Studying Infection Worries by Ecological Momentary Assessment: Development and Causal Factors in Sweden during the Early Phase of the Covid-19 Pandemic

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Table of Contents

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Abstract

Background: The foray of Covid-19 around the globe is sure to have instigated worries in many humans, and lockdown measures may well have created their own worries. Sweden, in contrast to most other countries, had first relied on voluntary measures, but had to change its policy in the face of an increasing number of infections.

Objective: The aim was to better understand the worried reactions to the virus and the lockdown measures. To grasp the reactions, their development over time was studied.

Methods: Results were based on an unbalanced panel sample of 261 Swedish participants filling in 3218 interview questionnaires by smartphone in a 7-week period in 2020. Causal factors considered in this study include the perceived severity of an infection, the susceptibility of a person to the threat posed by the virus, the perceived efficacy of safeguarding measures and the assessment of government action against the spread of Covid-19. The effect of these factors on worries was traced in two analytical steps: the effects at the beginning of the study, and the effect on the trend during the study. Results: Findings confirmed that the hypothesized causal factors (severity of infection, susceptibility to the threat of the virus, efficacy of safeguarding and the assessment of government preventive action did indeed affect worries. Conclusions: The results confirmed earlier research in a very special case and demonstrated the usefulness of a different study design, which takes a longitudinal perspective, and a new type of data analysis borrowed from multi-level study design.

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Keywords: Coronavirus; Longitudinal Studies; Worry; Fear; Pandemics

Introduction

The foray of Covid-19 around the globe is sure to have instigated worries in many humans, maybe even fear in some. Early results from the application of the Fear of COVID-19 Scale (FCV-192), a questionnaire designed for use worldwide, bear witness of that (e.g. Zolotov et al., 2020). Private as well as government policies may have mitigated the worries to a degree, but especially the governmental lockdown measures may well have created their own worries, anxieties and depression, as Mucci et al. (2020) have eloquently argued. The different worries and their different origins need to be sorted out to better understand what is happening around us.

Asmundson and Taylor (2020a), in the editorial to the March 2020 issue of the *Journal of Anxiety Disorders*, demand that psychology devote more time and energy to the study of affective reactions to pandemics or phenomena that might become pandemics. This is imperative because the reactions do not always appear to be adequate. Inadequate reactions include the failure to react at all, or in a fashion too limited, if the threat is serious, as well as overreactions to comparably harmless dangers. As health policies in many cases follow the reactions rather than the real threat, inadequate reactions by the public may impede recovery.

The best research design for determining worry or anxiety in a pandemic situation and identify its possible causes would be longitudinal. Studying affective reactions would have to address changes in the reactions themselves as well as changes in the potential factors that affect reactions and may create changes. Such longitudinal research is mostly missing (Pappa et al 2020).

Amundson and Taylor (2020a,b) cite some dispersed evidence of strong affective reactions among the public to pandemics, especially some from recent survey studies in connection with Covid-19. A broad basis of respondents and conditions was achieved in a study covering eight mental conditions in a cross-sectional survey in Spain (Gonzales-Sanguino et al. 2020). It found 21.6% of respondents develop anxiety symptoms, women more so than men, the elderly and the subjectively well-to-do more so than the younger generations and the less prosperous. The survey was conducted the last

week of March 2020, when Covid-19 was spreading over the whole world, and Spain was among the countries hit hardest. The study had no base for comparison (such as could have been provided by adding another country or another period in time. The sample, moreover, cannot claim representativity.

An online survey asked the German population (Jungmann & Witthöft, 2020) their present virus anxiety and also how it compared with anxiety some months earlier. An increase was found, moderated positively with high trait health anxiety. Present virus anxiety was linked with Cyberchondria, which is an exaggerated seeking for health information, and this relationship was also moderated by trait health anxiety. Persons who considered themselves well-informed about the pandemic were less anxious about it, with adaptive emotion regulation as moderator.

In a study in China, McKaya et al. (2020) tested and largely confirmed the theoretical concept of a behavioral immune system (BIS; Taylor, 2019) enabling and motivating individuals to involuntary measures that protect against infection at times of a pandemic. The elements of this system are anxiety sensitivity (the attention paid to changes that signal danger), disgust sensitivity (the extent to which one perceives sensations as consequence of disgust and the presence of a contamination agent), disgust propensity (the expectation to feel disgust in certain situations and fear of contracting COVID-19). The system of psychological mechanisms produces cues to the presence of infectious agents in a person’s environment and various emotional and cognitive reactions that make people avoid infection and disease. The study results, the authors claim, “lend support for individual variation in the activation of the BIS” (p. 2).

Another Chinese study shows (Chao et al., 2020) that the use of new rather than traditional media was associated with negative emotions (depression, anxiety, and stress). Watching stressful content also went along with negative emotions, as did media engagement. Some elements of media content, however, triggered positive emotional reactions: exceptional efforts and successes, speeches from experts, and knowledge of the disease and prevention.

A different kind of worry may keep patients away from consultation or from seeking emergency care, at times to the detriment of patients or ill persons in the care of others. The damage can go as far as death, as a list of 12 cases in pediatric care shows, which was published in a letter by Italian pediatrics to the *Lancet* (Lazzerini et al., 2020).

Much literature that addresses emotional reactions to threats does not stop at the affective aspect (e.g. Dillard, Yang & Li, 2018), but considers how fear or worries may contribute to psychological processes of relevance for fighting a health threat or coping with it. Humans have strategies of emotion regulation at their disposal, to which avoidance, reappraisal, contesting and suppression belong. Dillard et al.'s study on Zika found that people do use these strategies, often several of them, but without much success.

