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Early adoption of face masks in Denmark during COVID-19:

Assessing risk-compensation through psychological predictors, behavioral correlates and interrupted time-series analyses

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Abstract

A major concern during the COVID-19 pandemic has been whether the use of face masks leads to risk-compensation, i.e., generates false feelings of safety such that masks users relax other protective behaviors. Such concerns have, in particular, been prominent in countries where public use of face masks have not been traditionally recommended. In this paper, we assess the evidence for risk-compensation in such a country, Denmark, where the public use of face masks until recently was at a minimum. Using subsets of a large nationally representative collected at a daily basis (total N = 59,728), we demonstrate that face mask use is positively predicted by feelings of threat and negatively predicted by negative evaluations of the efficacy of the Danish health authorities general advice, suggesting masks are adopted as an additional layer of protection among those who feel threatened by COVID-19. Furthermore, we find that face mask use correlates positively with self-reported compliance with hygiene and distancing recommendations. However, people who use face masks also report higher infection-relevant contacts. This could suggest that people use face masks where they cannot keep a distance but can also be interpreted as risk-compensation, depending on the causal relationship between face mask use and contact behavior. To gauge causality, we use an interrupted time-series analyses to examine the effect of two changes in the Danish health authorities' policies on face mask use in public transportation. These changes, which occurred in response to rising infection numbers, lead to increased use and, importantly, increased rather than decreased compliance with other advice. These analyses suggest that in situations of rising infections national health authorities can recommend the use of face masks without concern for risk-compensation.

The use of face masks has become compulsory in many countries when using public transportation, shopping etc. as a tool in handling the COVID-19 pandemic (CFR Research, 2020). Some countries, however, have been slow in adopting the use of masks. One particularly pronounced concern has revolved around potential risk compensation effects of face mask use (Betsch et al., 2020; Mantzari et al., 2020). Do face masks facilitate false feelings of safety that decrease the observation of other key protective advice? This has also been a concern in Denmark (TV2, 2020) and until July 31 2020, the Danish national health authorities have only recommended the use of face masks shortly under special circumstances – for example if you are tested positive for COVID-19 or having symptoms and need to break self-isolation to transport yourself to the hospital (Sundhedsstyrelsen, 2020a). Accordingly, Denmark together with other Scandinavian countries has been one of the places in the world with lowest use of facial masks (YouGov, 2020).

In response to a rising number of infections, however, the Danish national health authorities expanded these recommendations on July 31 so that it was also recommended to use a face mask when using public transportation if it is difficult to keep a distance to others (Sundhedsstyrelsen, 2020b). Furthermore, it was announced that Danes can expect further recommendations or requirements to use face masks in the public, if Denmark experiences an increased spread of COVID-19 during the autumn of 2020 (DR, 2020). This has already been exemplified by local requirements of face mask use in public transportation related to COVID-19 outbreaks in specific municipalities in Middle Jutland (Altinget, 2020). The first of requirement was announced on August 7 and took effect on August 11 in Aarhus municipalities.[1]

In this paper we present a descriptive analysis of the use of face masks in Denmark and investigate the demographic, psychological and behavioral correlates of face mask use among Danes during the COVID-19 pandemic. Furthermore, we estimate the effects of (1) the announcement of the national recommendation on July 31 and (2) the announcement of the local requirement of face masks in public transportation in Aarhus on August 7. Overall, our analyses suggest that the adoption of face masks do not lead to risk-compensation. Furthermore, we find that required use of face masks lead to more rapid changes in public behavior compared to the recommendations and that this rapid adoption takes effect

[1] This was expanded to neighboring municipalities on August 10 and took effect for these other municipalities on August 13.

immediately upon the announcement of the mandatory policy rather than when the mandatory policy actually takes effect.

Theoretical Framework and International Evidence

This is the first study on face mask use in Denmark during the COVID-19 pandemic. To probe the psychological motivations underlying face mask use, we use a general framework for understanding protective behavior (i.e., whether people take protective actions against potential threats), protection motivation theory (PMT). According to PMT, the formation of protective motives occurs through threat and coping mechanisms (Rogers, 1985; Wang et al., 2019). The threat appraisal includes the perceived severity and vulnerability to the threat. Thus, risk perception motivates the intentions of individuals to adopt the recommended protective response towards a health threat (Rogers, 1985). The coping appraisal consists of three sub-constituents: response efficacy, self-efficacy and response cost. Response efficacy refers to an individual's belief that a recommended response will avert the threat (Wang et al., 2019). Self-efficacy is a person's expected capability in performing a recommended behavior (Yoon et al., 2012), while response cost refers to all perceived costs associated with the recommended behavior, including both monetary and non-monetary costs (Wang et al., 2019).

The international evidence of predictors of face mask use during the COVID-19 pandemic is limited. A few studies have investigated factors associated with PMT. One study by Bashirian et al. investigated factors associated with preventive behavior among healthcare workers in Iran during the COVID-19 pandemic. They find that both threat and coping appraisal predicted the intention to conduct COVID-19 preventive behaviors, such as using a face mask (Bashirian et al., 2020). Furthermore, a study investigating protective behavior to prevent transmission of influenza finds that both threat appraisal and response efficacy are associated with the intention to wear a face mask to prevent transmission of the flu (Gong et al., 2020). Thus, people with a higher level of threat perception and people with a higher level of response efficacy are more likely to report, that they will wear a face mask when a new type of influenza epidemic occurs (ibid.).

In addition, some studies have investigated the association between demographic characteristics and face mask use. One study investigating face mask use in the UK during the lockdown period find that mask wearing was significantly associated with being younger, male, living in an urban environment, having existing health problems and having an increased

perceived risk of COVID-19 (Shevlin et al., 2020). However, the finding that face mask use is associated with being younger is inconsistent with findings during other infectious respiratory disease epidemics (Sim, Moey & Tan, 2014). Furthermore, the findings of gender differences in face mask use are not consistent in the literature. Tang & Wong (2004) observed higher reported rates of face mask use among females during the SARS epidemic (Tang & Wong, 2004). Lau et al. (2010) also find that women were more likely to wear face masks regularly in public areas during the H1N1 outbreak (Lau et al., 2010), while other studies find no gender differences in mask-wearing compliance (Kuo, Huang & Liu, 2011; Taylor et al., 2009). Shevlin et al, 2020 argue that the finding that being male is associated with face mask use may reflect the higher COVID-19 mortality rates associated with being male (Shevlin et al., 2020).

