



**Master of Public Health  
Master de Santé Publique**

## **Social Support, Loneliness and Mental Health during the COVID-19 Pandemic in France: A Longitudinal Study**

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## List of Acronyms

<b>BIC</b>	<b>Bayesian Information Criteria</b>
<b>CAWI</b>	<b>Computer Assisted Web Interview</b>
<b>CCP</b>	<b>Committee for the Protection of People (French)</b>
<b>COVID-19</b>	<b>Coronavirus Disease (2019)</b>
<b>EHESP</b>	<b>École des Haute Études en Santé Publique</b>
<b>EU</b>	<b>European Union</b>
<b>GAD-7</b>	<b>Generalized Anxiety Disorder Scale</b>
<b>H1N1</b>	<b>Influenza A virus subtype (A/H1N1)</b>
<b>MERS</b>	<b>Middle East Respiratory Syndrome</b>
<b>RGPD</b>	<b>General Data Protection Regulation (French)</b>
<b>OSSS-3</b>	<b>Oslo Social Support Scale</b>
<b>PHQ-9</b>	<b>Patient Health Questionnaire Scale</b>
<b>PTSD</b>	<b>Post-traumatic Stress Disorder</b>
<b>SARS</b>	<b>Severe Acute Respiratory Syndrome</b>
<b>SARS-COV-2</b>	<b>Severe Acute Respiratory Syndrome coronavirus 2</b>
<b>SUBS</b>	<b>Substance Use Brief Screen</b>
<b>WHO</b>	<b>World Health Organization</b>

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## Abstract

**Introduction:** In times of crisis and stress, some factors, like social support, seem to protect mental health against adversities, however, other factors like feelings of loneliness are reported to increase negative mental health outcomes. In COVID-19 specifically, little is known on how social support and loneliness are evolving over time in France, and their impact on mental health. In line with this context, we aimed to (1) study the longitudinal trajectories of social support and loneliness in France during the COVID-19 pandemic, (2) explore which factors predict these longitudinal trajectories to identify the vulnerable groups in the population, and (3) determine if variations of these trajectories predict symptoms of depression and anxiety.

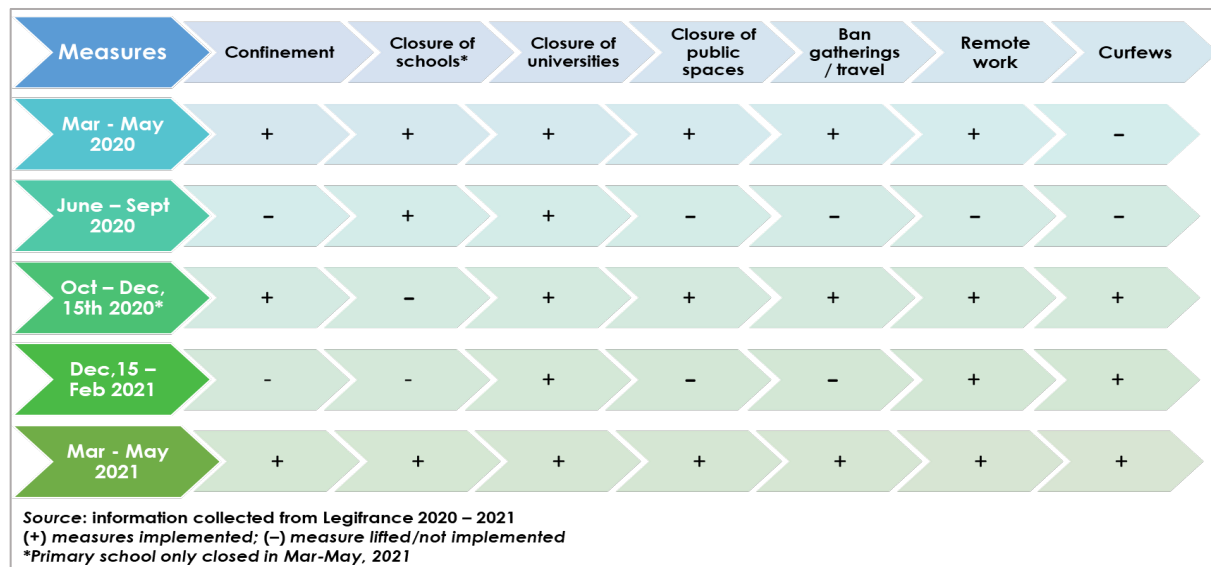
**Methods:** Data from 681 individuals in the COMET study collected at four periods of time from May 2020 until April 2021 was used. Group-based trajectory modelling was used to analyse social support and loneliness trajectories. Sociodemographic, health and COVID-19 related factors were explored through multinomial logistic regression to identify the predictors of these trajectories. Finally, linear regression models were used to test the association between the trajectories and symptoms of depression and anxiety. **Results:** Social support trajectories revealed four stable groups: 'poor' (17.0%), 'moderate' (42.4%), 'strong' (35.4%) and 'very strong' (5.1%). Loneliness trajectories identified also four groups: 'low stable' (17.8%), 'low rising' (40.2%), 'moderate stable' (37.6%) and 'high rising' (5.0%). Being single was a predictor of belonging to both: 'low social support' group (OR = 3.24, 95% CI [1.41 – 7.33]) and 'high rising' loneliness group (OR = 6.04, 95% CI [1.10 – 33.05]). Individuals with mental illnesses were more likely to belong to high loneliness groups. Higher levels of loneliness were associated with high symptoms of depression and anxiety, but not social support ( $\beta = 7.05$ , 95% CI [4.96 – 9.14]). **Conclusion:** Our findings showed that high and increasing levels of loneliness during the COVID-19 pandemic are predictive of increased symptoms of depression and anxiety. Specifically, single individuals and those with mental illnesses are mostly at risk. Interventions designed to combat loneliness are necessary during the pandemic and after.

**Key words:** COVID-19, social support, loneliness, mental health.

# Introduction

## COVID-19 pandemic

The COVID-19 pandemic, caused by the virus SARS-COV2, started in late 2019 with the first case registered in Wuhan, China (WHO, 2020). The pandemic and its containment measures have physically, psychologically and financially impacted, and are continuing to do so, the lives of many individuals across the globe (Haleem, et al., 2020). France has been one of the European countries that were particularly affected by the spread of COVID-19. Up until May 2021, more than 5.5 million COVID-19 cases have been reported in France and more than 100,000 deaths (Santé Publique France, 2021a). To counter the spread of the virus, the French government announced the first national lockdown on March 17, 2020, which lasted approximately two months. During this time, France witnessed its first peak of COVID-19 reported cases and deaths. The lockdown mandated the closure of schools and companies and favored stay-at-home measures unless for exceptional needs (Vie Publique, 2020a). A second, less strict, lockdown was imposed between October 28 and December 15, 2020 after a surge in COVID-19 infections in the country (Vie Publique, 2020b). Furthermore, a third lockdown was also imposed on March 20, 2021 in 16 departments in France and extended to metropolitan France on April 3, 2021 lasting until May 3, 2021. In between lockdowns, the French population had to comply with strict sanitary measures including wearing masks, social distancing, remote working and various curfews (Vie Pulique, 2021). Figure.1 summarizes the timeline of some measures taken facing the pandemic in France.



**Figure 1. The timeline of measures taken in France facing the COVID-19 pandemic in 2020-2021**



## **COVID-19's Impact on Mental Health**

While significant efforts focus on protective and treatment measures to battle the spread of the disease, the impact the pandemic might have on a person's overall mental health also requires attention. Exposure to acute and chronic psychological stress is predictive of a wide range of physical (obesity, cardiovascular and inflammatory diseases) and mental (traumatic stress symptoms, anxiety disorders, depression) disorders (Turner, et al., 2020; Yaribeygi, 2017). As such, the unprecedented situation imposed by COVID-19 likely contributes to a deterioration in physical and mental health. Previous pandemics have been shown to negatively impact the population's mental health, whether from fear of the disease itself, the impact of the imposed sanitary measures (like quarantine and social distancing) or the impact on the economy (Brooks, et al., 2020; Pfefferbaum & North, 2020). For example, lockdowns in the context of Spanish Flu, SARS, H1N1, Ebola and MERS were found to be associated with increased symptoms of anger, anxiety, depression and PTSD during and even after these pandemics had ended (Brooks, et al., 2020; Jeong, et al., 2016; Kelly, 2020; Maunder, 2009). Likewise, evidence emerges for the impact the current COVID-19 pandemic has on the population's mental health. Globally, increased prevalence rates have been reported for mental health problems. Results from systematic reviews reported prevalence rates of 8.1 – 81.9% for stress, 6.3 – 50.9% for anxiety, 14.6 – 48.3% for depression and 7.0 – 53.8% for PTSD (Cénat, et al., 2021; Henssler, et al., 2021; Luo, et al., 2020; Salari, et al., 2020; Wang, et al., 2020; Xiong, et al., 2020). Specific to France, in a cross-sectional study conducted in May 2020, severe depressive symptoms reached 8.8% and severe anxiety symptoms 8.7%, whereas around 70% of the respondents reported having sleep problems (Peretti-Watel P, 2020). Furthermore, ongoing cross-sectional data collected by the French national public health agency revealed that the prevalence of both anxiety and depression symptoms reached a peak of 22.7% in February 2021, compared to 13.5% and 9.8% respectively in 2017 (Santé Publique France, 2021b). In addition, France witnessed a doubling of suicidal thoughts during the third confinement compared to pre-pandemic (Santé Publique France, 2021b). Furthermore, half of the general practitioners have reported that, consultations related to stress, anxiety and depression were the sole consultation-types to increase during confinements besides those for COVID-19 symptoms (Monziols, et al., 2020).

Certain groups in the population are potentially more at risk than others for adverse mental health outcomes. Studies have identified that those infected by COVID-19, those considered at high-risk for infection (for example, elderly, healthcare workers, immunocompromised patients), those with pre-existing mental health symptoms or disorders, those with pre-existing physical

problems, and those with substance use problems are at increased risk for mental health problems in the context of the pandemic (Amerio, et al., 2020; Pfefferbaum & North, 2020). In addition, other groups reported to have increased depression and anxiety symptoms are women, students, singles and persons with less family and neighborhood support, persons with a lower income, those who fear contracting the virus. (Henssler, et al., 2021; Vindegaard & Eriksen, 2020; Xiong, et al., 2020). It was also demonstrated that university students showed increased symptoms of depression and anxiety during the pandemic (Essadek & Rabeyron, 2020; Husky, et al., 2020; Wathélet M, 2020).

While stressors such as disease, trauma and chronic stress are associated with psychiatric symptoms or disorders, studies show that some people are more resilient to these stressors and are therefore less likely to develop adverse mental health outcomes (Davydov, et al., 2010). In general, resilience factors are protective factors that shield the person against mental health outcomes during adversities (Bonanno, 2004). Even though certain psychosocial factors have been identified as increasing the overall negative impact of COVID-19 (Hossain, et al., 2020) some personality traits have been shown to correlate with positive psychological outcomes. Individuals with positive coping styles, or secure and avoidant attachment styles, usually presented fewer symptoms of anxiety and stress (Wang, et al., 2020). Besides, other factors might also be protective against negative psychological outcomes during the pandemic such as having access to accurate COVID-19 news in a timely manner, or actively following precautionary measures (i.e. washing hands physical distancing and wearing a mask) (Xiong, et al., 2020).

