Health behaviors and mental health during the COVID-19 pandemic:**A longitudinal population-based survey**

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Abstract

Objective: To understand the mental health response to repeated and prolonged stress during the Covid-19 related lockdown and the role of health behaviors to buffer against this stress.

Methods: In a longitudinal study with four measurement points over three months during the COVID-19 pandemic, about 3,500 randomly selected participants representative of the German population reported their mental health (anxiety, depression, loneliness), screen time, snack consumption, and physical activity.

Results: Symptoms of anxiety, depression, and loneliness were highest shortly after the lockdown came into effect. Over time, the symptoms were stable or went down slightly, suggesting patterns of habituation. Among people with higher vulnerability to poor mental health during the lockdown (e.g., women), the proportion with high levels of anxiety, depression, and loneliness was considerably larger. These groups also reported fewer health-promoting behaviors. More screen time, more snacking, and less physical activity were related to higher symptoms of anxiety, depression, and loneliness across all time points. Changes in health behaviors over time did not predict changes in mental health symptoms.

Conclusions: Mental health and health behaviors worsened as an immediate response to stress but mostly returned to pre-lockdown levels within three months. Engaging in healthier behaviors was associated with better mental health. This study provides important insights into (unintended) side effects of a national crisis and contributes to a better understanding of how to preserve mental health.

Keywords: mental health, physical activity, snacking, screen time, COVID-19

How can people protect their health and well-being in situations of high stress? This is one of the central questions in health psychology. The impact of the 2020 lockdown of public life around the world due to the 2019 coronavirus (COVID-19) pandemic has been compared to that of ecological disasters, political coups, and terrorist attacks (Baker et al., 2020). Unlike these specific events that are usually confined to a geographical area or specific group of people, the COVID-19 pandemic has affected people all over the world. It thus presents a unique opportunity to study how stress induced by such a situation affects mental health, and what behaviors protect and preserve it.

COVID-19, lockdowns, and mental health

The COVID-19 outbreak was associated with a lot of individual stress, including fear of infection with COVID-19 (Brooks et al., 2020) and its consequences, such as quarantine/isolation, health complications, and death. In response to this outbreak, general policy measures affecting everyone were put into effect to protect the population and ensure the functionality of the health system. Such measures can have unintended side effects. In Germany, the first policy measures became effective on March 10, 2020, when two federal states forbid demonstrations of a certain size. Within 2 weeks, all 16 German federal states had closed all schools and daycares (except for emergency care), playgrounds, and shops and put social distancing requirements into effect (Steinmetz et al., 2020). Such measures have effects on various levels: In addition to the obvious one of reducing social and physical contact, which has a strong impact on mental health outcomes, including depression and anxiety (see Leigh-Hunt et al., 2017 for a systematic review), they also affected the working situation of most adults, with a significant proportion now in short-time work, unemployed, furloughed, or working remotely from home (Möhring et al., 2020; Reuschke & Felstead, 2020). For many adults, such changes are associated with a decrease in or loss of income and high financial stress, as well as social stress due to stigma or less personal contact with co-

workers. Further, these policies are commonly associated with a loss of usual routines, which is associated with boredom and frustration (Brooks et al., 2020).

Given that the COVID-19-related policy measures have affected so many aspects of daily life, these policy measures likely do not lead to *one* major stressful life event but rather to a number of repeated stressors, including numerous smaller daily life stressors.

Importantly, repeated daily life stressors that are likely to be more common during a lockdown, such as family arguments or problems juggling work and family demands, have a cumulative effect and impair health and well-being (e.g., Almeida, 2016). This effect of stress on mental health can change over time. This is due to two general learning processes that affect a person's response to repeated stressful experiences: habituation and sensitization (e.g., Eisenstein et al., 2001). Habituation refers to a decreased level of response to a repeated stimulus, leading to a diminishing impact of the stressor on mental health over time; sensitization is defined as an increased level of response to a repeated (stressful) stimulus, leading to reinforcement of the effect of the stressor on mental health. While people without a specific vulnerability to mental health disorders are likely to respond with habituation to repeated stressors—that is, they report fewer symptoms of mental health impairment (e.g., depression or anxiety)—those with vulnerabilities either show a stronger response and little or no habituation or even respond with sensitization—that is, they report even stronger mental health impairments due to (repeated) stressors over time. For example, a higher risk of developing major depressive disorder in individuals with a genetic risk of depression was found only if they had been exposed to repeated (two or more) stressful life events; there was no difference in the probability of an adverse outcome if only one stressful life event had occurred (Caspi et al., 2003). Similarly, people with higher vulnerability to depression showed increased negative affect in response to a repeated stressor (suggesting sensitization), whereas participants in a healthy control group showed signs of habituation (Mata et al., 2013).

