Age Differences in COVID-19 Preventive Behavior

A Psychological Perspective

Lars Korn¹ , Regina Siegers¹, Sarah Eitze¹, Philipp Sprengholz¹, Frederike Taubert¹, Robert Böhm^{2,3}, and Cornelia Betsch¹

¹Media and Communication Science and Center for Empirical Research in Economics and Behavioral Sciences, University of Erfurt, Germany

²Faculty of Psychology, University of Vienna, Austria

³Department of Psychology and Copenhagen Center for Social Data Science, University of Copenhagen, Denmark

Abstract: Age is a critical risk factor for severe COVID-19. This is mirrored by older people showing preventive health behaviors more frequently. However, collective action across all age groups is necessary to reduce transmission. Therefore, this study assessed whether age differences are moderated by policy changes and whether policies further moderate the relationship between psychological determinants of behavior (risk perceptions and trust), age, and preventive behaviors. Risk perceptions, trust in institutions, self-reported frequency of preventive behaviors (mask-wearing, avoiding social gatherings), and demographics (e.g., age) were collected within the COVID-19 Snapshot Monitoring (COSMO), a German serial cross-sectional survey. A total of 19,069 participants across 20 measurement points were included (online sample, quota-representative for Age × Gender and federal state in Germany; mid-April to the end of November 2020). Regression analyses showed that age differences in avoiding social gatherings and mask-wearing remained stable under different health policies but were further moderated by psychological variables. The introduction of stricter policies alone was not related to higher adoption rates of preventive behaviors, but it mitigated the effects of age and risk perceptions. Moreover, under mandatory policies, the correlation between trust in institutions and behaviors was amplified. The present research made a strong case for quality, targeted health, and risk communication. Without mandatory policies, the importance of preventive behaviors must be well understood to achieve high adherence – especially in young people who are threatened by the disease less directly.

Keywords: health behavior, COVID-19, trust, risk perception, age

The coronavirus disease (COVID-19) pandemic is a major public health challenge with a global impact. Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has been spreading worldwide since the end of 2019. As of 28 July 2021, the virus has infected 195.5 million individuals, and around 3.9 million have died from COVID-19 or its complications (Dong et al., 2020). Age is the most prominent risk factor for severe and lethal courses of the disease (Levin et al., 2020; O'Driscoll et al., 2021; Ou et al., 2020) next to gender (Pérez-López et al., 2020), ethnicity (Sze et al., 2020), chronic preconditions (Huang et al., 2020), and smoking (World Health Organization, 2020b). Until vaccines become widely available and uptake is sufficiently high, large-scale behavioral change across all age groups is necessary to curb the spread of the disease.

While vaccine uptake is increasing, non-pharmaceutical interventions (NPI) will still be needed (Centres for Disease Control and Prevention [CDC], 2021). NPIs vary in impact

(Haug et al., 2020), which is also affected by the level of enforcement of certain behavioral rules (Hale et al., 2020). For instance, in many countries, masks were first recommended, then mandated. Schools and other educational institutions were closed, and people were required to reduce their private contacts (World Health Organization, 2020a).

Since the risk of COVID-19, especially its potential severity, is different for younger versus older people, older people may be more prone to engage in preventive behaviors (Li et al., 2020; Oliver et al., 2020; Wise et al., 2020; Yıldırım et al., 2020; an exception from this observation: Pasion et al., 2020). A systematic review conducted on the avian and swine flu showed that the age-behavior relationship may be affected by a number of psychological factors, such as trust in institutions and perceived affective risk or anxiety (Bish & Michie, 2010). Therefore, understanding the role of age in the effect of psychological

variables and policies on behavior is important for creating interventions, messages, and policies that change people's behavior effectively.

Accordingly, this study investigated this relationship between age, psychological variables, policies, and COVID-19 preventive behaviors. The contribution of the study is two-fold. First, it provides a theoretical and conceptual overview of the role of trust, risk perceptions and official policies in changing preventive behaviors. Second, an empirical investigation of the early course of the 2020 COVID-19 pandemic examines the main and interaction effects of age, psychological variables, and policies on two self-reported preventive behaviors: mask-wearing and the avoidance of social gatherings were subject to changing policies during the study period.

The Role of Trust

The trust, confidence, and cooperation (TCC) model state that trust is of utmost importance in risk communication and in adopting preventive behaviors, especially under uncertainty (Earle et al., 2007; Feufel et al., 2010). Trust is understood as perceiving institutions as competent, honest, and benevolent (Mayer et al., 1995); this cognitive attitude can motivate trustful actions (e.g., adherence to recommended behaviors or policies; Schaal, 2004). Trust in institutions also influences risk perceptions (Dryhurst et al., 2020), helps deal with complexity, and is crucial for legitimizing authorities' decisions (Bennett et al., 2010). Therefore, the level of trust in institutions should contribute to how individuals wear masks or follow physical distancing requirements and is thus a relevant factor of the disease dynamics during the COVID-19 pandemic (Betsch, Wieler, et al., 2020).

Indeed, in previous pandemics, trust was a key factor that affected compliance with recommended and mandatory measures (Condon & Sinha, 2010). For example, trust in the government was a major driver of vaccination intentions and other preventive behaviors during the H1N1 pandemic (van der Weerd et al., 2011). Research conducted during the COVID-19 pandemic has shown that older people have greater trust in institutions than younger individuals (Fridman et al., 2020). Furthermore, during the first 6 months of the COVID-19 pandemic, trust in institutions was related to increased protective behaviors, increased acceptance of policies, and higher risk perceptions (Eitze et al., 2021).

