# Lockdown Lives: A longitudinal study of inter-relationships amongst feelings of loneliness, social contacts and solidarity during the COVID-19 lockdown in early 2020.

Jolien A. van Breen[1]

Maja Kutlaca[2]

Yasin Koç[3]

Bertus F. Jeronimus[3]

Anne-Margit Reitsema[3]

Veljko Jovanovic[4]

Maximilian Agostini[3], Jocelyn J. Bélanger[5], Ben Gützkow[3], Jannis Kreienkamp[3], Georgios Abakoumkin[6], Jamilah H. B. Abdul Khaiyom[7], Vjollca Ahmedi[8], Handan Akkas[9], Carlos A. Almenara[10], Mohsin Atta[12], Sabahat Cigdem Bagci[13], Sima Basel[5], Edona Berisha Kida[8], Allan B.I. Bernardo[43], Nicholas R. Buttrick[14], Phatthanakit Chobthamkit[59], Hoon-Seok Choi[16], Mioara Cristea[17], Sára Csaba[18], Kaja Damnjanovic[19], Ivan Danyliuk[11], Arobindu Dash[20], Daniela Di Santo[21], Karen M. Douglas[15], Violeta Enea[22], Daiane Gracieli Faller[5], Gavan Fitzsimons[23], Alexandra Gheorghiu[22], Ángel Gómez[24], Ali Hamaidia[60], Qing Han[25], Mai Helmy[26], Joevarian Hudiyana[27], Ding-Yu Jiang[28], Željka Kamenov[29], Anna Kende[18], Shian-Ling Keng[30], Tra Thi Thanh Kieu[31], Kamila Kovyazina*, Inna Kozytska[11], Joshua

Krause3, Arie W. Kruglanski[1], Anton Kurapov[11], Nóra Anna Lantos[18], Edward P. Lemay jr Hamdi Muluk[27], Solomiia Myroniuk[3], Reza Najafi[42], Claudia F. Nisa[5], Boglárka Nyúl[18], Paul A. O'Keefe[30], Jose Javier Olivas, Osuna[24], Evgeny N. Osin[44], Joonha Park[45], Gennaro Pica[61], Antonio Pierro[21], Jonas Rees[46], Elena Resta[21], Marika Rullo[47], Michelle K. Ryan[48,3], Adil Samekin[49], Pekka Santtila[50], Edyta Sasin[5], Birga Mareen Schumpe[62], Heyla A Selim[51], Michael Vicente Stanton[52], Samiah Sultana[3], Robbie M. Sutton[15], Eleftheria Tseliou[6], Akira Utsugi[53], Caspar J. van Lissa[54], Kees van Veen[3], Michelle R. vanDellen[55], Alexandra Vázquez[24], Robin Wollast[35], Victoria Wai-lan Yeung[56], Somayeh Zand[42], Iris Lav Žeželj[19], Bang Zheng[57], Andreas Zick[46], Claudia Zúñiga[58], N. Pontus Leander[3]

Author affiliations

1 Leiden University
2 Durham University
3 University of Groningen
4 University of Novi Sad
5 New York University Abu Dhabi
6 University of Thessaly
7 International Islamic University Malaysia
8 Pristine University
9 Ankara Science University
10 Universidad Peruana de Ciencias Aplicadas
11 Taras Shevchenko National University of Kyiv
12 University of Sargodha
13 Sabancı University
14 University of Virginia
15 University of Kent
16 Sungkyunkwan University
17 Heriot Watt University
18 ELTE Eötvös Loránd University

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[1] , Cokorda Bagus Jaya Lesmana[33], Winnifred R. Louis[34], Adrian Lueders[35], Najma Malik[36], Anton Martinez[37], Kira McCabe[38], Jasmina Mehulić[29], Mirra Noor Milla[27], Idris Mohammed[39], Erica Molinario[32], Manuel Moyano[40], Hayat Muhammad[41], Silvana Mula[21],

University of Belgrade
Institute of Management and Organization, Leuphana University of Luneburg, Germany
University "La Sapienza", Rome
Alexandru Ioan Cuza University, Iasi
Duke University
Universidad Nacional de Educación a Distancia
University of Bristol
Menoufia University
Universitas Indonesia
National Chung-Cheng University
University of Zagreb
Yale-NUS College
HCMC University of Education
University of Maryland
Udayana University
University of Queensland
Université Clermont-Auvergne
University of Sargodha
University of Sheffield
Vanderbilt University
Usmanu Danfodiyo University Sokoto
University of Cordoba
University of Peshawar
Islamic Azad University, Rasht Branch
De la Salle University
National Research University Higher School of Economics
NUCB Business School
University of Bielefeld
University of Siena
University of Exeter
International Islamic Academy of Uzbekistan
New York University Shanghai
King Saud University
California State University, East Bay
Nagoya University
Utrecht University
University of Georgia
Lingnan University
Imperial College London
Universidad de Chile
Thammasat University

60 Setif 2 University
61 University of Camerino
62 University of Amsterdam
* Independent researcher

**Address for Correspondence:** j.a.van.breen@fgga.leidenuniv.nl

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**Abstract**

We examine how social contacts and feelings of solidarity shape experiences of loneliness during the COVID-19 lockdown in early 2020. From the PsyCorona database, we obtained longitudinal data from 23 countries, collected between March and May 2020. Results demonstrated that, although online contacts help to reduce feelings of loneliness, people who feel more lonely are less likely to use that strategy. Solidarity played only a small role in shaping feelings of loneliness during lockdown. Thus, it seems we must look beyond the current focus on online contact and solidarity to help people address feelings of loneliness during lockdown. Finally, online contacts did not function as a substitute for face-to-face contacts outside the home - in fact, more frequent online contact in earlier weeks predicted *more frequent* face-to-face contacts in later weeks. As such, this work provides relevant insight into how individuals manage the impact of restrictions on their social lives.

# Lockdown Lives: A longitudinal assessment of inter-relationships amongst feelings of loneliness, social contacts and solidarity during the COVID-19 lockdown.

At the end of 2019, a novel corona-virus disease (COVID-19) arose that, by the start of 2020, had triggered a global pandemic. Many countries imposed lockdown-type measures designed to curb the spread of the virus by limiting face-to-face contacts. Citizens were ordered to stay at home as much as possible, public spaces, shops, pubs, and restaurants were closed, and public transport was limited. The pandemic and the associated lockdown measures had an extensive impact on people's lives, not only because of concern for their health but also concern for close others, and concern for the future more generally. As the service and travel industry came to a halt many who had been employed in those sectors lost their jobs (Arthur, 2021; Hoehn-Velasco et al., 2021). Many others were required to work from home, in many cases while also tending to children who could no longer attend school. In sum, the pandemic and the associated lockdown represent an exceptional circumstance which generated a great deal of stress and uncertainty (Torales, et al., 2020).

Meaningful social relationships and a sense of social connectedness are essential to health and well-being (Baumeister & Leary, 1995; Holt-Lunstad et al., 2015; Slavich, 2020), and this is particularly true in times of stress and crisis, when people rely on others to provide help and social support (Haslam & Reicher, 2006; Taylor, 2006). However, during lockdown, people's social lives were severely disrupted as a result of the measures outlined above. Possible increases in loneliness, and poor mental health, were amongst the most widely anticipated consequences of the lockdown (Brooks et al., 2020), leading the public and researchers alike to consider how people could satisfy their social needs, avoid social isolation, and prevent loneliness in a time when people's social lives were severely restricted.

Both academic and public discourse identified online contact and group solidarity as key strategies to avoid social isolation and loneliness during lockdown. Specifically, many

public outlets suggested that people might be able to avoid feelings of loneliness by replacing face-to-face contacts with online forms of contact ("Coronavirus and loneliness", 2020; "Loneliness During Coronavirus", 2020). Second, many have considered that a sense of solidarity might help people to feel connected to the larger community ("COVID-19 virtual press conference", 2020; "#TogetherWeWin", 2020; Purtill, 2020). That is, feelings of loneliness may be avoided through feelings of solidarity with one's group, which offers a more indirect form of connectedness (Hunt & Benford, 2004; Putnam, 2000; Subašić et al., 2008). The present research, then, examines how online contact and solidarity shaped feelings of loneliness over the course of the lockdown. By analysing whether there is evidence for the ideas outlined above, our results will be informative in managing (possible) future lockdown periods.