Certain groups are more strongly affected by policy measures in general and might be at increased risk of experiencing diminished mental health in the face of COVID-19-related stressors: For instance, women have been especially impacted by the COVID-19-related economic downturn (Alon et al., 2020), because they make up a large proportion of employment sectors particularly affected by social distancing measures. Also, closures of schools and daycares massively increased childcare demands, and (working) mothers have largely taken over the job. Importantly, women are also more likely to experience mental health problems such as depression and anxiety (Jacobi et al., 2014) and thus are more vulnerable to poorer mental health as a consequence of COVID-19-related stressors (see Pierce et al., 2020 for such findings in the United Kingdom). Others strongly affected by policy measures are those whose employment is insecure, for example, because they are working fewer hours, have been furloughed, or have lost their job; such people experience particularly high stress due to financial insecurity, loss of routine, and social stigma (e.g., during the 2008–2013 financial crisis (Drydakis, 2015); but see also Recchi et al., 2020). Last, people in poor health may be particularly stressed in the current crisis, because the potential health consequences of a COVID-19 infection are likely more severe and they are more likely to be in stricter social and physical isolation (voluntarily, or because of particularly strict rules in institutions such as hospitals). Longer or stricter quarantine is associated with poorer mental health (Brooks et al., 2020).

The role of health behaviors for mental health (in the face of stress)

As described above, the policy measures implemented to protect the population from COVID-19 and its consequences for the world's health systems likely negatively affect mental health and well-being. Investigators examining factors involved in the onset of mental health disorders, such as depression, have focused on the interaction of stress and vulnerability or protective factors (Caspi et al., 2003). Vulnerability–stress models posit that the development of a mental health disorder is due to the interaction of stressful events with

one or more vulnerability factors. Similarly, protective models focus on factors that may neutralize or reduce the impact of adverse experiences on the development of a negative outcome such as impaired mental health or well-being (Fergus & Zimmerman, 2005). Such protective factors can be specific health behaviors: Health behaviors and mental health are strongly linked to each other. For example, physical activity in people with high vulnerability to depression is related to higher positive affect (Mata et al., 2012), fewer depressive symptoms (Mata et al., 2010), and significantly buffers the effects of repeated negative stressors (Mata et al., 2013). Snacking has been related to higher positive affect in the short term (e.g., Flueckiger et al., 2017) and higher negative affect in the long term (e.g., Hormes & Rozin, 2011). Longer screen times are related to poorer mental health and less physical activity (e.g., Allen et al., 2019; Wang et al., 2019). Therefore, the negative effects of COVID-19-related stressors on mental health should be particularly pronounced in people who are more physically active and report fewer snacks and shorter screen time. While the public health consequences of social isolation have been reported in preliminary systematic reviews, more research on the association between social isolation and health behaviors is strongly needed (Leigh-Hunt et al., 2017). It is yet unknown how health behaviors can promote mental health in the face of a crisis such as the COVID-19 pandemic.

Health behaviors during times of high stress (COVID-19)

Although previous research has shown that stressful life events, repeated stressors, and the (unintended) side effects of quarantine and COVID-19-related stressors are likely to impact mental health, and that health-promoting behaviors have the potential to buffer against such stress, very little is known about exercising health-promoting behaviors during times of high stress and quarantine/social confinement. The little available research on this topic suggests that the current lockdown might affect such health behaviors. A recent study on the effects of the COVID-19 pandemic on physical activity, using an international convenience sample of smartphone app-users between January and June 2020, showed that within 10 days

of the World Health Organization's (WHO) declaration of a pandemic, the mean value of daily steps decreased by about 6%, and within 30 days by about 27% (Tison et al., 2020).

Early cross-sectional data, collected within 2 weeks of the start of the lockdown, showed that 31% of Germans reduced their leisure-time sport activity during the lockdown (Mutz & Gerke, 2020; see Schnitzer et al., 2020, for similar results in Austria).

Thus, early findings based on a large, international convenience sample of smartphone users and on cross-sectional survey data from Germany and Austria suggest that a loss of usual routines, such as would be expected from the COVID-19-related policy measures, leads to a reduction in health-promoting behaviors and particularly physical activity; less is known about healthy nutrition or moderate amounts of screen time.

Research questions

The current study addressed (a) how the lockdown during the COVID-19 pandemic in Germany affected health behaviors and mental health, considering changes across time, and (b) how health behaviors are related to mental health, specifically, if increases in screen time or snacking were a risk and if maintenance of or an increase in physical activity protected mental health in the face of lockdown-related stress. These questions were examined both for the entire sample and for specific groups, separated by gender, employment situation (e.g., home office vs. working on-site), age, and whether they were taking care of children. This study contributes to existing research in important ways. First, this study is based on a large probability sample representing the population of Germany. Mental health and health behaviors were assessed within a week of the COVID-19 lockdown (hereafter, the lockdown) in Germany. Further, it is a longitudinal study with three measurement points, allowing us to observe changes over time. Second, health behaviors, particularly snacking and screen time, have rarely been considered in studies on the effects of the current lockdown, and their role in improving or deteriorating mental health has not been investigated. Examining how a large,

national sample reacts to an extensive number of stressors induced by the pandemic-related policies and how health behaviors can buffer against these stressors is of central importance.