The Role of Risk Perceptions

Risk perceptions are a key component of health behavior (van der Pligt, 1996), and the majority of psychological

health theories incorporate risk perceptions to explain health behaviors (e.g., Protection Motivation Theory, Health Belief Model, Health Action Process Approach; Becker, 1974; Brugger et al., 2018; Rogers, 1975). These theories share the main assumption that higher risk perceptions increase the likelihood that individuals will engage in preventive health behaviors, such as mask-wearing and avoiding social gatherings.

In general, risk perceptions have a cognitive and affective component (Ferrer & Klein, 2015; Slovic et al., 2004). The cognitive component comprises the evaluation of the probability of occurrence and the assumed severity of a negative event. Subjective susceptibility is also considered a cognitive risk component (Brewer et al., 2007). The affective component of risk refers to feelings like fear and worry due to a possible negative event (Loewenstein et al., 2001). Affective risk perceptions are often more strongly related to preventive behaviors than are cognitive risk perceptions (Loewenstein et al., 2001; Renner & Reuter, 2012).

Research on risk perceptions, age, and protective behaviors conducted during the COVID-19 pandemic has reported inconclusive results. The literature on the cognitive component of risk was mostly confined to the likelihood of getting infected (or dying from the disease when infected). For example, Bruine de Bruin (2021) found that older individuals evaluated their probability of being infected as lower than younger individuals, but these individuals perceived a higher likelihood of dying from COVID-19 when infected. Similarly, Masters et al. (2020) showed that the "baby boomer" generation (those 56–74 years of age) had a lower perceived probability of contracting COVID-19 compared to the "millennial" generation (those 24–39 years old) but displayed more frequent physical distancing behavior. Yıldırım et al. (2020) found that older individuals perceived a lower infection probability but also showed a lower level of preventive behaviors. Ali et al. (2020) also found that older individuals perceived their infection probability as lower than younger respondents. Pasion et al. (2020) found an inverted U-shaped relationship between age and perceived infection probability: older adults (older than 70 years), as well as younger adults (younger than 20 years), perceived their likelihood of getting infected as lower than middle-aged adults (between 20 and 59 years). Conversely, Wise et al. (2020) found that older individuals perceived a higher probability of infection. They also assessed another facet of cognitive risks – severity – and showed that the elderly perceived COVID-19 more severe than the young.

In the context of affective risks, Yıldırım et al. (2020) concluded that age is negatively related to affective risk perceptions, suggesting that older people may perceive less affective risk. However, Bacon and Corr (2020) showed that older individuals felt higher levels of concern regarding COVID-19. Finally, Dryhurst et al. (2020) operationalized

risk as a conglomerate of affective and cognitive risks and found no significant overall relationship between age and risk perceptions in a large-scale, cross-national survey.

In sum, the relationship between age, risk perceptions, and behavior seems to vary based on differences in how risk is conceptualized and operationalized. It may also be affected by the time during the pandemic and the location where it was measured; the situation and number of COVID-19 cases at the time and place of data collection may have contributed to the complex pattern of results. These dynamics could not be accounted for in most studies (exceptions: Ebert et al., 2020; Wise et al., 2020), as they used cross-sectional designs with only one measurement point. Thus, while this study provided data only from one country (Germany), it filled the remaining gap, assessing both cognitive and affective risk perceptions and relating them, in interaction with age and policies, to protective behaviors across time and disease dynamics.

While assuming that a higher (perceived) infection probability leads to a higher adoption rate of preventive behaviors is reasonable, several studies mentioned above showed the opposite. This counter-intuitive relationship could be due to the fact that adopting preventive behaviors may also reduce the perceived probability of getting infected, as this is the actual purpose of the behavior. Applied to mask-wearing, this reversed causality would mean that regular and correct mask-wearing in shops and public transport results in a reduced probability of getting infected (both subjectively and objectively). However, the perceived severity of infection should not be affected. Due to this consideration, the present study was constrained to perceived severity, susceptibility, and affective risks, which should have a clearer (positive) relationship with preventive behavior.

The Role of Policies

During the COVID-19 pandemic, several countries have implemented mandatory policies regarding various preventive behaviors, such as mask-wearing or avoiding social gatherings (Karaivanov et al., 2020; Lyu & Wehby, 2020). In Germany, for example, only two individuals have been allowed to meet in both private and public settings since 21 March 2020. Wearing masks on public transport and in public enclosed spaces became mandatory on 27 April 2020. Beginning on 6 May 2020, after a sharp decline in the number of infections, restrictions on social gatherings were lifted over the summer. However, a second shutdown became necessary on 2 November 2020, and the restrictions regarding social gatherings were reinstated.

In previous pandemics, implemented policies had an immense impact on preventive behaviors (Kumar et al., 2012). Research from the current pandemic has also shown, for example, that restricting social contacts by limiting the

possibility to meet (e.g., by closing schools or businesses) had a medium to high impact on infection rates (Brauner et al., 2021; Götz et al., 2021). A recent study conducted during the first months (March–May 2020) of the COVID-19 pandemic found that older people accepted restrictive policies more readily than younger people and perceived restrictive political decisions as more reasonable (Zettler et al., 2020). Non-compliance with social distancing policies was higher in younger than in older adults (Nivette et al., 2021).