## **Social support and loneliness: impact on mental health**

### **Social support**

In the context of the COVID-19 pandemic and the associated containment measures, one resilience factor of particular interest is social support. Social support refers to accessible support provided by an individual's social network and it plays a major role in protecting from mental illnesses (Cohen & Wills, 1985). Social support is a multi-faceted concept and while consensus has not yet been achieved on its components it can generally be divided into two dimensions: structural and functional (Kocalevent, et al., 2018). While the structural dimension refers to the size of the social network and frequency of interaction with it, the functional dimension refers to the quality of support that the network provides through emotional support (i.e. love and empathy) or instrumental support (i.e. gifts or assistance in chores) (Cohen & Wills, 1985). Two other related

dimensions are received social support- i.e. the supportive actions of others or perceived social support- the belief that support is available (Lakey & Cohen, 2000).

Absence or insufficiency of social support has been linked to negative mental health outcomes (Bonanno, 2004). In a systematic review and meta-analysis, social support was found to have a protective role for depression in adults (pooled OR = 0.74, 95% CI (0.72 – 0.76)) (Gariépy, 2016). In addition, a cross-sectional study on Italian older adults showed that perceived emotional support was protective against anxiety and depression through active help-seeking behavior from their social network (Nicolini, et al., 2021). Also, spousal support is reported to be the most protective against depression, followed that from friends and then family (Gariépy, 2016). Other studies focusing specifically on women have shown that increased social support was linked to increased well-being (Beesley, et al., 2018). However, gender roles in social support are not consistent as studies say women report higher levels of social support (Pillemer & Holtzer, 2016), and other studies found no relationship (Kocalevent, et al., 2018).

### **Social support and mental health during the COVID pandemic**

Although not much research has been conducted exploring the role of social support in mental health problems during the COVID-19 pandemic, a systematic review has shown that social support was protective against traumatic stress, burnout and anxiety in healthcare workers (Labrague, 2021). Furthermore, a 5-month longitudinal study in the UK, starting in parallel with lockdown in March 2020, reported that sufficient social support was associated with a faster decrease in symptoms of depression and anxiety over time (Fluharty, et al., 2020). Another longitudinal study conducted in the US, reported increased mental distress in individuals with low social support. While social distancing might be a risk factor for mental illness in times like the COVID-19 pandemic, exceptional social support, received through for example social media platforms, is a strong predictor for resilience (Riehm, et al., 2021).

### **Loneliness**

While social support might contribute to a person's resilience to mental health problems, loneliness could be a risk factor for mental health problems. Loneliness is defined as a distressing emotion that comes with the belief that one is socially isolated (Hawkley & Cacioppo, 2010). Loneliness is widely defined as: "a subjective negative feeling associated with a perceived lack of a wider social network (social loneliness) or the absence of a specific desired companion (emotional loneliness)" (Valtorta & Hanratty, 2013). Loneliness is not the equivalent of solitude or being alone, in fact, people can live relatively solitary lives and not feel lonely, or they can live abundant social lives yet still feel lonely (Hawkley & Cacioppo, 2010).

Results of European Social Survey in 2014 showed that the prevalence of loneliness in Europe is around 9% in adults, although Western Europe reports lower levels of loneliness (6.6%) compared to other European regions (10.8% for Eastern Europe), 1 in 10 people in France reports feeling frequently lonely (D'Hombres, et al., 2021).

Loneliness is a serious public health threat being associated with negative physical and mental health outcomes. A systematic overview showed that there is a significant relation between loneliness and increased all-cause mortality (Leigh-Hunt, et al., 2017). It is associated with impaired cognitive decline over time, (Boss, et al., 2015), dementia, Alzheimer's disease (Sundström, et al., 2020), and suicide (Calati, et al., 2019). Regarding mental health, several studies have reported an association between loneliness and depression (Cacioppo, et al., 2006 ; Erzen & Çikrikci, 2018; Tiikkainen & Heikkinen, 2010) and anxiety (Wang, et al., 2018). In addition, it has been shown that loneliness can be a risk-factor for substance abuse such as alcohol (Åkerlind & Hörnquist, 1992). Research has highlighted that some people are more vulnerable to feeling loneliness than others. Women, elderly, young adults, those living alone and having a small social network, and those with previous mental illnesses report more loneliness (Pinquart & Sörensen, 2003; Shovestul, et al., 2020).

### **Loneliness and mental health during the COVID-19 pandemic**

During the COVID-19 pandemic, loneliness has been reported to increase because of the sanitary measures and social isolation and has been associated with decreased mental health outcomes as well. A study during the third week of lockdown in the United States has shown that loneliness during the pandemic is linked to higher levels of depression and suicide (Killgore, et al., 2020). Also, a longitudinal study in four European countries (including France) reported the increase in loneliness during the pandemic specially for young adults and those with a history of mental illness (Varga, et al., 2021). Another cross-sectional study in the early phases of the pandemic in Spain found that, among other risk factors, loneliness was the strongest predictor of depression and anxiety (González-Sanguino, et al., 2020).

## **Aim of the study**

The COVID-19 pandemic and the accompanied sanitary measures provide a specific context in which to study the association between social support, loneliness and subsequent mental health outcomes. The current literature on the effect of the pandemic on mental health is mostly based on cross-sectional designs or on specific groups (e.g. healthcare workers), which doesn't allow to observe changes in social support and loneliness over time and for the general population.

In addition, little is known on the sociodemographic and pandemic related factors that may be associated with social support and loneliness trajectories in the context of COVID-19 pandemic.

Finally, few studies have investigated how a person's trajectories of social support and loneliness during the pandemic might contribute to increased risk of mental health problems, and to our knowledge there are no studies on the matter in the French population during the pandemic.

Identifying these factors and groups within the general population provides useful information for the development and implementation of mental health policies and interventions in the context of this crisis.

## **Study objectives**

We aim to study the longitudinal trajectories of social support and loneliness in France during the COVID-19 pandemic and determine their impact on mental health. Our specific objectives are:

- To examine how social support and loneliness evolve over time during the COVID-19 pandemic.
- To determine which factors predict these longitudinal trajectories.
- To examine if variations in these trajectories are predictive of adverse mental health outcomes, in particular, symptoms of anxiety and depression.

## **Methods**

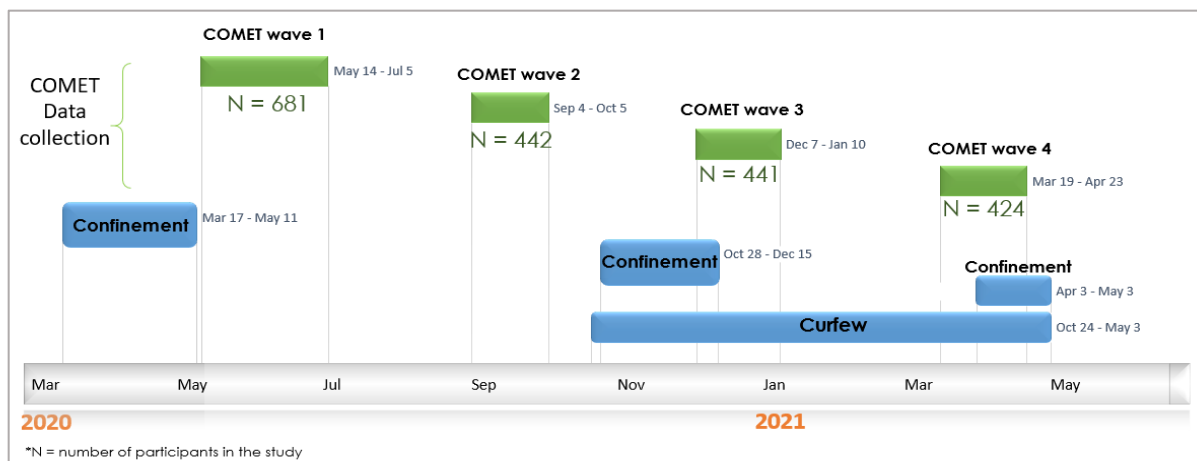
### **Study Design**

The COMET study is an international, online longitudinal survey aimed at the evaluation of the course of mental health symptoms during the COVID-19 pandemic and the identification of the individuals who are at risk or resilient to these symptoms. The COMET consortium includes participants from 14 countries (The Netherlands, Italy, Switzerland, Turkey, Spain, Germany, France, United Kingdom, Sweden, South Africa, Indonesia, China, Australia and the United States). Participants were recruited in May 2020 through a snowball sampling strategy using university mailing lists and different social network platforms (Facebook, Instagram, Twitter, etc.).

Inclusion criteria for participation in the study were: (a) Being 18 years of age or older (b) Having an adequate command of one of the study languages (Dutch, English, German, Italian, French, Swedish, Turkish, Mandarin, or Bahasa Indonesia); (c) Check mark the online informed consent. Prior to answering, participants were given information about the study and its objectives and an informed consent from their part was provided through a secure web link before starting the survey. Participation was voluntary and participants were free to withdraw from the survey at any time. Additionally, participants were compensated with an entry into a draw for one of ten “50 euros” vouchers. In total, 8,084 participants were recruited for participation in the first data wave.

Included participants were invited to complete a Computer Aided Web Interviewing (CAWI) survey containing validated questionnaires on, among others, depression, anxiety, PTSD, substance use, loneliness, coping, social support, contamination fear, social value orientations as well as questions on socio-demographic factors and their current situation during the COVID-19 pandemic. Questionnaires were available in the different languages of the participating countries. After the first data wave, participants were invited to contribute to 3 additional data collection waves, that took place in September 4<sup>th</sup> - October 5<sup>th</sup> 2020 , December 7<sup>th</sup> , 2020 - January 10<sup>th</sup>, 2020 and March 19<sup>th</sup> - April 23<sup>rd</sup>, 2021. For the specific purpose of this research, we will only use the data from participants who indicated during the first data collection wave to be residing in France. Initially, 681 French participants were recruited, with n= 442, n= 441 and n=424 participating in the follow-up waves. Figure 2 shows the COMET data collection waves with respect to the confinement dates in France.

For France, EHESP is the study sub-contractor and has assured that the French contribution to the COMET consortium is in accordance with French regulations concerning the *Comité de Protection des Personnes* (CCP), the *Règlement Général sur la Protection des Données* (RGPD) and the *Informatique et Libertés* law. Personal data is protected according to EU and national laws.



**Figure 2. COMET data collection waves with respect to the confinements in France in 2020-2021**

## Measures

**Social support:** at each data wave, social support was measured using the Oslo Social Support Scale (OSSS-3) (Kocalevent, et al., 2018). This scale determines the level of social support covering different aspects of it based on the three following questions and answers:

1. *How many people are so close to you that you can count on them if you have great personal problems?* (1 = none, 2 = 1-2, 3 = 3-5, 4 = 5+)
2. *How much interest and concern do people show in what you do?* (1 = none, 2 = little, 3 = uncertain, 4 = some, 5 = a lot)
3. *How easy is it to get practical help from neighbors if you should need it?*  
(1 = very difficult, 2 = difficult, 3 = possible, 4 = easy, 5 = very easy)

The OSSS-3 score ranges from 3-14, with higher scores being indicative of higher levels of social support. Usually the applied categories are: score of 3-8 = poor support; 9-11 = moderate support; and 12-14 = strong support (Kocalevent, et al., 2018). In our study, the average Cronbach alpha for the OSSS-3 scale over the 4 waves is 0.73.

**Loneliness:** at each data wave, feelings of loneliness were measured with a single item question (“*Do you feel lonely*”) allowing to provide insight into participants’ subjective feeling of loneliness. Scores range from 1-5 with a score of 1 = never, 2 = rarely, 3 = sometimes, 4 = often and 5 = frequently. Using a single item to measure loneliness is an accepted practice in large scale surveys and this approach has been shown to be highly correlated with multidimensional scales like the University of California Los Angeles (UCLA) loneliness scale (Russell, 2010) and the De Jong Gierveld Loneliness scale (De Jong Gierveld & Van Tilburg, 2006), which suggests

that the single-item approach does indeed capture some aspects of loneliness (Victor, et al., 2006).