A longitudinally designed Chinese study of emotional reactions to fear of communicable diseases, SARS in this case, found that older together with middle-aged persons experienced less anger and had less emotion-focused coping occur to themselves, all in comparison to younger adults. Over the complete period studied, emotion-focused coping increased more with the older and middle-aged than with the younger, but at the peak of SARS this was the other way around. This reversed the age differences by the end of the outbreak. Findings of this study suggest that older adults may be better at emotional regulation than are their younger counterparts, they react to a crisis with less anger and are better able to adapt their coping strategies to the changing environment (Yeung & Fung, 2007). The volatility of coping abilities makes worry, a disagreeable and often uncontrollable state, the focus of our analysis. A review of demographic and attitudinal determinants of protective behaviours during a pandemic shows that being a woman, having a higher educational level and higher age are associated with behaviour modification. Also, individuals' perceived susceptibility to and severity of the disease, as well as stronger belief in the effectiveness of recommended safeguarding behaviours predict behaviour change. Moreover, trust in authorities and a higher level of anxiety were also associated with compliance with protective behaviours (Bish & Michie, 2010).

There are also effects of worry of health threats in fields that are not directly linked to the threat itself. An Italian survey study, for instance, found that prejudice against African immigrants was higher the more threatening the risk of Ebola was perceived and the fewer people knew about that communicable disease (Prati & Pietrantoni, 2016). In the Covid-19 pandemic, prejudice arose against China and the Chinese, where the virus was first noticed (Co-author et al., 2020).

Another research tradition is interested in the consequences rather than the causes of frightening communication. This is the tradition of fear appeals effects research, which comes from situations where fear is a device to change people's knowledge, attitudes and especially behavior. The associations of the strength of use of fear appeals and their effect are often not linear due to fear-related unintended consequences, as an experimental Australian study on environmental issues shows (Hartmann et al., 2014).

Many terms are used for emotional reactions to dangers, threats or risks. Examples are anxiety, panic, fear, worry and concern. Irreespective of the differences in meaning,we assume that the more threatening a health risk is, the larger will the worries be. Threat is subjective; people differ in their assessments of what constitutes a big threat. The larger the damage that comes with a threat, the larger worries will be as well. This concept is called severity. It is closely related to susceptibility, the .likelihood to get infected. A third origin of threat is the perceived efficacy of measures of protection against the threat or its consequences. The higher the perceived efficacy, the less perilous the threat will appear to people. This factor is called response efficacy. A fourth origin is a person's trust of government to do the right thing to protect citizens from the health threat. The higher one's trust in government or one's agreement with government policies, the less dangerous the health threat will appear (Vaughan & Tinker 2009).

These terms and differentiations are used in several communication theories including the protection motivation theory (PMT, Maddux & Rogers 1983; Rogers 1983), the extended parallel processing model (EPPM; Witte 1992, 1994, 1998) and the health beliefs model (Rosenstock, 1974).

There are several ways to include change over time in research designs. Probably the simplest one is the inclusion of an analysis of the (linear) trend component in time series analyses. That measure is actually only meaningful if combined with an analysis of the effects of causal factors on the first measure applied at the outset. This covers the combined effects of predictors on the trend development since data collection for the Covid-19 virus began.

Factors possibly influencing worries are many: the perceptions and beliefs about the biomedical threat as such, the measures governments take and the recommendations they issue to private citizens to protect themselves, personality traits, and communication in the widest sense (Yang, Dillard & Li, 2018). Some of these origins are primarily static (e.g. traits and the virus itself), others are more dynamic (e.g. measures). This observation alone is enough to assume that the worries related to Covid-19 will be dynamic, too. Changes over time require longitudinal research designs, and such we chose.

The dependent variable in this study is worry of the coronavirus. The causal factors have to be selected from a larger number of such factors. Perceived severity of the virus (how serious a threat the virus was considered to be), perceived susceptibility of a person to the threat posed by the virus (the likelihood that one gets infected), perceived efficacy of safeguarding measures and the assessment of government action against the spread of Covid-19 were included in the study. The expectation is that worries increase with severity and susceptibility and decrease with perceived efficacy and agreement with government.

During the early phase of the Covid-19 pandemic, governments assessment, communication and actions taken highly differed between countries. While many governments decided to lock-down large parts of the society in an attempt to curb the spread of the pandemic, the Swedish society, by contrast, was not closed, but safeguarding measures were launched, and the population was urged to voluntarily follow recommendations similar to a lock-down, aiming to reduce the spread of the virus. Some formal restrictions, such as prohibition of visits to homes for the elderly and rules for

distancing at restaurants were also implemented. During this period, the number of deaths increased dramatically and reached considerably higher levels compared to for example the surrounding Nordic countries. The Swedish government's policy was widely debated and strongly questioned. For example, it was suggested in both national and international media that the population was exposed to an "experiment". However, Sweden's policy, in the end of April 2020, was also supported by WHO as a "role model" (Foundation for Economic Education, 2020).

The aim of this research was predominately descriptive as it intended to document levels and changes in worry on the individual level during the early phase of the Covid-19 pandemic in Sweden. The analysis also pursued the aim to demonstrate that data collected by smartphone with the ecological momentary assessment tool (EMA) in daily rhythm can be a basis for meaningful analyses of the formation of and change of emotions toward a phenomenon such as the Covid-19 pandemic. EMA was developed to study mood management and was usually applied by paper and pencil before the days of the smartphone. Respondents are contacted by EMA, with contacts serving as reminder that a questionnaire is due, or as a device to place the time of interview at a particular hour of the day, or in juxtaposition to particular events. Binge eating behavior, for instance, is considered by the affect regulation model as caused by negative moods, which are then reduced by the behavior. A meta-analytical study of research that used the EMA (Haedt-Matt & Keel, 2011) found strong evidence for the former and less strong for the latter contention. Another meta-analysis turned to positive perceptions of one's well-being and documents studies that asked participients up to 12 times a day to ask questions sent and to be answered on their phone (deVries, Baselmans, Bartels, 2020). Objective measures of physiological variables are compatible with the methodology, but have not been employed very often so far (Romanzini et al., 2019).