Hypotheses

On the basis of the literature reviewed above, the following hypotheses are proposed: (1) The lockdown will be associated with poorer mental health (i.e., more symptoms of anxiety, depression, loneliness) such that the number of symptoms will be highest at the start of the lockdown and will decrease over time (e.g., show signs of habituation). The following groups will experience more symptoms at the start of the lockdown and will show stable or even increasing levels of anxiety, depression, and loneliness (e.g., signs of sensitization): (1a) women, (1b) individuals taking care of children, (1c) people who work short-time, are furloughed, or unemployed, and (1d) people with poor health. (2) The lockdown will be associated with significant increases in screen time and snacking and with decreases in physical activity. (3) Individuals who report lower levels of screen time, lower levels of snacking, or higher levels of physical activity will report fewer symptoms of anxiety, depression, or loneliness. (4) There will be a dose–response effect between health behaviors and mental health over time: Individuals who decrease their screen time, decrease snacking, or increase their physical activity during lockdown (compared to pre-lockdown), will report a smaller increase in symptoms of anxiety, depression, or loneliness as an immediate response to the lockdown and a stronger decrease in symptoms over time than those who maintain levels of screen time, snacking, or physical activity; this difference in increase in mental health symptoms will be even more pronounced compared to those who increase levels of screen time, snacking, or decrease physical activity.

Control variables

Analyses will consider socio-demographic characteristics of the sample (see Table 1). Aspects such as the number of policy measures in effect during lockdown (e.g., closure of schools) and weather, an important predictor for the amount of physical activity (e.g.,

Schüttoff & Pawlowski, 2017), will be controlled for by adding the time variable in all analyses.

Methods

Data

The data were drawn from the Mannheim Corona Study of the German Internet Panel (GIP; Blom et al., 2015, 2020). Participants of the GIP were recruited with random probability sampling of the general population in Germany and offline recruitment to ensure the most accurate representation of the general population. More than 4,000 people of the general population in Germany aged 16 to 75 years have taken part in the GIP every other month since 2012 with refreshment samples included in 2014 and 2018.

The Mannheim Corona Study contains questions about the social and economic situation of participants (e.g., childcare, work situation) and the impact of the pandemic-related political measures on social interactions, mental health, and health behaviors. The study started on March 20, 2020, that is, within a week of schools and daycares closing (see Figure 1 for an overview of policy implementations during the measurement periods).

Figure 1. *COVID-19 related lockdown measures in Germany, confirmed cases and deaths, and measurement points of the survey in grey (t_0 – t_3).*

Note. Grey area represents timing of measurement points (t0-t3). Figure based on the Oxford Covid-19 Government Response Tracker, available at https://github.com/OxCGRT/covid-policy-tracker/blob/master/documentation/index_methodology.md

All participants of the Mannheim Corona Study had regularly participated in the GIP for a period of 18 months to 8 years (see Table 1 for participant details). Each week, 3,500 people took part. This sample was divided into eight random subsamples: Subsamples 1 to 7 were assigned to a specific day of the week; the eighth subsample was a control group and did not take part in the Corona Study. On each weekday, participants of the respective subsample received an e-mail with a link to the current survey. They had up to 48 h to fill out the questionnaire and were explicitly encouraged to do so within the first 24 h. Within any one week, the questionnaire was identical for all participants; most questions were identical across all measurements, but some measures (including health behaviors) were asked about once a month. For more detailed information about sampling, measurements, or weighting and representativeness, see <https://www.uni-mannheim.de/en/gip/corona-study>. The Mannheim Corona Study (as part of the German Internet Panel) is regularly controlled by the University's Data Protection Officer and fulfills the standards of the European Union General Data Protection Regulations (GDPR), which is equivalent to an approval by an Institutional Review Board.

Table 1. *Sociodemographic Characteristics of the Sample (weighted)*

Variable	Weighted percentage
Age (years)	
18–35	21.1%
36–59	48.6%
60+	30.3%
Gender	
Female	50.2%
Male	49.8%

Variable	Weighted percentage
Employment situation (in January 2020)	
Working	57.3%
Unemployed	2.3%
Retired	18.5%
Not working for pay (e.g., studying, on leave, housework)	21.9%
Employment situation (in April 2020)	
Working at the workplace	33.4%
Remote work	14.4%
Part-time work, furloughed, unemployed	15.7%
Retired	18.7%
Not working for pay (e.g. studying, on leave, housework)	17.8%
Subjective health status (in January 2020)	
Very good	12.5%
Good	53.7%
Sometimes good, sometimes bad	27.6%
Bad	5.1%
Very bad	1.2%
Education (highest level of school education)	
Low	27.2%
Middle	31.8%
High	40.9%
Family situation	
No children in household	77.7%
Couple with child(ren) in household	19.7%
Single parent	2.6%

Note. Percentages do not always add up to 100.0% due to rounding. Education low = without or with basic school-leaving qualification; middle = intermediate school-leaving qualification; high = higher education entrance qualification.