Some prior research has also specifically assessed the question of whether face mask use induce risk-compensation. Specifically, six cluster randomized controlled trials from Hong Kong, United States, Thailand and Saudi Arabia all find that wearing masks did not reduce the frequency of hand washing or hand sanitizing (Mantzari et al., 2020). Furthermore, a German study conducted during the COVID-19 outbreak find that individuals wearing masks exhibited other protective behaviors more often (Betsch et al., 2020). This study also found that a mandatory face mask policy increased the actual compliance of face mask use and that the introduction of this policy strengthened the positive relationship between face mask use and other protective behaviors (Betsch, 2020). Overall, these past studies suggest that face mask use do not induce risk-compensation.

Here, we assess whether face mask use involves risk-compensation among early adopters of face masks in Denmark in three ways. First, we investigate the relationship between fear and coping appraisals and face mask use. We focus on threat appraisals specifically related to COVID-19. If face mask use is motivated by genuine health concerns rather than a false sense of security, we should expect that face mask users are higher in threat appraisals. We also focus on coping appraisals related to COVID-19 but we do not focus specifically on appraisals related to face masks. Rather, we focus on generalized appraisals of efficacy and costs in relation to following the combined recommendations of the national Danish health authorities. If face mask use is motivated by a felt need for additional protection rather than a false sense of security, we may expect early adopters to be lower in generalized coping appraisals (i.e., appraise the existing recommendations as insufficient). Second, we examine the observed relationship between face mask use and three other measures of protective behavior. These measures are the number of infection-relevant contacts on a daily basis, attention to hygiene

and attention to keeping a distance. The risk-compensation hypothesis entails that face mask use is associated with less protective behavior. Finally, to increase causal traction, we use interrupted time-series analyses of the changes in face mask policy to examine the effect of changes in face mask use on other protective behavior. We examine the introduction of a nation-wide recommendation to use face masks when distance cannot be kept in public transportation and the introduction of a mandatory policy of always using masks in public transportation in Aarhus municipality specifically. Both measures reflected a rise in infections. The nation-wide recommendation did not occur together with other policy changes, while the policy change in Aarhus co-occurred with a recommendation to work from home. On the one hand, the policy change in Aarhus is thus confounded by other policy changes, which may depress risk-compensation. On the other hand, evidence from Germany during the COVID-19 outbreak shows that a mandatory face mask policy has a strong effect on the actual use of face mask (Betsch, 2020). The introduction of a mandatory policy may thus increase the likelihood of observing risk-compensation as the adoption of face mask is expected to be larger here than under the introduction of a mere recommendation.

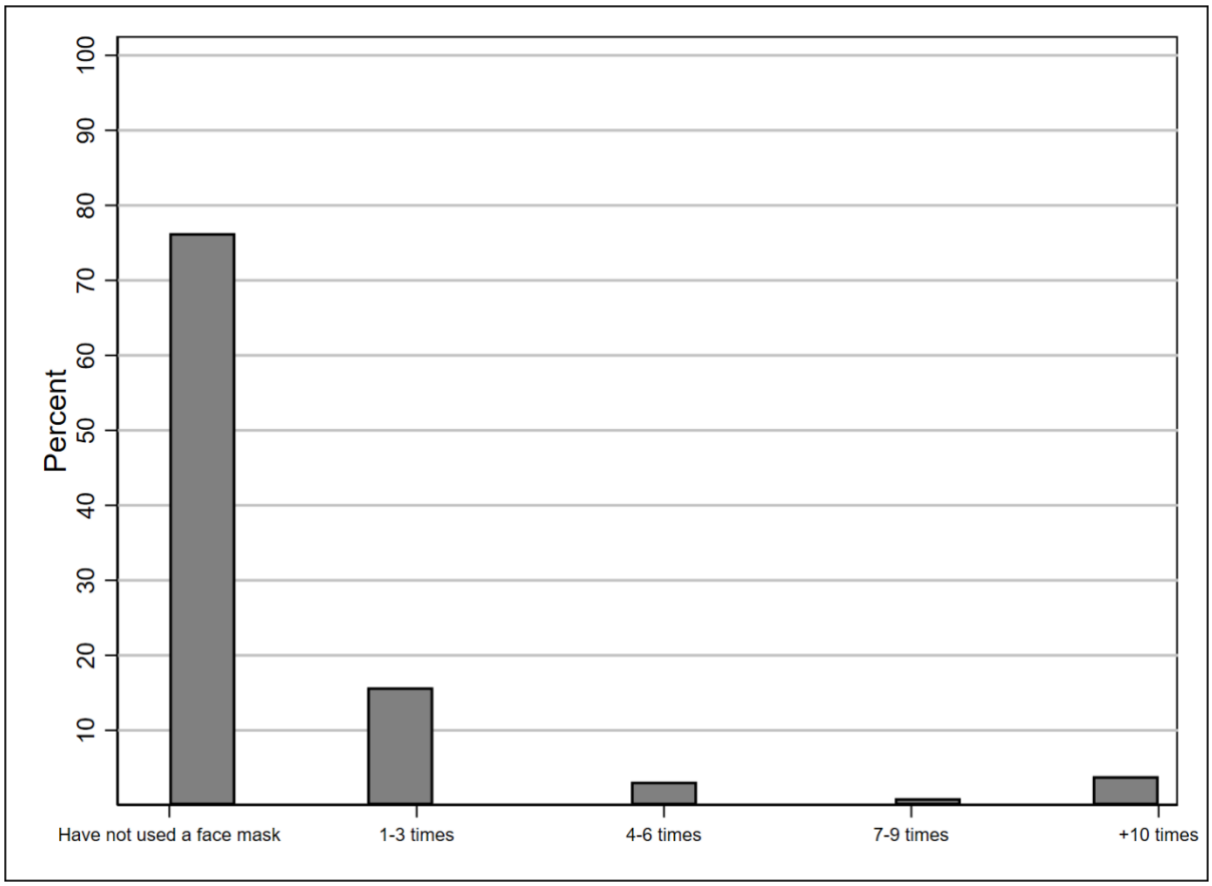
Materials and methods

Data. The survey data is collected by the survey company Kantar Gallup from May 13 until August 13 2020 with a new wave of approximately 500 respondents on each day. The first two weeks of data collection utilized Kantar Gallup's standing web panel (GallupForum) until the data infrastructure was build. From then on, Kantar Gallup recruits participants through stratified random sampling based on a database of CPR numbers (Danish social security numbers), so that it is approximately representative of the Danish population. The survey is sent electronically to respondents through a Danish nation-wide electronic mail system, e-Boks. Table A1 in the appendix gives an overview of the number of respondents per day. We address imbalances by post-stratifying our sample data to match the demographic margins from the population. All statistical analyses presented in the paper employ these post-stratification weights. Presently, a total of 59,728 Danish respondents have been surveyed. Due to the hesitation of the Danish health authorities regarding face masks, however, we only began surveying the respondents about face mask use from July 20. Hence, all analyses using this outcome only use respondents from July 20, leaving us with N = 15,134 for these analyses.

