weekly purchase rates of alcohol; Panel D – Estimated impact of COVID-19 on weekly consumption of alcohol. All panels include estimates first without and then with correcting for cigarette prices (estimates controlling price are indicated by “p” in parentheses).

Figure 3. Difference in Regular Smokers' Quitting Rates in 2020 vs. 2019

Regular smokers in 2019 (2020) defined as purchasing the equivalent of at least one cigarette per day in the first 10 weeks of 2019 (2020) – i.e., the pre-pandemic period in 2020. Proportion of quitters in a given week measured by proportion who have made their final cigarette purchase of the year by the end of that week. Bars indicate difference in 2020 proportion minus 2019 proportion by week. Difference in proportion who quit for at least 6 months (as of July 1st, week 27) is 10 ppt.

Supplementary Materials

Figure S1. Coefficients plot weekly proportion of cigarette purchases and quantity by demographic group.

Panel A

Panel B

Note: Panel A – Estimated impact of COVID-19 on weekly purchase rates of cigarettes across demographic groups; Panel B – Estimated impact of COVID-19 on weekly consumption of cigarettes across demographic groups; All panels include estimates with correcting for cigarette prices.

Figure S2. Weekly average prices of cigarettes observed in our dataset.

Note: The average price paid for a pack of cigarettes across weeks in respectively 2019 and 2020.

Figure S3. Time trend of Google searches for “corona and smoking”.

Note: The numbers represent the “search interest” relative to the highest point on the chart for the given region and time (Denmark, 2020). A value of 100 is the peak popularity for the term; while a value of 50 corresponds to half as popular, and 0 is included if there is not enough data to be reported for the term (Google Trends).

Table S1. Demographics in Panel A; smoking habit baselines in Panel B.

Panel A

	National Population	Sample
Sample size (N)	--	4042
Demographics		
Female	50.3%	65%
Age		
20-29	13%	15%
30-39	12%	27.3%
40-49	13%	24.3%
50-59	14%	18.4%
60-69	11%	11.8%
70-79	10%	3.2%
Employed	66%	72%
Household Income (\$)		
<47.4k	34%	19.5%
48-79k	26%	22.5%
>80k	39%	58%
Household Type		
Single	24%	16.7%
Single + children	4%	8.5%
Couple	33%	29.6%
Couple + children	24%	39.5%
3 or more adults	15%	5.7%
Capital Region (Copenhagen)	23%	42%

Panel B

<i>Baselines</i>	All	Non-smokers	Smokers	Occasionals	Regulars
Individuals N	4042	3059	983	628	325
Cigarettes purchase rate	0.0491	0	0.2021	0.0576	0.4946
p-value		0.0000		0.0000	
Cigarettes quantity	3.3376	0	13.7240	1.16816	38.1053
p-value		0.0000		0.0000	
Alcohol purchase rate	0.2030	0.1897	0.2445	0.2340	0.2657
p-value		0.0000		0.0865	
Alcohol quantity	0.7936	0.7304	0.9905	0.8876	1.1988
p-value		0.0000		0.2561	

Note: Panel A – The National populations are extracted from Statistics Denmark public datacenter:

<https://www.statistikbanken.dk/> Panel B – Reported p-values originate from rank-sum tests.

Table S2. Sensitivity check with purchase rate of all types of tobacco.

Any kind of tobacco					
	All	Non-smokers	Smokers	Occasionals	Regulars
Spring	0.001 (0.001)	-0.000 (0.000)	0.006 (0.006)	0.007 (0.005)	0.003 (0.014)
Summer	-0.000 (0.001)	-0.000 (0.000)	0.000 (0.005)	0.007 (0.005)	-0.014 (0.013)
Fall	-0.002* (0.001)	-0.000 (0.000)	-0.009 (0.005)	0.001 (0.005)	-0.029** (0.014)
COVID-19	0.006*** (0.002)	0.000 (0.000)	0.024*** (0.007)	-0.001 (0.006)	0.073*** (0.018)
Year (2020)	0.004* (0.002)	0.003*** (0.000)	0.006 (0.008)	0.003 (0.006)	0.011 (0.022)
COVID-19 X Year	-0.012*** (0.002)	0.001 (0.001)	-0.053*** (0.008)	-0.004 (0.006)	-0.150*** (0.021)
Weekly cig price	-0.020*** (0.006)	0.000 (0.002)	-0.084*** (0.023)	-0.020 (0.018)	-0.213*** (0.057)
Constant	0.119*** (0.021)	-0.001 (0.007)	0.495*** (0.083)	0.129* (0.067)	1.234*** (0.208)
N	420368	318136	102232	68432	33800
Clusters (individuals)	4042	3059	983	628	325