### **Mental health:**

The following self-report measures were included to assess psychological difficulties. All measures are validated questionnaires widely used in mental health research, with good psychometric properties:

*Depression:* The Patient Health Questionnaire (PHQ-9) (Kroenke & Spitzer, 2002) is a common self-report measure used to screen depressive symptoms. The questionnaire includes 9 questions (for example: “*Over the past two weeks, have you been bothered by having little interest or pleasure in doing things?*”) with a 4-option answer: 0 = not at all, 1 = several days, 2 = more than half the days and 3 = nearly every day. Overall scores range from 0 to 27, with scores of 0-4 indicating minimal depression, 5-9 = mild depression, 10-14 = moderate depression, 15-19 = moderately severe depression and  $\geq 20$  = severe depression. We also created a binary score, in which those who scored less than 10 were considered to have no depression and more than 10 to have depression (Manea, et al., 2011). In our study, the average Cronbach alpha for the PHQ-9 scale for the 4<sup>th</sup> wave was 0.88. The questionnaire has been translated to French (The Full questionnaire is in Appendix.1).

*Anxiety:* The Generalized Anxiety Disorder scale (GAD-7) (Spitzer, et al., 2006) is a reliable and valid 7-questions scale that measures anxiety symptoms (for example: “*For the past two weeks, how often have you been bothered by: feeling nervous, anxious or on edge?*”). Each item is scored on a 0-3 scale (0 = not at all, 1 = several days, 2 = over half the days and 3 = nearly every day). Overall scores range from 0-21, with scores of 0-4 indicating minimal anxiety, 5-9 = mild anxiety, 10-14 = moderate anxiety, and 15-21 = severe anxiety. We also created a binary score, in which those who scored less than 10 were considered to have no depression and more than 10 to have depression (Plummer, et al., 2016). In our study, the average Cronbach alpha for the GAD-7 scale for the 4<sup>th</sup> wave was 0.91. The questionnaire has been validated in French (Micoulaud-Franchi, et al., 2016) (The full questionnaire is in Appendix.1).

### **Predictors and covariates**

Based on the scientific literature, we identified several socio-demographic, psychosocial and COVID-19 related characteristics potentially associated with social support and loneliness trajectories. (Brooks, et al., 2020; Bu, Steptoe, & Fancourt, 2020a; Gariépy, 2016 ; Stolz, et al., 2021 ; Varga, et al., 2021).



*Socio-demographic variables:* age (in years), gender (male vs. female), marital status (married/domestic relationship or civil union; in a steady relationship whether cohabitating or not; single; divorced/separated/widowed), number of persons living in the household, area of residence (urban; suburban; rural), years of education.

*Work-related variables:* occupation (employed; student; unemployed; retired), change in work frequency (no change; change to more/fewer hours; job stopped/lost job; doesn't apply), income reduction (no reduction; reduction with governmental support; reduction without governmental support), had financial worries in the last 4 weeks (yes vs.no).

*COVID-19 related variables:* Number of COVID-19 regulations imposed by authorities in the week previous to answering the questionnaire, whether the participant considered these regulations appropriate (disagree; neutral; agree), frequency of going outdoors in the past two weeks (never/rarely; 3-5 days a week; everyday), whether the participant was quarantined for suspected COVID-19 infection (yes vs. no), whether the participant knows someone who has been infected with COVID-19 (yes vs. no), experiencing distress over coronavirus (very little; some; a lot)

*Health-related variables:* pre-existing chronic diseases (yes vs. no), pre-existing mental illnesses (yes vs. no), substance use assessed with the Substance Use Brief Screen (McNeely, et al., 2015): a self-administered screening tool that accurately detects past-year unhealthy use of tobacco, alcohol, and drugs (including illicit drugs and unhealthy use of prescription drug) (yes vs.no).

## **Statistical analyses**

### **Descriptive Statistics**

The study population was described by using means and standard deviation ( $\pm$  S.D.) for the continuous variables and frequencies and percentages for the categorical variables.

Difference between respondents and drop-outs on variables of interest was tested between the first and the last wave using logistic regression. Participants who discontinued participation in the COMET study did not differ significantly from those replied to the different follow-up waves. For those who replied to the consecutive data waves, the differences in replies across the 4 waves was tested using Chi-squared for categorical variables or using one-way ANOVA to test the difference across the 4 waves for continuous variables. Alpha was set at 0.05.

## Identification of social support and loneliness trajectories

Trajectories for social support and loneliness were determined using Group-based trajectory modeling (GBTM) (Nagin & Tremblay, 2001). GBTM is a person-centered, semiparametric technique for modeling heterogeneous change in longitudinal studies and it allows to identify different subgroups of individuals sharing similar change patterns across time (Andruff, et al., 2009). The premise behind GBTM is that the population is made up of a finite number of different groups. As a result, Nagin advises that the first stage in developing the model is to determine the number of groups that best fit the data. To perform the trajectory modeling, the PROC TRAJ package of SAS version 9.4 was used. PROC TRAJ allows different modeling estimates depending on data type (continuous, binary, or Poisson), and since loneliness and social support are both continuous scores, Censored-normal model distribution (CNORM) was used by specifying the minimum and maximum values for each variable. Several consecutive models were estimated and then compared using both statistical indexes and subject knowledge to determine the final best suited mode to our data. The following statistical indexes were used:

- Bayesian Information Criterion (BIC): which compares the log likelihoods between models, a BIC closer to zero indicates a better fit model.
- BIC values alter when the number of groups or the order of the groups vary, so BIC doesn't always show what is a meaningful change. As a result, the log Bayes factor may be used to measure this change using the formula:  $2 \log B_{10} \approx 2(BIC)$ . To calculate the value, we subtracted the BIC value of the simpler model from the BIC value of the more complex model, then multiplied the difference by two. Values ranging from 0 to 2 indicate that the complex model is weak, 2 to 6 indicate that it is moderate, 6 to 10 indicate strong evidence for the complex model, and values greater than 10 indicate that the complex model is very strong (Andruff, et al., 2009).
- Average posterior probability (APP): In GBTM, each person is allocated a probability of belonging to one of several groups. Then, each person is assigned to the group with the highest posterior membership probability. In addition to that, posterior membership probabilities are utilized to estimate the model's adequacy through APP and OCC (detailed under). APP is the approximation for internal reliability for each trajectory. An average greater than 0.7 (the closer to 1), the better the model fit.

- Odds of correct classification (OCC): it is calculated using the formula:  $\frac{\frac{APP_j}{1-APP_j}}{\frac{\pi_j}{1-\pi_j}}$  where  $\pi_j$  is the size of the trajectory j. The general recommendation is to have an OCC of 5 or more for all groups.
- The population size of trajectory group  $\pi_j$  is calculated by the model, and  $P_j$  is the actual proportion of individuals assigned to group j. These two numbers are similar when a model fits the data well.

A second step comprises of deciding the optimal polynomial order for each class trajectory. Polynomial order signifies the shape of the trajectory where it can be linear (first order) which is either increasing or decreasing, quadratic (second order) which includes a change point (increasing or decreasing) trajectory, or finally a cubic (third order) which includes two change points in the trajectory. To select the best polynomial order and hence the best fit model, the previously mentioned statistical indexes were used.

Finally, although missing data is usually a problem in longitudinal studies, PROC TRAJ can be used when data is missing at random (MAR), and subjects are included in the analysis if they have at least one data point available.

### **Predictors of social support and loneliness trajectories**

In the next step, the identified trajectories were associated with potential predictive factors through multinomial regression modeling. The “*nnet package*” of RStudio (version 3.6.1) was used to calculate the models. The third group for both the social support trajectory and the loneliness trajectory were taken as reference groups, since it allows to compare with the two lower groups, and with the highest group. Following an exploratory approach, a block-wise approach was used where baseline collected indicators of socio-demographic, work situation, health and COVID-19 related variables were used to build the model. Models were compared by using the likelihood ratio test.

### **Association between social support, loneliness and mental health outcomes**

As a final step, the identified trajectories for social support and loneliness were tested for their association with mental health outcomes (depression and anxiety) at wave 4 through multivariate linear regression using RStudio, conducted on the complete dataset, i.e. including only individuals for which we had information for all the variables of interest. For the final adjusted model, backward stepwise approach was used, and models were compared using the likelihood ratio test to determine the model with the best fit. Adjusted models included covariates from wave 1 (selected when univariate tests were  $p < 0.20$ ). When potential predictors showed

a significant difference between the 4 data collection waves, an average score was used. The residuals were checked for normality. Furthermore, we conducted sensitivity analysis using the dichotomous mental health outcomes to test the robustness of the findings. Logistic regression was used for this analysis (results in Appendix.3).

## Results

Table 1. shows the frequency distribution of the variables included in the study. Our study sample was predominantly female (78.6%), with a mean age of 47.49 ( $\pm$  14.92) years. Most of the population was married (53.4%) followed by being single (20.2%). The average number of years of education was 14.52 ( $\pm$  3.25) and most of the population was employed at the start of the data collection (73.6%). Financial worries decreased across the pandemic from 24.0% in wave 1 to 17.0 % in wave 4, while the stability in income increased where 75.4% reported no reduction in income in wave 1 compared to 89.9% in wave 4. More than 90% of the population reported at least one chronic disease, while less than 10% had been diagnosed with a mental illness.

The percentage of individuals considering that COVID-19 imposed regulations were appropriate decreased across the pandemic with 66% in wave 1 compared to 49% in wave 4.

Regarding substance use during the pandemic, alcohol was used most frequently (51.3% in wave 1) followed by tobacco (27.6% in wave 1) and then drugs (both prescription and other- 11.4% in wave 1). By wave 4, all substance use had decreased with 42.6%, 24.7% and 7.9% for alcohol, tobacco and drugs respectively.

Frequency of going out more than 3 days/week followed governmental restrictions related to the severity of the pandemic, with 59.3% reporting going out during the first wave, 89.6% reported going out frequently in wave 2 where the measures were eased up, dropping back to 75.9% in wave 3, to rise again to 83.7% in wave 4. Most of the study population (93-94.8%) felt little to some distress related to COVID-19 and less than 8% reported feeling a lot of distress across the 4 waves. Symptoms of depression and anxiety followed similar trends, where the percentage of people reporting them was the lowest in wave 2 (13.7% for depression and 11.1% for anxiety) and highest in wave 3 (24.3% for depression and 16.5% for anxiety).