Measures.

Outcome. Our outcome, use of face masks is measured by asking people how many times they have used a face mask within the last week. The questions is as follows: "*How many times have you used a face mask within the last week? 1) I have not used a face mask, 2) 1-3 times, 3) 4-6 times, 4) 7-9 times, 5) 10 times or more".* Figure 1 shows the distribution of face mask use among Danes.

Figure 1: Use of face masks among Danes.



Note: N = 15,134. The figure shows the distribution of answers to the question "How many times have you used a face mask within the last week? 1) I have not used a face mask, 2) 1-3 times, 3) 4-6 times, 4) 7-9 times, 5) 10 times or more".

Figure 1 presents the total distribution of face mask use among Danes from July 20 until August 13. The results show that 76.4 percent report that they have not used a face mask within the last week. Among the 23.6 percent reporting using a face mask, a large majority have only used a face mask 1-3 times. Specifically, 15.6 percent report that they have used a face mask 1-3

times within the last week. 3.1 percent report that they have used a face mask 4-6 times, 0.9 percent have used a face mask 7-9 times, and finally 3.9 percent report that they have used a face mask 10 times or more.

For the statistical analysis, we recode this into a binary variable, where 0 are respondents who have not used a face mask within the last week. 1 are respondents who have used a face mask at least 1-3 times within the last week. Below we present the factors that we identify as important correlates of face mask use.

Correlates of face mask use. We include 3 sets of correlates in our model. First, we include psychological correlates. Second, we include three behavioral measures. Third, we include a battery of demographic variables.

On the psychological predictors of face mask use, we include four measures of protection motivation: 1) threat appraisal, 2) response efficacy, 3) self efficacy and 4) response cost. All four measures are indices based on two questions each. All questions are answered on a 7-point scale from "Not at all" to "To a high degree". To measure threat appraisal, we have asked the following two questions: *"To what degree do you feel that… 1) You are exposed regarding the corona virus, 2) The corona-virus is a threat to Danish society".* To measure self efficacy, we have asked the following two questions: *"How much do you agree or disagree with the following statements regarding the advice by the health authorities about the behavior of the population during the corona epidemic: 1) It is easy for me to follow the advice of the health authorities, 2) I feel confident that I can follow the advice of the health authorities if I want to".* To measure response efficacy, we have asked the following two questions: *"How much do you agree or disagree with the following statements regarding the advice by the health authorities about the behavior of the population during the corona epidemic: 1) If I follow the advice of the health authorities, I will be as safe as possible during the corona epidemic, 2) If I follow the advice of the health authorities, I will help protect others from the corona virus".* To measure response cost, we have asked the following two questions: *"How much do you agree or disagree with the following statements regarding the advice by the health authorities about the behavior of the population during the corona epidemic: 1) If I follow the advice of the health authorities, my relationship with people outside the household will be impaired, 2) If I follow the advice of the health authorities, my life will be impaired".* All these four indices are scaled 0-1.

On the behavioral measures, we measure three aspects of protective behavior: 1) Attention to hygiene, 2) attention to keeping a distance, and 3) contact behavior. Attention to hygiene is measured using three questions regarding hygiene. All three questions are answered on a 7-point scale from "Not at all" to "To a high degree". The questions read as follows: *"To what degree were you yesterday aware of… 1) Ensure good hand hygiene by washing your hands frequently or using hand sanitizer, 2) Ensure frequent and thorough cleaning, 3) Cough or sneeze in your sleeve".* We generate an index scaled 0-1 of these three hygiene questions. Attention to keeping a distance is measured using five questions regarding social distancing. All five question are answered on a 7-point scale from "Not at all" to "To a high degree". The questions read as follows: *"To what degree were you yesterday aware of… 1) Avoid physical contact, 2) Keep distance to elderly and chronically ill people, 3) Keep 1-2 meters distance to other people, 4) Minimize visits to places, where many people typically meet, 5) Minimize activities where you are in contact with other people.* We generate an index scaled 0-1 of these five questions regarding social distancing. Contact behavior is measured using four questions regarding the number of contacts with 1) family, 2) colleagues, 3) friends and acquaintances, 4) strangers. The respondents were asked to report the number of contacts within these four categories. The questions reads as follows: *"How many persons have you been physically close to within the past 24 hours? Physically close is understood as closer than 1 meter for at least 15 minutes. Please give us your best guess. If you were not close to anyone, please enter 0 in the box below: 1) How many from your family that you do not live with have you been physically close to? 2) How many colleagues have you been physically close to? 3) How many friends and acquaintances (people you know the name of) have you been physically close to? 4) How many have you been physically close to that you didn't already know? (for example, in public transportation, playgrounds, in supermarkets)".* We generate a total contact index consisting of these four contact measures. We remove the top 0.1 percent outliers and code all answers above 100 as 100. Then we rescale the contact index into 0-1.

Furthermore, we include the demographic variables sex, age and education in the model. Sex is a dummy variable (0 for males; 1 for females). Age is a categorical variable with the following three categories: 18-34 years, 35-55 years and 56+ years. Education hold information about respondents educational level based on Danish applicable categories, which is then translated into the internationally comparable ISCED-scale and divided into two categories (0 for non-tertiary education; 1 for tertiary education).

Finally, we include a dummy indicating whether it is before or after the changed recommendations (0 for before; 1 for after). Table 1 reports the descriptive statistics for all the above correlates in our sample.

Table 1: Descriptive statistics.