Using data from the global PsyCorona database (www.psycorona.org), we studied responses to the COVID-19 pandemic in a convenience sample of 4,606 participants from 23 countries, over a 6-week period between late March and early May 2020. Using a random intercept cross-lagged panel model (RI-CLPM, Hamaker et al., 2015) we estimated relationships between social contact, loneliness, and solidarity at the between-person and within-person level. That is, we assessed differences between individuals and changes within individuals over the course of lockdown. In this way, we aimed to evaluate how lockdown affected people's social lives, and which factors shape people's feelings of loneliness as the lockdown progresses. Below, we elaborate on previous research regarding the relationships amongst loneliness, social contacts and solidarity.

## Loneliness

Loneliness is defined as the felt discrepancy between a person's *actual* social connectedness and *desired* social connectedness (Russell et al., 1980). People who perceive that they are less connected than they would like to be, tend to feel lonely. Such a lack of satisfying social relationships, and associated feelings of loneliness, have a detrimental

impact on well-being and health (Heinrich & Gullone, 2006) with an impact comparable to smoking and obesity (Holt-Lunstad et al., 2015). During the COVID-19 lockdown, feelings of loneliness were expected to increase, given that social contacts outside the household are reduced ("Coronavirus and loneliness", 2020; Brooks et al., 2020). However, as data on the lockdown is beginning to be published, empirical evidence for this notion is mixed. For instance, cross-sectional data from Luchetti and colleagues (2020) shows that during lockdown people did not seem to feel lonelier than they did before the lockdown. On the other hand, Killgore et al. (2020), did demonstrate an increase in feelings of loneliness in their sample of individuals with a diagnosis of schizophrenia. The Netherlands Institute for Social Research observed that *social* loneliness remained stable over 2020 when considering the number of contacts, although there was an increase in *emotional* loneliness – that is, the intimacy derived from these contacts is reduced (de Klerk et al., 2020). In sum, it seems reasonable to suggest that lockdown might lead to an increase in feelings of loneliness, but empirical work conducted thus far is less conclusive.

In integrating these findings, it is important to consider that loneliness is not only a consequence of lack of connections, but feelings of loneliness also shape people's *subsequent* tendencies to engage in social contacts (Cacioppo & Patrick, 2008; VanderWeele et al., 2012). In terms of how exactly loneliness impacts subsequent social tendencies, two patterns have been described in previous literature. *Temporary* feelings of loneliness can motivate people to increase their social behaviour, to compensate for loneliness (Cacioppo & Patrick, 2008). *Chronic* forms of loneliness, on the other hand, can lead people to withdraw – for instance because a person who feels chronically lonely experiences greater fear of rejection (Cutrona, 1982; Goll et al., 2015), or as a result of low mental health (Saeri et al., 2011). That is, people who feel chronically lonely may actively withdraw from social interaction. Given the temporary nature of lockdown, we might suggest that any increases in feelings of loneliness are temporary rather than chronic, thus inspiring people to pursue more social

connections. In sum, research suggests a reciprocal relationship between loneliness and social contact whereby (lack of) social contact impacts feelings of loneliness, and feelings of loneliness in turn shape the pursuit of social connectedness. Turning briefly to the public discourse on this topic, it is worth noting that this reciprocal relationship between feelings of loneliness and social contact does not seem to be discussed in the media, or in communication from public health bodies. For instance, in the UK, guidance from the National Health Service emphasised the importance of maintaining social contact during the lockdown, without discussing why it might be particularly difficult to do so for those who experience feelings of loneliness (e.g. "What you can do if you feel lonely during the coronavirus", 2020). As such, the reciprocal relationship between loneliness and social contact may represent an area where the public discourse may not accurately reflect people's experiences during lockdown. We aim to contribute to this question by presenting longitudinal data which shed light on changes within individuals to capture reciprocal relationships between loneliness and social contacts.

**Face-to-face and Online Contacts**

When considering social contact and loneliness during lockdown, we must differentiate between in-person or 'face-to-face' contacts, and social contact that takes place online. A central feature of lockdown was that face-to-face contacts with people outside of one's household were severely restricted throughout the lockdown period. In many countries, this was enforced by law, with fines given to those found to violate regulations (e.g. in the UK, see "Coronavirus (Covid-19) police powers", 2020). In response to reduced levels of face-to-face contact outside the home, people were encouraged to substitute their regular face-to-face contacts with *online* contact with their friends and relatives (e.g. "Loneliness

during Coronavirus", 2020)[2], as a way of preventing loneliness. Indeed, the psychological literature provides considerable evidence that online contacts are beneficial in combating loneliness (e.g. Caplan, 2003; Nowland et al., 2018), although more passive forms of internet use may be associated with an increase in loneliness (Stepanikova et al., 2010). The relationship between online and face-to-face contact has received considerable attention in the literature on computer-mediated communication. This literature raises the 'displacement hypothesis', which suggests that online and face-to-face contacts function as substitutes – those who have a great deal of online contact have fewer in-person contacts. The lockdown context is characterised by a degree of displacement – contacts that used to occur face-to-face must now occur online. However, this is not a 'natural' displacement, but rather one that is enforced by external constraints, such as "shelter-in-place" orders. The displacement hypothesis is contrasted with the 'reinforcement' or 'stimulation' hypothesis, whereby those who have more extensive online contacts also have more face-to-face contacts – in fact this effect has received considerable empirical support in recent work (Dienlin et al., 2017; Hall et al., 2019; Valkenburg & Peter, 2007). This suggests that online contacts may have the side effect of increasing people's engagement in face-to-face contacts (in spite of restrictions), which represents an undesirable effect in the context of lockdown.

In sum, although it seems reasonable to suggest that online contacts are beneficial in avoiding loneliness, it is less clear whether online and face-to-face contacts function as substitutes. The first aim of the current study, then, is to examine whether people use online contacts as a substitute for face-to-face contacts during lockdown.

[2] Note that here we do not mean *exclusively* online contacts. Rather, the idea is that people use online forms of contact to interact with people they would normally meet face-to-face.

## The Role of Solidarity

Aside from seeking direct contact with others (e.g., through online channels), people may also satisfy their need for social connectedness in more indirect ways, that do not depend necessarily on direct contact with another person. Specifically, feelings of solidarity can offer a sense of connectedness and shared fate with a community, country, or even the whole of humanity (Hunt & Benford, 2004; Putnam, 2000; Subašić et al., 2008). Solidarity has been defined in a variety of ways, but key components of its definition are mutual support and a sense of shared fate with another individual or group (Louis et al., 2019). Increases in feelings of solidarity and solidarity behaviours are common during and after mass emergencies and disasters (Kaniasty & Norris, 2004; Nontis & Rocha, 2020; Rodriguez et al., 2006). We examine the idea that greater solidarity is associated with reduced feelings of loneliness over the course of lockdown.

Again, to situate these arguments in the public discourse, it is worth noting that solidarity has also received a great deal of attention in the public discourse surrounding lockdown. The lockdown phase saw many local and global expressions of solidarity (e.g. "Official data suggests Britons are learning to help each other", 2020) – some focused on practical support, such as neighbours helping each other with grocery shopping ("Coronavirus: How Germany is showing solidarity amid the outbreak", 2020), and some were more symbolic, such as neighbours sharing a song from their balconies (Thorpe, 2020) or 'Clap for Carers' initiatives (https://clapforourcarers.co.uk). Our analysis will shed light on whether such feelings of solidarity were beneficial when it comes to assuaging feelings of loneliness.

## The Current Study

This study aims to examine how people satisfy their need for social connectedness and avoid feelings of loneliness in a time when face-to-face contact outside the home was restricted as a

result of the COVID-19 lockdown during March-May 2020. We consider the impact of direct (online contact) and indirect (solidarity) forms of social connectedness on feelings of loneliness over a six-week period between mid-March and early May 2020. Second, we situate our findings within the public discourse on the topic of lockdown. In doing so, we aim to shed light on the public understanding of the impact of lockdown, and identify any discrepancies between the topics discussed in the public discourse, and the effects arising from the data.

We draw on data from the PsyCorona project (www.psycorona.org) - a large-scale multi-national collaboration - including observations from 23 countries. We use a longitudinal design, collecting data at four time points over a 6-week period at the height of lockdown. The longitudinal design allows us to examine relationships at the between-persons level and the within-person level. The full conceptual model is shown in Figure 2.