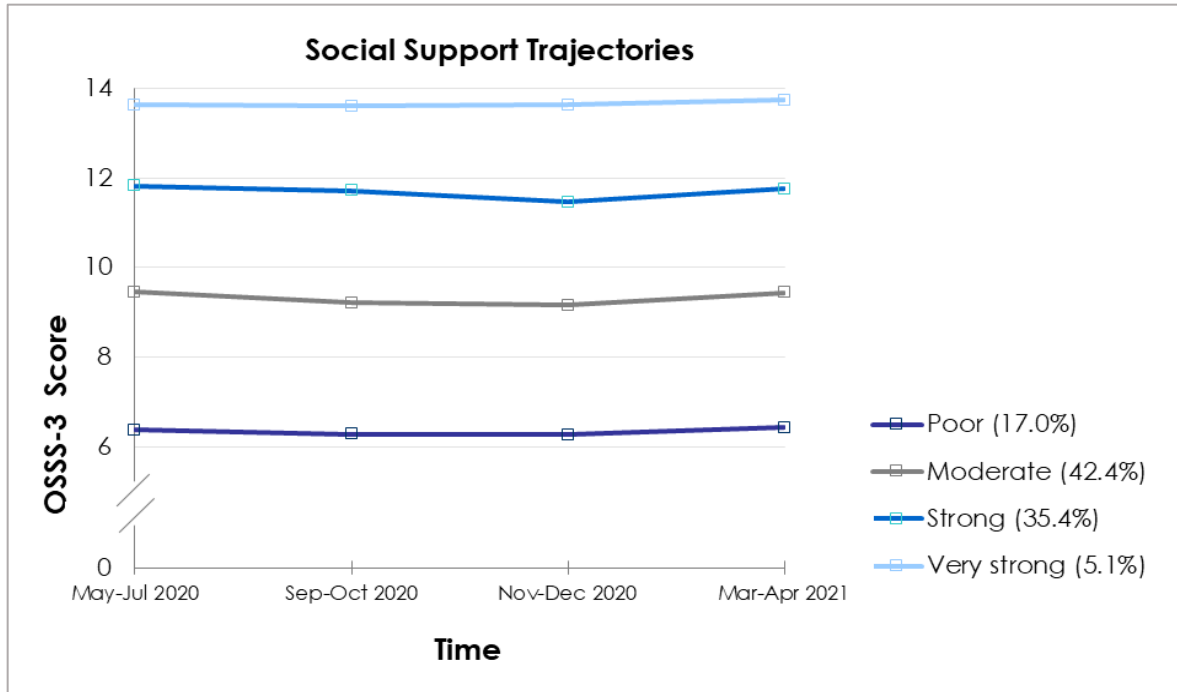
**TABLE 1. Descriptive Statistics for French participants in the COMET Cohort.**

		Wave 1 N=681	Wave 2 N= 442	Wave 3 N= 441	Wave 4 N = 424	p
Socio-demographic	Age (in years)	46.49 ± 14.92	---	---	---	
	Gender (female)	531 (78.6)	---	---	---	
	Residential Area					
	Urban	346 (52.0)	---	---	223 (53.6)	***
	Suburban	137 (20.6)	---	---	90 (21.6)	
	Rural	182 (27.4)	---	---	103 (24.8)	
	Relationship Status					
	Single	137 (20.2)	90 (20.6)	---	75 (17.9)	.
	Married, domestic relationship or civil union	363 (53.4)	238 (54.3)	---	230 (55.0)	
	In a steady relationship (cohabitating or not)	99 (14.6)	54 (12.3)	---	58 (13.9)	
Divorced, separated, widowed	81 (11.9)	56 (12.9)	---	55 (13.2)		
Number of people in household	2.52 ± 1.25	2.14 ± 0.88	2.47 ± 1.22	2.45 ± 1.22	.	
Education (in years)	14.52 ± 3.25	---	---	---		
Work situation	Occupation					
	Student	39 (5.8)	---	---	15 (3.6)	***
	Worker	499 (73.6)	---	---	299 (71.7)	
	Unemployed	77 (11.4)	---	---	49 (11.8)	
	Retired	63 (9.3)	---	---	54 (13.0)	
	Change in work frequency					
	No change	218 (32.2)	117 (26.7)	160 (37.2)	140 (33.6)	***
	Change (more/less)	280 (41.3)	206 (47.0)	162 (37.67)	152 (36.45)	
	Job stopped/lost job	41 (6.1)	22 (5.0)	17 (4.0)	17 (4.1)	
	Doesn't apply	139 (21.0)	93 (21.2)	91 (21.2)	108 (25.9)	
Income reduction/government support						
Neither	506 (75.4)	377 (85.7)	378 (87.7)	373 (89.9)	***	
Income reduced & support	44 (6.6)	12 (2.7)	12 (2.8)	3 (0.7)		
Income reduced & no support	121 (18.0)	51 (11.6)	41 (9.5)	39 (9.4)		
Financial worries (yes)	162 (24.0)	87 (19.8)	71 (16.8)	70 (17.0)	**	
Health	Chronic physical illness (yes)	638 (93.7)	---	---	403 (96.4)	.
	Mental illness (yes)	67 (9.9)	---	---	36 (8.6)	***
	Substance use (yes)					
	Tobacco	186 (27.6)	---	---	103 (24.7)	***
	Alcohol	346 (51.3)	---	---	177 (42.6)	***
	Medications recreationally / illegal drug	77 (11.4)	---	---	33 (7.9)	***
COVID-19 related factors	Number of COVID-19 regulations imposed	7.55 ± 3.14	5.74 ± 2.66	6.97 ± 2.89	6.58 ± 2.23	***
	Considers regulations appropriate					
	Disagree	137 (20.3)	---	---	146 (35.0)	***
	Neutral	90 (13.3)	---	---	68 (16.3)	
	Agree	449 (66.4)	---	---	203 (48.7)	
	Frequency of going outdoors					
	Never / rarely	275 (40.7)	46 (10.5)	104 (24.1)	68 (16.3)	***
	3-5 days a week/everyday	400 (59.3)	394 (89.6)	327 (75.9)	349 (83.7)	
	Quarantine for (suspected) COVID-19 (yes)	47 (7.0)	42 (9.7)	---	---	***
	Know someone who's been infected by COVID-19 (yes)	486 (71.8)	312 (70.8)	355 (82.4)	365 (87.5)	***
Experienced distress related to the coronavirus						
Very little	346 (50.9)	265 (60.5)	239 (55.5)	198 (47.6)	**	
Some	286 (42.1)	150 (34.3)	159 (36.9)	185 (44.5)		
A lot	48 (7.1)	23 (5.3)	33 (7.7)	33 (7.9)		
Mental Health	Depression Score	6.38 ± 5.63	4.78 ± 4.87	6.45 ± 5.48	6.07 ± 5.25	***
	Depression score >= 10	158 (24.0)	58 (13.7)	102 (24.3)	87 (21.5)	***
	Anxiety Score	4.81 ± 4.93	4.06 ± 4.55	4.97 ± 4.67	4.76 ± 4.73	*
	Anxiety score >=10	104 (15.6)	48 (11.1)	70 (16.5)	63 (15.4)	.

(---) data not collected during the wave; (\*\*\*) p-value<0.001; (\*\*) p-value<0.01; (\*) p-value<0.05; (.) p-value>0.05.

## Trajectories

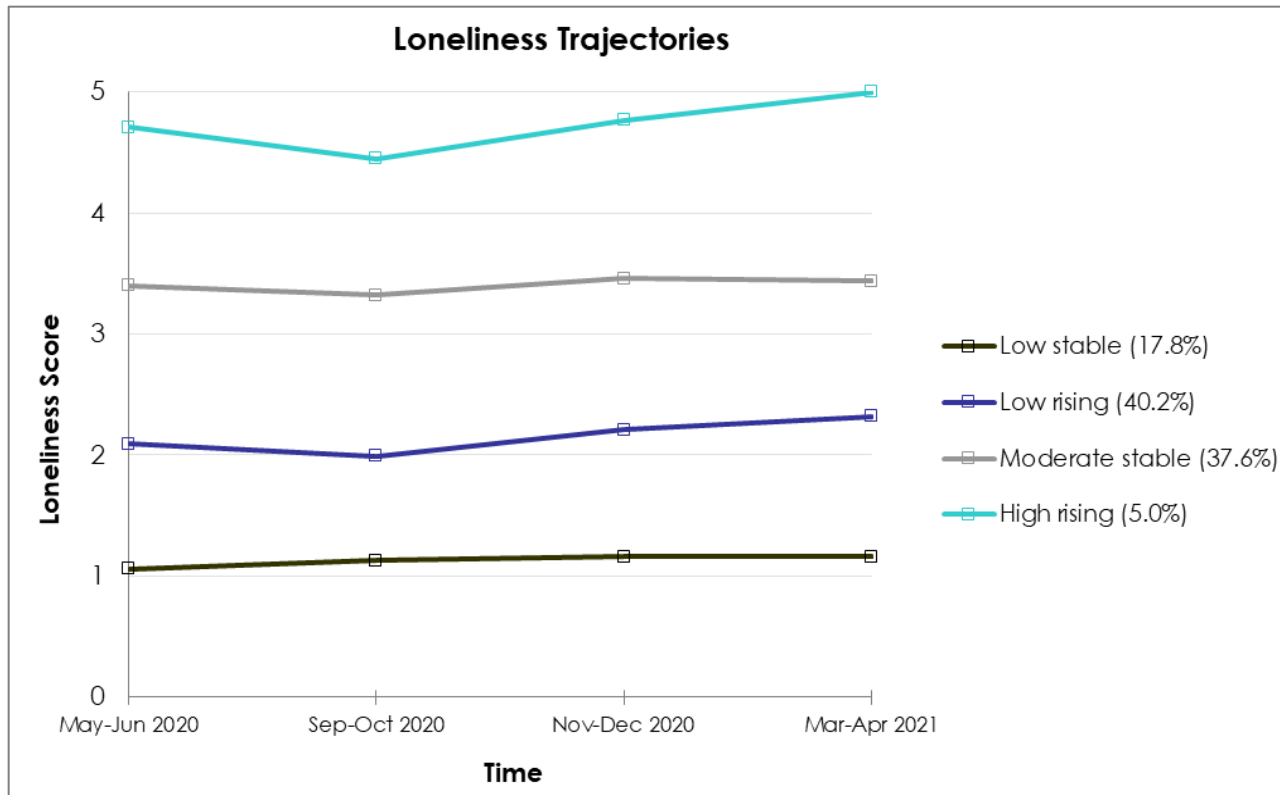
The detailed results of trajectory selection are mentioned in Appendix 2. The social support trajectories (Figure 3) represent the perceived social support across the pandemic and reveals four distinct sub-groups in our study population. The 4-group trajectory option was chosen although a 5-group solution had the best BIC, but the latter solution had 3 groups with low group membership (7.35%, 5.7% and 13%). The two largest groups in the study population were those with 'moderate' social support (42.4%) with an average OSSS-3 score  $9.34 \pm 0.73$  and 'strong' support (35.4%) with an average OSSS-3 score of  $11.74 \pm 0.67$ . In addition, one smaller group (5.1%) average OSSS-3 score  $13.66 \pm 0.29$  showed consistently 'very strong' support, while 17.0% belonged to the "poor support" group with an average OSSS-3 score  $6.28 \pm 1.00$  over time.



**Figure 3. Trajectories of Social Support among the French participants of the COMET study (N= 679)**

Regarding the loneliness trajectories, the best fit model was a 4-group model (Figure 4) representing perceived loneliness over time in our study population. Both the 'low stable' group and the 'moderate stable' group (comprising 17.8% and 37.59% respectively) remained relatively stable across the pandemic with average loneliness scores of  $1.09 \pm 0.15$  and  $3.38 \pm 0.44$  respectively. The 'low rising' group (40.2%; average loneliness score =  $2.13 \pm 0.35$ ) felt rarely lonely at the start of the study but showed a slowly increasing score as the pandemic

continued. The ‘high rising’ group (5.0%; average loneliness score =  $4.78 \pm 0.25$ ) reported feeling often or frequently lonely during the first wave, decreased slightly in the second wave, and continued increasing to reach a maximum score of 5 indicating feeling frequently lonely at wave 4.



**Figure 4. Trajectories of Loneliness among French participants of the COMET study (N= 680)**

### Predictors of social support trajectories

Table 2. shows the predictors of the identified social support trajectories compared to the ‘strong’ reference group. For each increase of one unit of educational years, the estimated odds of belonging to the poor social support group decreased by 0.90 (95% CI [0.82, 0.97]).

Furthermore, during the pandemic, those in the poor social support group were less likely to go out more than 3 times a week (OR = 0.51, 95% CI [0.29, 0.89]). However, they were more likely to be single (OR = 3.24, 95% CI [1.43, 7.33]) than married and more likely to have a previously diagnosed mental illness (OR = 2.31, 95% CI [-0.01, 1.69]) the latter being borderline significant.