Research Questions and Overview

Preventive behaviors during the current and previous pandemics were more prevalent in older people. The currently available evidence regarding age differences in risk perceptions and trust could explain parts of this difference; however, this evidence mostly comes from studies with cross-sectional designs with only one measurement point and/or different operationalizations of risk. As the current pandemic is extremely dynamic, with cases, death counts, and policies changing rapidly and repeatedly, risk perceptions and trust likely vary over time and as a function of this dynamic nature. Additionally, these aspects are likely more or less important given certain policies. Thus, based on the current evidence, drawing conclusions regarding the relationship between policies, trust and risk, age, and preventive behaviors is difficult.

This study aimed to answer the following research questions:

Research Question 1 (RQ1): Are age differences in showing preventive behaviors moderated by policy changes?

The same question was also applied to the effect of risk perceptions and trust on behavior:

Research Question 2 (RQ2): Are policies moderators in the relationship between risk perceptions, trust, and preventive behavior?

To answer these questions, two behaviors were selected for which the related policies changed over time. While mask-wearing remained mandatory after the pandemic's onset, social gatherings were prohibited during two lockdowns and were allowed in between these lockdowns. The independent and interacting effects of age, policies, and psychological variables on these two self-reported preventive behaviors were examined, and the three-way interactions between age, policy, and psychological variables were explored (i.e., whether the presence or absence of mandatory policies affected the relationship between psychological aspects and age on self-reported behaviors).

Methods

Data from an ongoing serial cross-sectional study that assessed the constructs of interest were analyzed weekly to fortnightly over the course of the pandemic.

Ethics Statement

The study was approved by the institutional review board at the University of Erfurt (#20200302/20200501). All participants provided informed consent before entering the study.

Participants and Design

COVID-19 Snapshot Monitoring (COSMO) study was designed as a serial cross-sectional online survey, with approximately 1,000 individuals participating at each measurement point (study protocol: <http://dx.doi.org/10.23668/psycharchives.2776>), 20 of which are reported here. Data collection started on March 3, 2020 and was ongoing at the time of submission. In April 2020, the measurement format for the preventive behaviors was changed from *Yes/ No/ I do not know* to a frequency-based answer format. Thus, only data from April 14 to November 17, 2020 were included.

Non-probability quota samples were used that represented the distribution of Age $\times$ Gender of the German adult population as well as the federal state according to the German census (see Electronic Supplementary Material, ESM 1, Table E1). Individuals between 18 and 74 years of age were eligible for participation. Participants were admitted to the survey or screened out on the first page on the basis of the quotas. An ISO 26362:2009-compliant online panel (<https://www.respondi.com/>, <https://www.iso.org/standard/43521.html>) was used for recruitment and compensation. Consequently, only individuals who were registered panel participants with an internet connection could participate in the surveys. Respondents were not invited for subsequent surveys after their initial participation.

Of the 20,977 participants who took part in the surveys, those in the upper and lower 2.5% quantile of participation time and those who participated with time breaks were excluded from the dataset to optimize data quality. In total, 19,069 participants composed the final dataset. The mean age was 45.75 years ($SD = 15.72$), and 51.2% of the sample was female. Around 55.5% of the sample had at least 10 years of education (with A level), and 36.7% lived in large cities (see Supplementary Table S1 for details). The average participation time was 23.77 min ($SD = 10.13$). With regard to the preventive behaviors and the indication of trust in different institutions, participants were able to omit the

questions that did not apply to them. This resulted in missing values; the sample per analysis varied accordingly. A flow chart and description of the samples of the different analyses can be found in ESM 1, Figure E1, and the online supplement (<https://osf.io/t48pj>).

Measures

All questionnaires can be accessed at <http://dx.doi.org/10.23668/psycharchives.2776>

Demographic Variables

The participants provided sociodemographic information on their gender, education (low: up to 9 years of schooling; medium: at least 10 years [without A level]; high: at least 10 years [with A level]), and the size of their community (small: < 20,000 inhabitants; medium: 20,001–100,000 inhabitants; large: >100,001 inhabitants; classification according to the German Federal Office for Building and Regional Planning).

Preventive Behaviors

Mask-wearing and avoiding social gatherings were assessed with one item on a 6-point scale ranging from 1 = *does not apply* or 2 = *never* to 6 = *always*. Participants who indicated that the behavior did not apply to them were excluded from the respective analysis, and the variables were recoded from 1 = *never* to 5 = *always*.

Psychological Variables

Susceptibility to and severity of SARS-CoV-2 infection covered the cognitive component of risk (Brewer et al., 2007). They were measured on 7-point scales from 1 = *not susceptible at all* to 7 = *extremely susceptible* and 1 = *completely harmless* to 7 = *extremely dangerous*, respectively. To cover the affective component of risk, participants evaluated the level of fear and worry elicited by COVID-19 on 7-point semantic differentials (e.g., “The novel coronavirus for me is ...” 1 = *worrying* to 7 = *not worrying* and 1 = *scary* to 7 = *not scary*; Bradley & Lang, 1994). Both variables were highly correlated ($r = 0.73$). Thus, the items were reversed and an average score was used for the analyses.