**Hypotheses**

We examined the relationships amongst feelings of loneliness, social contacts and solidarity over the lockdown period. We raised the following hypotheses, differentiating between relationships at the between-persons level and at the within-person level. Betweenpersons effects are those that capture differences between individuals, whereas within-person effects are those that capture changes within individuals over time. Given that we are interested in relationships between the different variables, we do not raise hypotheses for changes within a single variable over time, that is, we do not raise hypotheses for the autoregressive effects.

First, we examined whether online contact is used as an alternative to face-to-face contact during lockdown. This question is best assessed by examining changes over time within-persons, because at the between-person level any negative relationship between the types of contact is likely to be overshadowed by a general effect of sociability (Lee, 2009), which would produce a positive correlation amongst the types of contact: people who are

more sociable have more contacts of both kinds. At the within-person level, we hypothesised that a reduction in face-to-face contact in the earlier weeks will lead to an increase in online contact in the subsequent weeks (**H1**).

Hypotheses 2 and 3 focus on the relationship between social contact (face-to-face and online) and loneliness. We expected that loneliness is inversely related to both face-to-face (**H2a**) and online contact (**H2b**) at the between-person level - individuals who have fewer social contacts are expected to feel more lonely relative to those who have more frequent social contacts. However, we expect that at the within-person level, the relationship between these variables will look quite different. Specifically, we expected **(H3)** a *reciprocal* relationship between loneliness and online contact that is not visible at the between-person level, whereby low levels of online contact in the preceding week lead to increased feelings of loneliness in the following week and feelings of loneliness lead people to seek *more* online contact in the later weeks. We expect this reciprocal effect to appear only for online contacts because face-to-face contacts were so heavily restricted during the period under study that little change was possible.

Hypotheses 4 and 5 focus on the relationship between loneliness and solidarity. We expect that, at the between-person level, loneliness is negatively correlated with solidarity, so that people who feel more solidarity feel less lonely than people who feel less solidarity (**H4**). Similarly, at the within-person level, we expect that high levels of solidarity in early weeks lead to reduced feelings of loneliness in the later weeks (**H5**).

## Method

Our longitudinal study was planned and embedded within a larger longitudinal study examining the COVID-19 pandemic (PsyCorona project). For information on the PsyCorona project, please refer to the supplement. For the purposes of the current project, we extracted a

subsample of the complete dataset. The supplement gives details on how the dataset used in the current project was extracted from the PsyCorona dataset (in the section 'Data Sharing Procedure'). Data were collected in line with APA ethical guidelines.

**Project registration and data availability.**

The project was approved by the ethics board at the University of Groningen under project number PSY-1920-S-0390, and at NYU Abu Dhabi under protocol HRPP-2020-42. The codebook for the full PsyCorona survey is available at https://osf.io/qhyue/. Data and syntax for this project are available at https://osf.io/rgxhz/?view_only=27e2cbc3311947c39dbfd088a48de71f. This project was not pre-registered.

**Procedure**

For the purposes of this project, we identified the lockdown phase as running from the middle of March to the start of May. There is some variance by country with regards to when the lockdown started, what precisely it entailed, and when it ended. This variance is captured in the multilevel structure of our model, which uses Country as the level 2 variable. Broadly however, around mid-March a large number of countries had instituted some form of lockdown, or were preparing to begin lockdown, as can be seen in Figure 1 (based on the Oxford Stringency database; Hale et al., 2020). At the start of May, several countries were beginning to relax their lockdown restrictions (see Figure 1), and as such we considered the start of May to be a suitable cut-off point. In sum, our analysis focuses on a time period from the 19th of March to the 02nd of May.

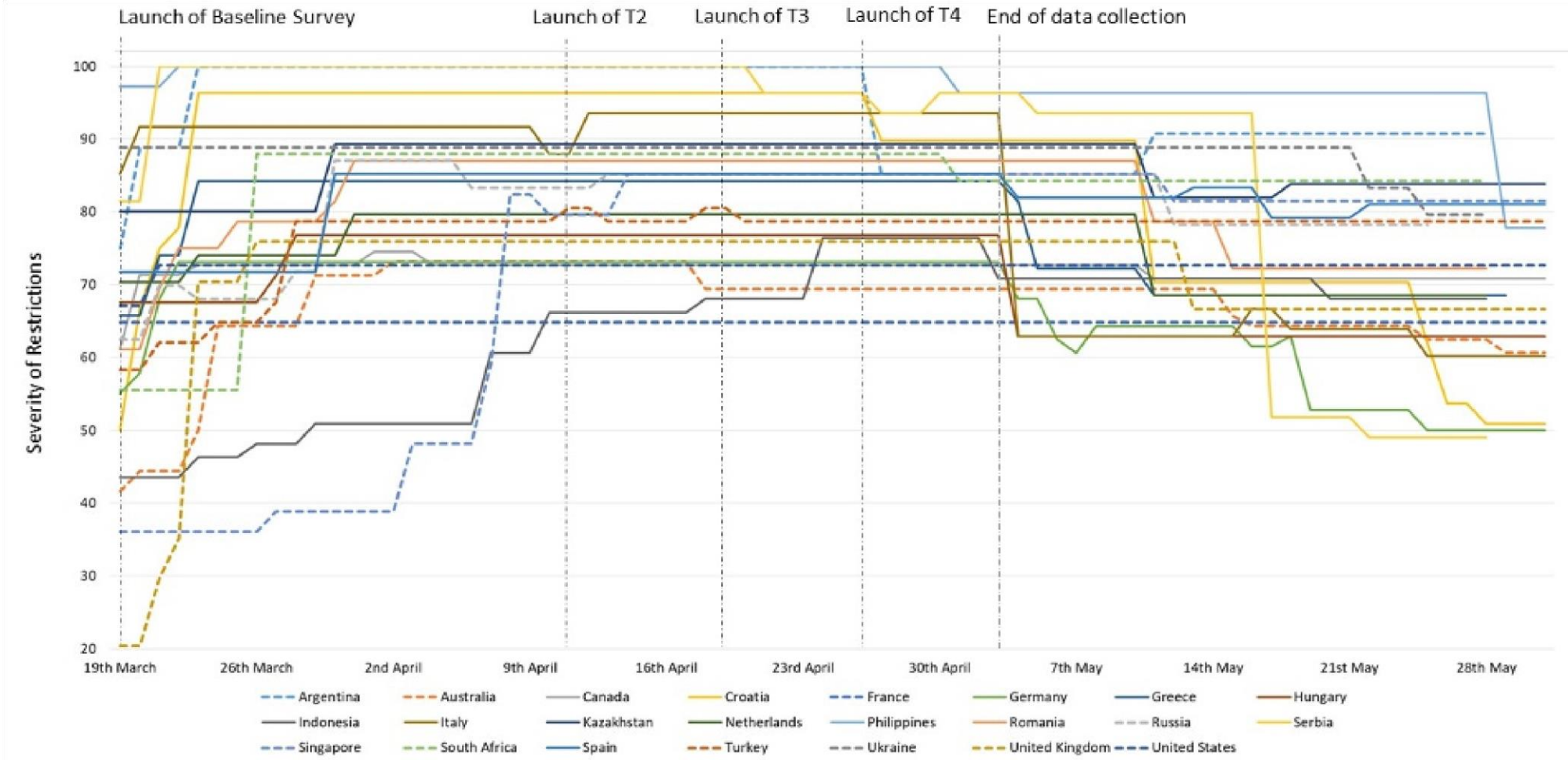
All waves of the survey were hosted on the Qualtrics platform. Participants were recruited to the baseline survey through a variety of different channels, including the personal and educational networks of the researchers, and social media channels. At the end of the baseline survey, participants were asked whether they were willing to be contacted for follow-up surveys, and if so, to provide their email address. Those who did so were then sent

an email on the Friday of the following week to invite them to take part in the follow-up surveys.

The variables of interest in the current project were embedded in a broader survey (for details please refer to the PsyCorona codebook at https://osf.io/qhyue/). Generally, the four survey waves were similar in structure. When participants accessed the survey, the first page asked them to choose the language in which they wanted to complete the survey. They were then provided with project information and asked to provide/renew informed consent. The number of face-to-face and online contacts people had had in the last week were assessed at the start of the survey, as were feelings of loneliness. For those waves that included the measure of solidarity ($T_2$; $T_3$; $T_4$), this measure was included towards the end of the survey. Demographic information was included right at the end of the baseline survey, but was not repeated in subsequent waves. Participants indicated their age, gender, country of residence and nationality.