A research group around Huckins et al. (2020) took the chance to add another wave of interviews to an ongoing study of students' mental health to assess the reactions toward the pandemic in spring 2020, employing smartphone EMA technology. They found students to be more depressed and more

anxious than they had been in a comparison period before. Our aim is to assess the suitability of smartphone-based EMA technology beyond the study of mood.

Methods

Recruitment of participants

An online invitation letter was available from March 25th to May 17th. A link to the website with the invitation letter was spread in social media all over Sweden, and participants came from the whole country. Students at the Department of Psychology, Umeå University, Sweden, were informed via email. An article describing the study in the local newspaper in Umeå also attracted participants. PRO, an organisation for retired people was also approached.

The invitation letter informed participants that the study would assess experiences and reactions to the spreading of the coronavirus and that survey questions would be distributed via the SEMA[3] app. They were asked to respond to a survey once a day for 14 days, but participants who were unable to respond daily were also welcomed. After providing their email address, participants got an email from which they could download the app. The invitation letter also described that GDPR legislation was followed, that participation in the study was voluntary and that participants could withdraw at any time.

Data collection

We used the SEMA[3] (Smartphone Ecological Momentary Assessment) tool, a readily downloadable app at no charge to participants who possess a smartphone with either Android or iOS operating systems. The tool was developed by a group of researchers at the Melbourne School of Psychological Sciences and is suitable for conducting intensive longitudinal survey research (https://psychologicalsciences.unimelb.edu.au/research/research-initiatives/our-work/feel-research-lab/resources). This tool allows to deliver surveys at fixed points in time or fixed time intervals. During the period of data collection over almost eight weeks, new questions were added in order to closely monitor the development, ask questions of relevance for participants and assess reactions

close in time to experiences, as in line with the ecological momentary assessment methodology

First, participants received an introduction survey covering sociodemographic variables, followed by daily surveys with thematic questions. There were questions asked every day: general worry of the coronavirus, severity, susceptibility, and efficacy of safeguard measures. There were also other questions, scheduled at different intervals, covering aspects such as propensity for behavior change, personal response efficacy and social factors such as loneliness due to the pandemic. Each day at 10 AM, a survey was released, and participants then had 12 hours to complete it. Depending on when the introduction was answered, the first thematic survey could appear on the same day. Not all participants responded on a daily basis.

After approximately 14 days, participants were thanked, irrespective of the number of surveys handed in. They were also asked about their experience of taking part in the study. Furthermore, they were invited to continue filling in surveys at a lower rate, twice a week. In these follow-up surveys, participants received the questions on worry, susceptibility, severity and efficacy of safeguard measures that were previously asked daily. Assessment of governmental actions appeared for the first time on April 1. Questions on specific aspects of worry were added to the survey from April 16 on.

Participants were continuously admitted to the study between March 25th and May 14th. Due to the different dates of entry to and exit from the study, different lengths of participation in the study and different spacing between surveys, our sample presents unbalanced panel data (Biörn, 2017). Overall, 328 adults participated in the survey; given that three survey waves are considered to be the minimum for conducting multilevel analysis (Singer & Willett, 2003, p. 10), we dropped all participants who only completed the introduction and two or less additional surveys (n = 68: 31% of these completed only one survey, 31.5% two, and 37% three surveys, including the introduction survey). The average age of the analytical sample was M = 49.6 (SD = 15.75) years, 77% were female (n = 201) and 8.4% had attained university education. No gender, age, and education differences were found between drop-outs and remaining participants, the latter of whom were the

sample with n = 262. Participants in the final sample handed in between 4 and 29 surveys, including the introduction survey. This amounted to an average of M = 12.31 (SD = 5.46) surveys per participant. Figure 1 presents an overview of how many participants replied to how many surveys. The total number of surveys we received from the sample of respondents is 3218. The analyses reported below are based on these 3218 cases.

No personal data was collected since each participant had a code without any link to the participant's id-number or mail address. The study followed the General Data Protection Regulation (GDPR) rules. Moreover, no sensitive information was collected. A risk and vulnerability analysis was carried out in collaboration with the Information Technology Service Department at Umeå University according to a standardized protocol documenting information types and assessment of the information based on security aspects confidentiality, accuracy and accessibility. Thereafter a risk analysis was performed.

[About here Figure 1]

Recruitment of the participants commenced on March 25th 2020 and ended on May 14th. At the beginning, participants filled in a survey with demographic variables, including age (M = 50.35, Range: 20 – 82, SD = 15.63), gender (75.5% females), years of education completed, residency, and several control measures.

For inclusion in the study, participants had to be (1) of adult age (18+ years old), (2) be fluent in Swedish, (3) have access to a smartphone (or a tablet). No personal data were collected since each participant had a code without any link to the participant's id-number or mail address. The study followed the General Data Protection Regulation (GDPR) rules). Moreover, no sensitive information was collected, and therefore, no official ethical approval was required. A risk and vulnerability analysis was carried out in collaboration with the Information Technology Service Department at Umeå University according to a standardized protocol documenting information types and assessment of the information based on security aspects confidentiality, accuracy and accessibility.

Most survey questions were adapted from previously used measures in a small pilot study, translated from English to Swedish, and tailored to fit the study setting. Questions on specific worries and trust in government were originally formulated in Swedish. Unless otherwise noted, the following measures were assessed on a 7-point Likert scale ranging from 1 (*Do not agree*) to 7 (*Agree*).