	Mean	SD	Min	Max	N
Psychological					
Threat appraisal	0.50	0.24	0	1	12,022
Self efficacy	0.79	0.23	0	1	12,022
Response efficacy	0.80	0.22	0	1	12,022
Response cost	0.48	0.32	0	1	12,022
Behavioral					
Contact behavior	0.08	0.15	0	1	12,022
Hygiene attention	0.83	0.16	0	1	12,022
Distance attention	0.74	0.21	0	1	12,022
Demographics					
Sex (female)	0.49	0.50	0	1	12,022
18-34 years	0.30	0.46	0	1	12,022
35-55 years	0.37	0.48	0	1	12,022
56+ years	0.33	0.47	0	1	12,022
Education (tertiary)	0.65	0.48	0	1	12,022
Other					
Change in recommendations (after)	0.48	0.50	0	1	12,022

For the interrupted time-series analysis of the local intervention in Aarhus, we use a dummy (0 for all other municipalities[2] than Aarhus; 1 for Aarhus). However, Danish zip codes are not exclusively associated with a single municipality[3]. Specifically, this means that a small proportion of citizens in 3 out of 22 zip codes for Aarhus Municipality, actually lives in another municipality than Aarhus.

[2] Five municipalities are excluded from the comparison group since a face mask requirement was also announced for these municipalities on August 10.

[3] The coding of this variable is based on a list from the regional administrative entity Mid Jutland Region (Region Midtjylland, 2020).

Statistical analysis.

The statistical analysis is twofold. First, we use logistic regression models to regress face mask use on the demographic, psychological, and behavioral correlates. Second, we use an interrupted time series analysis (ITSA) to estimate the effects of (1) the national recommendation and (2) the local requirement of face masks in public transportation in Aarhus Municipality. ITSA is considered the best approach for dealing with interventions when randomisation is not possible (Kontopantelis et al., 2015; Penfold & Zhang, 2013).

In (1) we use a single-group (i.e., the Danish population) ITSA design in which we have no comparison group. Instead, we project the pre-treatment trend into the treatment period, which then is the counterfactual (i.e., the trend the series would have followed absent an intervention). This means that we assume that there is no unobserved time-varying confounders or that such confounders change relatively slowly so that it is distinguishable from a jump of the treatment indicator.

The identifying assumption of the single-group ITSA model highlights why one has to be cautious if there are other factors changing (at a fast rate) simultaneously with the intervention under study. Multiple-group ITSA potentially provides some help to assess the fundamental identifying assumption of the design and as such should be applied if possible (Linden 2017a and 2017b). In multi-group ITSA, we exploit the availability of one or more control group with which we compare the treatment group. In our data, we model the Aarhus-specific intervention in a multi-group design. Here, the Aarhus data series are treated while the data series of the remaining country function as the comparison group[4]. For the two ITSA-models, we use moving averages to smooth short-term fluctuations and account for autocorrelation by using Newey-West standard errors. According to Penfold & Zhang (2013) a minimum of 8 time periods before and after the intervention is recommended (Penfold & Zhang, 2013). However, since the local requirement in Aarhus was announced on August 7, we do not have quite enough post-intervention observations yet. We perform the analyses as a preliminary analysis, and perform updated analyses when more data is available.

[4] Five municipalities are excluded from the comparison group since a face mask requirement was also announced for these municipalities on August 10. Because of too few post-intervention observations for these municipalities, a multi-group ITSA is not yet possible for these municipalities.

Results

First, we investigate the demographic, psychological and behavioral correlates of face mask use. Lastly, we investigate the effects of the (1) the national recommendation and (2) the local requirements of face masks in public transportation in Aarhus on (a) face mask use, (b) contact behavior, (c) hygiene attention and (d) distance attention.

In table 2, we present the results of the five logistic regression models. Model I includes the demographic correlates. Model II includes the four psychological correlates, and Model III-V includes the three behavioral correlates.

Figure 2 illustrates the average marginal effects (AME) of all our predictors on the probability of having used a face mask within the last week. For the categorical variables, the AME's can be interpreted as the change in the average predicted probability of having used a face mask compared to the reference category for the variable. All psychological and behavioral indices are scaled 0-1. Thus, the AME's can be interpreted as the change in the predicted probability of having used a face mask, when comparing the minimum and maximum levels of the psychological and behavioral measures.

In the following, we comment on the average marginal effects of the demographic, psychological and behavioral correlates of face mask use.

First, the results for the demographic correlates of face mask use show that neither sex nor education are significantly correlated with face mask use. For age, we only observe a small difference when comparing people older than 56 years with people aged 18-34. The average predicted probability of using a face mask is 3.0 percentage points lower for people older than 56 compared to people aged 18-34[5]. Furthermore, we see that time (before/after the change in recommendations) is significantly correlated with face mask use. As expected, people are more likely to use a face mask after the changed recommendations were announced. The difference in the predicted probability of face mask use between before and after the change is 3.1 percentage point.

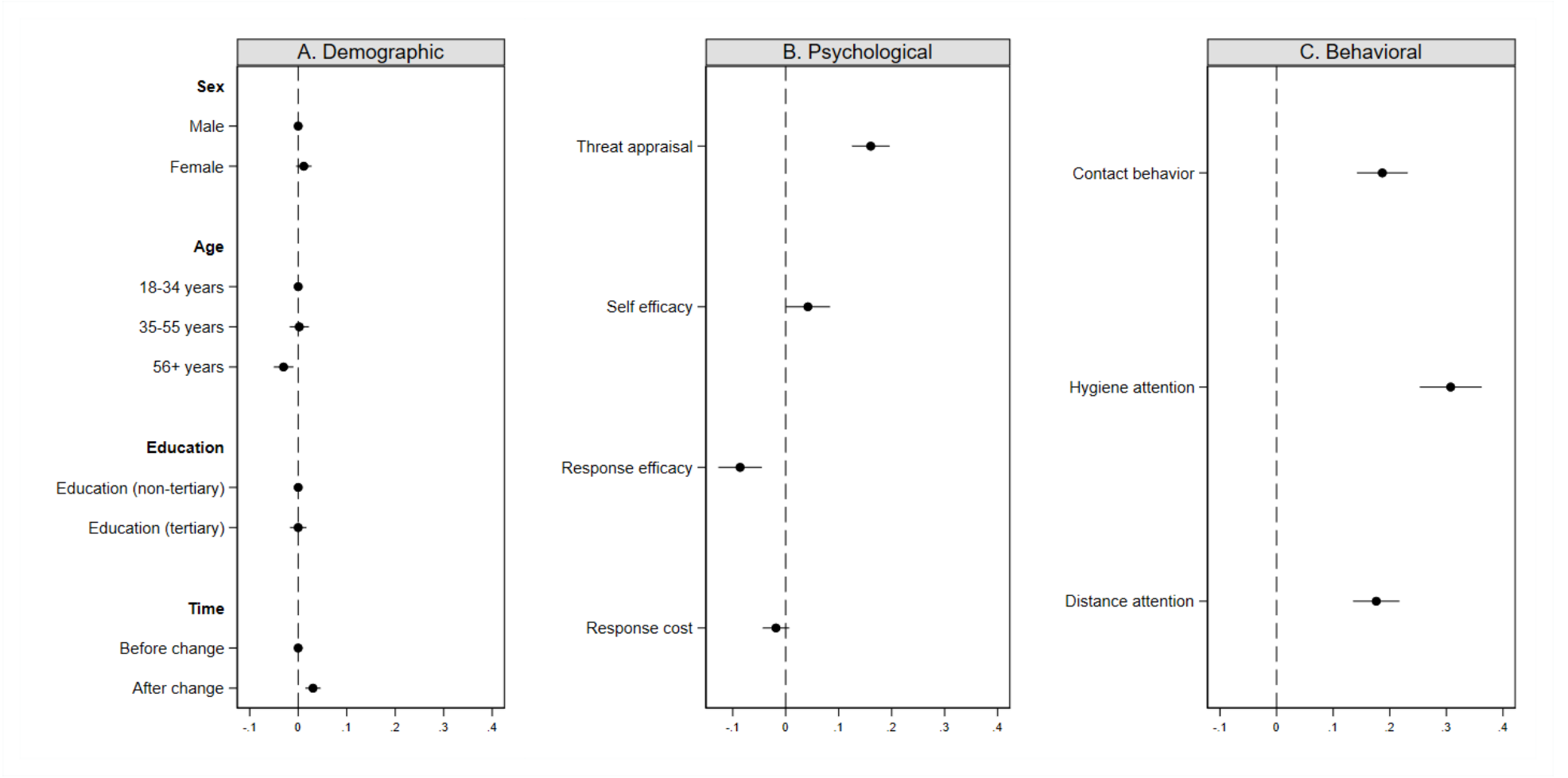
[5] A robustness analysis comparing the results for Model I-Model V before and after the change in recommendations on July 31 is available in table A2 and A3 in the appendix. The results before and after the change are not significantly different.

