Results of the NSCR COVID-19 behavior study
(pre-print, version 2)

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Note that these are preliminary results from a not yet peer-reviewed study in progress. The final results will be available at osf.io/7ek9d. The study was financed by the NSCR and RIVM and conducted independently by the authors.

Background and summary

Drawing on video footage of a public shopping street in Amsterdam between May 21 and June 4 2020, this study provides insight into five topics regarding social distancing compliance and face-mask behavior in public spaces during the COVID-19 pandemic. The key results are as follows: 1) Violations of the 1.5-meters distance directive are commonplace in public space. 2) People crowding is strongly positively associated with the rate of social distancing violations, suggesting that distancing violations may potentially be regulated through pedestrian movement management. 3) Most people wear their face-mask correctly, covering both the mouth and the nose. 4) Face-masks are not associated with social distancing behavior, alleviating the concern that face-masks may lead to less adherence to social distancing measures. 5) Face-masks are either not associated or negatively associated with face-touching, indicating that face-masks do not seem to have an adverse face-touching effect.

1. Social distancing compliance

Across the average observation time of 25 seconds, more than half of people (55%) violates the 1.5-meters guidelines, while around 12% is within a close 0.5-meters radius of another member of the public (note that these measures only apply to distance to strangers). This incident rate effectively implies that the vast majority of people moving in public areas are likely to engage in distancing violations. This was estimated (with a logit model) by regressing 1.5-meters distancing violations on the number of seconds each person was observed, OR = 3.18, CI 95% [1.87, 5.41], $p < .001$. After around 60 seconds, the predicted probability of social distancing violation approximates 100%.

2. Social distancing compliance and people crowding

Social distancing violations are strongly positively associated with the (standardized) level of people crowding, both captured as proximity within 1.5-meters ($B = 0.42$, CI 95% [0.32, 0.52], $p < .001$) and 0.5-meters ($B = 0.25$, CI 95% [0.17, 0.33], $p < .001$). This finding is consistent with prior evidence from Amsterdam that also reports a positive association between social distancing violations and people crowding (Hoeben et al., 2020). These results

suggest that higher levels of people crowding render it more difficult to comply with social distancing directives.

3. Use of face-masks

The majority (80% CI 95% [0.74, 0.85]) of people wears the mask correctly, defined as covering both mouth and nose. In comparison, a smaller proportion wears the face-mask in a manner that only covers either the mouth or the nose (8% CI 95% [0.04, 0.11]), or covers neither the nose nor the mouth (12% CI 95% [0.08, 0.17]; e.g., mounted on the chin, sitting on forehead). These results indicate that people are often capable of wearing the face-mask properly, at least in a public setting where face-masks are worn voluntarily.

4. Face-masks and social distancing compliance

A linear probability model shows that face-masks are not associated with social distancing, measured with a cut-point of either 1.5-meters (B = 0.03, CI 95% [-0.07, 0.13], p < .548) or 0.5-meters (B = -0.004, CI 95% [-0.07, 0.06], p < .908). This indicates that face-masks do not alter the level of social distancing among individuals in public areas. This finding contrasts prior field experimental research from Italy (Marchiori, 2020) and Germany (Seres et al., 2020; Seres, Gyula et al., 2020), showing that face-masks promote social distancing.

This mixed evidence may be due to country-differences in the perceived acuteness of the pandemic and in perceptions of mask use, or differences in the situational contexts under study—sidewalk encounters (Marchiori, 2020), store queuing (Seres et al., 2020; Seres, Gyula et al., 2020), and in the current case, pedestrian movement on a wide pedestrianized shopping street. Nevertheless, our and the prior evidence alleviates the concern that face-masks may create a false sense of security that leads to less adherence to social distancing measures (WHO, 2020).

5. Face-masks and face-touching

Across the average observation time of 25 seconds, 11% (CI 95% [0.08, 0.14]) touches their face, 8% (CI 95% [0.06, 0.11]) touches the center of their face, and 5% (CI 95% [0.03, 0.08]) touches their mucosal ‘t-zone’ comprising eyes, nostrils, or the mouth. Note that especially touches of the t-zone are a route of entry of respiratory viruses, including the coronavirus (Rahman et al., 2020). Further, around 9% (CI 95% [0.05, 0.13]) of mask-wearers touch their mask (including the part of the mask-strap covering the facial region).

Further, a linear probability model showed that face-masks are not associated with face-touching, B = 0.007, CI 95% [-0.07, 0.08], p = .843, with face-touching defined as touches directly of the face or the face-mask (inclusive mask-straps covering the facial region). This is further stressed by Bayes factor evidence suggesting that the H_0 is approximately 19 times more likely than H_a (note that this analysis was pre-specified, see osf.io/bj7tg).