Worry was measured by a single item question, *"To what extent are you worried about the coronavirus?"*, on a scale from 0 – 10, where 0 corresponds to *"Not worried at all"* and 10 corresponds to *"Very worried"* (M = 6.67, SD = 2.54). This question was included in every survey, including the introduction survey Using a single item is justified by the need to keep the daily questionnaire as short as possible to reduce the number of possible drop-outs.

Specific worries were assessed on five items, once a week from April 16 on: Are you worried about getting infected by the coronavirus yourself?", "Are you worried about someone close to you being infected by the coronavirus?", "Are you worried that your personal finances have or will be affected by the spread of the coronavirus?", "Are you worried that the Swedish economy has or will be affected by the spread of the coronavirus?", and "Are you worried that the world economy has or will be affected by the spread of the coronavirus?" (Specific worries combined: M = 3.98, SD = 1.84, α = .71, on a scale of 1-7). General worry item and the combined five specific worries showed good internal consistency (Cronbach α = .76). This indicates that the single item measure produced results of a quality comparable to the scaled 5-item measure and supports the validity of the single-item measure.

Perceived Severity of Covid-19: Severity of the disease was measured by three direct questions *"Corona is a threat to everyone," "Fighting the Coronavirus is not a matter of illness or health, it is a matter of life and death"; "There is no greater health threat than Corona right now"*. All three items were averaged to create a compound score (M = 5.29, SD = 1.55, α = .84).

Perceived Susceptibility to Covid-19: Susceptibility was measured with three scaled questions about the risk of catching a disease: *"Compared to others in my age, I am less likely to be infected"; "I*

don't think my family will get infected", and *"Even when the corona virus gets closer, I don't think I'll get it"*). All three items were averaged to create a compound score (M = 2.51, SD = 1.44, α = .84).

Efficacy of safeguard measures: The three items *"The actions taken so far can slow the spread of the corona virus," "The recommendations that apply to everyday behavior will work and will reduce the spread of the coronavirus,"* and *"Politicians responsible for public health will be able to control the spread of the coronavirus"* were combined, and a compound score was created (M = 2.51, SD = 1.44, α = .91).

Assessment of government: A single item question was used to measure how people assessed governmental performance in the management of the Covid-19 pandemic: *"How do you assess government's way of handling Covid-19"* on a 10-point scale, ranging from 1 *"The government makes the right decisions"* to 10 *"The government makes the wrong decisions"*. (M = 4.16, SD = 2.97). This question appeared in the main as well as the follow-up survey.

Results

The analysis used a basic model borrowed from multi-level study design. Two regressions were run for the two dependent variables, the intercept indicative of the worries at the outset and the ensuing trend development. Stepwise including independent variables required six models to be computed. Model A represents the Unconditional Mean Model, which provides information about the variation of the outcome worry. Model B, also called Unconditional Growth Model (cf. Singer & Willett, 2003, p. 97), adds time to the study as an additional predictor, allowing to quantify differences between participants with respect to the rate of change in their worries Models C through F added the four independent variables one by one.

[About here Table 1]

Descriptive statistics show that on average adults in our Swedish sample show a level of worry of 6.20 at the very beginning of their participation in the study, and this level of worry increases over

time by an estimated .07 per day. Noteworthy are the large standard deviations coming along with both mean values, indicating that with respect to their initial status of worry as well as with respect to their rate of change people differ widely. The negative correlation coefficient between initial status and rate of change suggests that those with higher levels of worry at the beginning are increasing their worries less rapidly compared to those who are initially less worried.

[About here Table 2]

Table 2 presents an overview of all models that were tested. Model A represents the Unconditional Mean Model, which provides information about the variation of the outcome worry. It does not include either a time variable or any predictor. The mean value of worry across all occasions and individuals is 6.54 (on a scale from 0 – 10), indicating that participants of the study were worried to some extent, between the two extreme values. The estimated within-person variance amounts to .77, indicating that people do change their level of worry to some extent; between-person variance yields 5.38, indicating that a large amount of variation in worry lies between the participants of the study. The intercept as well as the two variance components are significant at the .001 level, meaning that adding additional variables may reduce the magnitude of the two variance components.

Model B, also called Unconditional Growth Model (cf. Singer & Willett, 2003, p. 97), adds the participation time of the individuals to the study as an additional predictor, allowing therefore to quantify differences between participants with respect to the rate of change in their worries. According to Model B the average change trajectory of participants has an intercept of 6.29*** in worry and a slope of .045, significant at a .001 level, indicating that the level of worry increases between the end of March and the beginning of May. The within-person variance component (.56***) of Model B summarizes how much the data vary around the individual linear change trajectory (not around the person-specific mean), while the two variance components on level 2, initial status and rate of change, estimate the between-person variability in initial status (5.25***) and rates of change (.015***). Adding other factors that would reduce the amount of variability in

these components would help to improve the model fits. That Model B is a better fit than Model A can be derived from a direct comparison, as shown by the values for R_e^2 and R_0^2. The first stands for the within-person residual in model A and B: comparing both values shows that there is a decline of 27% (.77 – .56 / .77), meaning that 27% is explained by introducing the time variable. The second value, R_0^2, stands for the variance component at the outset.. Comparing both Models indicates an improvement of Model B with respect to this component by 2% (5.38 – 5.25 / 5.38 = .02). Therefore including a time variable in the Model particularly improves the estimate of worries at the outset.