* p<0.1, ** p<0.05, *** p<0.01

Note: Results of fixed effect estimates of the effect on COVID on all types of tobacco. The estimation structure is further explained in the Material and methods section.

Table S3. Full regression table on cigarette consumption.

Panel A

	Cigarettes purchase rate									
	All	All+price	Non-smokers	Non-smokers+price	Smokers	Smokers+price	Occasionals	Occasionals+price	Regulars	Regulars+price
Spring	0.002 (0.001)	0.001 (0.001)	-0.000 (0.000)	-0.000 (0.000)	0.009* (0.005)	0.005 (0.006)	0.008* (0.004)	0.007 (0.005)	0.013 (0.014)	0.000 (0.014)
Summer	-0.001 (0.001)	-0.000 (0.001)	-0.000 (0.000)	-0.000 (0.000)	-0.003 (0.005)	-0.001 (0.005)	0.006 (0.005)	0.007 (0.005)	-0.023* (0.014)	-0.017 (0.014)
Fall	-0.004*** (0.001)	-0.003* (0.001)	-0.000 (0.000)	-0.000 (0.000)	-0.014*** (0.005)	-0.010* (0.005)	0.001 (0.005)	0.002 (0.005)	-0.044*** (0.013)	-0.032** (0.014)
COVID-19	0.006*** (0.002)	0.006*** (0.002)	0.000 (0.000)	0.000 (0.000)	0.026*** (0.007)	0.025*** (0.007)	0.000 (0.006)	-0.000 (0.005)	0.077*** (0.018)	0.074*** (0.018)
Year (2020)	0.003 (0.002)	0.003 (0.002)	0.003*** (0.000)	0.003*** (0.000)	0.003 (0.008)	0.003 (0.008)	0.003 (0.006)	0.003 (0.006)	0.004 (0.022)	0.004 (0.022)
COVID-19 X Year	-0.016*** (0.002)	-0.012*** (0.002)	0.001 (0.000)	0.001 (0.001)	-0.066*** (0.009)	-0.053*** (0.008)	-0.008 (0.006)	-0.005 (0.006)	-0.183*** (0.023)	-0.149*** (0.021)
Cigarettes price		-0.019*** (0.006)		0.000 (0.002)		-0.077*** (0.023)		-0.016 (0.018)		-0.200*** (0.057)
Constant	0.045*** (0.001)	0.113*** (0.021)	0.000 (0.000)	-0.001 (0.007)	0.183*** (0.006)	0.469*** (0.082)	0.054*** (0.004)	0.114* (0.066)	0.446*** (0.015)	1.187*** (0.208)
Baseline 2019	0.0491	0.0491	0	0	0.2021	0.2021	0.0576	0.0576	0.4946	0.4946
N	420368	420368	318136	318136	102232	102232	68432	68432	33800	33800
Clusters (individuals)	4042	4042	3059	3059	983	983	628	628	325	325