Trust in institutions was assessed with four items, each rating trust in the Federal Centre for Health Education (BZgA), Robert Koch Institute (RKI), Federal Ministry of Health, and Ministry of Health of the participant’s federal state (McDonald’s hierarchical omega (ω_h) = 0.92) on a 7-point scale from 1 = *very little trust* to 7 = *a great deal of trust*. The participants had the option to indicate when they could not make a statement, which was coded as missing values. As all regression analyses used a mean score across all four items as a predictor, participants with at least one

missing value in the trust items were excluded from the analysis.

Policies

Since 27 April 2020, mask-wearing has been mandatory when shopping or using public transportation. Thus, measurement points after April 27, 2020 were coded as mandatory mask policy (1) and as voluntary otherwise (0). Between May 6 and November 2, 2020, the German government eased contact restrictions. Thus, data collected at measurement points between the two dates were marked as “no lockdown” (0) and as “lockdown” instead of (1).

Procedure

The survey comprised two parts. First, participants provided demographic information and were asked about their general living situations. Second, participants received several questions about COVID-19. While the survey included a large battery of items, only the variables reported above were considered for analysis. These variables were assessed regularly, while other topics and corresponding measures changed between surveys. Risk variables came first (susceptibility, severity, fear, worry), followed by the self-reported frequency of preventive behaviors and trust. Lastly, participants received a short debriefing with sources for COVID-19 information and psychological support.

Data Analysis Procedure

The data and analysis script are available via the Open Science Framework (OSF; Korn et al., 2021). For data management, analysis, and visualization, the R-environment and various packages were used. Dichotomous variables were effect-coded (−0.5 and 0.5), and numeric variables were centered at the mean when they were part of interactions to obtain the average effects of the independent variables. Thus, the effect of a variable could be interpreted as a grand mean effect and the interaction as a deviation from this grand mean effect (Te Grotenhuis et al., 2017). An α -level of .05 was applied for all analyses.

The infection numbers varied considerably between March and November 2020 (Figures 1A and 2A; retrieved from Robert Koch Institute, 2020). Therefore, the time factor was likely to have different effects on behavior. This effect was accounted for by segmenting the regressions based on estimated breakpoints of the time variable. Details on the breakpoint estimation can be found in Muggeo (2003) and the supplementary text. Furthermore, the regressions reported below built upon each other. Model 1 focused on the effects of time segments, age, and policies on mask-wearing and avoiding social gatherings. Model 2 added demographic variables, model 3 added psychological variables, and model 4 allowed interactions between policies, psychological variables, and age. Standardized beta

estimates were provided for convenient comparison of the results. Additionally, to account for skewness and possible ceiling effects in the distributions of the dependent variables, standard errors, standardized 0.95 confidence intervals, and standardised p -values were calculated based on heteroskedasticity- and autocorrelation-consistent (HAC) estimators of the variance-covariance matrix (Newey & West, 1986). Unstandardized regression results can be found in the online supplement (<https://osf.io/t48pj>). In the regression analyses, weighting procedures were not applied to account for non-representative distributions in the participants' characteristics (Gelman, 2007); rather, the analyses only controlled their impact.

Results

In the subsequent regression analyses, interaction effects between age and policy were used to assess whether age differences in behavior were moderated by (mandatory) policies (RQ1). The interaction effects between psychological variables and policies further assessed whether policies affected the relationship between psychological variables and behavior (RQ2). Additionally, the three-way interactions between age, policy, and psychological variables were explored to determine whether psychological aspects that corresponded with age also varied under different implemented policies.

Mask-Wearing

As depicted in Figure 1A, the relationship between mask-wearing and measurement points was positive but not linear. As a result of the breakpoint analysis, time was integrated into the regression as two linear segments. The slope was especially steep in the early stages of the pandemic ($\beta = 2.382$, see <https://osf.io/t48pj/> for details); slope estimates were based on the segmented regressions shown in ESM 1, Table E2. Then, the slope decreased, and a plateau was reached. As infection rates continued to increase in October 2020, mask-wearing also continued to increase, resulting in an overall slightly positive slope in the second time segment ($\beta = 0.116$).

ESM 1, Table E2 shows the results of the linear regressions that predicted mask-wearing. The most complex model (model 4) explained 39% of the variance. Age was indeed positively associated with mask-wearing ($\beta = 0.052$, $p < .001$). Contrary to previous research (Betsch, Korn, et al., 2020; Gostin & Wiley, 2020; Götz et al., 2021; Kumar et al., 2012), the introduction of a mandatory mask policy was not associated with increased mask-wearing ($\beta = 0.146$, $p = .155$). Instead, the effects of age