The covariance component quantifies the association between initial status of worry and development over time. As such it allows to answer the question of whether people who are more worryful at the beginning also become more (or less) worrying over time. Re-expressing the covariance as a correlation coefficient (cf. Singer & Willett, 2003, p. 100) the relationship amounts to –.16, meaning that those who are worrying more at the beginning are becoming slightly less worrying over time. Overall, Model B shows some of the within-person variation comes along with time, further that most of the variability in worry resides between the participants at the start, only a small amount of variability, albeit significant, is found in the change over time.

Model C and Model D bring in threat appraisal. In order to facilitate interpretation, we centered perceived severity on its sample mean (M = 5.044; to avoid that individuals who participated in more waves would be given greater weight, the mean centering was done on the person-level data). Therefore both intercepts, the one of the initial status, 6.43, as well as the one of rate of change, .03, represent now the average fitted values, both significant at the P < .01 level. Participants with an average value of perceived severity show a value of initial status which is .03 point higher. The estimated rate of change in worry for a participant with average level of perceived severity of Covid-19 amounts to .01. Although this is a fairly small level of increase, it is significant at a P < .01 level, suggesting that during the period of study participants on average increased their level of worries

about COVID-19.

Considering the variance components of Model C, we notice that the within-person variance decreases from .56 to .52, which corresponds to a small reduction by .7%. More remarkable is the reduction of variance in the initial status from 5.25 to 4.52 by 14% by adding severity as a predictor that explains levels of worry at the beginning of participants' trajectory. Given that the value is significantly different from 0 ($P < .001$), other factors may be added to the model to explain the existing variance in Model C. Also the variance component of rate of change, R_1^2, diminishes by introducing the predictor of perceived severity from .15 to .13 which corresponds to 13%. Given that R_1^2 remains significantly different from 0, other predictors may still reduce the amount of the variance in this component of Model C.

In Model D, we add susceptibility, the other component of threat appraisal, which should further explain why people increase their worries over time. We used, as we did before, the mean-centered value of susceptibility ($M = 5.401$). The addition allows the following conclusions: First, controlling for the effects of susceptibility on initial status and rate of change, the effects of severity on initial status and rates of change on participants' worries amounts to .21 ($P < .001$) respectively to .01 ($P < .05$). Second, keeping constant the value of severity, the effects of susceptibility on initial status and rates of change on participants' worry amounts to .14 ($P < .001$) respectively to –.01 ($P < .01$), meaning that participants who differ by one point on perceived susceptibility at the initial status show higher levels of worry by .14. Even if they are more worried at the beginning, their average rate of change is .01 lower, indicating that participants who believe to be more susceptible at the beginning reveal a slower rate of increase of worry over time compared to those who feel less worried at the initial status: susceptibility is negatively associated with the rate of change in worry.

By adding susceptibility as a predictor of initial status of worry as well as of the rate of change, also the amount of variance shrinks to some extent. The within-person variance gets reduced from .52

to .51 ($P < .001$), while the initial state variance drops by about 1% point from 4.52 to 4.48 ($P < .001$), while the rate of change variance remains unchanged.

In order to improve the model further, we add perceived e*fficacy of the safeguard measures* Again, we mean-centered the variable (perceived efficacy: $M = 5.3$) in order to facilitate interpretation of the coefficients. Considering perceived efficacy of safeguarding in Model E indicates an effect on levels of worry in the expected direction, holding perceived severity and susceptibility constant: two people who differ by one point in their view whether safeguards were effective or not, did show a difference in level of worry by –.15. In other words, the less people were convinced that safeguard measures were effective, the more were they worried about Covid-19. While this effect is significant at a level of $P = .001$, no effect can be seen with respect to the rate of change ($P = .479$), meaning that people do not change their minds about safeguards measures. In the following model, we therefore drop the perceived effecacys of safeguards measures as a predictor of the trajectory, but not as a predictor of initial status. Given the impact of attributed efficacy of safeguards measures on the initial status of worry, the corresponding variance component in Model E shrinks from 4.48 to 4.40 by almost 2%.

The final model F adds as new predictor to what extent people think that the government properly handled the Covid-19 crisis in Sweden. Assessment of government predicts initial status of worry, but not the change of worry over time: keeping all other variables-- perceived severity, susceptibility and efficacy of safeguarding measures-- constant, lower levels of agreement with government measures do indicate a higher level of being worried about the Coronavirus ($\beta = .13$, $P = .008$). Given that assessment of government performance does not change the trajectory of worry over time, we finally excluded this variable as a predictor of rate of change.

The Deviance Statistics, including the BIC and AIC, indicate how the models improve by adding the single variables. Additionally, as recommended by Singer & Willett (2003), the Pseudo-R statistics has been computed for the within-person variance, the initial status as well as for the rate of change

variance components, to show how the variance components shrink from model to model, which indicates a growing quality of the model.

Discussion

Foremost this analysis demonstrates the suitability, and maybe even the necessity of this type of statistical model building, and, according to our formulated aims with regard to EMA methodology, it also shows that meaningful data collection can be done by employing this method along with using smartphones to collect data. The model building result has several aspects. The first is closely linked with the state of knowledge about people's ways of reacting to imminent threats. That reaction is affected by socio-demographic and personality variables, which are more or less static, or change very slowly. Furthermore, modifiable psychological factors, such as individual response efficacy, also are relevant for levels of worry in a situation of a pandemic. However, in the current study we did not evaluate the impact of those factors, that might explain the large interindividual differences in level of worry and rate of change. More valuable for understanding and forecasting such reactions would be the knowledge of people's perception of risks, their risk assessment and the processing of observations and information, which are all risk-specific qualities, meaning they differ from case to case, while the processing agency, the human being who has to assess a risk, faces this task with a more or less stable set of experiences, knowledge and coping abilities.