* p<0.1, ** p<0.05, *** p<0.01

Panel B

	Cigarettes quantity									
	All	All+price	Non-smokers	Non-smokers+price	Smokers	Smokers+price	Occasionals	Occasionals+price	Regulars	Regulars+price
Spring	0.397*** (0.134)	0.193 (0.138)	0.002 (0.032)	-0.006 (0.027)	1.624*** (0.543)	0.812 (0.560)	0.333 (0.205)	0.225 (0.208)	4.237*** (1.579)	2.001 (1.640)
Summer	-0.012 (0.135)	0.084 (0.131)	-0.034 (0.027)	-0.030 (0.027)	0.055 (0.547)	0.439 (0.533)	0.077 (0.236)	0.128 (0.228)	0.012 (1.587)	1.068 (1.544)
Fall	-0.239* (0.132)	-0.050 (0.129)	-0.029 (0.026)	-0.021 (0.027)	-0.892* (0.537)	-0.142 (0.524)	0.010 (0.240)	0.110 (0.220)	-2.720* (1.547)	-0.652 (1.522)
COVID-19	0.630*** (0.168)	0.587*** (0.165)	0.018 (0.024)	0.017 (0.025)	2.535*** (0.684)	2.362*** (0.669)	-0.114 (0.256)	-0.137 (0.253)	7.899*** (1.971)	7.423*** (1.930)
Year (2020)	0.215 (0.175)	0.221 (0.176)	0.097*** (0.019)	0.098*** (0.019)	0.582 (0.719)	0.605 (0.721)	0.176 (0.253)	0.179 (0.253)	1.403 (2.114)	1.467 (2.122)
COVID-19 X Year	-0.949*** (0.215)	-0.400** (0.188)	0.059** (0.025)	0.081** (0.037)	-4.083*** (0.875)	-1.897** (0.764)	0.542* (0.290)	0.834*** (0.297)	-13.447*** (2.503)	-7.424*** (2.203)
Cigarettes price		-3.213*** (0.679)		-0.131 (0.138)		-12.802*** (2.736)		-1.710 (1.079)		-35.260*** (7.845)
Constant	2.784*** (0.124)	14.686*** (2.475)	0.000 (0.009)	0.486 (0.509)	11.449*** (0.511)	58.874*** (9.976)	1.663*** (0.186)	7.998** (3.981)	31.262*** (1.498)	161.879*** (28.571)
Baseline 2019	3.3376	3.3376	0	0	13.7240	13.7240	1.16816	1.16816	38.1053	38.1053
N	420368	420368	318136	318136	102232	102232	68432	68432	33800	33800
Clusters (individuals)	4042	4042	3059	3059	983	983	628	628	325	325

* p<0.1, ** p<0.05, *** p<0.01

Note: Results of fixed effect estimates of the effect on COVID on cigarette consumption. The estimation structure is further explained in the Material and methods section. Panel A – Estimated impact of COVID-19 on weekly purchase rates of cigarettes; Panel B – Estimated impact of COVID-19 on weekly consumption of cigarettes; All panels include estimates first without and then with correcting for cigarette prices

Table S4. Full regression table on alcohol consumption.**Panel A**

	Alcohol purchase rate									
	All	All+price	Non-smokers	Non-smokers+price	Smokers	Smokers+price	Occasionals	Occasionals+price	Regulars	Regulars+price
Spring	-0.007** (0.003)	-0.012*** (0.003)	-0.006* (0.004)	-0.011*** (0.004)	-0.009 (0.007)	-0.015** (0.007)	-0.006 (0.008)	-0.013 (0.008)	-0.017 (0.012)	-0.019* (0.012)
Summer	-0.022*** (0.003)	-0.020*** (0.003)	-0.019*** (0.004)	-0.017*** (0.004)	-0.031*** (0.007)	-0.028*** (0.007)	-0.027*** (0.008)	-0.023*** (0.008)	-0.039*** (0.012)	-0.038*** (0.012)
Fall	-0.013*** (0.003)	-0.008** (0.003)	-0.010*** (0.004)	-0.006 (0.004)	-0.021*** (0.007)	-0.016** (0.007)	-0.021** (0.008)	-0.013 (0.008)	-0.023* (0.012)	-0.021* (0.012)
COVID-19	0.066*** (0.004)	0.065*** (0.004)	0.060*** (0.004)	0.059*** (0.004)	0.082*** (0.008)	0.081*** (0.008)	0.077*** (0.009)	0.075*** (0.009)	0.093*** (0.014)	0.093*** (0.014)
Year (2020)	0.023*** (0.003)	0.023*** (0.003)	0.023*** (0.004)	0.023*** (0.004)	0.021*** (0.007)	0.022*** (0.007)	0.023*** (0.008)	0.023*** (0.008)	0.019 (0.012)	0.019 (0.012)
COVID-19 X Year	0.001 (0.004)	0.015*** (0.004)	0.002 (0.004)	0.015*** (0.004)	-0.001 (0.008)	0.015* (0.008)	0.004 (0.010)	0.025** (0.010)	-0.012 (0.013)	-0.005 (0.013)
Cigarettes price		-0.078*** (0.012)		-0.072*** (0.013)		-0.096*** (0.025)		-0.121*** (0.030)		-0.045 (0.044)
Constant	0.161*** (0.002)	0.449*** (0.043)	0.150*** (0.002)	0.416*** (0.048)	0.194*** (0.005)	0.549*** (0.092)	0.186*** (0.006)	0.634*** (0.112)	0.210*** (0.009)	0.377** (0.163)
Baseline 2019	0.2030	0.2030	0.1897	0.1897	0.2445	0.2445	0.2340	0.2340	0.2657	0.2657
N	420368	420368	318136	318136	102232	102232	68432	68432	33800	33800
Clusters (individuals)	4042	4042	3059	3059	983	983	628	628	325	325