Measures

Anxiety

Anxiety was assessed using the German version of the five-item State-Trait Anxiety Inventory short scale (Englert et al., 2011; Spielberger et al., 1970). Statements such as “I am nervous” or “I am worried that something could go wrong” are rated on a 4-point scale from *not at all* to *very much*. The five items represent the two dimensions, “worry” and “emotionality.” Cronbach’s alpha was 0.92. From Week 5 on, only the two items stated above (on being nervous and something going wrong), were assessed. They are the items with the

highest factor loading on “worry” and “emotionality,” respectively. Cronbach’s alpha for the two items was 0.77.

Starting in Week 5 (April 18–25, 2020), three items on depression and loneliness were added (also in response to the request by the COVID-19 and Mental Health Measurement Working Group of the Johns Hopkins Bloomberg School of Public Health from March 18, 2020). Depression was assessed with two items from the second Patient Health Questionnaire (PHQ-2; Kroenke et al., 2009; Löwe et al., 2010): “In the last 7 days, how often have you felt down, depressed or hopeless?” and “In the last 7 days, how often have you had little interest or pleasure in doing things?” Cronbach’s alpha was 0.84. Loneliness was measured by asking, “In the last 7 days, how often have you felt lonely?” (adapted from the Center for Epidemiologic Studies Depression Scale; Radloff, 1977). All answers were given on a 4-point scale from 1 (*not at all or less than one day*) to 4 (*on 5–7 days*).

Screen time

Screen time was assessed for weekdays only, because (a) screen time on weekdays is substantially lower than during weekends, and (b) for the majority of participants, the lockdown more strongly affected weekday activities such as work or school. At the first measurement point, participants reported how many hours and minutes in total they spent on an average weekday with computers, smartphones, gaming, watching TV or streaming, and with other electronical devices (question based on Przybylski & Weinstein, 2019), for both the week before the lockdown and the past week. At the following two measurement points, participants reported only on the past week.

Participants reported how many snacks they ate per day (i.e., amount of foods high in sugar, salt, or fat consumed outside of meals, such as chocolate, ice cream, cookies, chips, pretzels etc.; question based on Flueckiger et al., 2017). At the first measurement point, they again reported on the week before the lockdown and the past week; at the following measurement points participants reported only on the past week.

Physical activity

To measure physical activity, at the first measurement point, participants reported for how long (hours and minutes) they had engaged in moderate (not exhausting, e.g., fast walking), or vigorous physical activity (heart beats fast, e.g., fast jogging; items adapted from Godin & Shephard, 1985). At the first measurement point (t0), participants reported their activity in the week of March 2–8, that is, the week before the lockdown measures in Germany, and in the past week (April 3–10; see Table S1 for an overview of measurement dates). At the following two measurement points, participants described only the past week. To transform time spent in vigorous and moderate exercise into MET minutes (MET = metabolic equivalent of task), minutes spent in vigorous activity were multiplied by 8 and minutes spent in moderate activity by 4 (following Haskell et al. (2007). The WHO recommends at least 600 MET minutes of moderate and/or vigorous activity per week.

Statistical analyses

Multilevel models with random effects were estimated to account for the nested structure of the data (i.e., several observations over time are nested within one respondent; Steele, 2008) to test Hypotheses 1–3. The analyses controlled for age, gender, employment status, health status, education, and family situation (see Table 1). To test within-person changes in mental health and their relation to changes in health behaviors (Hypothesis 4), a first-difference model was used: For both the dependent and the independent variable, the respondent's prior value was subtracted and examined whether changes in health behavior are related to changes in mental health. These models offer good protection against bias due to unobserved time-constant heterogeneity (Vaisey & Miles, 2017). All analyses were conducted with STATA 16. The respective do-File is available in the Supplemental Materials; the data are freely available for scientific use and can be requested at the GESIS Data Archive for the Social Sciences at (<https://www.uni-mannheim.de/en/gip/for-data-users/>).

The weights in our analyses were based on a two-stage weighting procedure. First, a response propensity weight was calculated, which projects the employment and occupational sector characteristics of the Corona Study participants to those of the GIP sample. Second, a raking weight was estimated, which extrapolates the characteristics of Corona Study participants to those of the general population in Germany (i.e., in terms of age, gender, marital status, highest level of education, household size, and federal state).

Results

To examine how much of the variance in health behaviors and mental health was due to individual characteristics, and how much was due to within-person changes over time, intraclass correlations were calculated. For screen time, 36% of the variance was due to individual characteristics, for snacks 40%, exercise (the sum of moderate and vigorous activity) 45%, anxiety 72%, depression 76%, and loneliness 75%. Thus, all variables of interest showed a considerable within-person variation over time and thus multilevel modeling was used.