Research so far tells us that the self-perceived susceptibility to fall victim to a threat, the perceived severity of a risk (i.e. the damage it can do), the belief in the efficacy of the institutional safeguarding measures taken, and trust in government or other institutions responsible for public health were among the causal factors of risk assessment and related variables. The first noteworthy general result of our study is that the particular case of the COVID-19 pandemic confirms the older results with a very special case, a different study design, which takes a longitudinal perspective, and a new type of

data analysis as crucial methodological innovation.

The innovation carries a potential with it to enlarge the analytical perspective. When we also look at the data taking temporal development into account, we find an impact, more or less of the same variables as the older, cross-sectional studies did. The impact was actually found for all causal variables when the distribution of the worries at the beginning of the study period was predicted. The similarity is the second general result.

But it is not the worries in the beginning alone that were affected, there were also effects on the trends in the development of worries. These effects are the third important general result, which clearly suggests that a cross-sectional analytic design would have missed an important part of the reality of peoples' thinking about COVID-19, the dynamic nature of the predictors. That not all of them produced linear trends shows that differentiation is called for, which we highlight as the fourth main finding. In our case the contribution of perceived efficacy of the safeguarding measures and the support for the government did not have an impact on the trajectory of worry, and the impact on the initial status of worry must be considered modest. This might be surprising due to the rapid increase in Covid-19 mortality rates in Sweden and the intense debate regarding the Swedish policy, but might be linked to the largely unchanged policy in Sweden during the period under study, as well as a generally high and stable trust among Swedes in the Public Health Agency, the health care system and other societal authorities and institutions as well as in the government. Another reason for the small effects on worry trends is that very few participants stayed on board and handed in information over the whole period of around eight weeks, and the average duration for participation was 12.3 days (waves). Therefore, even if significant effects were shown, the possibility to demonstrate larger shifts in trend was small.

Limitations

A study with so many measurement points in time has to rely on modern digital technology, which

makes it something of a challenge to control sampling. For practical purposes, it might be best not even to try to control access to the questionnaire and to filing the responses. That means a sample for such a study can take the form of a panel, that is the repeated application of the questionnaire to the same persons, but you will have erratic schedules of participation, and high differences in the number of days a person filed answers.

Since the interviews are generally considered the minimum for multi-level analysis, and these three be collected within two days, there was not much time for change. Actually, this is no disadvantage as the pace of change is an open research issue which could be advanced with data as ours at times of a pandemic threat, given that individuals report during longer time periods. Also, it is a limitation that our analytical sample cannot be claimed to be representative of the source population. This should be considered when interpreting the results.

Other limitations were technical problems with the SEMA app, such as difficulties to download the app and that participants sometimes did not receive any survey, or the response disappeared if the participant got a phone call at the same time. The result was that many were interested but could not participate and that some information might be lost. We had no information about participants' Covid-19 infection status, therefore no conclusions can be drawn about the impact of an infection on the level of worry.