* p<0.1, ** p<0.05, *** p<0.01

Panel B

	Alcohol quantity									
	All	All+price	Non-smokers	Non-smokers+price	Smokers	Smokers+price	Occasionals	Occasionals+price	Regulars	Regulars+price
Spring	-0.020 (0.025)	-0.046* (0.025)	0.009 (0.027)	-0.018 (0.027)	-0.110* (0.057)	-0.132** (0.059)	-0.109* (0.065)	-0.127* (0.067)	-0.112 (0.111)	-0.142 (0.115)
Summer	-0.102*** (0.026)	-0.090*** (0.026)	-0.067** (0.027)	-0.054* (0.028)	-0.212*** (0.065)	-0.202*** (0.064)	-0.153** (0.072)	-0.144** (0.072)	-0.334** (0.131)	-0.320** (0.127)
Fall	-0.044* (0.026)	-0.021 (0.028)	-0.009 (0.027)	0.016 (0.031)	-0.155** (0.063)	-0.134** (0.062)	-0.147** (0.069)	-0.129* (0.069)	-0.171 (0.131)	-0.143 (0.126)
COVID-19	0.335*** (0.026)	0.330*** (0.026)	0.289*** (0.027)	0.283*** (0.027)	0.479*** (0.064)	0.474*** (0.064)	0.439*** (0.074)	0.435*** (0.074)	0.559*** (0.121)	0.552*** (0.121)
Year (2020)	0.098*** (0.022)	0.099*** (0.022)	0.080*** (0.023)	0.081*** (0.023)	0.154*** (0.057)	0.155*** (0.057)	0.086* (0.046)	0.087* (0.046)	0.291** (0.144)	0.292** (0.144)
COVID-19 X Year	0.023 (0.027)	0.092*** (0.033)	-0.005 (0.027)	0.067** (0.031)	0.108 (0.071)	0.169* (0.094)	0.129** (0.061)	0.179** (0.073)	0.067 (0.177)	0.149 (0.243)
Cigarettes price		-0.404*** (0.132)		-0.420*** (0.149)		-0.355 (0.285)		-0.292 (0.315)		-0.482 (0.578)
Constant	0.565*** (0.018)	2.063*** (0.483)	0.514*** (0.018)	2.070*** (0.543)	0.725*** (0.052)	2.039* (1.048)	0.637*** (0.042)	1.719 (1.173)	0.904*** (0.133)	2.688 (2.102)
Baseline 2019	0.7936	0.7936	0.7304	0.7304	0.9905	0.9905	0.8876	0.8876	1.1988	1.1988
N	420368	420368	318136	318136	102232	102232	68432	68432	33800	33800
Clusters (individuals)	4042	4042	3059	3059	983	983	628	628	325	325

* p<0.1, ** p<0.05, *** p<0.01

Note: Results of fixed effect estimates of the effect on COVID on alcohol consumption. The estimation structure is further explained in the Material and methods section. Panel A – Estimated impact of COVID-19 on weekly purchase rates of alcohol; Panel B – Estimated impact of COVID-19 on weekly consumption of alcohol. All panels include estimates first without and then with correcting for cigarette prices