Table 2: Demographic, psychological and behavioral correlates of face mask use.

	Model I	Model II	Model III	Model IV	Model V
Psychological					
Threat appraisal		0.886***			
		(0.101)			
Self efficacy		0.232*			
		(0.117)			
Response efficacy		-0.475***			
		(0.116)			
Response cost		-0.102			
		(0.071)			
Behavioral					
Contact behavior			1.029***		
			(0.127)		
Hygiene attention				1.701***	
				(0.156)	
Distance attention					0.970***
					(0.116)
Sex					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	0.063	0.038	0.071	-0.020	0.034
	(0.044)	(0.045)	(0.044)	(0.045)	(0.045)
Age					
18-34 years	Ref.	Ref.	Ref.	Ref.	Ref.
35-55 years	0.012	-0.036	0.034	-0.062	-0.068
	(0.054)	(0.054)	(0.054)	(0.054)	(0.055)
56+ years	-0.168**	-0.265***	-0.123*	-0.324***	-0.321***
	(0.057)	(0.059)	(0.058)	(0.059)	(0.060)
Education					
Non-tertiary	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary	-0.000	0.042	0.019	0.037	0.023
	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)
Time					
Before change	Ref.	Ref.	Ref.	Ref.	Ref.
After change	0.167***	0.144**	0.168***	0.156***	0.153***
	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)
Constant	-1.206***	-1.367***	-1.330***	-2.537***	-1.843***
	(0.061)	(0.116)	(0.064)	(0.140)	(0.099)
Observations	12,022	12,022	12,022	12,022	12,022
R_2	0.0024	0.0103	0.0073	0.0124	0.0080

Notes. Unstandardized logistic regression coefficients. Robust standard errors in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 2: Average marginal effects of demographic, psychological and behavioral correlates of face mask use.



Note: N = 12,022. The psychological and behavioral indices are all scaled 0-1. Lines are the associated 95 % confidence intervals. The AME's are based on the models in table 2.

The results for the psychological correlates show that both threat appraisal, self-efficacy and response efficacy are significantly correlated with face mask use, with threat appraisal being the strongest psychological correlate of face mask use. Specifically, the average predicted probability of face mask use for people with the highest level of threat appraisal is 16.1 percentage point higher compared to those with the lowest level of threat appraisal. Thus, a higher level of threat appraisal is associated with a higher probability of face mask use, suggesting that face mask use do not reflect a (potentially, false) sense of safety. Furthermore, we see that the average predicted probability of face mask use is 4.2 percentage point higher for those with the highest level of self-efficacy compared to those with the lowest level of self-efficacy. Thus, people who feel that they can follow the advice of the health authorities are more likely to use a face mask. For response efficacy, however, the people with the highest level of response efficacy are less likely to use a face mask. Specifically, the average predicted probability of face mask use is 8.6 percentage lower for those with the highest level of response efficacy compared to people with the lowest level of response efficacy. At first sight, this negative correlation might seem counterintuitive. However, this can be due to the fact that we use a general measure of response efficacy. Therefore, a lower level of response efficacy might indicate that people do not find the health recommendations sufficient, and therefore are more willing to take further protective behavior measures such as wearing a face mask.

Furthermore, the results for the behavioral correlates show that all three protective behavior measures are significantly correlated with face mask use. For contact behavior, we observe that a change from the minimum level to the maximum level of infection-relevant contacts corresponds to a 18.7 percentage point difference in the average predicted probability of face mask use. Thus, a higher number of infection-relevant contacts is associated with a higher probability of face mask use. For hygiene attention, which is the strongest behavioral correlates of face mask use, we identify a 30.8 percentage point difference in the predicted probability of face mask use, when comparing those with the highest level of hygiene attention with those having the lowest level of hygiene attention. For distance attention, the average predicted probability of face mask use is 17.6 percentage point higher for people with the highest level of distance attention compared to those with the lowest level of distance attention. Thus, a higher level of distance attentions is also associated with a higher probability of face mask use. The results for the behavioral measures show that face mask use is positively associated with attention to both hygiene- and distance-related advice from the health authorities. This speaks against the existence of risk-compensation. At the same time, however, face mask users report

more contacts. This could be interpreted as risk-compensation. Alternatively, it demonstrates that people use face masks exactly has intended: When they want to but cannot keep distance. The findings above on the psychological correlates are consistent with this latter interpretation, with face masks users being higher in self-efficacy and, hence, capable of making appropriate judgments. Ultimately, however, it depends on the causal relationship between face mask use and number of contacts. If face mask use motivates engaging with more people, it entails risk-compensation. If the fact that a person needs to engage with more individuals motivate face mask use, it does not.