Mental health during the lockdown (Hypothesis 1)

Mental health (i.e., symptoms of anxiety or depression or feelings of loneliness) was not assessed pre-lockdown; therefore we report changes in mental health during the lockdown. As expected, symptoms of anxiety, depression, and loneliness were highest directly after the start of the lockdown and then went slightly down, corresponding to a pattern of habituation (see Figure 2 and Table 2 for test statistics; variables 04/2020, 05/2020, and 06/2020 represent changes over time holding all other variables constant).

Figure 2. *Changes in mental health during the lockdown.*

Note. On the y axis, 1 = *not at all*, 2 = *a little bit*, 3 = *considerably*, 4 = *very much* for anxiety; for depression and loneliness: 1 = *not at all or less than one day*, 2 = *on 1–2 days*, 3 = *on 3–4 days*, 4 = *on 5–7 days*. Gray shadings show 95% confidence intervals.

Table 2. *Health Behaviors and Mental Health: Results of Multilevel Models (Random Effects)*

Variable	Anxiety	Depression	Loneliness
Screen time			
Averaged over all measurements	-0.000011 (0.0000)	0.000071* (0.0000)	0.000061* (0.0000)
04/2020	Reference category		
05/2020	-0.098*** (0.0109)	Reference category	Reference category
06/2020	-0.14*** (0.0117)	-0.069*** (0.0110)	-0.057*** (0.0113)
Constant	1.82*** (0.0142)	1.47*** (0.0173)	1.34*** (0.0168)
Controls	Yes	Yes	Yes
Observations	10249	6733	6731
N	3945	3721	3721
Snacks			
Averaged over all measurements	0.019*** (0.0044)	0.024*** (0.0073)	0.015* (0.0069)
04/2020	Reference category		
05/2020	-0.091*** (0.0114)	Reference category	Reference category
06/2020	-0.13*** (0.0118)	-0.070*** (0.0108)	-0.060*** (0.0117)
Constant	1.78*** (0.0143)	1.45*** (0.0163)	1.34*** (0.0166)
Controls	Yes	Yes	Yes

Variable	Anxiety	Depression	Loneliness
Observations	10253	6737	6735
<i>N</i>	3946	3721	3721
Physical activity			
Averaged over	-0.027* (0.0136)	-0.058** (0.0195)	-0.025 (0.0189)
all measurements			
04/2020	Reference category		
05/2020	-0.10*** (0.0118)	Reference category	Reference category
06/2020	-0.14*** (0.0126)	-0.066*** (0.0116)	-0.056*** (0.0119)
Constant	1.84*** (0.0144)	1.53*** (0.0194)	1.38*** (0.0190)
Controls	Yes	Yes	Yes
Observations	9747	6547	6545
<i>N</i>	3842	3708	3708

Note. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Observations are

the number of observations in the analyses; *N* = number of participants in the analyses.

Controls = Control variables (i.e., age, gender, employment situation, subjective health status, education, and family situation). Variable names in bold: Coefficients present relation between variables (e.g., screen time in minutes and depression = 0.000071) averaged across all time points and above and beyond the time trend. Constant represents average anxiety, depression, and loneliness at first measurement (reference category); subsequent measurements represent changes over time, holding all other variables constant.

Women, people who were unemployed, furloughed, or on a part-time schedule, and those with poor general health showed higher levels of anxiety. All people not working at their workplace (i.e., people working remotely or part-time, unemployed/furloughed) showed higher levels of depression and anxiety. People with poor general health showed higher levels of depression and feelings of loneliness. Couples with children felt less lonely than single parents and those without children (see Supplemental Materials, Table S2). The same pattern becomes apparent for the share of participants with average values of 3 or higher for anxiety, depression, and loneliness: The percentage of participants with high anxiety, depression, and loneliness symptoms was significantly higher among these groups. Interestingly, couples living with children reported high levels of anxiety, depression, and loneliness less often than

those without children in their household. The share of people with high values was largest among single parents (for anxiety and loneliness, often twice as high as in families with children; see Supplemental Materials, Table S2).

Considering the change in mental health symptoms over time in these potentially more vulnerable groups, we see that anxiety, depression, and loneliness all went slightly down in both men and women and in people across different employment situations, with or without children living in their household, and with different health states, corresponding to patterns of habituation rather than sensitization (see Supplemental Materials, Figure S1).

Health behaviors before and during the lockdown (Hypothesis 2)

Generally, as hypothesized, compared to levels before the lockdown, screen time and snack consumption significantly increased and physical activity decreased within the first month after the lockdown commenced. Interestingly, the amount of snacking and physical activity went back to pre-lockdown levels within two months; only screen time increased further (see Figure 3 and Table 2 for test statistics; variables 04/2020, 05/2020, and 06/2020 represent changes over time holding all other variables constant). Detailed results, also for different subgroups, are described below.