Figure 1. (A) Mean values of mask-wearing frequency over the course of 2020. Error bars and error bands correspond to 95% confidence intervals. The right y-axis depicts infection numbers retrieved from RKI (2020). With the introduction of mandatory mask policies in shops and public transportation, the mask-wearing frequency increased massively. Additionally, in fall 2020, with the increasing number of COVID-19 cases, the participants reported wearing masks more frequently. (B) Interaction effect between age and perceived severity of the disease and policy on mask wearing frequency. The plot depicts predicted values from regression model 4, indicating that perceived severity predicted mask-wearing among younger respondents more accurately when mask-wearing was voluntary (left). This Age $\times$ Severity interaction disappeared when mask-wearing became mandatory (right). (C) The area-of-significance plot represents the simple slope of the effect of perceived severity of the disease on mask-wearing frequency as a function of age under voluntary and mandatory mask-wearing policies. The areas indicate for which range of values of the age variable the relationship between severity and mask-wearing behavior is significant. As reported above, this plot also shows that perceived severity has a stronger effect on younger individuals, which becomes weaker with age until it is no longer significant at around age 60. (D) Interaction effect between age, trust in institutions, and policy on mask-wearing frequency. The plot depicts predicted values from regression model 4, indicating that when mask-wearing was voluntary, higher mask-wearing frequency was linked to higher trust in institutions, especially among older respondents (left). When mask-wearing became mandatory, it was associated with higher trust across all age groups (right). (E) The area-of-significance plot of the interaction between age, trust in institutions, and policy also shows that the effect of trust under the weaker policy has a significant effect on mask-wearing only from the age of about 40 years, while this effect under stronger restrictions has an effect between > 0.05 across all age groups. Note that for the interaction plots, the ages of 30 and 60 were chosen to cluster the interval-scaled variable age inconsistency with the time series plot. A comprehensive representation of the effect of the entire age spectrum can be seen in the significant plots.

Figure 2. (A) Mean values of avoiding social gatherings over the course of 2020. Error bars and error bands correspond to 95% confidence intervals. The right y-axis depicts infection numbers retrieved from RKI (2020). With the easing of the restrictions in spring 2020, the frequency declined. The decline stagnated between August and October and increased again right before the second lockdown at the beginning of November. (B) Interaction between age, perceived severity, and policy on avoiding social gatherings. Especially at low levels of perceived severity, age differences were large when policies were loose (left). Under stronger restrictions, however, no associations between age, severity effects, and avoidance behavior were found (right). (C) The area-of-significance plot represents the simple slope of the effect of perceived severity of the disease on avoidance behavior as a function of age under weaker and stronger restrictions. The effect of perceived severity under looser policies decreases with age until it is no longer significant after about 70 years of age. Under stronger restrictions, severity no longer has any influence on avoidance behavior, regardless of age. (D) Significant three-way interaction between age, trust in authorities, and policies. When policies restricted social gatherings (right), trust was stronger related to complying with the behavior in younger participants than in older participants. When restrictions were loose, all participants showed the same associative strength between higher trust and avoidance of social gatherings (left). (E) The area of significance plot supports the above statement and shows that under stricter restrictions, the positive effect of trust decreases with increasing age until it is finally no longer significant at high ages above around 78 years. Under lighter restrictions, the effect remains significant at ~ 0.1 -level across all age groups. Note that for the interaction plots, the ages of 30 and 60 were chosen to cluster the interval-scaled variable age inconsistency with the time series plot. A comprehensive representation of the effect of the entire age spectrum can be seen in the significant plots.

varied under the different policies, as indicated by a significant Policy $\times$ Age interaction effect (RQ1; $\beta = -0.034$, $p < .001$); the change to a mandatory policy reduced the association between age and mask-wearing.

Regarding the psychological variables, higher perceived cognitive and affective risk as well as higher trust in institutions were related to more frequent mask-wearing (all $ps < .001$; $\beta_{\text{severity}} = 0.136$, $\beta_{\text{susceptibility}} = 0.051$, $\beta_{\text{affective}} = 0.101$, $\beta_{\text{trust}} = 0.111$). All associations between the psychological variables and mask-wearing varied with age (all $ps < .001$). For younger participants, severity perceptions had a higher influence on avoidance behavior compared to older participants ($\beta = -0.038$); susceptibility was more strongly related to avoidance behavior among older participants but had barely any influence on younger participants ($\beta = 0.013$). With regard to affective risks and trust in institutions, the correlation with mask-wearing behavior was stronger among younger respondents ($\beta = -0.010$). Lastly, the association between trust in institutions and mask-wearing was more pronounced among older participants ($\beta = 0.028$).

RQ2 asked whether psychological variables were more or less relevant to behaviors under different policies. The results showed that the association between trust and mask-wearing increased when mask policies were introduced ($\beta = 0.055$, $p = .030$). No such effect of policies on the relationship between risk perceptions and mask-wearing frequency was found (all $ps > .090$).

Three significant three-way interactions were found between age, psychological variables, and policy, suggesting a complex interplay of all factors. Figures 1B and 1C depict the three-way interaction between severity, age, and policy on mask-wearing ($\beta = 0.041$, $p < .001$). The relationship between perceived severity and mask-wearing was stronger among younger respondents when mask-wearing was voluntary (left), but this Age $\times$ Severity interaction disappeared when mask-wearing was mandatory (right). The three-way interaction between trust, age, and policies is depicted in Figures 1D and 1E ($\beta = -0.051$, $p < .001$). Under a voluntary mask-wearing policy, the higher mask-wearing frequency was linked to higher trust in institutions, especially among older respondents (left). When mask-wearing was mandatory, higher mask-wearing frequency was associated with higher trust across all age groups (right). The third three-way interaction between susceptibility, age, and policies is depicted in ESM 1, Figure E2 ($\beta = 0.010$, $p < .001$). The results showed that susceptibility was related to behavior when mask-wearing was not mandatory for participants of higher age.

After including psychological variables and all interactions in the regression in model 4, being a woman was a significant demographic predictor for higher mask-wearing frequency, while higher education was related to lower levels of mask-wearing.