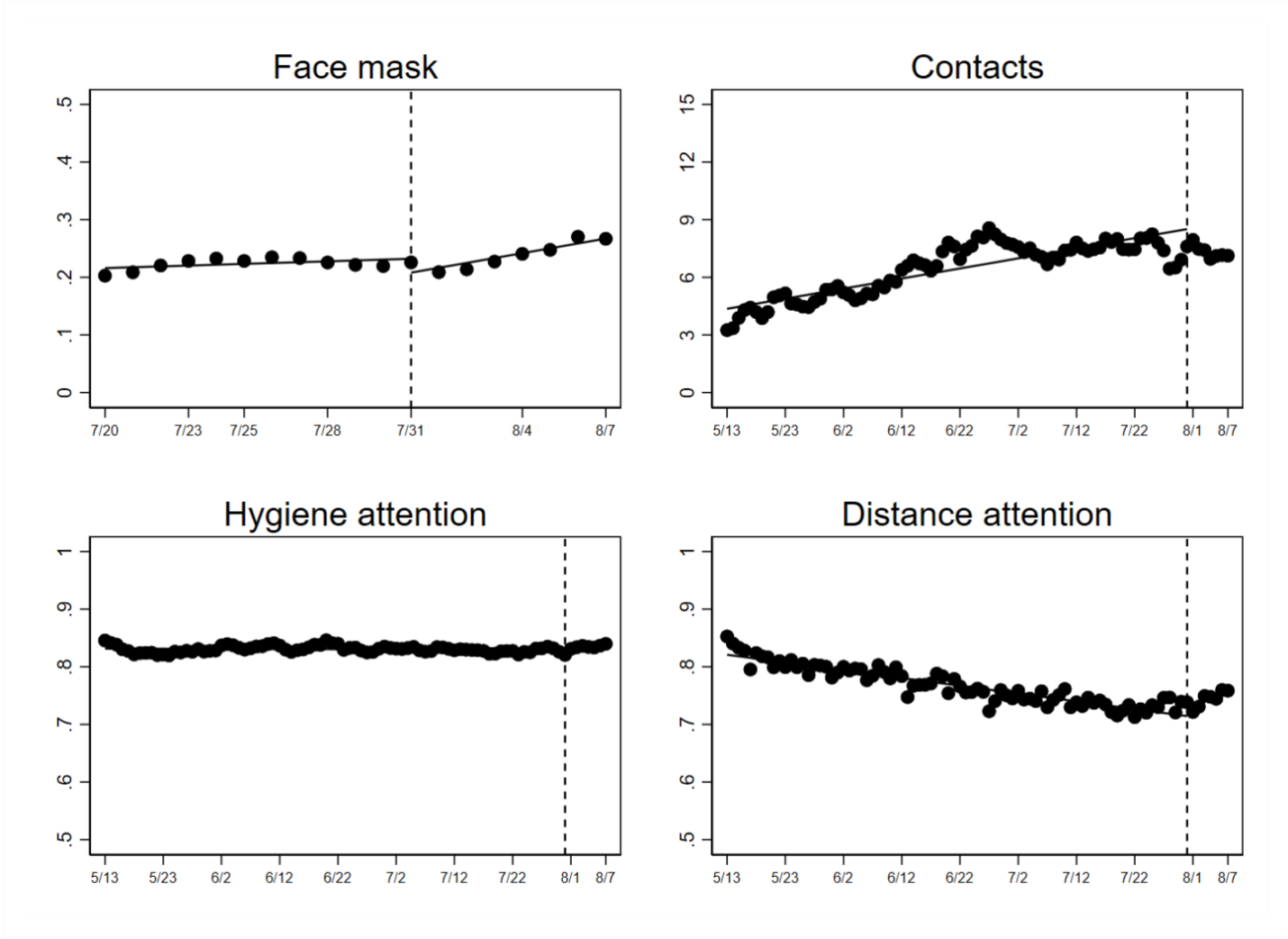
To increase our understanding of the causal effects of face mask use, we investigate the effects of two different interventions regarding face masks. First, we investigate the effects of the nationwide change in the recommendations. This, intervention is relatively small in terms of intrusion, but clear in the sense that it was not accompanied by other recommendations or requirements. Second, we investigate the effects of the local requirement of face masks in Aarhus Municipality. This intervention is relatively large in terms of intrusion, but was accompanied by a recommendation of working from home. We begin with the analysis of the nationwide recommendations. We present the results in Table 3 below. The graphical results are presented in Figure 4.

Table 3. The effect of the nationwide recommendation change.

	Model I	**Model II**	**Model III**	**Model IV**
	Face masks	Contacts	Hygiene	Distance
Time	0.001	0.053***	-0.000	-0.001***
	(0.001)	(0.008)	(0.000)	(0.000)
Intervention	-0.024	-0.791	-0.003	0.014**
	(0.013)	(0.430)	(0.003)	(0.005)
Time X intervention	0.007**	-0.158***	0.002***	0.006***
	(0.002)	(0.015)	(0.000)	(0.001)
Constant	0.216***	4.361***	0.832***	0.821***
	(0.007)	(0.299)	(0.003)	(0.004)
Observations	19	87	87	87

Notes. Newey-West standard errors in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 3. The effect of the nationwide recommendation change.



Note: N = 19 (face mask). N = 87 (contacts, hygiene attention and distance attention). Dots are the actual values, and lines the predicted values. The dashed vertical line indicates the announcement of the national recommendation of face masks in public transportation when distancing is difficult on July 31.

After the nationwide change in recommendations, we find no immediate treatment effect for face mask use, contacts and hygiene attention. However, we identify an immediate small significant positive treatment effect for distance attention when the nationwide recommendations was changed. Furthermore, the results show that the change in recommendations was followed by a significant change in the trends for all four protective behavior measures. For face mask use, hygiene attention and distance attention, we find significant increases in the trends after the changed recommendation relative to the pre-intervention trends. For contact behavior, we find a significant decrease in the trend relative to

the pre-intervention trend. Thus, for all the protective behavior measures, we find that the intervention lead to significant, albeit small changes, in the trends.

To summarize, the results for all the four protective behavior outcomes indicates that the intervention (i.e. the nationwide change in recommendations) lead to increased protective behavior. Specifically, we observe (1) an increase in face mask use, (2) a decrease in infection-relevant contacts, (3) an increase in hygiene attention, and (4) and increase in distance attention. Thus, the increased use of face masks after the intervention, does not seem to reduce other types of protective behavior.