The baseline survey was disseminated between the 19th of March 2020 and the 14th of April. Follow-ups were disseminated on Friday the 11th of April, Friday the 18th of April and Friday 25th of April.

**Figure 1.** Data from the Oxford severity index (Hale et al., 2020) showing the intensity of government mitigation measures in different countries




over the period under study.

**Participants.**

As noted above, our analysis focuses on a time period from the 19th of March to the 02nd of May. To be eligible for inclusion, participants needed to have completed the baseline survey, and at least two (but possibly three) follow up surveys by the cut-off date (02nd of May). To allow for country-level analyses, we selected only those participants from countries that had a minimum of 20 participants. The countries included are: Argentina, Australia, Canada, Croatia, France, Germany, Greece, Hungary, Indonesia, Italy, Kazakhstan, the Netherlands, the Philippines, Serbia, Romania, Russia, Singapore, South Africa, Spain, Turkey, Ukraine, the United Kingdom and the United States of America.

The criteria above yielded a convenience sample of 4606 participants, who – by 2nd of May 2020 – had completed the baseline survey and (at least) two follow-up surveys. Of these participants, all completed the baseline ($T_1$). $T_2$ included 3777 participants, $T_3$ included 4111 participants, and $T_4$ was completed by 3478 participants. Key demographics are shown in Table 1 below.

We did not conduct an a-priori power analysis - we included as many participants as could be collected during the period under study (19th March 2020- 02nd May 2020). Power analysis procedures that apply to RI-CLPM designs are not readily available, and other papers using this procedure do not commonly offer power analyses (e.g. Osborne et al., 2017). Nevertheless, to provide an indication of the power achieved with this sample, we conducted a sensitivity analysis using G*Power (Faul et al., 2009). In this analysis, we include all the paths to be estimated as predictors (N=65, see Figure 2) in a multiple regression model. Given a=0.05, and power is 1-b=.80, a sample of N = 4606 can reliably detect relationships where b=.049 or larger.

**Table 1.**

Overview of demographics.

| **Demographic** | | **Percent of total sample** |
|---|---|---|
| Age | Between 18-34 | 43.9% |
| | Between 35-54 | 37.2% |
| | Over 55 | 18.9% |
| Gender | Women | 72.9% |
| | Men | 26.2% |
| | Non-binary | 0.9% |
| Country of residence | Argentina | 0.8% |
| | Australia | 0.5% |
| | Canada | 2.3% |
| | Croatia | 2.3% |
| | France | 3.2% |
| | Germany | 2.5% |
| | Greece | 6.3% |
| | Hungary | 3.2% |
| | Indonesia | 1.5% |
| | Italy | 2.2% |
| | Kazakhstan | 1.3% |
| | Netherlands | 7% |
| | Philippines | 1.3% |
| | Republic of Serbia | 5.2% |
| | Romania | 1.6% |
| | Russia | 0.7% |
| | Singapore | 0.8% |
| | South Africa | 0.5% |
| | Spain | 13.7% |
| | Turkey | 1.7% |
| | Ukraine | 1.4% |
| | United Kingdom | 4.4% |
| | United States of America | 35.5% |
| Citizenship | Citizen | 93.4% |
| | Immigrant | 6.6% |

| | | |
|---|---|---|
| Survey Language | English | 47.9% |
| | Spanish | 14.5% |
| | Other | 37.6% |

**Measures**

Below, we describe the measures of central interest for the current study.

***Face-to-face and Online contact***

The frequency of face-to-face contact and of online contact were assessed separately, by asking participants: "In the past 7 days, how many days did you have face-to-face [online] contact with friends and relatives outside your household? These items were rated on an 8point scale ranging from 0 days to 7 days. Contact was measured at baseline ($T_1$), and in each of the follow up waves ($T_2$-$T_4$). Note that we ask specifically about friends and relatives, excluding more casual contacts (e.g. a cashier at the supermarket). As such, our measure focuses on the more meaningful contacts outside of one's household.

***Loneliness***

Feelings of loneliness were assessed with 3 items in the baseline survey, of which 1 item was repeated in the follow-up surveys, and this item was used in our analysis. The loneliness item was "During the past week, did you feel lonely?" The item was rated on a 5point Likert-type scale, ranging from 1 (never) to 5 (all the time). Feelings of loneliness were measured at baseline ($T_1$), and in each of the follow up waves ($T_2$-$T_4$).

***Solidarity***

Feelings of solidarity were assessed with 2 items average between-person correlation per wave ($r$>.60, $p$ < .001), one focusing on solidarity with others within one's country ("I feel a sense of solidarity with people in my country"), and the other focusing on solidarity with those in other countries, both rated on a 5-point Likert-type scale ranging from 1

(strongly disagree) to 5 (strongly agree). Feelings of solidarity were measured at each of the follow-up waves ($T_2$- $T_4$). For each wave, the responses to the items were averaged into a single measure of solidarity (Spearman-Brown reliability coefficient for two item scales at the different time points was .77 [$T_2$], .76 [$T_3$], and .78 [$T_4$]).

***Random factors: Country of Residence***

To account for differences between countries, we included country of residence as a control variable.

**Analytical procedure**

The data has a longitudinal structure: the central concepts are measured at four different time points. We ran a Random Intercept Cross Lagged Panel Model analysis (RICLPM, Hamaker et al., 2015) using MPLUS (Muthén & Muthén, 2017). Traditional crosslagged panel models do not separate within-person change from between-person stability and can lead to incorrect conclusions (Berry & Willoughby, 2017; Hamaker et al., 2015; Osborne & Sibley, 2020). RI-CLPM is able to model between-person differences by estimating a random intercept for each variable across 4 time points. This is done by fixing the factor loadings of each variable at each time point to 1, and by allowing the random intercepts to correlate. These random intercepts reflect the average levels of two types of contact, loneliness and solidarity for each participant across all time points. To model within-person changes, we created within-person centred latent variables, constrained factor loadings for each measurement occasion to 1 and the residual variance to 0. Next, the within-person latent variables at later time point were regressed onto the within-person latent variables at earlier time. We let the model estimate the covariances between all within-person latent variables at each time point. However, the covariance between random intercepts and the within-person measures at $T_1$ (or $T_2$ for Solidarity) were constrained to 0. One additional issue is that the autoregressive effects in RI-CLPM do not capture stability, but within-person carry-over effects - whether a variable *increases or decreases* within people over time

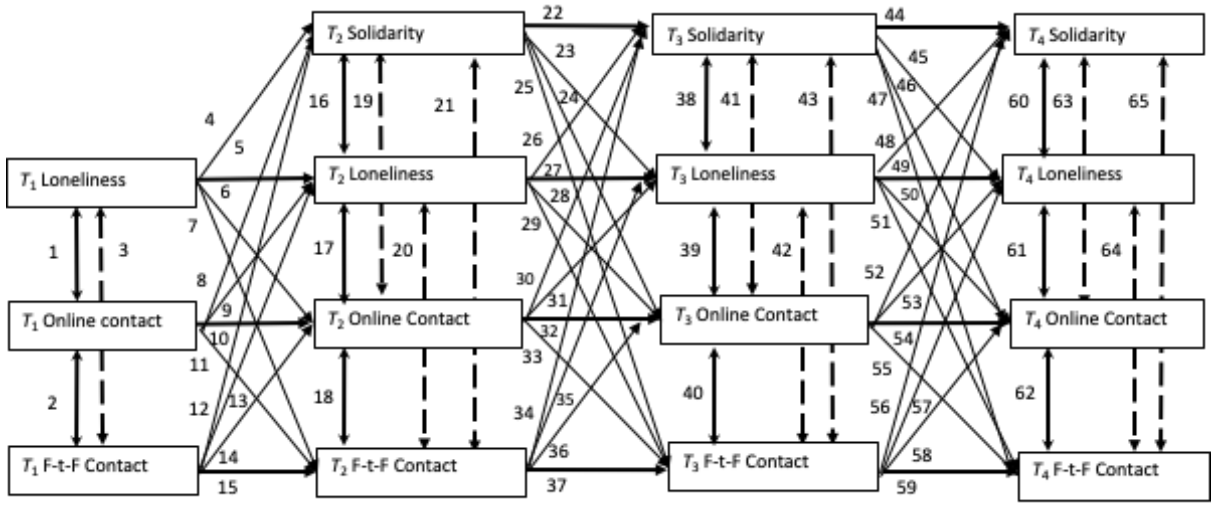
(Osborne & Sibley, 2020). Finally, to account for nesting and non-normal distribution of contact variables, we estimated the model using maximum likelihood estimation with robust standard errors (MLR) that can handle missing data and it is robust to violations of normality and nonindependence of data (Muthén & Asparouhov, 2002). Given that we had information available on participants' country of residence, we ran the model with and without country level nesting, to explore whether there are country-level differences. In the results section below, we report all findings that reach significance at the $p<.05$ level. However, the large sample size allowed for many effects to reach traditional levels of statistical significance. Therefore, we chose to focus our interpretation on those findings that passed a more conservative threshold and reach significance at $p<.01$ or smaller. Figure 2 shows a visual representation of the full model to be fitted.