Table S5. Regression table on money spent in cigarettes in US\$

	Money spent on cigarettes				
	All	Non-smokers	Smokers	Occasionals	Regulars
Spring	0.067 (0.045)	-0.008 (0.012)	0.299 (0.182)	0.084 (0.072)	0.734 (0.530)
Summer	0.013 (0.048)	-0.016 (0.011)	0.103 (0.194)	0.069 (0.082)	0.171 (0.563)
Fall	-0.020 (0.048)	-0.009 (0.011)	-0.054 (0.196)	0.081 (0.092)	-0.327 (0.563)
COVID-19	0.207*** (0.057)	0.010 (0.010)	0.818*** (0.231)	-0.068 (0.087)	2.610*** (0.667)
Year (2020)	0.084 (0.056)	0.030*** (0.006)	0.250 (0.230)	0.070 (0.082)	0.616 (0.677)
COVID-19 X Year	-0.184** (0.073)	0.026*** (0.009)	-0.838*** (0.296)	0.304*** (0.105)	-3.149*** (0.858)
Constant	0.896*** (0.041)	0.000 (0.003)	3.683*** (0.169)	0.528*** (0.064)	10.071*** (0.491)
Baseline	1.12	0	4.61	0.53	12.87
N	420368	318136	102232	68432	33800
Clusters (individuals)	4042	3059	983	628	325

* p<0.1, ** p<0.05, *** p<0.01

Note: conversion rate 1 US\$ to 6.26 DKK as of Aug 4, 2021 (Google Finance).

Table S6. Regressions on the impact of COVID-19 during the strict lockdown period and the post-lockdown period on cigarette purchase rate (Panel A) and cigarette quantity (Panel B)

Panel A

Cigarette purchase rate during different periods										
	All	All+price	Non-smokers	Non-smokers+price	Smokers	Smokers+price	Occasionals	Occasionals+price	Regulars	Regulars+price
Spring	0.001 (0.001)	0.001 (0.001)	-0.000 (0.000)	0.000 (0.000)	0.004 (0.004)	0.004 (0.004)	0.005 (0.003)	0.004 (0.003)	0.002 (0.011)	0.002 (0.010)
Summer	0.001 (0.001)	-0.001 (0.001)	0.000 (0.000)	0.000 (0.000)	0.004 (0.004)	-0.004 (0.004)	0.005 (0.003)	0.004 (0.004)	0.002 (0.011)	-0.019* (0.011)
Fall	-0.001 (0.001)	-0.003*** (0.001)	-0.000 (0.000)	0.000 (0.000)	-0.002 (0.005)	-0.013*** (0.005)	-0.000 (0.004)	-0.002 (0.004)	-0.007 (0.013)	-0.036*** (0.012)
Cigarettes price	-0.035*** (0.006)	-0.009* (0.005)	0.003 (0.002)	0.003* (0.002)	-0.151*** (0.024)	-0.047** (0.021)	-0.021 (0.017)	-0.004 (0.017)	-0.415*** (0.060)	-0.133** (0.054)
Year (2020)	-0.005*** (0.002)	-0.001 (0.002)	0.003*** (0.000)	0.004*** (0.000)	-0.028*** (0.006)	-0.015** (0.007)	-0.001 (0.005)	0.003 (0.006)	-0.082*** (0.015)	-0.052*** (0.019)
Lockdown	0.000 (0.001)		0.000 (0.000)		-0.000 (0.005)		-0.004 (0.004)		0.008 (0.013)	
Year X Lockdown	-0.000 (0.002)		0.001** (0.001)		-0.005 (0.007)		0.005 (0.005)		-0.025 (0.017)	
Post-lockdown		0.005*** (0.001)		-0.000 (0.000)		0.021*** (0.006)		0.005 (0.004)		0.053*** (0.015)
Year X Post-lockdown		-0.011*** (0.002)		-0.001 (0.001)		-0.044*** (0.008)		-0.009 (0.006)		-0.115*** (0.020)
Constant	0.177*** (0.022)	0.080*** (0.020)	-0.010 (0.006)	-0.012* (0.007)	0.760*** (0.087)	0.366*** (0.078)	0.133** (0.060)	0.070 (0.063)	2.029*** (0.222)	0.966*** (0.198)
N	420368	420368	318136	318136	102232	102232	68432	68432	33800	33800
Clusters (individuals)	4042	4042	3059	3059	983	983	628	628	325	325