Figure 3. *Changes in health behaviors before and during the lockdown.*

Note. Gray shading shows 95% confidence intervals. WHO = World Health Organization.

Screen time

Screen time increased by 52 min from March to April (from 310 to 362 min/day); this trend continues into May and June (+80 min/day and +40 min/day compared to before the lockdown, respectively; Figure 2). Across all lockdown measurement points, women, parents, and those claiming good health reported less screen time. People working remotely spent more time in front of a screen (see Supplemental Materials, Figure S2).

Amount of snacking

People ate on average 0.56 more snacks/day in April compared to before the lockdown. In May and June, the number of snacks per day returned to pre-lockdown levels of about 1.5 snacks/day (see Figure 3). Women, parents (but not single parents), and those with poor health ate more snacks. Employment status had no effect on the amount of snacking (see Figure S2).

Physical activity

Before the lockdown, 65.3% of all participants were as active as recommended by the WHO; a month after the lockdown this number decreased to 57.9%, but in May and June it increased and even surpassed pre-lockdown proportions with 69.2% and 76.1%, respectively (see Figure 3). Women, parents, all people not working at their workplace (i.e., working remotely, furloughed or unemployed), and those with poor health were less active. Comparing these different subgroups, it is notable that particularly a lower share of women did not meet the WHO recommendations for physical activity during the entire lockdown (Figure S2).

Cross-sectional relations between health behaviors and mental health during lockdown (Hypothesis 3)

Because mental health (i.e., anxiety, depression, or feelings of loneliness) was not assessed pre-lockdown, we examine the relation between health behaviors and mental health during the lockdown using multi-level modeling, with anxiety, depression, and loneliness as dependent variables, the three different health behaviors as independent variables, and the

demographic variables reported in Table 1 and time as control variables. As predicted, more screen time, more snacking, and less physical activity were related to more symptoms of anxiety, depression, and loneliness; even after controlling for sociodemographic characteristics and averaging across all time points (Table 2; two exceptions: anxiety was not related to screen time, and physical activity was not related to loneliness). The constant shows the average anxiety, depression, and loneliness at the first measurement point (i.e., 04/2020 or 05/2020); the subsequent measurements show the change compared to the first measurement point holding all other variables constant.

Dose–response effects over time between amount of screen time, snacking, and physical activity and mental health symptoms (Hypothesis 4)

In the last step of our analyses we examined whether changes in health behavior were related to changes in mental health symptoms. Did the lockdown-induced reduction in physical activity or the increase in screen time lead to changes in mental health and well-being? Our results do not support this expectation in the short run, and a change in health behaviors generally did not predict a change in mental health symptoms. There is one exception: an increase in the number of snacks consumed coincided with an increase in anxiety symptoms (see Table 3 for results). Therefore, Hypothesis 4 is not supported for screen time and physical activity, but partially for snacking.

Table 3. *Dose–Response Effects Over Time Between Amount of Screen Time, Snacking, and Physical Activity and Mental Health Symptoms*

Variable	Δ Anxiety	Δ Depression	Δ Loneliness
Δ Screen time	-0.000010 (0.0000)	0.000043 (0.0000)	0.0000046 (0.0000)
Constant	-0.072*** (0.0063)	-0.069*** (0.0117)	-0.053*** (0.0120)
Observations	6104	3012	3010
<i>N</i>	3052	3012	3010
Δ Snacks	0.014** (0.0044)	0.0033 (0.0070)	0.0039 (0.0063)
Constant	-0.067*** (0.0064)	-0.071*** (0.0114)	-0.055*** (0.0120)
Observations	6108	3016	3014

<i>N</i>	3054	3016	3014
Δ Physical activity (WHO recommended level)	-0.011 (0.0184)	-0.039 (0.0269)	-0.016 (0.0241)
Constant	-0.071*** (0.0068)	-0.069*** (0.0120)	-0.056*** (0.0123)
Observations	5760	2839	2837
<i>N</i>	2880	2839	2837

Note. Results of regressions with changes in health behaviors as independent variables and changes in mental health as dependent variables (first-difference model). Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Observations are the number of observations in the analyses; N = number of participants in the analyses. Δ = Change. WHO = World Health Organization.

Discussion

This study examined the mental health response to repeated and prolonged stress and how health behaviors can buffer effects of such stress. Data came from a unique data set in which mental health and health behaviors were regularly assessed over three months in a large, nationally representative sample of adults from Germany. As predicted, symptoms of anxiety, depression, and loneliness were highest shortly after the lockdown came into effect. The symptoms were stable or went down slightly over time, suggesting patterns of habituation to the situation. Among people with higher vulnerability to poor mental health during the lockdown, the proportion with high levels of anxiety, depression, and loneliness was considerably larger. These groups also reported fewer health-promoting behaviors. More screen time, more snacking, and less physical activity were related to higher symptoms of anxiety, depression, and loneliness across all time points. Changes in health behaviors over time did not predict changes in mental health symptoms.