Avoiding Social Gatherings

As seen in Figure 2A, no linear relationship was found between avoiding social gatherings and the measurement points. As a result of the breakpoint analysis, time was added to the regression, thereby predicting avoidance of social gatherings as four segments. After a stable phase during the first lockdown ($\beta = 0.084$; see the OSF supplement for details and ESM 1, Table E3), restrictions were relaxed in early May 2020, and people avoided social gatherings less frequently ($\beta = -0.668$). Between August and October 2020, the level of avoiding social gatherings remained relatively stable ($\beta = -0.053$) until the number of cases increased in October. Then, avoiding social gatherings steadily increased, even before the second lockdown required this particular behavior in November ($\beta = 0.177$). During the second lockdown, avoidance continued to rise, approaching the levels of the first lockdown.

ESM 1, Table E3 shows the results of the segmented linear regressions that predicted the avoidance of social gatherings. The most complex model (model 4) explained 15% of the variance. Again, no significant main effect of policy was found ($\beta = 0.050$, $p = .248$); however, higher age was linked to more avoidance behaviors when policies were voluntary (RQ1; $\beta = -0.015$, $p < .001$).

Of the psychological variables, higher affective risk, severity, and trust were related to higher avoidance of social gatherings (all $ps < .001$; $\beta_{\text{severity}} = 0.045$, $\beta_{\text{affective}} = 0.109$, $\beta_{\text{trust}} = 0.123$), while perceived susceptibility was not ($\beta_{\text{susceptibility}} = 0.005$, $p = .528$). Again, the associations of all psychological variables with avoiding behavior varied with age (all $ps < .001$). For younger participants, severity perceptions had a higher influence on avoidance behavior than older participants ($\beta = -0.018$); susceptibility was more strongly related to avoidance behavior among older participants than younger participants ($\beta = 0.020$). With regard to affective risk and trust in institutions, the correlation with avoidance behavior was stronger among younger respondents ($\beta_{\text{affective} \times \text{age}} = -0.014$, $\beta_{\text{trust} \times \text{age}} = -0.013$).

One significant two-way interaction effect was found between psychological aspects and policy (RQ2; $\beta = -0.057$, $p < .001$). When the restrictions were loose, avoidance behavior was more strongly related to perceived severity. Under stronger restrictions, however, no associations were found between severity effects and avoidance behavior. All other two-way interactions between psychological variables and policy were nonsignificant (all $ps > .149$).

Finally, all three-way interactions between age, policy, and psychological variables were significant (all $ps < .001$). Two of them are depicted in Figure 2, and the rest can be found in the ESM 1, Figure E3. When restrictions were loose, younger people's avoidance of social gatherings was stronger associated with perceived severity of COVID-19.

This was especially evident at low levels of perceived severity, where age differences were especially large (Figures 2B and 2C, left; $\beta = 0.011$). Under stronger restrictions, however, no associations between age or severity effects and avoidance behavior were found (right). When restrictions were loose, higher susceptibility was related to more avoidance behaviors only among the older participants ($\beta = 0.006$). When social gatherings were restricted, the relationship between susceptibility and behavior was negligible in the older age group. Within the younger group, however, higher ratings of susceptibility were associated with less avoidance of social gatherings. With regard to affective risk, the two-way interaction with age (as described above) on avoidance behavior was more pronounced when a restrictive policy was in place ($\beta = -0.006$). Finally, a significant three-way interaction effect was found between age, policies, and trust (Figure 2D, 2E; $\beta = -0.016$). When policies restricted social gatherings, trust was stronger in complying with the behavior in younger participants than in older participants.

Regarding demographic variables, the analysis revealed that women showed higher avoidance behavior after controlling for all other predictors.

Discussion

This work aimed to shed light on age differences in COVID-19 preventive behaviors and their interplay with health policies and psychological variables. The results showed first that age differences in avoidance of social gatherings and mask-wearing remained stable irrespective of the policies in place (RQ1). Second, the associations between the psychological variables and preventive behaviors changed under mandatory policies (RQ2). Third, for both behaviors (i.e., mask-wearing and avoidance of social gatherings), a number of complex three-way interactions existed between age, policies, and the psychological variables, which indicated that the interplay between policies and psychological variables also varied with age. On an abstract level, policies seemed to act as a delimiter for the influence of individual perceptions on preventive behaviors. This was in line with theoretical accounts like Trait Activation Theory (Tett et al., 2013) and Situational Strength Theory (Meyer et al., 2020) that assume that strong situations limit the opportunity to express individual differences.

In detail, for mask-wearing, the relationship between perceived risk and preventive behaviors weakened when a mandatory policy was in place, and age differences in perceived risk no longer played a role. Trust, however, was more related to compliance under a mandatory policy, and age effects of trust on mask-wearing disappeared in this instance. Regarding avoiding social gatherings, the link between affective risks and preventive behavior weakened

when a restrictive policy was in place. Moreover, when restrictions were imposed, the relationship between age and perceived severity disappeared.