To explore the robustness of this result across other plausible data and model specifications, we estimated 256 alternative models, which included all combinations of: the independent variables, linear or logistic models, persons with partially or fully covering masks, and four versions of the dependent variables—that is, in addition to the dependent variable as defined in above regression (i.e., touches of the face or mask), this includes touches directly of the face, center-face, or the t-zone. Across all specifications, 75% of the models are negatively associated with the outcome and below an alpha level of .05. Noteworthy, all 192 models that remained below this alpha threshold were specified with one of the alternative (direct hand-to-face contact) versions of the dependent variable—with an average predicted probability of a positive touching outcome of 4% for non-mask wearers and 11% for mask wearers. However, it should also be noted that only 14% of the 192 models remained significant under a conservative alpha threshold of .005.

Taken as a whole, these results are in line with recent studies suggesting that face-masks are either not associated with face-touching (Perez-Alba et al., 2020; Tao et al., 2020) or are negatively associated with face-touching (Lucas et al., 2020), especially of the mucosal region of the face (Chu et al., 2020). In sum, this indicates that face-mask does not—as it has been flagged as a possible concern (ECDC, 2020)—seem to have any adverse face-touching effect. Conceptually, our results suggest that face-mask may serve as a barrier that prevents direct hand-to-face contact. By comparison, the null result found if the outcome was operationalized as touches to the face or the mask may reflect that the circumstance that humans have a high baseline of face-touches (Kwok et al., 2015), with frequent subconscious touches of the facial region irrespective of whether or not it is covered by a mask.

Methods

The data comprised video footage of everyday public behavior captured by one security camera in a shopping street of Amsterdam, Netherlands, during the COVID-19 outbreak. Data were recorded May 21, 24, and 28, and June 4. With the permission of the Dutch Public Prosecutor, we obtained data from the Amsterdam police, and the study was approved by the Ethics Committee for Legal and Criminological Research (CERCO) at Vrije University. We sampled 205 persons wearing a face-mask and, to construct a relatively balanced sample, 207 persons without a face-mask, comprising a total sample of 412 persons. This sample satisfied an a priori statistical power analysis suggesting that 339 observations would detect a small effect ($f^2 = 0.05$), with a power of 90%, and conservative $\alpha = .005$ (note that valid sample size varies a little across the analyses conducted, but all remains over this threshold).

Two trained research assistants coded data in accordance with a behavioral codebook (see enclosed Appendix). The coding began by splitting the footage into 51 30-minutes time segments, randomly sampled across the period between 9.00 a.m. and 9.00 p.m. For each time segment, we planned to sample seven persons with and seven without a face-mask. Each person was observed for the duration they were video captured walking along the street, on

average 25 seconds (in sum, we conducted 171 person-minutes of observation). To test the inter-rater reliability of the codebook, we selected 44 individuals and 25 contexts for independent double coding, with a Krippendorff's (2004) alpha (α) larger than .8 as a benchmark for good agreement—each score is reported as part of the below variable presentation.

Measures

- *Face-mask* distinguished between whether the mask was worn in a fully-covering manner (covering both nose or mouth), was partially-covering (covering either nose or mouth), or was non-covering (not covering nose nor mouth) (α = 1.00).
- *Face-touching* was captured as a binary variable distinguishing between whether or not the person hand-touches his or her face (α = 89). Face was defined as including the mucosal t-zone (i.e., eyes, nostrils, mouth) and non-mucosal areas (i.e., ears, cheeks, chin, or forehead), as well as touches of face-masks covering the facial region. As alternative operationalizations of face-touching, we measured whether the person specifically had direct hand contact with the face (α = .87), the center of the face (α = 1.0), or the t-zone (α = .50). Note that the low α score for t-zone measure may be considered underestimated because the low incident rate of the measure leads to an unreasonably low α score despite a high percentage of agreement (98%) between the coders. Gwet's (2008) AC1 is considered a more robust interrater statistic in such cases, and this test yield an acceptable score of .98.
- *0.5-meters social distancing* captures whether or not the person is closer than 0.5 meters from another member of the public (α = .55). Similar to the issue regarding t-zone (see above), both a percentage agreement of 91% and the AC1 of .89 indicated acceptable agreement.
- *1.5 meters social distancing* captures whether or not the person is closer than 1.5 meters from another member of the public (α = .89).
- *People crowding* captured the number of individuals moving throughout the street around the time the persons were sampled (α = 1.00). For each time segment, this was calculated as the mean of two 1-minute counts of people walking through the street.
- *Observation time* captured the number of seconds the person was observed (α = .94). Note that we winsorized one extreme outlier to the nearest non-outlier score, given that this single typo case would otherwise make the variable appear disproportionally unreliable.