**Preliminary Analyses**

**Attrition Analysis.** There was larger attrition in the last wave (i.e., 24.5%) compared to the earlier waves ($T_2$ = 18%; $T_3$ = 10.7%). Importantly, those who felt more lonely at baseline were less likely to participate in the last wave than those who felt less lonely ($\beta$= 0.12 [*SE* = 0.03], $p < .001$) as well as those who less online contact ($\beta$= -0.04 [*SE* = 0.01], $p = .003$) . Please refer to table B in the supplement for further details.

**Figure 2.**

Representation of the analytical model.




## Results

We fit a Random Intercept Cross Lagged Panel Model (RI-CLPM; Hamaker et al., 2015), which models both between-person variance and within-person change. The results are shown in Figure 3. The model was a good fit to the data: $\chi^2(30)= 84.35$, $p < .001$; CFI = .997; RMSEA = .02 (90% CIs = .015, .025) , SRMR = .013 (Hu & Bentler, 1999). Table 2 gives descriptive statistics, including descriptive statistics per country. Bivariate correlations between the central variables at the different time points can be found in Table C in the supplement.

We first describe auto-regressive effects, examining how each of the key variables changed over the course of the 4 measurement points. We did not raise hypotheses regarding the autoregressive effects because our central interest was the relationships between variables, rather than changes in a single variable. After describing the autoregressive effects, we turn to the hypotheses. An overview of the autoregressive effects is shown in Table 3.

Feelings of loneliness increased within people, from $T_2$-$T_3$ and from $T_3$-$T_4$ . The number of face-to-face contacts outside the home first decreased from $T_1$-$T_2$, but then *increased*, from $T_2$-$T_3$ and from $T_3$-$T4$. Similarly, the number of days on which people had online contacts

with others first decreased somewhat between $T_1$ and $T_2$, and then showed a small increase in later weeks. Solidarity increased between $T_3$-$T_4$.

**Hypothesis tests.**

Regarding the relationship between the two types of contact, online contact and faceto-face contact were not correlated at the between-person level, $\beta$= -0.01 [*SE* = 0.02], $p$ = .727. At the within-person level, hypothesis 1 suggested that during lockdown online contacts would replace face-to-face contacts, that is, a negative association between the two types of contact. Instead, results showed that (when controlling for $T_1$ face-to-face contact) more frequent online contact in earlier weeks predicted *more frequent* face-to-face contacts outside the home in later weeks ($T_2$-$T_3$, $\beta$= 0.07 [*SE* = 0.02], $p$ = .001; $T_3 - T_4$, $\beta$= 0.08 [*SE* = 0.03], $p$ = .002). That is, there was no support for Hypothesis 1 that online contact was used as an alternative to face-to-face contact.

Loneliness was not associated with face-to-face contact outside the home at the between-person level, $\beta$ = -0.03 [*SE* = 0.02], $p$ = .164, and as such there was no evidence for Hypothesis 2a. However, there was support for Hypothesis 2b regarding online contacts: feelings of loneliness were lower amongst people who had more online contacts than amongst people who had fewer online contacts (β= -0.07 [SE = 0.02], $p$ < .001).

Hypothesis 3 then focused on the relationship between loneliness and online contacts at the within-person level, we postulated a reciprocal relationship between loneliness and online contact. In line with this, more online contact ($T_3$) predicted a decrease in loneliness ($T_4$, $\beta$= -0.08 [0.03], $p$ = .005). However, the idea that loneliness would lead people to compensate by seeking more online contacts in the subsequent week was not supported, as more lonely people ($T_2$) reported *fewer* online contacts ($T_3$) ($\beta$= -0.11 [0.04], $p$ = .003). In sum, loneliness and online contact were indeed reciprocally related over time, but the relationship took a different form than hypothesised: online contacts were *reduced* as a consequence of increased loneliness.

In line with hypothesis 4, people who reported more solidarity felt less lonely than people who felt low solidarity, $\beta$= -0.19 [0.02], $p < .001$. Solidarity did not predict changes in feelings of loneliness at the within-person level ($T_2$-$T_3$-T$_4$, $p > .35$)[3], and as such there was no evidence for hypothesis 5.

In sum, then, the hypotheses regarding the between-persons effects were largely supported (H2; H4), but a more complex picture emerged for the within-person effects (H1; H3; H5). We elaborate on these patterns in the Discussion section below.

**Exploratory analyses.**

Our hypotheses focused on the impact of social contacts and solidarity on loneliness, but for completeness, we will briefly discuss the relationships amongst social contact and solidarity. At the between-persons level, people who reported more solidarity also had more online contacts, $\beta$= 0.01 [0.02], $p < .001$, and also slightly reduced face-to-face contacts, β= 0.05 [0.02], $p = .024$, relative to people who felt low solidarity. At the within-person level, solidarity did not predict changes in online contacts ($T_2$-$T_3$-$T_4$; all $p$>.671), or changes in faceto-face contacts ($T_2$-$T_3$-$T_4$; all $p$>.353). In sum, relationships amongst solidarity and social contacts appeared only at the between-persons level.

We considered several alternatives to the model described above, specifically we considered models that included country of residence as a nesting factor, as well as a model

[3] There was some evidence for a relationship in the opposite direction whereby loneliness predicts solidarity: Solidarity at Time 2 was predicted by loneliness at Time 1, β = -.08, $SE$ = .04, $p$ = .019. However, this crosslagged effect was very small in size and not present at the other time points, so should be interpreted with caution.

including age and gender as control variables. The differences between the model we report above and the alternative models were negligible – please refer to the supplementary materials for details.

**Table 2.**

Descriptive statistics for the central variables at all time points, separated by country.