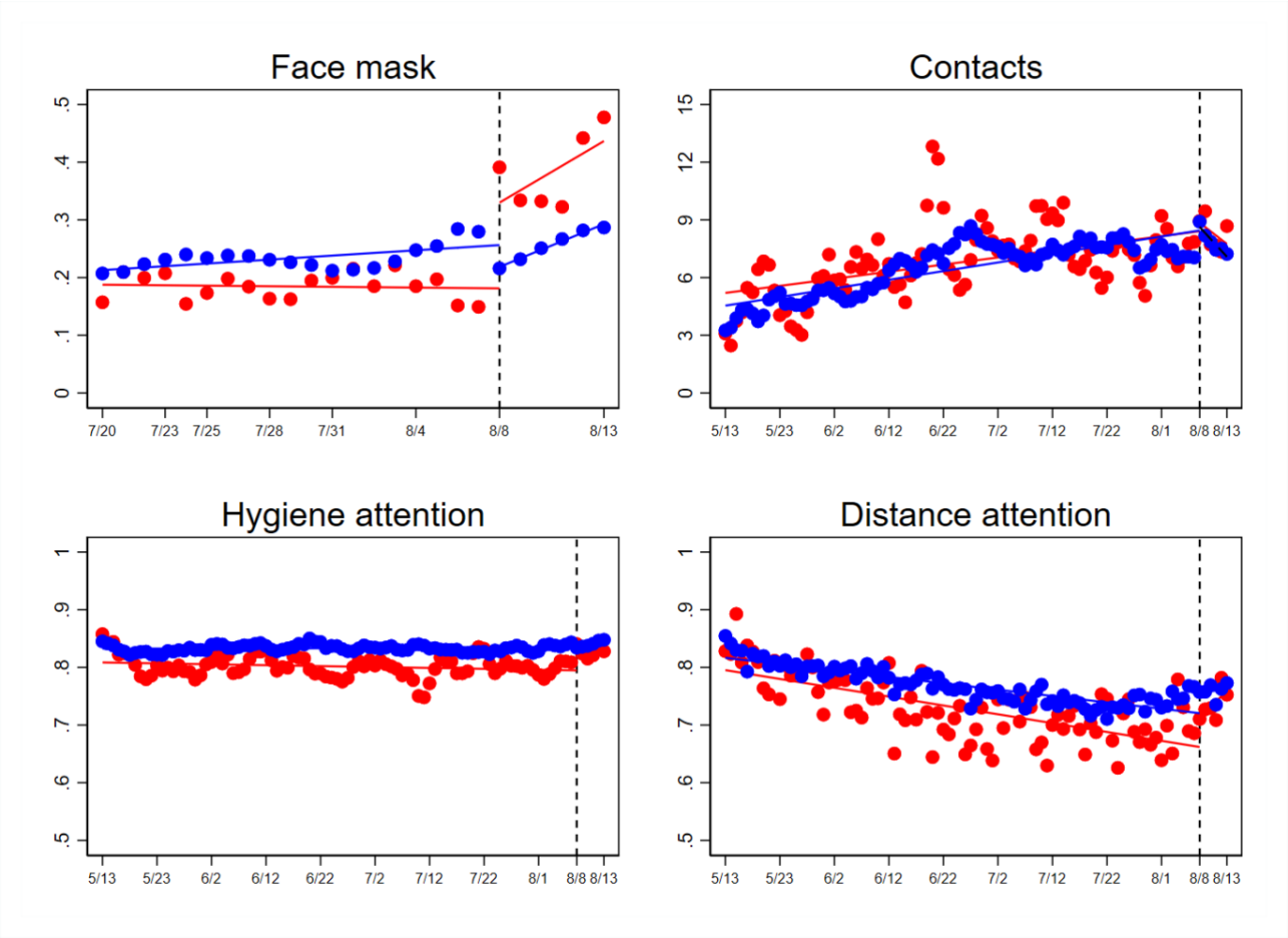
In the following, we investigate the effects of the local requirement of face mask use in Aarhus Municipality. We present the results in table 4 below. The graphical results are presented in figure 5, below the table.

Table 4. The effect of requirements of face mask use in Aarhus.

	Model I	**Model II**	**Model III**	**Model IV**
	Face masks	Contacts	Hygiene	Distance
Time	0.002*	0.045***	0.000	-0.001***
	(0.001)	(0.006)	(0.000)	(0.000)
Treated	-0.025	0.661	-0.024**	-0.021
	(0.013)	(0.605)	(0.008)	(0.012)
Treated X time	-0.003	-0.008	-0.000	-0.000
	(0.002)	(0.012)	(0.000)	(0.000)
Intervention	-0.038*	0.181	-0.001	0.034***
	(0.015)	(0.385)	(0.002)	(0.007)
Intervention X time	0.013***	-0.355***	0.003***	0.003
	(0.001)	(0.042)	(0.000)	(0.002)
Treated X intervention	0.187***	0.259	0.035***	0.013
	(0.046)	(0.721)	(0.008)	(0.014)
Treated X intervention X time	0.009	0.098	-0.004*	0.009***
	(0.012)	(0.139)	(0.002)	(0.003)
Constant	0.213***	4.539***	0.833***	0.817***
	(0.007)	(0.275)	(0.002)	(0.005)
Observations	50	186	186	186

Notes. Newey-West standard errors in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 4. The effect of requirements of face mask use in Aarhus.



Note: N = 50 (face mask). N = 186 (contacts, hygiene attention and distance attention). Dots are the actual values, and lines the predicted values (red = Aarhus; blue = municipalities without requirements of face mask use). The dashed vertical line indicates the announcement of the requirement of face masks in public transportation in Aarhus on August 7.

After the announcement of the local requirement in Aarhus Municipality on august 7, we observe a significant positive immediate treatment effect on face mask use, which is illustrated by the distance between the red slopes before and after the invention. Thus, the citizens in Aarhus immediately adapted to a higher level of face mask use, even before the requirement took effect on August 11. Furthermore, we also observe an immediate significant, albeit small, increase in hygiene attention.

Again, we find that increased face mask use does not lead to decreases in other protective behavior measures. These results contribute with important insights to the debate of risk compensation of face masks. If increased face mask use leads to false feelings of safety, we should observe a decrease in the other protective behavior measures, when face mask use is increased. This is not the case. However, it is important to stress the fact that this conclusion applies to a situation with increasing infection numbers. Thus, our results suggest that face masks can be introduced in a context of increasing infection numbers, without leading to risk compensation effects.