Quite similarly, for each increase in one unit of educational years, the estimated odds of belonging to the ‘moderate’ social support group decreased by 0.93 (95% CI [0.87 – 1.00]).

Those in the 'moderate' social support group were more likely to be single (OR = 2.20, 95% CI [1.18, 4.09]) than married, and less likely to use alcohol (OR = 0.64, 95% CI [0.42, 0.96]) compared to those in the 'strong' reference group. Finally, those in the 'very strong' group, were more likely to be unemployed (OR = 6.05, 95% CI [1.10, 33.05]) compared to those employed.

**Table 2. Predictors of social support trajectories among French participants of the COMET cohort (N = 568)**

Predictors of social support trajectories		Low		Moderate		Very high		
		OR	95% CI	OR	95% CI	OR	95% CI	
Socio-demographics	<i>Age (years)</i>	1.01	0.99, 1.04	1.00	0.99, 1.02	1.02	0.98, 1.06	
	<i>Gender (male as reference)</i>							
	female	1.13	0.58, 2.18	1.05	0.65, 1.71	1.97	0.64, 6.08	
	<i>Area (urban as reference)</i>							
	suburban	1.23	0.62, 2.46	0.75	0.45, 1.25	0.45	0.11, 1.76	
	rural	1.45	0.75, 2.78	0.81	0.49, 1.32	1.66	0.64, 4.28	
	<i>Nb. of people in HH</i>	1.03	0.79, 1.34	1.18	0.98, 1.42	1.12	0.76, 1.63	
	<i>Education (years)</i>	<b>0.90*</b>	<b>0.82, 0.97</b>	<b>0.93*</b>	<b>0.87, 1.00</b>	1.12	0.95, 1.33	
	<i>Relationship status (married as reference)</i>							
	single	<b>3.24**</b>	<b>1.43, 7.33</b>	<b>2.20*</b>	<b>1.18, 4.09</b>	1.25	0.34, 4.53	
steady	0.90	0.36, 2.26	1.03	0.55, 1.92	0.66	0.16, 2.79		
Separated/widowed	1.49	0.61, 3.65	0.93	0.46, 1.87	0.52	0.10, 2.73		
Work situation	<i>Occupation (employed as reference)</i>							
	student	0.30	0.07, 1.29	0.52	0.21, 1.27	1.49	0.26, 8.55	
	unemployed	2.50	0.92, 6.77	1.84	0.78, 4.30	<b>6.04*</b>	<b>1.10, 33.05</b>	
	retired	0.40	0.11, 1.44	0.77	0.30, 1.98	4.96	0.59, 41.51	
	<i>Work frequency change (no change as reference)</i>							
	More/less hours	1.29	0.68, 2.45	0.86	0.55, 1.36	0.96	0.40, 2.29	
	Job stopped/lost job	0.95	0.30, 3.03	0.87	0.34, 2.18	0.42	0.04, 4.42	
	Doesn't apply	1.06	0.37, 2.99	0.82	0.37, 1.80	<b>0.07*</b>	<b>0.01, 0.58</b>	
<i>Income reduction and governmental support (No reduction as reference)</i>								
Reduction + support	1.06	0.40, 2.79	0.47	0.21, 1.04	-----	-----		
Reduction - support	1.56	0.78, 3.12	0.86	0.50, 1.48	1.28	0.48, 3.45		
COVID-19 related	Nb. of regulations imposed	0.94	0.86, 1.03	1.00	0.94, 1.07	0.97	0.84, 1.11	
	<i>Got quarantined for suspected COVID-19 (not quarantined as a reference)</i>							
	Got quarantined	0.38	0.10, 1.49	1.17	0.57, 2.43	0.28	0.03, 2.42	
	<i>Frequency of going out during the pandemic (not/rarely going out as a reference)</i>							
	Go out 3-5 days/everyday	<b>0.51*</b>	<b>0.29, 0.89</b>	0.82	0.54, 1.23	2.16	0.84, 5.54	
	<i>Substance use doing COVID-19 (no use is always the reference)</i>							
	Tobacco use	1.02	0.53, 1.95	1.07	0.66, 1.72	0.40	0.13, 1.23	
Drug use	1.41	0.59, 3.37	1.12	0.58, 2.17	0.79	0.14, 4.41		
Alcohol use	0.77	0.44, 1.36	<b>0.64*</b>	<b>0.42, 0.96</b>	2.13	0.90, 5.08		
Health	<i>Mental illness confirmed (no illness as a reference)</i>							
	Mental illness	2.31	0.99, 5.41	1.36	0.68, 2.71	0.83	0.16, 4.39	
	<i>Physical illness (no illness as a reference)</i>							
Physical illness	2.26	0.44, 1.36	0.84	0.36, 1.99	0.56	0.10, 3.19		

(\*\*\*)  $p$ -value<0.001; (\*\*)  $p$ -value<0.01; (\*)  $p$ -value<0.05; Or = Odds ratio; CI = confidence interval



## Predictors of Loneliness trajectories

Table 3. shows the predictors of loneliness trajectories. Using the 'moderate stable' group as a reference, we observed the following predictors associated with the 'low stable' group:

Compared to married, being single or separated/widowed predicted lower odds of belonging to the 'low stable' group (single (OR = 0.08, 95% CI [0.02, 0.26]) and separated/widowed (OR = 0.29, 95% CI [0.12, 0.75])). Furthermore, with every additional measure related to COVID-19, the estimated odds of belonging to the "low stable group" decreased by 0.88 (95% CI [0.80, 0.96]). In addition participants in this group had lower odds to have used drugs during the pandemic (OR = 0.13, 95% CI [0.03, 0.61]) compared to those who never used, and lower odds to have been diagnosed with mental illness (OR = 0.25, 95% CI [0.08, 0.81]) compared to those without mental illness. Similarly, those in the 'low rising' group were less likely to be single or separated/widowed compared to married. (single: OR = 0.32, 95% CI [0.17, 0.61], separated/widowed: OR = 0.34, 95% CI [0.16, 0.72]). Furthermore, compared to employed, students had more odds to belong to this group (OR = 3.01, 95% CI [1.13, 8.01]). In addition, those who had their income reduced (whether they received governmental support or not) were less likely to be in this group (with support: OR = 0.39, 95% [0.17, 0.91], without support: OR = 0.49, 95% CI [0.28, 0.85]). In addition participants in this group had lower odds to have used drugs during the pandemic (OR = 0.51, 95% CI [0.26, 0.98]) compared to those who never used, and lower odds to had been diagnosed with mental illness (OR = 0.25, 95% CI [0.12, 0.53]) compared to those without mental illness. Finally, persons in the 'high rising' group had higher odds to be single compared to married (OR = 6.03, 95% CI [1.67, 21.82]).

**Table 3. Predictors of loneliness trajectories among the French participants of the COMET cohort (N = 568)**

Predictors of Loneliness trajectories		Low stable		Low rising		High rising		
		OR	95% CI	OR	95% CI	OR	95% CI	
Socio-demographics	Age (years)	1.02	0.99, 1.04	1.00	0.98, 1.02	1.01	0.97, 1.05	
	<i>Gender (male as reference)</i>							
	female	0.68	0.36, 1.29	1.19	0.70, 2.00	0.61	0.22, 1.71	
	<i>Area (urban as reference)</i>							
	suburban	0.60	0.29, 1.24	0.80	0.47, 1.36	1.10	0.35, 3.42	
	rural	1.21	0.65, 2.27	0.85	0.51, 1.42	0.91	0.28, 2.97	
	Nb. of people in HH	0.98	0.76, 1.27	1.02	0.84, 1.23	0.96	0.61, 1.51	
	Education (years)	0.95	0.87, 1.03	0.99	0.93, 1.07	0.94	0.81, 1.10	
	<i>Relationship status (married as reference)</i>							
	single	<b>0.08***</b>	<b>0.02, 0.26</b>	<b>0.32***</b>	<b>0.17, 0.61</b>	<b>6.03**</b>	<b>1.67, 21.82</b>	
steady	0.46	0.18, 1.17	1.04	0.54, 2.01	1.51	0.24, 9.53		
Separated/widowed	<b>0.29*</b>	<b>0.12, 0.75</b>	<b>0.34**</b>	<b>0.16, 0.72</b>	2.26	0.47, 10.81		
Work situation	<i>Occupation (employed as reference)</i>							
	student	2.62	0.62, 10.99	<b>3.01*</b>	<b>1.13, 8.01</b>	0.96	0.13, 7.26	
	unemployed	0.38	0.12, 1.20	1.03	0.46, 2.30	1.10	0.25, 4.78	
	retired	0.55	0.16, 1.88	0.94	0.35, 2.55	0.45	0.04, 5.41	
	<i>Work frequency change (no change as reference)</i>							
	More/less hours	0.98	0.53, 1.81	0.98	0.61, 1.58	0.96	0.35, 2.59	
	Job stopped/lost job	0.60	0.14, 2.61	1.72	0.66, 4.46	2.10	0.35, 12.57	
	Doesn't apply	1.00	0.34, 2.95	0.64	0.29, 1.45	0.63	0.11, 3.50	
	<i>Income reduction and governmental support (No reduction as reference)</i>							
	Reduction + support	0.78	0.29, 2.12	<b>0.39*</b>	<b>0.17, 0.91</b>	0.28	0.03, 2.89	
Reduction - support	0.70	0.35, 1.42	<b>0.49*</b>	<b>0.28, 0.85</b>	0.49	0.14, 1.80		
COVID-19 related	Nb. regulation imposed	<b>0.88**</b>	<b>0.80, 0.96</b>	0.95	0.89, 1.02	0.96	0.83, 1.12	
	<i>Got quarantined for suspected COVID-19 (not quarantined as a reference)</i>							
	Got quarantined	1.17	0.43, 3.17	0.46	0.20, 1.09	0.42	0.05, 3.74	
	<i>Frequency of going out during the pandemic (not/rarely going out as a reference)</i>							
	Go out 3-5 days/daily	1.07	0.61, 1.88	1.02	0.67, 1.57	0.60	0.24, 1.49	
	<i>Substance use during COVID-19 (no use is always the reference)</i>							
	Tobacco use	0.74	0.36, 1.49	1.30	0.79, 2.14	0.55	0.18, 1.71	
	Drug use	<b>0.13*</b>	<b>0.03, 0.61</b>	<b>0.51*</b>	<b>0.26, 0.98</b>	0.21	0.04, 1.12	
Alcohol use	1.11	0.64, 1.94	0.84	0.54, 1.30	1.75	0.70, 4.38		
Health	<i>Mental illness confirmed (no illness as a reference)</i>							
	Mental illness	<b>0.25*</b>	<b>0.08, 0.81</b>	<b>0.25***</b>	<b>0.12, 0.53</b>	1.49	0.48, 4.59	
	<i>Physical illness (no illness as a reference)</i>							
Physical illness	0.49	0.15, 1.64	0.57	0.23, 1.43	1.35	0.24, 7.53		

(\*\*\*)  $p$ -value<0.001; (\*\*)  $p$ -value<0.01; (\*)  $p$ -value<0.05, OR = Odds ratio; CI = confidence interval.