| | | Face-to-face Contact | | | | Online Contact | | | | Loneliness | | | | Solidarity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T2 | T3 | T4 |
| **Total** | **Mean** | 1,55 | 1,38 | 1,55 | 1,77 | 4,68 | 4,28 | 4,15 | 4,05 | 2,28 | 2,39 | 2,37 | 2,32 | 0,93 | 0,90 | 0,94 |
| | **SD** | 2,21 | 2,02 | 2,11 | 2,17 | 2,41 | 2,38 | 2,38 | 2,45 | 1,13 | 1,10 | 1,09 | 1,08 | 1,30 | 1,29 | 1,29 |
| | **N** | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 | 4606 |
| **Argentina** | **Mean** | 0,85 | 0,66 | 1,13 | 1,00 | 5,71 | 5,65 | 5,44 | 5,44 | 2,10 | 2,34 | 2,16 | 2,16 | 1,36 | 1,23 | 1,64 |
| | **SD** | 1,58 | 1,30 | 1,79 | 1,11 | 1,69 | 1,77 | 1,81 | 1,79 | 1,10 | 1,16 | 0,92 | 0,95 | 1,17 | 1,23 | 1,02 |
| | **N** | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 |
| **Australia** | **Mean** | 2,43 | 1,13 | 1,21 | 2,00 | 4,40 | 3,94 | 3,63 | 3,17 | 2,05 | 2,50 | 2,37 | 2,17 | 0,91 | 0,89 | 1,00 |
| | **SD** | 2,75 | 1,36 | 1,62 | 1,81 | 2,16 | 2,08 | 2,50 | 2,04 | 0,92 | 1,03 | 1,07 | 0,92 | 1,46 | 0,99 | 1,16 |
| | **N** | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| **Canada** | **Mean** | 1,69 | 1,32 | 1,63 | 1,95 | 4,59 | 4,42 | 4,03 | 3,86 | 2,55 | 2,67 | 2,59 | 2,61 | 1,16 | 1,05 | 1,15 |
| | **SD** | 2,12 | 1,82 | 2,04 | 2,29 | 2,39 | 2,13 | 2,50 | 2,43 | 1,16 | 1,03 | 1,19 | 0,96 | 1,07 | 1,16 | 1,02 |
| | **N** | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 |
| **Croatia** | **Mean** | 1,69 | 2,33 | 2,20 | 2,52 | 4,70 | 4,14 | 4,21 | 3,94 | 2,44 | 2,35 | 2,21 | 2,19 | 1,54 | 1,39 | 1,29 |
| | **SD** | 2,22 | 2,32 | 2,12 | 1,94 | 2,27 | 2,40 | 2,43 | 2,45 | 1,11 | 1,01 | 1,06 | 1,02 | 1,14 | 1,17 | 1,15 |
| | **N** | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 |
| **France** | **Mean** | 1,30 | 0,99 | 1,37 | 1,48 | 5,45 | 4,94 | 4,47 | 4,40 | 2,09 | 2,27 | 2,22 | 2,18 | 0,82 | 0,86 | 0,83 |
| | **SD** | 2,33 | 1,86 | 2,15 | 2,24 | 1,99 | 2,14 | 2,29 | 2,31 | 1,09 | 1,13 | 1,10 | 1,12 | 1,32 | 1,10 | 1,26 |
| | **N** | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 |
| **Germany** | **Mean** | 1,94 | 1,88 | 2,25 | 2,55 | 5,20 | 4,67 | 4,16 | 4,01 | 1,91 | 1,98 | 1,96 | 1,94 | 1,60 | 1,63 | 1,66 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SD** | 2,25 | 2,02 | 2,26 | 2,12 | 2,04 | 2,16 | 2,09 | 2,35 | 1,00 | 1,02 | 1,02 | 1,05 | 1,01 | 0,96 | 0,92 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 |
| **Greece** | **Mean** | 1,59 | 1,67 | 2,26 | 2,62 | 5,65 | 5,22 | 5,01 | 5,06 | 2,28 | 2,31 | 2,35 | 2,29 | 0,97 | 1,08 | 1,07 |
| | **SD** | 2,18 | 2,10 | 2,28 | 2,42 | 1,88 | 2,08 | 2,27 | 2,16 | 1,11 | 1,10 | 1,03 | 1,10 | 1,11 | 1,05 | 1,14 |
| | **N** | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 |
| **Hungary** | **Mean** | 1,19 | 1,28 | 1,52 | 1,31 | 4,54 | 3,78 | 4,17 | 3,96 | 2,64 | 2,86 | 2,69 | 2,56 | 1,05 | 1,23 | 1,17 |
| | **SD** | 1,83 | 1,59 | 1,61 | 1,41 | 2,19 | 2,42 | 2,30 | 2,35 | 1,22 | 1,07 | 1,08 | 1,16 | 1,10 | 1,04 | 1,14 |
| | **N** | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 | 149 |
| **Indonesia** | **Mean** | 2,87 | 2,67 | 2,52 | 2,85 | 4,50 | 3,53 | 3,82 | 3,12 | 2,30 | 2,51 | 2,36 | 2,47 | 0,71 | 0,69 | 0,60 |
| | **SD** | 2,77 | 2,63 | 2,62 | 2,75 | 2,47 | 2,35 | 2,41 | 2,46 | 1,29 | 1,10 | 1,21 | 1,12 | 0,99 | 1,02 | 1,31 |
| | **N** | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| **Italy** | **Mean** | 1,35 | 1,21 | 1,86 | 1,94 | 5,92 | 5,43 | 5,21 | 5,12 | 2,35 | 2,46 | 2,59 | 2,56 | 1,32 | 1,18 | 1,13 |
| | **SD** | 2,24 | 1,75 | 2,38 | 2,42 | 1,85 | 2,03 | 2,02 | 2,14 | 1,05 | 0,95 | 1,00 | 0,96 | 0,98 | 1,17 | 1,24 |
| | **N** | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |
| **Kazakhstan** | **Mean** | 1,36 | 1,50 | 1,11 | 2,18 | 5,02 | 3,88 | 3,89 | 3,73 | 2,41 | 2,31 | 2,50 | 2,55 | 1,02 | 0,64 | 0,88 |
| | **SD** | 1,97 | 2,00 | 1,70 | 2,64 | 2,32 | 2,19 | 2,30 | 2,47 | 1,28 | 1,32 | 1,21 | 1,13 | 0,98 | 1,12 | 0,99 |
| | **N** | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 |
| **Netherlands** | **Mean** | 1,67 | 2,05 | 2,06 | 2,40 | 4,50 | 4,43 | 4,17 | 3,62 | 2,01 | 2,15 | 2,28 | 2,26 | 1,26 | 1,16 | 1,07 |
| | **SD** | 2,06 | 2,06 | 1,91 | 1,96 | 2,34 | 2,20 | 2,27 | 2,45 | 1,04 | 0,99 | 1,03 | 1,05 | 0,96 | 0,99 | 1,06 |
| | **N** | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 | 323 |
| **Philippines** | **Mean** | 1,34 | 0,66 | 1,42 | 1,00 | 4,47 | 3,74 | 3,86 | 3,67 | 2,83 | 2,81 | 2,92 | 2,71 | 0,30 | 0,21 | 0,39 |
| | **SD** | 2,31 | 1,65 | 2,32 | 2,04 | 2,42 | 2,67 | 2,36 | 2,35 | 1,20 | 1,17 | 1,10 | 1,02 | 1,20 | 1,37 | 1,34 |
| | **N** | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 |
| **Republic of Serbia** | **Mean** | 1,19 | 1,32 | 1,67 | 1,98 | 5,45 | 5,26 | 5,02 | 4,72 | 2,25 | 2,27 | 2,29 | 2,30 | 0,97 | 1,04 | 1,05 |
| | **SD** | 1,73 | 1,82 | 1,99 | 1,99 | 1,90 | 1,99 | 2,10 | 2,29 | 1,03 | 1,01 | 1,05 | 1,08 | 1,37 | 1,36 | 1,28 |
| | **N** | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| **Romania** | **Mean** | 1,19 | 1,40 | 1,54 | 1,80 | 5,01 | 4,73 | 4,49 | 4,17 | 2,55 | 2,60 | 2,40 | 2,42 | 1,43 | 1,29 | 0,96 |
| | **SD** | 1,79 | 1,98 | 2,00 | 1,98 | 2,28 | 2,38 | 2,13 | 2,59 | 1,33 | 1,43 | 1,22 | 1,14 | 1,44 | 1,15 | 1,32 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Russia** | **N** | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 |
| | **Mean** | 1,47 | 1,88 | 1,32 | 1,22 | 5,28 | 5,04 | 5,18 | 3,89 | 2,19 | 2,17 | 2,36 | 1,78 | 0,75 | 0,70 | 1,11 |
| | **SD** | 2,29 | 2,58 | 2,45 | 2,02 | 2,22 | 2,14 | 2,16 | 2,81 | 1,23 | 1,09 | 1,10 | 0,88 | 1,42 | 1,13 | 1,23 |
| **Singapore** | **N** | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| | **Mean** | 3,79 | 2,00 | 1,59 | 1,97 | 3,77 | 3,70 | 3,82 | 3,33 | 2,85 | 2,70 | 2,35 | 2,70 | 0,52 | 0,66 | 0,85 |
| | **SD** | 2,61 | 2,57 | 2,74 | 2,80 | 2,77 | 2,25 | 2,42 | 2,47 | 1,11 | 1,15 | 1,01 | 1,06 | 1,05 | 1,20 | 1,15 |
| **South Africa** | **N** | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 |
| | **Mean** | 3,00 | 2,05 | 1,78 | 2,24 | 5,04 | 3,77 | 4,65 | 4,10 | 2,24 | 2,50 | 2,43 | 2,52 | 0,98 | 1,11 | 1,36 |
| | **SD** | 2,77 | 2,55 | 2,43 | 2,39 | 2,52 | 2,54 | 2,31 | 2,64 | 1,23 | 1,22 | 1,16 | 1,21 | 0,91 | 1,19 | 1,09 |
| **Spain** | **N** | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | **Mean** | 0,82 | 0,84 | 0,89 | 1,01 | 5,77 | 5,23 | 5,12 | 5,09 | 1,93 | 2,18 | 2,19 | 2,11 | 1,89 | 1,85 | 1,76 |
| | **SD** | 1,71 | 1,76 | 1,77 | 1,78 | 1,79 | 2,01 | 2,04 | 2,06 | 1,07 | 1,06 | 1,04 | 1,02 | 0,99 | 1,02 | 1,03 |
| **Turkey** | **N** | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 | 631 |
| | **Mean** | 1,42 | 0,88 | 1,24 | 1,41 | 5,08 | 5,00 | 4,23 | 3,92 | 2,46 | 2,54 | 2,64 | 2,61 | -0,53 | -0,32 | -0,21 |
| | **SD** | 1,84 | 1,38 | 1,71 | 1,87 | 2,08 | 1,91 | 2,07 | 2,25 | 1,08 | 1,17 | 1,12 | 1,14 | 1,39 | 1,48 | 1,43 |
| **Ukraine** | **N** | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 |
| | **Mean** | 2,02 | 1,63 | 2,21 | 2,10 | 4,73 | 4,58 | 4,65 | 3,84 | 2,06 | 2,20 | 2,02 | 2,08 | 0,40 | 0,63 | 0,40 |
| | **SD** | 2,38 | 2,00 | 2,27 | 2,33 | 2,40 | 2,52 | 2,15 | 2,50 | 1,09 | 1,05 | 1,08 | 1,06 | 1,15 | 1,13 | 1,36 |
| | **N** | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| **United Kingdom** | **Mean** | 1,58 | 1,21 | 1,50 | 1,60 | 4,71 | 4,48 | 4,09 | 4,21 | 2,11 | 2,20 | 2,12 | 2,19 | 0,86 | 0,81 | 0,78 |
| | **SD** | 2,17 | 1,92 | 2,27 | 2,17 | 2,46 | 2,29 | 2,35 | 2,31 | 1,15 | 1,14 | 1,10 | 1,13 | 1,18 | 1,21 | 1,13 |
| | **N** | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 |
| **United States of America** | **Mean** | 1,76 | 1,41 | 1,46 | 1,69 | 3,80 | 3,45 | 3,38 | 3,30 | 2,44 | 2,51 | 2,47 | 2,42 | 0,47 | 0,40 | 0,45 |
| | **SD** | 2,37 | 2,08 | 2,13 | 2,21 | 2,58 | 2,41 | 2,39 | 2,47 | 1,12 | 1,10 | 1,10 | 1,09 | 1,29 | 1,29 | 1,31 |
| | **N** | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 | 1634 |