This study provided new insights on the interplay of age, psychological variables, and policies and yielded implications for theory as well as future pandemic management. With voluntary as opposed to mandatory policies in place, age differences and perceived severity of infection had a greater influence on behaviors. Thus, health theories that strongly build upon risk perceptions (e.g., Becker, 1974; Brugger et al., 2018; Rogers, 1975) should also consider public policies as potential moderators of key variables, such as perceived risk. Policies moderate the relationship between individual difference variables and beliefs and may result in these variables becoming less strongly expressed in the manifestation of preventive behaviors. This insight may be helpful for studies that do not find the effects of risk perceptions on behavior, for example. Research using these theories should at least report the context of the study so that the possible effects of psychological variables on behavior are not underestimated but are better understood. Regarding trust, the results were in line with the TCC model (Earle et al., 2007; Feufel et al., 2010), as adherence to restrictive policies was highest for those who trusted the regulating authorities (i.e., those for whom strict regulations were probably in accordance with their own moral values and performance aspirations; Peeters & Czapinski, 1990; Skowronski & Carlston, 1989).

Moreover, the results also showed that evidence-based health communication is especially important (and complex) under less restrictive policies and that some levers (even under mandatory policies) could help foster compliance with the required behaviors (e.g., fostering trust when making mask-wearing mandatory). As shown in Figure 1, policies can also be used to stabilize preventive behaviors at a high level of uptake, even when case numbers and risk perceptions decline. The results suggested that younger age groups need justifications for regulations when voluntary rather than mandatory policies are implemented. Targeted information about the severity of COVID-19 could help them understand and accept the regulations. In the absence of policies, perceiving higher severity led to more preventive behavior in younger people. Thus, long-COVID (i.e., the severe long-term consequences of COVID-19 infections; Lenzen-Schulte, 2020) is highly relevant here because long-COVID also affects young people. As disease dynamics change rapidly, information about higher hospitalization rates of young people infected with new mutations is also relevant.

Previous results have shown inconsistent results regarding age differences in preventive behaviors (e.g., Bish & Michie, 2010; Wise et al., 2020; Yildirim et al., 2020). The present analyses of a large-scale, serial, cross-sectional

online survey showed that age alone was a stable but not exclusive determinant of preventive behaviors, as stable, independent effects of other psychological variables on preventive behaviors existed. Next to age, only a small number of sociodemographic factors were relevant. Interestingly, more frequent mask-wearing was related to lower education. This finding might indicate additional underlying dimensions, such as increased information-seeking behavior (Jacobs et al., 2017), that result in sources of misinformation (Orso et al., 2020). Or it may indicate that people with lower education are more likely to work in jobs with a higher risk of exposure to the disease.

In this study, more variance was explained in the mask-wearing analyses ($R^2 = 0.39$) than in the analysis of avoiding social gatherings ($R^2 = 0.15$). Other major variables and their interactions may have been missing, especially in the case of social gatherings. This may include emotions, social norms, personality traits (i.e., extraversion vs. introversion) or social pressure (i.e., the expectation of significant others to attend social gatherings; Ścigała et al., 2020; Zettler et al., 2020). Additionally, the effectiveness of making a policy mandatory may vary for the two behaviors. While non-adherence to mask-wearing in public places is visible and can be sanctioned, this is not the case for private gatherings. Moreover, wearing a mask versus not wearing a mask is easier to define than a social gathering. Thus, adherence to well-defined measures may be easier than to more fuzzy measures and thus may have less error variance in the ratings.

Finally, avoiding social contact may be a more difficult behavior than wearing a mask. Humans are social beings, and avoiding social contact is against human nature. The fact that older people avoided contact more may be due to the fact that they felt more at risk and because it was easier for them; social networks tend to narrow over the course of a person's lifetime (Bruine de Bruin, 2021). This may have made it easier for the elderly to comply with contact restrictions. In sum, these behaviors differ in several factors, and the current analysis took only risk perceptions and trust as potential determinants into account, which was a limitation of the study.

Strengths and Limitations

The current study had some further limitations. Although the samples represented the quotas for Age (18–74) × Gender of the German population, the sample characteristics deviated from the general population in terms of education and age. Participants were only eligible for participation when under 74 years of age. The reason behind this was the assumption that online surveys show a self-selection bias that may be more pronounced among the older age group; using the internet at this age may be systematically confounded with several relevant lifestyles

and health-related characteristics (Weber et al., 2020). Furthermore, the sample had, on average, higher levels of education than the general German population. However, education was included as a control variable in the regressions, and since data were collected from around 20,000 participants, conclusions for all educational levels could still be drawn.

The data presented here were from a serial cross-sectional survey, which meant that only associational inferences were possible. However, on the population level (over 20 measurement points), the changes in reported behavior still provided important insights. Furthermore, in repeated cross-sectional surveys with multiple measurement occasions, the trajectories of responses were comparable to those from panel surveys (given that participants were sampled from the same population; see Zettler et al., 2021). With the observation of the two focal preventive behaviors, the resulting changes in behaviors may thus serve as the best evidence available for informing future pandemic policymaking alongside further behavioral data, such as cell phone mobility data.