Estimation

Data were estimated with a range of statistical models, including regression models, all specified with cluster-corrected standard errors to account for the hierarchical data structure (i.e., individuals nested across time segments). For inference criteria, we follow the recommendations to consider $p < .05$ as 'suggestive' and $p < .005$ as 'significant' (Benjamin et al., 2018), and as a supplement to *p*-values we report Bayes factors, which may quantify possible evidence in favor of the null hypothesis (Dienes, 2014). Specifically, we report Bayesian information criterion approximated Bayes factors, which are computationally simple and do not

require specification of a prior (a unit-information prior is assumed) (Wagenmakers, 2007). Further, as part of the analysis of face-tocuhing, we conducted exploratory multiverse analysis to assess the robustness of our results across alternative data and model specifications (Steegen et al., 2016). Finally, note that continuous variables were standardized by subtracting the mean and dividing by two standard deviations, so estimates are comparable with binary predictors (Gelman, 2008).

Limitations

One limitation of the current study is that we are interested in causal process—do face-masks lead to face-touching or social distancing behaviors—while our observational approach conveys correlational insights. For example, it may be that it is other unobserved factors than the mask itself that underpins the negative association with face-touching (e.g., that certain risk-averse individuals choose to wear masks). Another study limitation concerns how generalizable our results—based on cross-sectional data from one Amsterdam street—are to other settings and phases of the pandemic.

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APPENDIX

CODEBOOK & CODING PROCEDURE

To prevent that the same individuals are coded twice by accident, the coders are responsible for separate days. On Sunday, the shops are closed, so the number of people we code will be a lot lower. We code the same camera. We code in total 400 individuals, 200 with masks and 200 without masks (defined by the code, "mask_ YesNo").

We have randomly divided the two days of each coder into 30-minutes segments. These have been assigned a random number, describing the order by which the segments should be coded. Begin the coding exactly o'clock or half-past, and continue coding 25 minutes (we skip the last 5 minutes of the segment to prevent incidental double coding of individuals also present in the subsequent segment). Note if the segment cannot be coded for a technical reason then proceed to the next randomly selected segment.

In the first minute of the time slot, count the number of people crossing the selection line (see below) in either direction (towards or away from the camera), including both walking and bicycling (e.g., 04:00:00 – 04:01:00). Repeat this at the 15th minute (e.g., 04:15:00 – 04:16:00). We also count police officers and other state officials.

The "selection line" is defined as follows: There is a billboard at the back of the screen. From here, a horizontal line can be drawn to both sides of the street. On the left side of the street, there is a white text, which is on that same line. Whenever the selected person touches the line with one of their feet, the observation starts. When the person is walking with a pram/baby stroller, start coding when the pram touches the line.

The individual selection procedure is as follows. First, find the o'clock or half-past time where the segment starts. Second, keep the video running until a mask-person touches the selection line—this mask-wearing person is coded if the person may be observed for the duration of walking along the street. Third, when the mask-person moves so close to the camera that he/she leaves the view, we select the first non-mask person crossing the selection line, if observable for the duration of walking the street.

Definitions and exclusions

- Masks are understood as "standard mask", similar (but not necessarily identical) to those on the picture. We do not define masks as scarfs or sweaters around the head or face shields—individuals wearing these artifacts are excluded entirely (not coded at all).

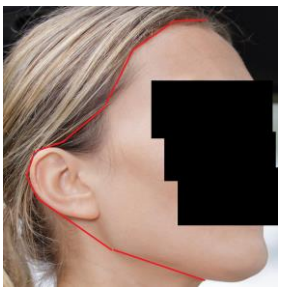
- We do not code persons on bikes (or on vehicles where you need to use both hands).
- We do not code police officers or other state representatives (i.e., we only code ordinary members of the public).
- In the case of a child, when he/she is walking together with an adult, code the adult. When the child is alone, code—except when the child should be with an adult. Further, we only

code ONE randomly selected person among persons who are walking in a group (the remaining group members are not coded).