## Association between trajectories and mental health outcomes

### Depression

The results of the multivariate linear regression testing the association between social support and loneliness trajectories and depression are shown in Table 4. In the first non-adjusted model (adjusted R<sup>2</sup> = 0.06), the association between social support trajectories and depression scores

showed that being in the poor social support group was associated with more depressive symptoms. In the second non-adjusted model (adjusted  $R^2 = 0.34$ ), those who belong to the 'low stable' and 'low rising' loneliness groups have lower depression scores (low stable lonely:  $\beta = -6.18$ , 95% CI [-7.49, -4.87], low rising:  $\beta = -3.24$ , 95% CI [-4.23, -2.24] respectively). Being in the 'high rising' group was associated higher levels of depressive symptoms ( $\beta = 7.73$ , 95% CI [5.57, 9.89]). When entering both types of trajectories in the same model 3 (adjusted  $R^2 = 0.35$ ), belonging to either 'low stable' loneliness group ( $\beta = -6.08$ , 95% CI [-7.43, -4.73]) or "low rising" ( $\beta = -3.14$ , 95% CI [-4.17, -2.10]) was significantly associated with lower depression scores and the 'high rising' trajectory was associated with higher depression scores. Social support trajectories were no longer significantly associated with depressive symptoms. When taking additional covariates into account in model 4 (adjusted  $R^2 = 0.37$ ), the results were slightly attenuated but still in the same direction. 'Low stable' or 'low rising' groups are less likely to be have depressive symptoms ( $\beta = -4.78$ , 95% CI [-6.23, -3.34]), ( $\beta = -3.00$ , 95% CI [-4.04, -1.96]). Furthermore, those in the 'high rising' group are more likely to be depressed ( $\beta = 7.05$ , 95% CI [4.96, 9.14]). The results of the sensitivity analysis test using the dichotomous PHQ-9 variable as an outcome portrayed the same direction of the results. (Appendix. 3)

**Table 4. The association of social support and loneliness trajectories with symptoms of depression in French participants of the COMET cohort (N = 364)**

		Model 1	Model 2	Model 3	Model 4 <sup>§</sup>
		$\beta$ [95% CI]	$\beta$ [95% CI]	$\beta$ [95% CI]	$\beta$ [95% CI]
Social Support Trajectories (Strong group as reference)	Low	<b>3.15***</b> <b>[1.61, 4.69]</b>		0.80 [-0.56, 2.16]	0.85 [-0.51, 2.20]
	Moderate	0.06 [-1.15, 1.28]		-0.78 [-1.81, 0.25]	-0.84 [-1.84, 0.16]
	Very strong	-1.60 [-3.69, 0.49]		-0.62 [-2.40, 1.15]	-0.77 [-2.47, 0.93]
Loneliness Trajectories (Moderate stable as reference)	Low stable		<b>-6.18***</b> <b>[-7.49, -4.87]</b>	<b>-6.08***</b> <b>[-7.43, -4.73]</b>	<b>-4.78***</b> <b>[-6.23, -3.34]</b>
	Low rising		<b>-3.24***</b> <b>[-4.23, -2.24]</b>	<b>-3.14***</b> <b>[-4.17, -2.10]</b>	<b>-3.00***</b> <b>[-4.04, -1.96]</b>
	High rising		<b>7.73***</b> <b>[5.57, 9.89]</b>	<b>7.39***</b> <b>[5.21, 9.57]</b>	<b>7.05***</b> <b>[4.96, 9.14]</b>

<sup>§</sup>Model adjusted for: age, gender, education, relationship status, knowing someone with COVID-19, diagnosed mental illness, and having distress related to COVID-19 pandemic; (\*\*\*)  $p$ -value<0.001; (\*\*)  $p$ -value<0.01; (\*)  $p$ -value<0.05;  $\beta$  = linear regression coefficient; CI = confidence interval.

## Anxiety

Table 5 shows the results of the associations between social support and loneliness trajectories and anxiety. In the first non-adjusted model (adjusted R<sup>2</sup> = 0.03), the association between social support trajectories and anxiety shows that being in the poor social support group was associated with anxiety. In the second non-adjusted model (adjusted R<sup>2</sup> = 0.32), unlike the other groups which were associated with lower anxiety scores, being in the ‘high rising’ group was associated with feeling more anxious during the pandemic ( $\beta = 6.11$ , 95% CI [4.13, 8.10]). When entering both types of trajectories in the same model 3 (adjusted R<sup>2</sup> = 0.24), belonging to either the ‘low stable’ group ( $\beta = -4.17$ , 95% CI [-5.45, -2.89]) or ‘low rising’ ( $\beta = -2.32$ , 95% CI [-3.28, -1.35]) was significantly associated with lower anxiety scores. When taking additional covariates into account in model 4 (adjusted R<sup>2</sup> = 0.36), the results were slightly attenuated but still in the same direction. The ‘low stable’ group or ‘low rising’ group have lower symptoms of anxiety ( $\beta = -2.60$ , 95% CI [-3.86, -1.34]), ( $\beta = -1.96$ , 95% CI [-2.86, -1.05]). Furthermore, those in the ‘high rising’ loneliness group have higher anxiety scores ( $\beta = 5.77$ , 95% CI [3.95, 7.60]). The results of the sensitivity analysis test using the dichotomous GAD-7 variable as an outcome portrayed the same direction of the results.

**Table 5. The association of social support and loneliness trajectories with symptoms of anxiety in French participants of the COMET cohort (N = 369)**

		Model 1	Model 2	Model 3	Model 4 <sup>§</sup>
		$\beta$ [95% CI]	$\beta$ [95% CI]	$\beta$ [95% CI]	$\beta$ [95% CI]
Social Support Trajectories (Strong group as reference)	Low	<b>1.76*</b> <b>[0.40, 3.12]</b>		0.01 [-1.26, 1.28]	-0.14 [-1.34, 1.06]
	Moderate	0.17 [-0.91, 1.25]		-0.51 [-1.48, 0.46]	-0.60 [-1.49, 0.30]
	Very strong	-1.84 [-3.67, 0.00]		-1.14 [-2.80, 0.52]	-1.15 [-2.66, 0.37]
Loneliness Trajectories (Moderate stable as reference)	Low stable		<b>-4.31***</b> <b>[-5.54, -3.08]</b>	<b>-4.17***</b> <b>[-5.45, -2.89]</b>	<b>-2.60***</b> <b>[-3.86, -1.34]</b>
	Low rising		<b>-2.33***</b> <b>[-3.25, -1.40]</b>	<b>-2.32***</b> <b>[-3.28, -1.35]</b>	<b>-1.96***</b> <b>[-2.86, -1.05]</b>
	High rising		<b>6.11***</b> <b>[4.13, 8.10]</b>	<b>6.07***</b> <b>[4.07, 8.08]</b>	<b>5.77***</b> <b>[3.95, 7.60]</b>

<sup>§</sup>Model adjusted for: age, gender, number of people in the household, consider the COVID-19 regulation appropriate, mental illness, financial worries and having distress related to COVID-19 pandemic; (\*\*\*)  $p$ -value<0.001; (\*\*)  $p$ -value<0.01; (\*)  $p$ -value<0.05;  $\beta$  = beta coefficient; CI = confidence interval.

## Discussion

To our knowledge, our research is the first longitudinal study looking at trajectories of social support and loneliness across the first year of the COVID-19 pandemic and their associations with mental health outcomes in a sample of participants from the general population in France. Exploring social support and loneliness and associated predictors during the pandemic is important to improve our understanding of how these factors may evolve and clarify how the trajectories of some individuals differ from those of others. Using data from a cohort recruited among the general population in France, we identified four distinct trajectory groups for both social support ((poor (17.0%), moderate (42.4%), strong (35.4%) and very strong (5.1%)) and loneliness (low stable (17.8%), low rising (40.2%), moderate stable (37.6%) and 'high rising' (5.0%))) between May 2020 and April 2021. Low social support and high loneliness trajectories appeared especially strongly associated with being single, not going out frequently and having a history of mental illness. Higher levels of depression and anxiety were associated with high loneliness in particular, but not with social support. Identification and monitoring of persons who feel increasingly lonely during the pandemic may be needed to prevent mental health problems in this group.

### Social support trajectories

Social support refers to the accessible psychosocial support provided by one's social network (Kocalevent, et al., 2018). Social support is a resilience factor and has been shown to be associated with mental health outcomes, where low levels of perceived social support result in increased risk of depression and anxiety (Bonanno, 2004). Our analysis of social support trajectories revealed four distinct groups. The majority of our study sample reported to have moderate (42.4%) or strong social support (35.4%), that remained consistent and did not seem to be impacted by the pandemic and its associated protective measures such as confinement and social distancing. We also identified a small group (5.0%) reporting very strong social support, conversely, 17.0 % of our study population felt they had poor social support. Both of these groups also remained stable throughout the study period.

Social support prevalence rates vary across the literature. Pre-pandemic cross-sectional data on perceived social support measured with the OSSS-3 reported that the French estimates of poor and moderate social support was somewhat higher than our current findings (21.1% vs.17.0% for poor social support, and 54.7% vs.42.4% for moderate social support). In addition, strong social support was reported at 24.3%, which is lower than our findings (Mental well-being and social support statistics, 2018). However, the prevalence of social support might have

evolved since 2014, to our knowledge, there are no published studies on perceived social support in the French general population during the COVID-19 pandemic. A general population survey with 20,792 individuals from three Belgian regions conducted during the confinement in March-April 2020 reported 29.4% low social support, 47.8% moderate and 22.8% strong social support (Lorant, et al., 2021). These results are higher than our findings in terms of low and moderate social support and lower in terms of strong social support. However, the study is cross-sectional in nature and give no information on the evolution of social support over time since the start of the pandemic, which might explain the differences in prevalence. One longitudinal study followed 260 Chinese participants from pre-COVID, through the peak of COVID-19 and the subsequent decline in cases. While they reported an increase in perceived social support between pre-COVID and the peak of the pandemic, social support remained stable between the second and third wave during the pandemic similar to our results (Xu, et al., 2020).

## **Predictors of Social support**

Our study did not find any association between age and gender with perceived social support although previous studies have reported a decrease in social support with age (Kocalevent, et al., 2018). Regarding gender, findings are not consistent through the literature where some studies report increased perceived social support in women compared to men (Kendler, et al., 2005) and others report no difference between the genders (Kohrt & Worthman, 2009). In fact, Kocalevent et al. (2018) hypothesizes that the shift in gender roles where both males and females work and have equal responsibilities and similar roles is responsible for these results.

Compared to married participants, those who were single, separated or widowed had higher odds of belonging to the 'low' or 'moderate' social support trajectories.

Sources of social support (i.e. from spouse, family, coworkers or community) are associated with the individual's level of perceived social support. Spousal support has been reported to be associated with high levels of perceived social support (Cohen & Wills, 1985) followed by the support received from family and friends (Gariépy, 2016). Regarding our study, the fact that social support levels seem to be established since the beginning of the pandemic, without change over time, might actually be related to the main source of social support provided to our participants (i.e. spouse) which didn't change much in our sample.

Furthermore, social support usually increases with socio-economic and employment status (Melchiorre, et al., 2013). This was also evident in our results which showed that people

with higher education levels were less likely to belong to the 'low' and 'moderate' social support trajectories. However, in our sample being unemployed was surprisingly significantly associated with belonging to the highest social support group. In general, research has reported that employment is associated with higher perceived social support through providing a greater access to social connections and possibly greater support through co-workers (Snyder, 2009). However, unemployed persons in our study population have been in this status since before the beginning of the pandemic. Therefore, they probably are used to obtain their social support from somewhere else, contrary to the employed who actually lost their interaction with their social circle at work with the beginning of the sanitary measures (Oakman, 2020).

Going out frequently was protective against perceiving low social support. This can be explained probably by the fact that this gives more possibility to garner social support. Finally, those that didn't use alcohol during the pandemic were more likely to belong to the 'moderate' social support group. Alcohol drinking has been increasing during the pandemic (Jacob, et al., 2021), but studies on its association with perceived social support are scarce. A cross-sectional study conducted during the pandemic have reported an association between increased alcohol use and decreased social support in university students (Lechner, et al., 2020).