Both the measures on preventive behaviors as well as trust in institutions contained missing values. Individuals with missing responses perceived lower cognitive and affective risk than individuals who completed all survey items. Thus, these missing values may have expressed of the absence of trust or engaging in preventive behaviors. The relationship between trust and behavior may have been different for these extreme values. The total frequency of protective behavior displayed in Figures 1A and 2A may therefore be overestimated. Also, both preventive behaviors were measured with one item each. It could be argued that showing preventive behaviors might vary depending on context. For example, the frequency of mask-wearing might be higher in contexts where it is an obligation compared to situations where it relies more on voluntariness. Thus, a single item might overestimate actual adherence rates and less consider contextual variability of showing preventive behaviors. Although the specificity might be lower when assessing the behavior with one item, responses to context-specific items and general items are likely to be positively related. Additionally, a general item to cover preventive behaviors can be advantageous when there is interest in time-based analyses. Policies and recommendations may change, for example, how, where, and when to wear masks, but the measures remain unchanged. This procedure enabled time-based analyses.

The data were gathered in Germany – a Western, educated, industrialized, rich, and democratic (WEIRD) society. Thus, the results may be restricted to the Western hemisphere (Henrich et al., 2010) and should be examined within its cultural-psychological perspective. As cases, numbers of deaths, policies, economic support, and overall

handling of the crisis have varied between countries, these contextual factors should also be considered when generalizing the results. Moreover, the study assessed self-reports and preventive behaviors may be subject to social desirability (Podsakoff et al., 2003); thus, the absolute magnitude of preventive behaviors may be overestimated.

The age effects (main effects as well as interaction effects) were rather small. However, even statistically small effects can have a large impact in a dynamic disease situation, wherein the transmission is fuelled by young people, and the burden of the disease rests mostly on the elderly. Future studies must determine whether the effects of other age-related variables, such as social norms and social network structures, are hidden in the age effect found by this analysis.

Lastly, one of the potentially most surprising findings was the lack of direct effects of the policies. As seen in Figures 1 and 2A, the time variable that included time segments in which relevant changes of COVID-19 case numbers occurred could be the key to this observation. The variance in the dependent variables from the policies was potentially explained by the time variable, as policies often followed the case number development. However, since the analyses dealt with a time series dataset and ignoring the non-linear time component with the underlying different pandemic dynamics would lead to a stronger bias of the results, this more conservative representation, which might underestimate the effect of the policies, was chosen.

Conclusion

The current contribution indicated that age differences strongly affected protective behaviors against COVID-19, even after implementing mandatory policies. Moreover, mandatory policies made risk perceptions less relevant for preventive behaviors while trust became more relevant for adherence. Thus, mandatory policies can increase preventive behaviors when there is a higher degree of trust in the relevant institutions and policymakers. This is especially the case among younger age groups. The present research also made a strong case for quality, targeted health and risk communication, as without mandatory policies, the importance of the preventive behaviors must be well understood to achieve high adherence – especially in young people who are threatened by the disease less directly.

As of the end of December 2020, another focal preventive behavior became important: vaccinations. The current contribution may offer insights also on this issue, especially as vaccinations will not be mandatory in many countries. This means that a complex interplay between age and psychological variables that will affect vaccination behavior is possible. The current study could inform policymakers and help them develop adequate communication solutions to ultimately address and tackle the pandemic.

Electronic Supplementary Material

The electronic supplementary materials are available with the online version of the article at <https://doi.org/10.1027/1016-9040/a000462>

ESM 1. Supplementary text explaining the reasoning and methodological background of segmented regressions. Tables showing participants accumulated across 20 measurement points and respective distributions of demographic variables in the German population, and segmented, linear regression models predicting mask wearing and the avoidance of social gatherings. Figures show a CONSORT 2010 flow diagram of the survey, and interaction plots for mask-wearing and for avoiding social gatherings.

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Open Data

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ORCID

Lars Korn

<https://orcid.org/0000-0001-6544-3839>

Lars Korn

Media and Communication Science
University of Erfurt
Nordhäuser Str. 63
99089 Erfurt
Germany
lars.korn@bnitm.de

Lars Korn is a postdoc at the University of Erfurt and is currently involved in the COVID-19 Snapshot Monitoring (COSMO) project and a DFG-funded project on the vaccination decision and the decision to take antibiotics. His previous research mainly focused on vaccination decisions and its social-interactive aspect.

Regina Siegers is a survey statistician currently working at the University of Erfurt, within the COVID-19 Snapshot Monitoring (COSMO) project. Her research interests include graphical causal modeling, evidence-based social intervention and policy, and the interplay of risk perception and behavior.

Sarah Eitze works at the University of Erfurt, within the COVID-19 Snapshot Monitoring (COSMO) project. Previous research includes topics from the field of health psychology, including vaccination decisions with a focus on people of higher age, health knowledge, and decision-making strategies.

Philipp Sprengholz is a PhD student investigating the interplay between public health policies and individual behavior. He is currently engaged in the COVID-19 Snapshot Monitoring (COSMO) project and is interested in the application of state-of-the-art technology as well as implicit methods in psychological research.

Frederike Taubert works as a research assistant at the University of Erfurt within the COVID-19 Snapshot Monitoring (COSMO) project. She is currently studying psychology at the University of Erfurt in the master's program.

Robert Böhm is a professor of Applied Social Psychology and Behavioral Science at the Department of Psychology and Department of Economics, University of Copenhagen. His research interests are at the intersection of social psychology and behavioral economics, focusing on human decisions in social interactions.

Psychologist Cornelia Betsch is a professor of health communication at the University of Erfurt. Her work aims at understanding principles of health behavior by applying a judgment and decision-making and strategic-interaction perspective to infectious disease control. She is interested in social and individual aspects of health and medical decision-making.