Figures and Tables

Figure 1

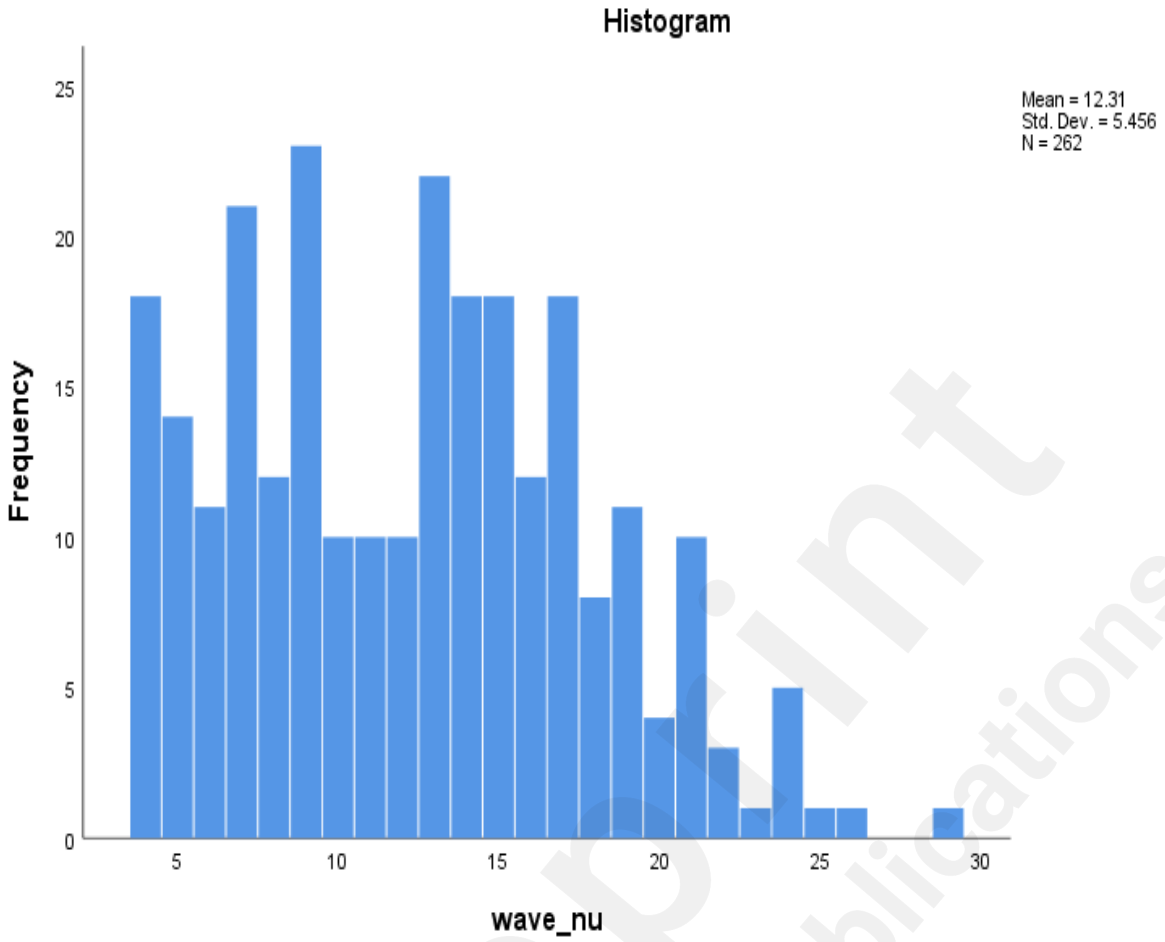

Table 1
Descriptive statistics for the individual growth parameters obtained by fitting separate within-person OLS regression models for worry as a function of linear time (n = 241)

	Initial Status (intercept)	Rate of change (slope)
Mean	6.20	0.07
Standard Deviation	2.35	0.27
Bivariate correlation		–0.35**

Table 2
Models predicting general worry

		Model A	Model B	Model C	Model D	Model E	Model F
Fixed Effects							
Initial status	Intercept	6.54*** (.14)	6.29*** (.14)	6.43*** (.14)	6.44*** (.14)	6.43*** (.13)	5.96*** (.25)
	Severity			.20*** (.04)	.21*** (.04)	.21*** (.04)	.19*** (.04)
	Susceptibility				.14*** (.04)	.13** (.04)	.14*** (.04)
	Efficacy of safeguarding					–.15** (.04)	–.11*** (.03)

	Agreement with government						.13** (.05)
Rate of change	Intercept		.045*** (.01)	.03** (.01)	.03** (.01)	.03** (.01)	.04** (.02)
	Severity			.01** (.005)	.01* (.005)	.01* (.005)	.01** (.004)
	Susceptibility				–.01** (.004)	–.01* (.004)	–.01** (.004)
	Efficacy of safeguarding					.003, n.s. (.004)	–
	Agreement with government						–.002, n.s. (.003)
Variance Components							
Level 1	Within-person	.77*** (.02)	.56*** (.02)	.52*** (.02)	.51*** (.02)	.51*** (.02)	.50*** (.02)
Level 2	In initial status	5.38*** (.48)	5.25*** (.48)	4.52*** (.44)	4.48*** (.44)	4.40*** (.43)	4.36*** (.45)
	In rate of change		.015*** (.002)	.013*** (.002)	.013*** (.002)	.013*** (.002)	.011*** (.002)
	Co-variance		–.045* (.02)	–.065** (.02)	–.06** (.02)	–.06** (.02)	–.06** (.02)
	R_e^2		.27 (27%)	.071 (.7%)	.02 (2%)	0 (0%)	.01 (2%)
	R_0^2		.02 (2%)	.14 (14%)	.01 (1%)	02 (2%)	.04 (1%)
	R_1^2			.13 (13%)	.0 0%	0 (0%)	.15 (15%)
	Deviance	9441	8869	7265	7238	7218	6649
	AIC	9447	8881	7281	7258	7242	6675
	BIC	9466	8918	7328	7317	7312	6750

* $P < .05$, ** $P < .01$, *** $P < .001$

References

Asmundson, G. J. G., & Taylor, S. (2020a). Coronaphobia:Fear and the 2019-nCoV outbreak. *Journal of Anxiety Disorders 70*, 102196. https://doi.org/10.1016/j.janxdis.2020.102196

Asmundson, G. J. G., & Taylor, S. (2020b). How health anxiety influences responses to viral outbreaks like COVID-19: What all decision makers, health authorities, and healthcare professionals need to know. *Journal of Anxiety Disorders 71*, 102211. https://doi.org/10.1016/j.janxdis.2020.102211

Biörn, E. (2017). *Econometrics of panel data. Methods and applications*. Oxford University Press

Bish, A., & Michie, S. (2010). Demographic and attitudinal determinants of protective behaviours

during a pandemic: A review. *British journal of health psychology*, *15*(4), 797-824. https://doi.org/10.1348/135910710X485826

Co-author et al., (2020). Blaming Devices in Online Communication of the COVID-19 pandemic: Stigmatizing cues and negative sentiment gauged with automated analytic techniques. *Journal of Medical Internet Research*. https://doi.org/10.2196/21504

Chao, M., Chen, X., Liu, T., Yang, H., & Hall, B. J. (2020). Psychological distress and state boredom during the COVID-19 outbreak in China: the role of meaning in life and media use. *European Journal of Psychotraumatology*, *11*(1), 1769379. https://doi.org/10.1080/20008198.2020.1769379

de Vries, L. P., Baselmans, B. M. L., Bartels, M. (2020). Smartphone-based ecological momentary assessment of well-being: A systematic review and recommendations for future studies. Journal of Happiness Studies, https://doi.org/10.1007/s10902-020-00324-7

Dillard JP, Yang C, Li R (2018) Selfregulation of emotional responses to Zika: Spiral of fear. PLoS ONE 13(7):e0199828. https://doi.org/ 10.1371/journal.pone.0199828

González-Sanguino, C., Ausín, B., Castellanos, M. Á., Saiz, J., López-Gómez, A., Ugidos, C., & Muñoz, M. (2020). Mental health consequences during the initial stage of the 2020 Coronavirus pandemic (COVID-19) in Spain. *Brain, Behavior, and Immunity*, *87*, 172–176. https://doi.org/10.1016/j.bbi.2020.05.040

Haedt-Matt, A. A., Keel, P. K. (2011). Revisiting the affect regulation model of binge eating: A meta-analysis of studies using ecological momentary assessment. *Psychological Bulletin, 137*(4), 660-681.