## **Loneliness trajectories**

Loneliness, defined as perceived social isolation, is a public health threat and is associated with all-cause mortality and morbidity (Leigh-Hunt, et al., 2017). When looking at longitudinal trajectories of loneliness during the COVID-19 pandemic, the majority of our study sample fell into to the 'low rising' (40.2%; average loneliness score =  $2.13 \pm 0.35$ ) and the 'moderate stable' (37.6%; average loneliness score  $3.38 \pm 0.44$ ) trajectories. We also identified a 'low stable' group (17.8%; average loneliness score  $1.09 \pm 0.15$ ) and a 'high rising' group (5.0%; average loneliness score;  $4.78 \pm 0.25$ ) which showed a steady increase during the study period. Both the 'low' and 'high rising' groups showed a small decrease in the reported level of loneliness during the summer period when the sanitary measures were eased up, with a subsequent increase in loneliness in parallel with the second and third confinements. A study conducted on 38,200 individuals from the general population in the UK during the first seven weeks of confinement also reported four loneliness trajectories (Bu, et al., 2020a). However, they reported 48.2% for low loneliness, 14.0% for mid-low, 23.4% for mid-high and 14.3% for high loneliness, the latter which is higher than our findings. The trends among the groups were almost stable at the beginning and the end except for a regression in the highest group in week 6. This might be due to the short period in which the data was collected and the difference in the tools used.

However, compared to an online survey done in between December 2019 and January 2020 on 1000 French participants (aged 15 and above), our study population showed a lower percentage of individuals feeling frequently lonely (5.0% vs 19%) (Berhuet, et al., 2020). To our knowledge, there is no other longitudinal data on loneliness in France during the pandemic to compare our outcomes with.

## **Predictors of loneliness**

Our results show that relationship status plays a major role in perceived loneliness. Being single strongly predicted being in the 'high rising' group. Additionally, those who were single or separated/widowed were less likely to belong to the 'low stable' or 'low rising' group. This result goes in line with other research indicating that being married is associated with lower loneliness specially if the couple lives together (Ben-Zur, 2012; Pinqart & Sörensen, 2003).

Being a student predicted belonging to the 'low rising' group. Although the average loneliness score of this group was lower compared to the 'moderate stable' group, loneliness scores in this trajectory were rising specially during the confinements. This fits with other reports on university students feeling lonelier during lockdown periods where they were cut from their social circles compared to non-lockdown periods (Bu, et al., 2020a). Income reduction was associated with having lower odds of belonging to the 'low rising' group compared to the 'moderate' group, even if support from the government was received. In general, having lower income has been demonstrated as a risk factor for increased loneliness (Shovestul, et al., 2020). In addition, research has demonstrated the relationship between income shock (defined as an unexpected decrease in one's income) and increased levels of loneliness in older adults in the US basically due to the stress associated with the shock (Hawkley & Cacioppo, 2010). An increased number of COVID-19 measures was also associated with lower odds of belonging to the 'low stable' group. In a study combining two longitudinal datasets (pre-pandemic) and a cross-sectional dataset (in the pandemic) in older adults in Austria found an association between the increased number of COVID-19 restriction measures and increased feeling of loneliness and also found that lower levels of loneliness were observed during the easing of lockdown rules (Stolz, et al., 2021). Regarding substance use, those who consumed recreational drugs were less likely to belong to 'low stable' and 'low rising' groups compared to the 'moderate' group. In fact, individuals feeling lonely can cope with this feeling by using drugs or alcohol (Åkerlind & Hörnquist, 1992). Specific to COVID-19, increased feelings of loneliness were also associated with increased drug use and alcohol use in a cross-sectional study on young adult Americans (Horigian, et al., 2021). The absence of mental illness has been reported



in both pre-pandemic and pandemic studies to be protective from increased levels of loneliness (Bu, et al., 2020b; Varga, et al., 2021) this is compatible with our results showing that those with a history of mental illness were less likely to belong to the 'low stable' and 'low rising' groups.

Finally, other commonly reported risk factors for increased loneliness reported in the literature are age and gender. However, these factors weren't significant in our study. This might be due to the selective sample, where fewer variation could be observed for these variables. However, another explanation might be that the pandemic and the sanitary measures impacted both genders and that loneliness was increased for different age groups and both men and women.

## **Association between social support, loneliness and depression and anxiety**

The COVID-19 pandemic and its subsequent sanitary measures (confinements, remote working and social distancing) has been reported in the literature to have an impact on the mental health of many persons. In France specifically, data from the French national health agency show that the prevalence of depression and anxiety in the general population have increased throughout the pandemic. Compared to the pre-pandemic period (2017), the prevalence of depressive symptoms in our study population was almost double (9.8% vs 20.9% respectively) (Santé Publique France, 2021b). More specific, the prevalence in our study was the highest during the first and second confinement while the lowest during summertime. This is compatible with the French cross-sectional data where the highest reported prevalence for depression was 20.4% and 20.6% in the first and second confinement and 19.0% for the third one, although they also reported a significant increase of the prevalence of depression in February 2021, a period which was not covered by our data collection (Santé Publique France, 2021b). The prevalence of anxiety symptoms (14.6%) in our sample increased slightly compared to pre-pandemic period (13.5% in 2017) (Santé Publique France, 2021b). Reported anxiety prevalence rates did not differ significantly between the different waves of data collection in our study.

When associating the identified social support and loneliness trajectories with the risk of high levels of depression and anxiety during the fourth data wave, our results show that low social support appeared to be associated with increased symptoms of depression and anxiety in the non-adjusted model only, but when taking into account the role of loneliness and other covariates, it was no longer significant. The role of perceived social support in protecting against

anxiety and depressive symptoms has also been reported (Gariépy, 2016). The pandemic is a unique period whereby social gatherings and interactions have been interrupted, and probably not asking for support from friends and relatives was preferred over putting them at risk of infection. Importantly, individuals in the 'high rising' loneliness trajectory had the highest levels of anxiety and depression symptoms, even after adjustment for confounding factors. The fact that loneliness is associated with depression and anxiety has been reported widely in the literature (Beutel, et al., 2017) (Tiikkainen & Heikkinen, 2010) and our outcomes show that this is also particularly the case during the COVID-19 pandemic, but only for those who have high levels of loneliness that increase over time. The role of social support in buffering the relationship between risk factors (including loneliness) and mental health outcomes has been reported in the literature, however, this effect is most noticeable when the social support measure is matched with the specific stressor (Cohen & Wills, 1985). A longitudinal study reported the absence of the buffering effect of social support between loneliness and increased anxiety, however, interaction analysis revealed that only family support was buffering in this case (Xu et al., 2020)

## **Strengths and limitations**

Our study has several strengths, among which its longitudinal design. We collected data at 4 different and equally distant time points (3 during confinement and 1 out of confinement) which provides a good opportunity to understand changes in social support and loneliness throughout the pandemic. Furthermore, the data collection was in real-time and therefore minimizing recall bias. Additionally, we used GBTM to analyze the trajectories of social support and loneliness allowing the identification of different homogeneous subgroups of individuals and observe their variation across the pandemic. In addition, we conducted further analysis to identify the predictors of these trajectories, and their associations with mental health outcomes, in particular anxiety and depression.

Our study has some limitations as well. First, the COMET study was developed as a response to the emergence of the COVID-19 pandemic and hence, we didn't have data collected pre-pandemic to allow us to compare our variables of interest on. Therefore, we cannot be sure whether the different determined trajectories are in reaction to the pandemic, or that they are a continuation of already present subgroups in the population concerning these factors.

Second, our sample was recruited mainly through a snowball sampling method by using social media platforms and universities mailing lists. This method is inexpensive and easy to conduct. However, it has its disadvantages as well. First, to keep the survey relatively short in order to minimize non-response, many questions would have been helpful if they would have been included in the questionnaire (e.g. city of residence to have more precise information on confinement measures, boredom, sleeping disturbances). Secondly, it may have resulted in selection bias and therefore might hinder the generalizability in terms of prevalence rates. Our sample had an over-representation of females, middle-aged individuals, employees whose income wasn't affected by the crisis and those with physical illness. This might also lead to an underestimation in our findings regarding the impact on under-represented groups. Third, the web-based setting of the study led to non-response on certain items and loss of follow-up mainly between the first and second data wave. It is possible that that non-responders to the study or specific items on the questionnaire might have worse mental health outcomes and therefore our findings might be an underestimation. Yet, those who were loss-to-follow up were non-significantly different than those who remained in our study. In addition, our use of a group-based modelling strategy for the estimation of our social support and loneliness trajectories, allowed us to include subjects with partial data, thus minimizing the impact of loss-to-follow-up. A multiple imputation analysis of missing covariates will allow us to narrow the uncertainty with the missing values.

Third, we used validated tools to measure our outcomes. However, answers were self-reported which might also generate information bias: Mental illnesses are in general underreported in epidemiological studies (Takayanagi, et al., 2014), however, it is difficult to estimate to what extent this affected our results given our study was largely focused on mental health in COVID-19, a situation of which epidemiological information is still inconclusive. In addition, while our exposures of interest were assessed by validated tools, they do have some limitations in their use. The OSSS-3 social support scale was translated to French, but to our knowledge, an official validation for the tool with the French population has not been conducted. The loneliness questionnaire is composed of only one question. While this type of question has been used in other studies it assumes however, a common understanding of "loneliness" among the participants specially that we are measuring the perceived loneliness and not the actual social isolation (Victor, et al., 2006). The full UCLA loneliness scale, for example, is widely used in mental health studies, however, given the nature of our online survey which should be short, 20 questions might be time consuming and increase risk of missingness (Russell, 2010).

Finally, the study sample size doesn't allow us to conduct further stratified analysis to observe, for example, the differences in age groups. However, it is possible to see if our outcomes can be replicated for the whole COMET cohort, which includes 8,084 persons and gives more statistical power to detect smaller differences.

## **Future Implications**

Our findings revealed subgroups of individuals that experienced higher levels of loneliness compared to others (i.e. singles and those with mental illnesses). Further, it showed that the increased perception of loneliness is associated with an increase in symptoms of depression and anxiety during the pandemic. This strongly necessitates strategizing and implementing interventions designed to combat loneliness, especially for these vulnerable groups.

Interventions can be integrated at the societal and individual levels: First, at the societal level, raising awareness on the risks of loneliness and the importance of social relationships.

Furthermore, many interventions to combat loneliness and its associated mental health outcomes are designed for elderly. While this is important, our research showed other vulnerable groups are at risk as well. Therefore, policies that are put in place should include everyone that is at risk. For example, ensuring the continuous screening and early detection of mental health symptoms and illnesses (Mann, et al., 2017). Second at the individual level, several low-cost, COVID-19 friendly interventions have been reported in the literature as effective in decreasing the feelings of loneliness. Online Cognitive behavioral therapy (CBT) which is a talking therapy that aims at decreasing negative feelings towards current adversities, has been proven to decrease feelings of loneliness in people with depression and anxiety (Mann, et al., 2017). Mindfulness exercises, which are meditation-based exercises, have also been shown to decrease levels of loneliness in different age groups (Williams, et al., 2021) and in enhancing relationships (Carson, et al., 2004). There is no one-size fit all intervention, it is essential to continuously monitor the effectiveness of the interventions for the individuals at risk in reducing feelings of loneliness and consequently reducing the symptoms of depression and anxiety.

## **Conclusion**

Our study shows that high and increasing levels of loneliness during the COVID-19 pandemic are associated with increased symptoms of anxiety and depression. Especially those being single and with mental illnesses are mostly at risk to belong to this specific group. The pandemic

didn't end yet, and therefore, interventions designed to combat loneliness are a must to improve well-being.