* p<0.1, ** p<0.05, *** p<0.01

Panel B

Cigarette quantity during different periods										
	All	All+price	Non-smokers	Non-smokers+price	Smokers	Smokers+price	Occasionals	Occasionals+price	Regulars	Regulars+price
Spring	0.452*** (0.116)	0.550*** (0.113)	0.011 (0.015)	0.061** (0.029)	1.821*** (0.471)	2.072*** (0.451)	0.397** (0.173)	0.480*** (0.160)	4.704*** (1.368)	5.295*** (1.308)
Summer	0.392*** (0.112)	0.304** (0.128)	-0.002 (0.014)	0.035 (0.029)	1.619*** (0.455)	1.141** (0.520)	0.193 (0.147)	0.289 (0.199)	4.507*** (1.330)	2.864* (1.517)
Fall	0.249** (0.115)	0.113 (0.121)	-0.002 (0.012)	0.034 (0.027)	1.030** (0.472)	0.360 (0.491)	0.118 (0.165)	0.234 (0.202)	2.878** (1.385)	0.615 (1.428)
Cigarettes price	-2.923*** (0.627)	-1.249** (0.569)	0.156* (0.089)	0.217** (0.100)	-12.505*** (2.540)	-5.813** (2.316)	0.287 (0.935)	-0.393 (1.036)	-38.403*** (7.244)	-16.786** (6.649)
Year (2020)	-0.250* (0.139)	0.268 (0.178)	0.098*** (0.017)	0.165*** (0.031)	-1.334** (0.570)	0.589 (0.726)	0.432* (0.226)	0.694** (0.287)	-4.910*** (1.646)	0.377 (2.120)
Lockdown	-0.178 (0.115)		-0.008 (0.009)		-0.707 (0.471)		-0.269 (0.168)		-1.594 (1.384)	
Year X Lockdown	0.622*** (0.184)		0.144** (0.056)		2.111*** (0.735)		0.816*** (0.314)		4.734** (2.124)	
Post-lockdown		0.427*** (0.135)		-0.014 (0.015)		1.798*** (0.550)		-0.031 (0.164)		5.503*** (1.611)
Year X Post-lockdown		-1.015*** (0.217)		-0.079** (0.036)		-3.928*** (0.880)		-0.039 (0.303)		-11.801*** (2.537)
Constant	13.898*** (2.316)	7.435*** (2.097)	-0.578* (0.330)	-0.828** (0.374)	58.943*** (9.380)	33.150*** (8.524)	0.482 (3.494)	2.895 (3.850)	177.305*** (26.699)	94.404*** (24.450)
N	420368	420368	318136	318136	102232	102232	68432	68432	33800	33800
Clusters (individuals)	4042	4042	3059	3059	983	983	628	628	325	325

* p<0.1, ** p<0.05, *** p<0.01

Note: Results of fixed effect estimates of the effect of COVID-19 on cigarette consumption. The estimation structure is further explained in the Material and methods section. Panel A – Estimated impact of COVID-19 on weekly purchase rates of cigarettes; Panel B – Estimated impact of COVID-19 on weekly consumption of cigarettes; All panels include estimates first without and then with correcting for cigarette prices

Table S7. Regressions on the impact of COVID-19 on cigarettes quantity before the price increase.