Hartmann, P., Apaolaza, V., D'souza, C., Barrutia, J. M., & Echebarria, C. (2014). Environmental threat appeals in green advertising: The role of fear arousal and coping efficacy. *International Journal of Advertising*, *33*(4), 741-765. https://doi.org/10.2501/IJA-33-4-741-765

Huckins, F., da Silva, A. W., Wang, W., et al., (2020). Mental health and behavior of college students during the early phases of the COVID-19 pandemic: Longitudinal smartphone and ecological momentary assessment study. *J Med Internet Res 22*(6),| e20185 | p. 1. http://www .jmir.org/2020/6/e20185/

Jungmann, S. M., Witthöft, M. (2020). Health anxiety, cyberchondria, and coping in the current COVID-19 pandemic: Which factors are related to coronavirus anxiety? *Journal of Anxiety Disorders*, *73*, 102239, https://doi.org/10.1016/j.janxdis.2020.102239

Lazzerini, M., Barbi, E., Apicella, A., Marchetti, F., Cardinale, F., & Trobia, G. (2020). Delayed access or provision of care in Italy resulting from fear of COVID-19. *The Lancet Child & Adolescent Health*, *4*(5), e10-e11. https://doi.org/10.1016/ S2352-4642(20)30108-5

Maddux, J. E., Rogers, R.W. (1983). Protection motivation and self-efficacy: a revised theory of fear appeals and attitude change. *Journal of Experimental Social Psychology, 19*(5), 469- 479. https://doi.org/10.1016/0022-1031(83)90023-9

McKaya, D., Yangb, H., Elhaic, J. Asmundsond. G., J., G. Anxiety regarding contracting COVID-19 related to interoceptive anxiety sensations: The moderating role of disgust propensity and sensitivity. *Journal of Anxiety Disorders 70*, 102196. https://doi.org/10.1016/j.janxdis.2020.102233

Mucci, F., Mucci, N., Diolaiuti, F. (2020). Lockdown and isolation: psychological aspects of COVID-19 pandemic in the general population. *Clinical Neuropsychiatry, 17* (2), 63-64. https://doi.org/10.36131/ CN20200205

Pappa, S., Ntella, V., Giannakas, T., Giannakoulis, V. G., Papoutsi, E., & Katsaounou, P. (2020). Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain, behavior, and immunity*. https://doi.org/10.1016/j.bbi.2020.05.026.

Prati, G., & Pietrantoni, L. (2016). Knowledge, risk perceptions, and xenophobic attitudes: evidence from italy during the ebola outbreak. *Risk Analysis*, *36*(10), 2000-2010. https://doi.org/10.1111/

risa.12537

Rogers, R. W. (1983). Cognitive and physiological processes in fear appeals and attitude change: a revised theory of protection motivation, in Cacioppo, J.T. & Petty, R.E. (Eds.) *Social Psychophysiology: a sourcebook* (pp.153-176). Guilford Press.

Romanzini, C. L. R., Romanzini, M., Batista, M. B., et al., (2019). Methodology used in ecological momentary assessment studies about sedentary behavior in children, adolescents, and adults: Systematic review using the checklist for reporting ecological momentary assessment studies. *J Med Internet Res 21*(7),| e11967 | p. 1. http://www .jmir.org/2019/7/e11967/

Rosenstock, I. M. (1974). Historical Origins of the Health Belief Model. *Health Education Monographs*, *2*(4), 328–335. https://doi.org/10.1177/109019817400200403

Singer, J. D., Willett, J. B., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. Oxford university press.

Taylor, S. (2019).*The psychology of pandemics: Preparing for the next global outbreak of infectious disease*. Cambridge Scholars Publishing

Vaughan, E., & Tinker, T. (2009). Effective health risk communication about pandemic influenza for vulnerable populations. *American journal of public health*, *99*(S2), S324-S332. https://doi.org/10.2105/AJPH.2009.162537

Witte, K. (1992). Putting the worry back into worry appeals: the extended parallel processing model. *Communication Monographs*, *59*(4), 329-349. https://doi.org/10.1080/03637759209376276

Witte, K. (1994) Fear control and danger control: a test of the extended parallel process model (EPPM). *Communication Monographs*, *61*(2), 113-134. https://doi.org/10.1080/03637759409376328

Witte, K. (1998) Fear as motivator, fear as inhibitor: using the extended parallel processing model to explain fear appeal successes and failures, in Andersen, P. A.& Guerrero, L. K. (Eds.) *Handbook of Communication and Emotion: Research, Theory, Application, and Contexts* (pp. 423-450). Academic Press.

Yang, C., Dillard, J. P., & Li, R. (2018). Understanding fear of Zika: Personal, interpersonal, and media influences. *Risk Analysis*, *38*(12), 2535-2545. https://doi.org/10.1111/risa.12973

Yeung, D. Y. L., & Fung, H. H. (2007). Age differences in coping and emotional responses toward SARS: A longitudinal study of Hong Kong Chinese. *Aging and Mental Health*, *11*(5), 579-587. doi: 10.1080/13607860601086355.

Zolotov, Y., Reznik, A., Bender, S., Isralowitz, R. (2020). COVID-19 fear, mental health, and substance use among Israeli university students. *International Journal of Mental Health and Addiction*, 1-7. https://doi.org/10.1007/s11469-020-00351-8

Foundation for Economic Education (2020, April 30). *WHO Official: Sweden's Policy of Individual Responsibility "a Model" for the Rest of World*. https://fee.org/articles/who-official-sweden-s-policy-of-individual-responsibility-a-model-for-the-rest-of-world/