Mental health symptoms over time during the lockdown

In line with our expectations, symptoms of anxiety, depression, and loneliness in the general population suggest patterns of habituation. However, contrary to our predictions, groups that are likely more vulnerable to poorer mental health during the lock down did not

show an increase in symptoms over time, but rather, very small decreases. This finding is in contrast to other research that showed signs of sensitization in the face of repeated stressors in vulnerable groups (Caspi et al., 2003; Mata et al., 2013). Importantly, these previous research findings are based on a—with respect to mental health—comparably homogeneous group of people: People with high vulnerability to one mental illness, major depressive disorder. The groups identified as potentially more vulnerable to lower mental health in our study were much more heterogeneous: For example, people living in households with children vary greatly in their well-being and resources available to buffer stress resulting from lockdown policies (e.g., Prime et al., 2020). The same argument can be made for the other potentially vulnerable groups, such as women or those with disrupted employment situations. Policy makers should pay particular attention to potentially vulnerable groups. For example, in single parents, the share of participants with very high anxiety symptoms right after the lockdown began was almost twice as high as that in the general population. Such anxiety can spill over to children and increase the probability of child maladjustment. When parental and family well-being are preserved, children can cope better with adversities (see Prime et al., 2020, for an overview). Therefore, focusing on factors that promote resilience in the face of the challenges is of particular importance.

Health behaviors before and during the lockdown and their relation to mental health

As predicted, the lockdown was associated with significant increases in screen time and snacking and a decrease in physical activity. Screen time continually increased in the first two months after lockdown commenced and even after three months was still higher than before the lockdown. Monitoring screen time is important, because it has been associated with lower well-being (e.g., Allen et al. (2019) and Wang et al. (2019)) but also with less physical activity and more snacking (e.g., Mansoubi et al., 2014; Pearson & Biddle, 2011)—all important predictors of mental and somatic health.

Interestingly, snacking and physical activity went back to pre-lockdown levels within two and three months after the lockdown started. In fact, getting back to pre-lockdown levels for physical activity and snacking in Germany could be related: Higher temperatures and low rain probability are related to more physical activity, potentially outside. Along with more physical activity outside, there is less opportunity for typical snack situations (e.g., sitting in front of the TV). But weather might not be the only explanation. Other analyses (Tison et al., 2020) showed a similar pattern of decline and then fast “normalization” for a variety of countries in different climate zones: Shortly after social distancing was ordered in a region, the mean number of steps decreased sharply and then went back to normal often before the regional order of social distancing was lifted. Also, in Germany, the number of lockdown orders during May and June was lower than during March: For example, while playgrounds and stores selling nonessential goods in all 16 federal German states were closed on March 24, in May, only five states continued with closure of playgrounds and only three with nonessential shopping (Steinmetz et al., 2020). Both playgrounds and shopping are related to physical activity and being outside.

Importantly, the pattern of physical activity and snacking was not equal across the different subgroups. Especially the finding that the proportion of women meeting physical activity recommendations stayed below pre-lockdown levels, even three months after the lockdown started, is worrisome, because it has ramifications for somatic and psychological health. Being as physically active as recommended is associated with a 31% lower overall mortality risk and to a greater than 50% risk reduction in acquiring major chronic medical conditions, such as stroke or Type 2 diabetes (Rhodes et al., 2017). Also, it substantially increases positive affect (Reed & Buck, 2009) and buffers the effects of stress, even in vulnerable groups (e.g., Mata et al., 2013). Therefore, particularly in times of high stress such as a lockdown situation, physical activity can essentially protect and maintain positive affect and well-being. Similar gender patterns can be found for snacking, where women’s increased

snacking intake was not back to baseline levels three months later. In the combination with lower physical activity, this has the potential to cause weight gain, with all its health consequences.

Dose–response effects over time between amount of screen time, snacking, and physical activity and mental health symptoms

In contrast to our hypothesis, we did not find a dose–response effect of more engagement in health-promoting behaviors (i.e., decrease in screen time or snacking, or increase in physical activity) and fewer symptoms of anxiety, depression, or loneliness—with the exception of higher snacking predicting higher anxiety at later measurements. These findings are in contrast with other experimental (e.g., Ekkekakis et al., 2011) or intensive longitudinal studies, for example, on physical activity, which have reported a dose–response effect also in the face of stress (Ekkekakis et al., 2011; Flueckiger et al., 2016). Importantly, the COVID-19 pandemic has had an impact on all facets of daily life. It may be difficult to identify the impact of three distinctive health behaviors in this complex situation that has been largely driven by a multitude of external factors. Additionally, the comparably long measurement gaps of about one month make it difficult to detect how change in a specific health behavior is related to a multicausal construct such as mental health.