Cigarettes quantity week 11 to week 27										
	All	All+price	Non-smokers	Non-smokers+price	Smokers	Smokers+price	Occasionals	Occasionals+price	Regulars	Regulars+price
Spring	0.126 (0.146)	0.131 (0.146)	0.018 (0.023)	0.019 (0.023)	0.463 (0.596)	0.479 (0.597)	-0.045 (0.232)	-0.045 (0.231)	1.491 (1.743)	1.538 (1.743)
Summer	0.018 (0.163)	0.067 (0.164)	-0.010 (0.018)	-0.005 (0.019)	0.106 (0.666)	0.292 (0.671)	-0.281 (0.256)	-0.278 (0.253)	0.888 (1.949)	1.444 (1.964)
Fall	-0.163 (0.170)	-0.108 (0.172)	0.004 (0.019)	0.010 (0.020)	-0.682 (0.697)	-0.478 (0.703)	-0.175 (0.256)	-0.172 (0.255)	-1.707 (2.043)	-1.096 (2.063)
COVID-19	0.688*** (0.158)	0.629*** (0.157)	-0.004 (0.019)	-0.011 (0.020)	2.841*** (0.641)	2.620*** (0.637)	0.180 (0.281)	0.176 (0.279)	8.230*** (1.818)	7.567*** (1.814)
Year (2020)	0.215 (0.175)	0.219 (0.176)	0.097*** (0.019)	0.098*** (0.019)	0.582 (0.719)	0.598 (0.720)	0.176 (0.253)	0.177 (0.253)	1.403 (2.115)	1.450 (2.117)
COVID-19 X Year	-0.522*** (0.183)	-0.360* (0.190)	0.072** (0.034)	0.090** (0.039)	-2.373*** (0.744)	-1.764** (0.773)	0.710** (0.294)	0.720** (0.306)	-8.616*** (2.131)	-6.791*** (2.230)
Cigarettes price		-4.480*** (1.295)		-0.503 (0.332)		-16.856*** (5.204)		-0.260 (2.163)		-50.457*** (14.962)
Constant	2.784*** (0.124)	-3.087* (1.730)	-0.000 (0.008)	-0.659 (0.440)	11.449*** (0.505)	-10.644 (6.953)	1.663*** (0.163)	1.322 (2.862)	31.262*** (1.477)	-34.871* (19.982)
N	319318	319318	241661	241661	77657	77657	51982	51982	25675	25675
Clusters (Individuals)	4042	4042	3059	3059	983	983	628	628	325	325

* p<0.1, ** p<0.05, *** p<0.01

Note: Results of fixed effect estimates of the effect of COVID-19 on cigarette consumption. The estimation structure is further explained in the Material and methods section. The estimates are the impact of COVID-19 on weekly consumption of cigarettes; All models are estimated first without and then with correction for the cigarette prices.

Table S8. Danish media coverage on the potential correlation between smoking and the risk of getting COVID-19.

Source	Description	Date	Headline	Link	Correlation between smoking and risk of getting COVID-19
TV2	Danish broadcasting corporation	March 23 rd 2020	<i>Smokers at increased risk of dying from corona</i>	here	+
Dagens Medecin	Specialized medical newspaper	March 27 th , 2020	<i>Smokers at increased risk of becoming infected with coronavirus.</i>	here	+
Lunge	Lung patient association	March 27 th , 2020	<i>Smokers at increased risk of becoming infected with coronavirus.</i>	here	+
DR	Danish broadcasting corporation	April 3 rd , 2020	<i>Read the answers about smoking and corona: There is a huge gain already after eight hours of stopping.</i>	here	+
Politiken	Major newspaper	April 6 th , 2020	<i>Stopping smoking makes you better at handling COVID-19 infection</i>	here	+
Newsbreak	News agency	April 6 th , 2020	<i>Higher risk of COVID-19 for smokers</i>	here	+
Berlingske	Major newspaper	April 23 rd , 2020	<i>Spectacular studies: Smokers may be at lower risk of getting coronavirus</i>	here	Perhaps -
Danish Ministry of Health	Agency for prevention against infectious diseases and biological threats	May 25 th , 2020	<i>Subjects with higher risk of COVID-19</i>	here	Not clear
Kristligt Dagblad	Major newspaper	May 30 th 2020	<i>Corona and smoking experience in Norway</i>	here	+/-
Berlingske	Major newspaper	July 1 st , 2020	<i>Experience from COVID-19 can save lives</i>	here	+
Fyens Stiftstidende	Major newspaper	September 9 th 2020	<i>Smoking is much more deadly for COVID-19</i>	here	+
Danish Ministry of Health	Agency for prevention against infectious diseases and biological threats	March 12 th , 2021	<i>Subjects with higher risk of COVID-19</i>	here	+

Note: the overview does not seek to be exhaustive and does not include Danish regional newspapers or local television programs, for instance.