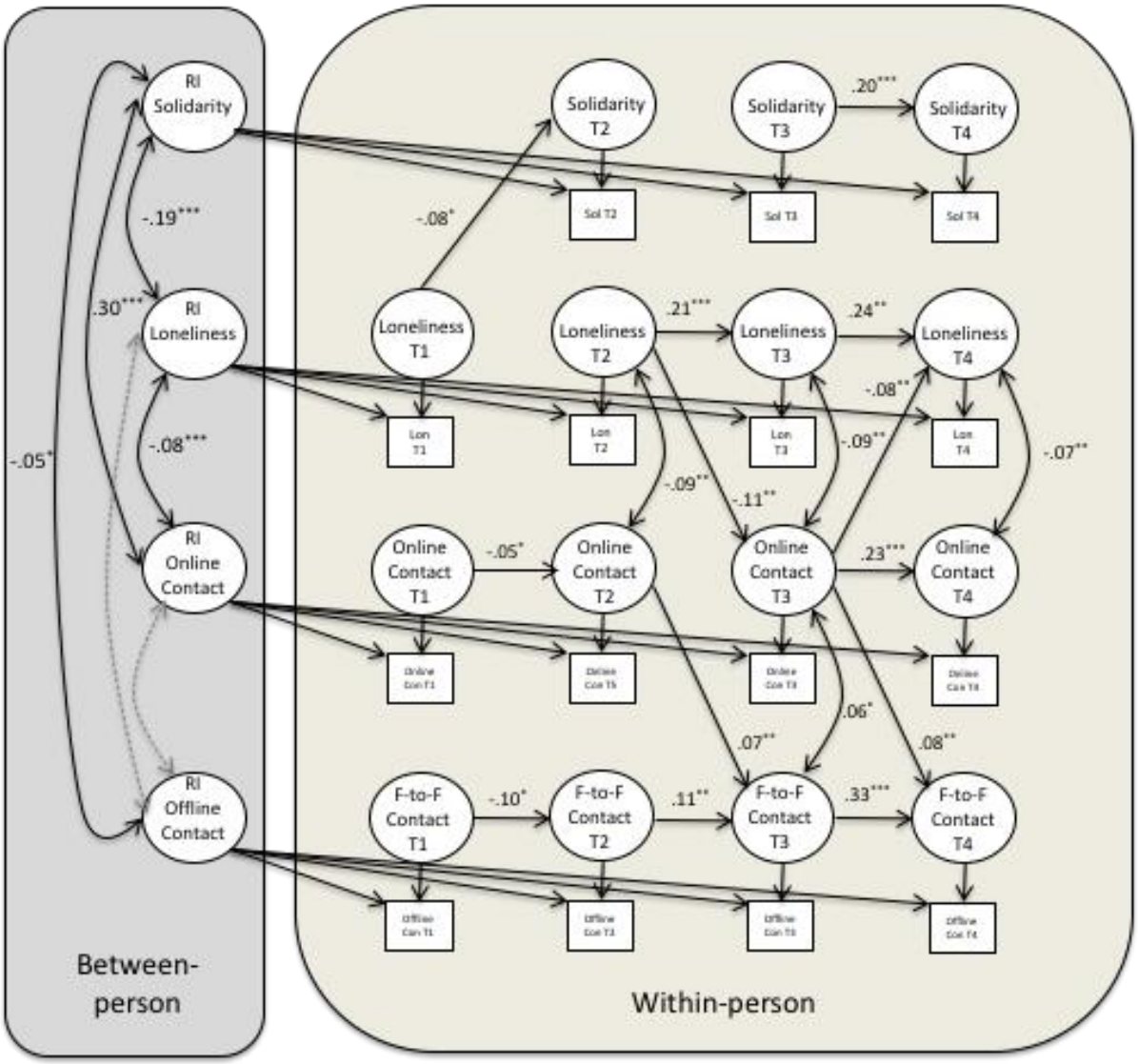
**Table 3**

Overview of the autoregressive effects modelling change in each of the central variables.

| | From T1 to T2 | | From T2 to T3 | | From T3 to T4 | |
|---|---|---|---|---|---|---|
| **Autoregressive effect** | **b (SE)** | **p-value** | **b (SE)** | **p-value** | **b (SE)** | **p-value** |
| Loneliness | .02 (.04) | .572 | 0.21 (0.04) | .000 | 0.24 (0.03) | .000 |
| Online contact | -05 (.02) | .025 | 0.05 (0.03) | .117 | 0.23 (0.03) | .000 |
| Face-to-face contact | -0.10 (0.04) | .009 | 0.11 (0.04) | .006 | 0.33 (0.03) | .000 |
| Solidarity | - | - | 0.06 (.06) | .378 | 0.20 (0.05) | .000 |

**Figure 3**

Random intercept cross-lagged panel model. The model is fully saturated with cross-lagged and auto-regressive paths included. However, for clarity, only paths that reach significance are shown.



## Discussion

In this paper, we studied how social contacts and feelings of solidarity shape experiences of loneliness during the COVID-19 lockdown. Our analyses demonstrated that fewer online contacts were associated with more loneliness at the between-person level (in line with Hypothesis 2b). Solidarity and loneliness were also negatively correlated at the between-person level, so that greater solidarity was associated with lower feelings of loneliness (in line with Hypothesis 4). These findings suggest that both solidarity and the availability of online contact can help people manage the strain of lockdown. When we consider changes *within* people over time, however, our hypotheses received only weak support. We only found support for the idea that more frequent online contacts are associated with reduced feelings of loneliness the following week, and as such H3 was partially supported.