- We only code individuals that walk in the direction of the camera, and may be observed for the duration of the walking the street. Otherwise, exclude. That is to say, if a person for some reason are not observable (e.g., because the person walks behind trees or for the whole observation period walks on the right of the street), then skip the individual and select another person.
- Whenever a person is longer than 30 seconds in the screen, code a maximum of two minutes. If a person walks from the camera and then towards the camera or walks in/out of a store, exclude.
- We ideally code 7 non-mask person and 7 mask-persons per segment (this is to ensure that our sample is representative across hours of day). We aim to have an equal number of mask and non-mask persons coded in each segments, so that if you only manage to sample say 5 mask persons in a segment, we only sample 5 non-mask persons.
- The missing variable may be used in cases where it is unclear what occurs (i.e., instead of simply guessing whether or not a person touched her face, in a situation where this was unclear).

BEHAVIORAL INVENTORY FACE-MASKS	
Code	*Definition*
phase	Note the coding phase. Test = test phase. Irr = interrater reliability phase. Rest = normal records. Irr prox = extra interrater reliability test of proximity variables. Rest 2 = further normal records. Test (0); Irr (1); Rest (2); Irr prox (3); Rest 2 (4)
coder_code	Note the coder identity. Josephine (0); Laura (1)
date_observation	Note the date when video was recorded (e.g., 25.6.2020).
clock_time_video_starts	Note the real/clock time when the video starts (e.g., 09:00). Will be identical for all individuals sampled from this video.
video_time_observation_starts	Note the video time (not clock time) when the observation of the individual begins (e.g., 04:08.57).
person_id	A running person ID
description	Describe the coded individual so that it is possible to later identify the person on the video.
gender	Based on individual's visual appearance. Female (0), Male (1); Missing (77).
age	Based on the individual's visual appearance. Essentially, use your gut feeling as make you best guess! Propose an age (e.g., 26).
mask_YesNo	The individual does wear a mask on the head or around the head. No (0), Yes (1), Missing (77).
fully_covering	The individual carries a face-mask covering **both** mouth **and** nose in the beginning of the observation. No (0), Yes (1), Missing (77), Irrelevant (99) *If "mask_YesNo" is No then code as irrelevant (99). Also note that the three how-mask variables (fully, partially, non-covering) questions are mutually exclusive.*

partially_covering	The individual carries a face-mask covering **only** mouth **or** nose in the beginning of the observation. No (0), Yes (1), Missing (77), Irrelevant (99) *If "mask_YesNo" is No then code as irrelevant (99). Also note that the three how-mask variables (fully, partially, non-covering) questions are mutually exclusive.*
non_covering	The individual carries a face-mask **not** covering mouth **or** nose in the beginning of the observation (e.g., under the chin, hanging around neck, sitting in forehead). No (0), Yes (1), Missing (77), Irrelevant (99) *If "mask_YesNo" is No then code as irrelevant (99). Also note that the three how-mask variables (fully, partially, non-covering) questions are mutually exclusive.*
mask_front_touching	The individual touches his/her face-mask at the front fabric with the hand (e.g., adjusting the mask by touching the fabric; removing it by grapping the fabric). The touch should be hand-to-mask, and includes touching with a gloved hand. The hand includes fingers, palm and back of hand (from the wrist down). This variable excludes cases where the mask is adjusted by grabbing the straps/elastic behind the head or on the side of the head. If the person sanitizes his/hers hands with alcohol before *and* after touching the fabric, this is not recorded as a positive. Note that this variable is not mutually exclusive with the other mask and face touching variables. No (0), Yes (1), Missing (77), Irrelevant (99) *If "mask_YesNo" is No then code as irrelevant (99).*
mask_strap_touching	The person touches (e.g., adjusts) the straps/elastics that mounts the mask around the head or ears. Note that in the atypical cases where the person wears a mask mounted behind the back, we only code the part of the straps, which are within the "face_touching" area (see below variable). This is captured in below picture (the rationale is here that we want to compare the touching of similarly sized areas, notwithstanding the type of mask worn). This excludes cases where the person alcohol sanitizes his/hers hands before and after touching the straps. Note that this variable is not mutually exclusive with the other mask and face touching variables. No (0), Yes (1), Missing (77), Irrelevant (99) *If "mask_YesNo" is No then code as irrelevant (99).*