Conclusion

In this paper, we have investigated the use of face masks in Denmark during the COVID-19 pandemic. As a country, Denmark is a late adopter of policies to recommend that the general public uses face masks to protect themselves and others from infection during the pandemic. Accordingly, few Danes have used face masks at the current stage of the pandemic. Denmark thus provides a unique case for understanding the psychological motivations of new adopters of face masks and, in particular, whether this adoption is motivated by a false sense of security, which induces risk-compensation such that other protective behaviors are observed to a lesser extent. Risk-compensation has thus been a major concern of the health authorities both in Denmark and internationally.

Throughout the data collection period an average of 23.6 percent of the Danes report that they have used a face mask. Overall, we find little evidence that these early adopters engage in risk-compensation. Psychologically, early adopters tend to feel more threatened by the virus and they are concerned that the existing health recommendations are not sufficient for protection. Furthermore, they report to be more attentive to other health recommendations related to hygiene and distancing. They also report to be more in contact with other people but the combined findings suggest that this is a cause of face mask use rather than an effect. Thus, we found no evidence that two interventions that increased the adoption of face masks decreased other protective behaviors. If anything, these interventions increased other protective behavior. Specifically, we investigated the effects of (1) a national recommendation and (2) a local requirement of face masks in public transportation in Aarhus Municipality. We find that the nationwide change in the recommendations lead to increased protective behavior. Thus, we identified small significant increase in the trends for face mask use, hygiene attention and

distance attention after the intervention. For contact behavior, the intervention lead to a significant decrease in the trend for contact behavior. The results for the intervention in Aarhus show a large immediate significant treatment effect of the announcement of requirements of face masks in public transportation.

Overall, these results support the conclusion that an increase in face mask use do not have risk compensation effects in a context of increasing infection numbers.

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Appendix

Table A1: Overview of data collection.

Date	N
5/13	603
5/14	442
5/15	549
5/16	552
5/17	581
5/18	666
5/19	635
5/20	461
5/21	490
5/22	628
5/23	525
5/24	716
5/25	646
5/26	502
5/27	597
5/28	537
5/29	628
5/30	980
5/31	787
6/1	1663
6/2	816
6/3	970
6/4	1,206
6/5	983
6/6	984

Date	N
6/7	1,388
6/8	1,220
6/9	719
6/10	889
6/11	1,009
6/12	785
6/13	647
6/14	651
6/15	642
6/16	618
6/17	498
6/18	664
6/19	533
6/20	318
6/21	180
6/22	944
6/23	806
6/24	543
6/25	510
6/26	457
6/27	627
6/28	739
6/29	728
6/30	709
7/1	714

Date	N
7/2	446
7/3	706
7/4	755
7/5	856
7/6	615
7/7	353
7/8	501
7/9	519
7/10	552
7/11	557
7/12	691
7/13	700
7/14	804
7/15	532
7/16	543
7/17	787
7/18	651
7/19	596
7/20	665
7/21	537
7/22	545
7/23	443
7/24	488
7/25	578
7/26	487

Date	N
7/27	675
7/28	527
7/29	354
7/30	781
7/31	417
8/1	392
8/2	470
8/3	545
8/4	481
8/5	491
8/6	397
8/7	421
8/8	210
8/9	447
8/10	466
8/11	268
8/12	1,188
8/13	606

Table A2: Correlates of face mask use before the changed recommendation.

	Model I	Model II	Model III	Model IV	Model V
Psychological					
Threat appraisal		0.879*** (0.147)			
Self efficacy		0.127 (0.166)			
Response efficacy		-0.253 (0.164)			
Response cost		-0.166 (0.102)			
Behavioral					
Contact behavior			0.980*** (0.175)		
Hygiene attention				1.418*** (0.215)	
Distance attention					0.942*** (0.162)
Sex					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	0.067 (0.064)	0.035 (0.064)	0.074 (0.064)	-0.003 (0.065)	0.038 (0.064)
Age					
18-34 years	Ref.	Ref.	Ref.	Ref.	Ref.
35-55 years	0.089 (0.077)	0.039 (0.078)	0.114 (0.078)	0.031 (0.078)	0.016 (0.079)
56+ years	-0.092 (0.084)	-0.199* (0.086)	-0.052 (0.084)	-0.223** (0.085)	-0.243** (0.087)
Education					
Non-tertiary	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary	-0.029 (0.069)	0.003 (0.070)	-0.008 (0.070)	0.001 (0.070)	-0.010 (0.070)
Constant	-1.245*** (0.084)	-1.450*** (0.162)	-1.365*** (0.088)	-2.351*** (0.190)	-1.860*** (0.136)
Observations	6,032	6,032	6,032	6,032	6,032
R_2	0.0011	0.0083	0.0058	0.0083	0.0066

Notes. Robust standard errors in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3: Correlates of face mask use after the changed recommendation.

	Model I	Model II	Model III	Model IV	Model V
Psychological					
Threat appraisal		0.899*** (0.141)			
Self efficacy		0.335* (0.166)			
Response efficacy		-0.689*** (0.164)			
Response cost		-0.040 (0.098)			
Behavioral					
Contact behavior			1.080*** (0.185)		
Hygiene attention				1.986*** (0.228)	
Distance attention					1.003*** (0.167)
Sex					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	0.058 (0.061)	0.043 (0.062)	0.066 (0.061)	-0.037 (0.062)	0.029 (0.062)
Age					
18-34 years	Ref.	Ref.	Ref.	Ref.	Ref.
35-55 years	-0.059 (0.074)	-0.105 (0.075)	-0.041 (0.075)	-0.149* (0.076)	-0.146 (0.076)
56+ years	-0.237** (0.079)	-0.326*** (0.082)	-0.186* (0.079)	-0.418*** (0.082)	-0.393*** (0.083)
Education					
Non-tertiary	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary	0.029 (0.065)	0.082 (0.066)	0.046 (0.066)	0.074 (0.066)	0.057 (0.066)
Constant	-1.006*** (0.078)	-1.154*** (0.162)	-1.133*** (0.082)	-2.575*** (0.200)	-1.680*** (0.138)
Observations	5,990	5,990	5,990	5,990	5,990
R_2	0.0019	0.0112	0.0071	0.0151	0.0077

Notes. Robust standard errors in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$