The unexpected patterns may nevertheless be informative. First, results showed that, after an initial drop ($T_1$-$T_2$), the number of face-to-face contacts outside the home began to increase in the later weeks ($T_2$-$T_3$; $T_3$-$T_4$). Second, the number of online contacts also increased over time, but they did not *replace* face-to-face contacts (as H1 suggested). Within individuals, more frequent online contact with friends and relatives within a given week, predicted *more* frequent face-to-face contacts with them in subsequent weeks. Such a positive relationship between the types of contact is in line with evidence for reinforcement effects (see e.g. Dienlin et al., 2017) in the literature on computer-mediated communication. The positive relationship between online and offline contacts over the weeks might be explained with reference to general sociability (as noted above), whereby those who have more online contacts also have more face-to-face contacts outside the home (Lee, 2009), relative to those who have few online contacts, simply because they are more sociable. However, an effect of

sociability cannot explain our findings here, because our current findings identify change *within individuals* over the weeks. Rather, this effect might arise because online contact with one's friends and family makes people more acutely aware of the desire to meet face-to-face, making it more difficult to resist the 'temptation' the following week. More practically speaking, people might use the online contact moment to make plans to meet face-to-face the following week. In sum, it seems that the pursuit of social connectedness can translate to behaviour that - from an epidemiological perspective - constitutes risk behaviour, namely more frequent face-to-face contact during lockdown. This finding is in line with the patterns demonstrated elsewhere (e.g. RIVM, 2020).

Turning to feelings of loneliness, several interesting patterns appeared. We saw that - as expected - loneliness and online contact showed reciprocal influences. Greater feelings of loneliness at $T_2$ were associated with *reduced* online contacts at $T_3$. Less frequent online contacts at $T_3$ then predicted greater feelings of loneliness at $T_4$ (in line with H4a). This finding suggests that people who feel more lonely are less likely to pursue online contacts, which in turn leads them to feel more lonely, and thereby creating a 'vicious cycle' of loneliness (see also Saeri et al., 2011; Cacioppo & Patrick, 2008; Caplan, 2003). We had argued that feelings of loneliness would motivate people to seek more contacts the following week (H4a), based on the fact that the temporary nature of the lockdown would result in feelings of loneliness that are situational rather than chronic. However, our findings suggest that the feelings of loneliness triggered by lockdown function more as *chronic* feelings of loneliness – leading people to withdraw further. This finding might be integrated with findings from previous work by suggesting that the lockdown did not lead to increases in feelings of loneliness overall (Luchetti et al., 2020), but specifically affected those who are already at risk of (chronic) loneliness (see also Killgore et al., 2020).

Loneliness, social contacts and solidarity during lockdown

Regarding the relationship between feelings of loneliness and solidarity, feelings of solidarity seemed to have little effect on people's feelings of loneliness during lockdown. There was little change in solidarity over the study period - feelings of solidarity neither increased nor decreased. Further, any small changes in solidarity that did occur did not impact feelings of loneliness. In interpreting this finding, it is worth noting that our measure of solidarity was included from $T_2$ (early April) onwards, that is, our findings cannot speak to any effects that solidarity might have over a longer time period, or any changes that may have occurred earlier in the pandemic.

Although our research question (and hypotheses) focused on loneliness, we analysed interrelationships amongst all variables, including the relationship between contacts and solidarity. Regarding this relationship, we might have expected that solidarity would affect the contacts people seek. Research has shown that solidarity encourages normative behaviour (Drury et al., 2016; Gee & McGarty, 2013), and in this context, this might translate to a tendency to avoid face-to-face contact, and focus on online contact instead, in line with government guidelines. There was some evidence for this at the between-persons level – people who felt greater solidarity had more online contacts and (somewhat) fewer face-toface contacts than those who felt less solidarity. As such, this finding suggests that at the population level greater solidarity is associated with greater norm compliance. However, these effects did not come across at the within-person level – that is, there was no evidence that feelings of solidarity produced changes in behaviour on a week-by-week basis.

Finally, we would like to raise two methodological points. First, our analysis indicated very little difference between the 23 countries under study. This may be due in part to the fact that we chose to focus on a time period when lockdown was widespread and as such the situation in different countries was relatively comparable, but nevertheless speaks to the

generalizability of these findings. Second, the attrition analysis indicated that feelings of loneliness impacted attrition, so that those who felt more lonely at baseline were less likely to participate in the later survey waves. This may go some way to explaining why absolute levels of loneliness did not seem to increase over the course of lockdown (see the autoregressive effects, as well as Luchetti et al., 2020). More generally, this suggests that research is likely to underestimate true levels of loneliness if those who are feeling especially lonely are less likely to be represented in data.

One of the aims of this work was to situate our findings within the public discourse surrounding lockdown. Overall, we might say that the public discourse is quite accurate in capturing differences between individuals. The between-persons effects showed that people who feel more solidarity and have more online contacts, are less likely to feel lonely during lockdown, relative to people who have fewer online contacts and feel less solidarity. These between-persons effects, then, are in line with the public discourse on the topic ("Coronavirus and Loneliness", 2020; "Loneliness during Coronavirus", 2020; COVID-19 virtual press conference, 2020). However, the within-person effects arising from our analysis do not have clear parallels in the public discourse. Specifically, the public discourse does not seem to consider the reciprocal relationship between loneliness and social contact, whereby people who feel lonely find it increasingly difficult to pursue the social connections they need. That is, encouraging online contact as a method to avoid loneliness may be of limited use to those who feel lonely.

Additionally, the finding that solidarity did not predict changes in feelings of loneliness has interesting implications for policy. In a number of countries, government agencies invested in generating a sense of solidarity amongst citizens, for instance through advertising campaigns using variations on a theme of 'Stronger Together' (in Italy, in the

Netherlands, in the United Kingdom). However, very little change was observed in levels of solidarity amongst our participants, and those changes that did occur did not predict changes in the behaviours under study (engagement in online and face-to-face contacts). Although this issue was not the central objective of our study, it raises questions regarding the effectiveness of such campaigns.

Finally, when discussing online contact as an alternative to face-to-face contact the public discourse typically does not consider whether people actually use online contact in this way – our analysis suggests that online and face-to-face contact do not function as substitutes. In sum, results from this work show that, while the public discourse gives a relatively accurate account of how different individuals are affected by lockdown, changes within individuals over the course of lockdown were not captured in the public discourse.

**Strengths and Limitations.** The dataset used in this work has both strengths and limitations. First, the longitudinal nature of the dataset is a strength, following people over a 6-week period during the height of lockdown. At the same time, 6 weeks is a relatively short period, and as such this dataset might be more accurately described as 'shortitudinal' (Dormann & Griffin, 2015). Certainly, it seems reasonable to assume that phenomena such as loneliness develop over longer periods of time, and we might thus expect the effects we identify here to be strengthened if the full lockdown had been longer. Second, participants from many different countries were included in the dataset. This feature, too, represents both a strength, in the sense that many diverse perspectives were included, but also a weakness, in the sense that not all countries were equally represented – the United States and European countries were over-represented. Similarly, the sample included more women than men. In sum, the sample represents a convenience sample, and as such is not representative of the

general population. Likewise, to what extent these results generalize to other stressful contexts requires future study.

One further limitation that requires discussion is the fact that the social contact variables focused on social contacts *outside the household*. That was the domain that was most restricted during the pandemic. However, it stands to reason that social contacts within the household (i.e. household composition) may also affect loneliness – when contacts outside the household are restricted a person who lives alone may suffer more from that than a person who lives with others. We incorporated household composition into our model, and ran multiple-group analyses to examine whether the processes may indeed be different for those who live with others and those who live alone. There was no evidence for such differences, the results supported the idea of equivalence across the two groups. This model is described in detail in the supplementary materials.

**Conclusion.** In this work, we examined how people can meet their need for social connectedness and avoid loneliness during the COVID-19 lockdown, when face-to-face contacts were restricted. We analyse inter-relationships amongst feelings of loneliness, solidarity, online contact and face-to-face contact, using longitudinal data collected over a six-week period between March-May 2020. We situated these findings within the public discourse on the lockdown, to highlight areas of misunderstanding between the public interpretation of lockdown and the findings arising from the data. Our analysis highlights, first, that although online contacts are beneficial in combating feelings of loneliness, they cannot fully substitute face-to-face contact. Second, our analysis highlights that feelings of loneliness limited people's ability to reach out to others via available means (e.g. online contacts). In sum, our findings suggest that we must look beyond the current focus on online contact and solidarity, if we want to help people address their feelings of loneliness. We hope

these findings will help to better understand the social effects of lockdown, and – should future lockdowns be required – prepare for those effectively.

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