	
face_touching	The individual hand-to-face touches him/herself at least once at the face, defined broadly as including: eyes, nostrils/nose, mouth, ears, cheeks, chin, and forehead (see picture below, which draws the line between chin and neck, which is not coded). Touches of glasses and earphones are counted as positive. The touch should be conducted with the hand, and includes touching with a gloved hand. The hand includes fingers, palm and back of hand (from the wrist down). If the person has sanitized hands with alcohol immediately before face-touching, this is not recorded as a positive (sanitizing after is not a criteria here). Note that this variable is not mutually exclusive with the other mask and face touching variables. No (0), Yes (1), Missing (77). 
o_zone_touching	The individual hand-to-face touches him/herself at least once in a "o-zone" (see picture below). The touch should be conducted with the hand, and includes touching with a gloved hand. The hand includes fingers, palm and back of hand (from the wrist down). If the person has sanitized hands with alcohol immediately before face-touching, this is not recorded as a positive (sanitizing after is not a criteria here). If the person touches his/hers glasses within the o-zone, this is counted as a positive. Note that this variable is not mutually exclusive with the other mask and face touching variables. Note that this variable is not mutually exclusive with the other mask and face touching variables.  No (0), Yes (1), Missing (77), Irrelevant (99) *If "face-touching" is No then code as irrelevant (99).*

t_zone_touching	The individual hand-to-face touches him/herself in a "t-zone" area at least once. The t-zone area includes nostrils, eyes, and mouth (see picture below). The touch should be conducted with the hand, and includes touching with a gloved hand. The hand includes fingers, palm and back of hand (from the wrist down). If the person has sanitized hands with alcohol immediately before touching the zone, this is not recorded as a positive (sanitizing after is not a criteria here). In cases where it is unclear whether the hand only touches the area between the eyes, or the eye included, we assume that the eyes are also touched. There may however be cases where a person clearly touches the area between the eyes (e.g., scratching with one finger) and this would not be recorded as a positive. Note that this variable is not mutually exclusive with the other mask and face touching variables.  No (0), Yes (1), Missing (77), Irrelevant (99) *If "face-touching" or "o_zone_touching" is No then code as irrelevant (99).*
smoking	The person is smoking (cigarette or vapor), which is a risky behavior that may involve that the person touches face. Is not mutually exclusive with face touching. No (0), Yes (1), Missing (77).
mobile_talking	Mobile phone talking, with the phone to the ear, is a potentially risky behavior. Is not mutually exclusive with face touching. No (0), Yes (1), Missing (77).
eating	Eating with hands is a potentially risk behavior. Also includes drinking (e.g., from a bottle or tin). Is not mutually exclusive with face touching. No (0), Yes (1), Missing (77).
non_hand_touch	The person touches the face (see the "face_touching" picture) and/or the mask with some other body part than the hand or some object that prevents the person from hand touching these areas (e.g., by using the lower arm, the shoulder, a piece of cloth). No (0), Yes (1), Missing (77).
other_risky	Note another type of potentially face-touching risky behavior conducted by the individual.

	Describe the behavior (string).
in_group	At the beginning of the observation the person is together with someone (vs. alone), walking and/or standing with someone, as they move throughout space. No (0), Yes (1), Missing (77).
crowding	The individual passes at least one other person on the street on the same side of the street and therefore has a chance to transgress the 1.5-meter guideline. The same side of the street is defined either as from the left shops until the trees (first side) or as from the trees until the right shops (second side). No (0), Yes (1), Missing (77).
proximity	The individual is in the physical proximity of less than 1.5 meter to someone else at least once, including another pedestrians or a bicyclist. This includes both cases where the person move into the intimate zone of someone else, and if someone intrudes into the intimate zone of the individual. This excludes proximate persons who the person arrives together with/are in company with. For measuring the proximity, we use the tiles on the street (see drawings). Horizontally, we use 15 tiles as the cut point for proximity (15 tiles = 1.43 meters). Whenever you can measure the distance of people walking behind each other, we apply 4 as cut point vertically on the street (4 tiles = 1.47 meters). No (0), Yes (1), Missing (77).
close_proximity	The individual is in close physical proximity of less than 0.5 meter to someone else at least once, including another pedestrians or a bicyclist. This includes both cases where the person move into the intimate zone of someone else, and if someone intrudes into the intimate zone of the individual. This excludes proximate persons who the person arrives together with/are in company with. For measuring the proximity, we use the tiles on the street (see drawings). Horizontally, we use 5 tiles as cut point (5 tiles = 47.5 meters). Whenever you can measure the distance of people walking behind each other, we use 1 tile as cut point vertically on the street (1 tile = 0.49 meters). No (0), Yes (1), Missing (77), Irrelevant (99) *If "No" in "proximity", this is irrelevant (99).*
video_time_observation_ends	Note the video time (not clock time) when the observation of the individual ends (e.g., 04:34.01).
comments	Please note anything that may be important for the quality of the case, weird stuff, potential outliers, etc.