Strengths and Limitations of the Study

One of the great strengths of this study is its sample: Participants were recruited offline using random probability sampling to achieve the most accurate representation of the German population. The same participants reported on their mental health and health-related behaviors roughly monthly over three months of a lockdown due to a major global crisis. This longitudinal design allowed us to observe changes over time. While the data are based on self-reports, the questionnaires used validated measures. Indicators of mental health were assessed only after the lockdown had started. While this is sensible, given that retrospective reports on

affective states are particularly error prone (e.g., Fahrenberg et al., 2007), this implies that mental health trajectories are only available for the duration of the crisis.

Conclusions

This is one of the first studies to describe the effect of a global health crisis in a large population sample over time. Habituation, an attenuated response to repeated or prolonged stressors over time, was the best description for all participants concerning their mental health and for two of the three health-promoting behaviors examined. Health-promoting behaviors were clearly related to indicators of mental health. More vulnerable groups were more likely to experience symptoms of poorer mental health and showed less engagement in health promoting behaviors. Unintended side effects of the current crisis-related policy measures, particularly for mental health, have rarely been the focus in politics but are likely to have a major long-term impact. This paper makes a unique contribution by describing mental health during a lockdown and showing that health-promoting behaviors can promote mental health during a crisis. This crisis will have a long-term impact on ways of life and work; for example, a higher level of digitalization and remote work is likely to stay. Therefore, thinking about ways to reduce health risks associated with screen time is important. Stressful situations, such as the COVID-19 pandemic with its broad social, economic, and—of course—health consequences, affect people globally. In this paper, we identified behaviors that can promote mental health and resilience in such situations. These behaviors have the potential to attenuate the unintended side effects of crisis-related measures, such as social distancing, to protect mental health in the population.

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Supplemental Materials

Table S1. *Overview of Measurement Dates (Month, Week of Study, Specific Dates) for**Mental Health and Health Behaviors*

Variable	Date				
	3/2020	4/2020	5/2020	6/2020	
	(t ₀)	(t ₁)	(t ₂)	(t ₃)	
	Week 0	Week 3	Week 4	Week 9	Week 11
	March 2–8	(April 3–10)	(April 10–17)	(May 15–22)	(May 29– June 5)
Screen time	x		x	x	x
Snacks	x		x	x	x
Physical activity	x	x		x	x
Anxiety		x	x	x	x
Depression				x	x
Loneliness				x	x

Note. Week 0 was the last week before lockdown; assessments for Week 0 were retrospective.

Table S2

Percentage of the Population With High Values (Average of 3 or Higher on a 4-Point Scale) on Anxiety, Depression, and Loneliness at Three Measurement Points

Variable	Symptom	Measurement month		
		04/2020	05/2020	06/2020
Overall	<i>Anxiety</i>	9.9	7.9	6.5
	<i>Depression</i>	–	8.1	7.4
	<i>Loneliness</i>	–	9.9	8.0
Gender				
Women	<i>Anxiety</i>	12.5	9.9	7.7
Men		7.3	6.0	5.3
Women	<i>Depression</i>	–	8.9	7.8
Men		–	7.3	7.1
Women	<i>Loneliness</i>	–	10.9	8.4
Men		–	8.9	7.6
Employment				
At work	<i>Anxiety</i>	8.2	5.6	5.8
Home office		7.6	7.7	6.4
Part-time, furloughed, unemployed		14.3	11.1	7.4
At work	<i>Depression</i>	–	5.0	5.5
Home office		–	7.1	4.8
Part-time, furloughed, unemployed		–	15.9	12.6
At work	<i>Loneliness</i>	–	6.7	5.7
Home office		–	6.7	6.0
Part-time, furloughed, unemployed		–	19.2	14.3
Children				
Children in household	<i>Anxiety</i>	8.4	6.6	4.2
No children		10.0	8.4	7.0
Single parent		19.4	6.0	8.0
Children in household	<i>Depression</i>	–	7.0	6.6
No children		–	8.3	7.4
Single parent			8.8	12.3
Children in household	<i>Loneliness</i>	–	8.1	7.2
No children		–	10.0	7.9
Single parent			19.1	13.9
Health				
Good or very good	<i>Anxiety</i>	7.6	5.1	3.9
Not so good or bad		14.2	13.7	11.8
Good or very good	<i>Depression</i>		5.2	4.2
Not so good or bad			14.3	14.5
Good or very good	<i>Loneliness</i>		7.4	5.1

Variable	Symptom	Measurement month		
		04/2020	05/2020	06/2020
Not so good or bad			15.3	13.5

Fig. S1. Levels of and time trends in well-being during the lockdown.

Note. On the y axis, 1 = not at all, 2 = a little bit, 3 = considerably, 4 = very much for anxiety; for depression and loneliness: 1 = not at all or less than one day, 2 = on 1–2 days, 3 = on 3–4 days, 4 = on 5–7 days. Gray shadings show 95% confidence intervals.

Fig. S2. Levels of and time trends in health behaviors before and during the lockdown.

Note. Gray shadings show 95% confidence intervals. WHO = World Health Organization.