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## Appendix. 1 – Generalized Anxiety Disorder (GAD-7) and Patient Health Questionnaire (PHQ-9) Questionnaires in French and English.

### 1. Generalized Anxiety Disorder (GAD-7) questionnaire in English.

	Over the past 2 weeks, how often have you been bothered by the following problems?	Not at all	Several Days	Over half the days	Nearly every day
1	Feeling nervous, anxious, or on edge	0	1	2	3
2	Not being able to stop or control worrying	0	1	2	3
3	Worrying too much about different things	0	1	2	3
4	Trouble relaxing	0	1	2	3
5	Being so restless that it's hard to sit still	0	1	2	3
6	Becoming easily annoying or irritable	0	1	2	3
7	Feeling afraid as if something awful might happen	0	1	2	3

### 2. Generalized Anxiety Disorder (GAD-7) questionnaire in French.

	Au cours des deux dernières semaines, à quelle fréquence avez-vous été dérangé(e) par les problèmes suivants?	Jamais	Plusieurs jours	Plus de la moitié des jours	Presque tous les jours
1	Sentiment de nervosité, d'anxiété ou de tension	0	1	2	3
2	Incapable d'arrêter de vous inquiéter ou de contrôler vos inquiétudes	0	1	2	3
3	Inquiétudes excessives à propos de tout et de rien	0	1	2	3
4	Difficulté à se détendre	0	1	2	3
5	Agitation telle qu'il devient difficile de rester tranquille	0	1	2	3
6	Devenir facilement contrarié(e) ou irritable	0	1	2	3
7	Avoir peur que quelque chose d'épouvantable puisse arriver	0	1	2	3

### 3. Patient Health Questionnaire (PHQ-9) in English

	Over the past 2 weeks, how often have you been bothered by any of the following problems?	Not at all	Several Days	More than half the days	Nearly every day
1	Little interest or pleasure in doing things	0	1	2	3
2	Feeling down, depressed or hopeless	0	1	2	3
3	Trouble falling asleep, staying asleep, or sleeping too much	0	1	2	3
4	Feeling tired or having little energy	0	1	2	3
5	Poor appetite or overeating	0	1	2	3
6	Feeling bad about yourself – or that you’re a failure or have let yourself or your family down	0	1	2	3
7	Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8	Moving or speaking so slowly that other people could have noticed. Or, the opposite- being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9	Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

### 4. Patient Health Questionnaire (PHQ-) in French

	Au cours des deux dernières, à quelle fréquence avez-vous été dérangé par les problèmes suivants ?	Jamais	Plusieurs jours	Plus de la moitié du temps	Presque tous les jours
1	Peu d'intérêt ou de plaisir à faire les choses	0	1	2	3
2	Être triste, déprimé(e) ou désespéré(e)	0	1	2	3
3	Difficultés à s'endormir ou à rester endormi(e), ou dormir trop	0	1	2	3
4	Se sentir fatigué(e) ou manquer d'énergie	0	1	2	3
5	Avoir peu d'appétit ou manger trop	0	1	2	3
6	Avoir une mauvaise opinion de soi-même, ou avoir le sentiment d'être nul(le), ou d'avoir déçu sa famille ou s'être déçu(e) soi-même	0	1	2	3
7	Avoir du mal à se concentrer, par exemple, pour lire le journal ou regarder la télévision	0	1	2	3
8	Bouger ou parler si lentement que les autres auraient pu le remarquer. Ou au contraire, être si agité(e) que vous avez eu du mal à tenir en place par rapport à d'habitude	0	1	2	3
9	Penser qu'il vaudrait mieux mourir ou envisager de vous faire du mal d'une manière ou d'une autre.	0	1	2	3

## Appendix. 2: The steps to selecting the best trajectory model for Social Support and Loneliness

### Social Support

**Step 1:** We chose the groups by selecting the best BIC (Table A2.1). Group 5 had the highest BIC, but it had three group with low membership (7.4%, 5.7% and 13.0%), therefore group 4 was chosen

Group	BIC	2ΔBIC
1	-4491.16	-Ref-
2	-4127.84	726.64
3	-3939.9	1102.52
4	<b>-3870.47</b>	<b>1241.38</b>
5	<b>-3863.16</b>	<b>1256</b>
6	-3867.5	1247.32

**Step 2:** After choosing the 4<sup>th</sup> group in the first step since it has the highest BIC, we test to see which the best polynomial order is. We obtain 256 trajectories. We're portraying the first 6 with the best BIC (Table A2.2)

	Polynomial Orders	0-0-0-0	<b>0-2-0-0</b>	0-1-0-0	0-0-0-1	1-0-0-0	0-0-1-0
trajectories	BIC	<b>-3842.36</b>	<b>-3844.72</b>	-3845.10	-3845.24	-3845.60	-3845.61
1	P	17.18	17.03	17.18	17.18	17.18	17.18
	π	17.25	17.42	17.29	17.24	17.27	17.25
2	P	42.73	42.44	42.29	42.73	42.73	42.73
	π	40.65	41.03	40.75	40.62	40.64	40.67
3	P	34.95	35.39	35.39	34.95	34.95	34.95
	π	36.48	35.94	36.33	36.40	36.48	36.46
4	P	5.14	5.14	5.14	5.14	5.14	5.14
	π	5.62	5.61	5.63	5.74	5.62	5.62
1	APP1	0.93	0.94	0.93	0.93	0.93	0.93
2	APP2	0.86	0.86	0.86	0.86	0.86	0.86
3	APP3	0.89	0.88	0.88	0.89	0.89	0.89
4	APP4	0.91	0.91	0.91	0.92	0.91	0.91
1	OCC 1	63.15	74.17	64.65	63.10	63.24	63.14
2	OCC 2	8.68	8.97	8.94	8.66	8.66	8.71
3	OCC 3	14.35	12.74	13.30	14.12	14.35	14.36
4	OCC 4	173.07	173.07	174.08	185.76	172.95	174.66

We observed the statistical and graphical results and chose **0-2-0-0** as it has the second-best BIC but, the difference in P and π for each trajectory group are smaller in 0-2-0-0 than in the 0-0-0-0 which indicate a better fit. In **0-2-0-0**, OCC are all greater than 5, and the APP > 0.70.



## Loneliness

Step 1: We chose the groups by selecting the best BIC (Table A2.1). Group 5 had the highest BIC, but it had two groups with low membership (3.5% and 3.6% and 13.0%), therefore group 4 was chosen.

Group	BIC	2ΔBIC
1	-3268.92	-Ref-
2	-3036.48	464.88
3	-2934.54	668.76
4	-2913.09	711.66
5	<b>-2918.9</b>	<b>700.04</b>
6	-2914.86	708.12

Step 2: After choosing the 4<sup>th</sup> group in the first step since it has the highest BIC, we test to see which the best polynomial order is. We obtain 256 trajectories whereby we project the first 6 having the highest BIC (Table A.2.4).

	Polynomial Orders	0-1-0-0	0-0-0-0	0-1-0-2	0-2-0-0	1-0-0-0	0-0-0-2
trajectories	BIC	-2891.97	-2892.33	-2892.85	-2892.86	-2893.03	-2893.13
1	P	17.18	17.18	17.18	17.18	17.18	17.18
	π	17.03	16.71	16.89	16.81	16.34	17.15
2	P	40.23	37.89	40.23	37.15	37.89	40.97
	π	42.32	40.71	42.01	39.95	40.37	42.98
3	P	37.44	39.35	37.59	39.35	38.62	36.86
	π	35.62	36.71	36.06	37.26	37.31	34.88
4	P	5.14	5.58	4.99	6.31	6.31	4.99
	π	5.03	5.87	5.05	5.98	5.97	4.99
1	APP 1	0.88	0.87	0.86	0.86	0.86	0.88
2	APP 2	0.82	0.81	0.81	0.81	0.81	0.81
3	APP 3	0.78	0.77	0.79	0.78	0.78	0.77
4	APP 4	0.82	0.83	0.83	0.80	0.80	0.83
1	OCC 1	36.10	32.30	30.81	31.56	31.97	34.35
2	OCC 2	6.10	6.21	5.88	6.37	6.26	5.79
3	OCC 3	6.40	5.76	6.54	6.01	6.07	6.28
4	OCC 4	86.40	77.11	94.48	61.72	61.28	92.40

We observed the statistical and graphical results and chose **0-1-0-2** as it has the second-best BIC but, the difference in P and π for each trajectory group are closer to each other in 0-1-0-0 and 0-0-0-0 which indicate a better fit. In **0-1-0-2**, OCC are all greater than 5, and the APP > 0.70.

### Appendix. 3: Sensitivity Analysis Results for the association between social support, loneliness and depression symptoms.

Table A4.1. The association of social support and loneliness trajectories with symptoms of depression in French participants of the COMET cohort (N = 364)

		Model 1	Model 2	Model 3	Model 4 <sup>§</sup>
		OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Social Support Trajectories (Strong group as reference)	Low	<b>3.00**</b> [1.54, 4.65]		0.80 [-0.56, 2.16]	0.85 [-0.51, 2.20]
	Moderate	0.85 [0.45, 1.57]		-0.78 [-1.81, 0.25]	-0.84 [-1.84, 0.16]
	Very strong	0.53 [0.12, 1.13]		-0.62 [-2.40, 1.15]	-0.77 [-2.47, 0.93]
Loneliness Trajectories (Moderate stable as reference)	Low stable		<b>0.04**</b> [0.00, 0.17]	<b>0.04**</b> [0.00, 0.18]	<b>0.06**</b> [0.00, 0.34]
	Low rising		<b>0.32***</b> [0.18, 0.58]	<b>0.34**</b> [0.18, 0.63]	<b>0.30**</b> [0.14, 0.61]
	High rising		<b>6.90**</b> [2.28, 25.68]	<b>6.07**</b> [1.95, 23.11]	<b>5.84**</b> [1.70, 24.57]

<sup>§</sup>Model adjusted for: age, gender, education, relationship status, knowing someone with COVID-19, diagnosed mental illness, and having distress related to COVID-19 pandemic;  
 (\*\*\*) *p*-value<0.001; (\*\*) *p*-value<0.01; (\*) *p*-value<0.05; OR = Odds ratio; CI = confidence interval.

## Appendix. 4. Sensitivity Analysis Results for the association between social support, loneliness and anxiety symptoms.

**Table A4.2. The association of social support and loneliness and trajectories with symptoms of anxiety in French participants of the COMET cohort (N = 369)**

		Model 1	Model 2	Model 3	Model 4 <sup>§</sup>
		OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Social Support Trajectories (Strong group as reference)	Low	2.07 [0.96, 4.46]		0.01 [-1.26, 1.28]	-0.14 [-1.34, 1.06]
	Moderate	1.03 [0.52, 2.08]		-0.51 [-1.48, 0.46]	-0.60 [-1.49, 0.30]
	Very strong	0.23 [0.01, 1.18]		-1.14 [-2.80, 0.52]	-1.15 [-2.66, 0.37]
Loneliness Trajectories (Moderate stable as reference)	Low stable		<b>0.07**</b> [0.00, 0.33]	<b>0.08*</b> [0.00, 0.38]	0.20 [0.01, 1.13]
	Low rising		<b>0.41*</b> [0.20, 0.80]	<b>0.41*</b> [0.20, 0.84]	<b>0.45*</b> [0.20, 0.99]
	High rising		<b>10.40***</b> [3.58, 34.88]	<b>10.92***</b> [3.65, 38.07]	<b>15.12***</b> [4.44, 59.51]

<sup>§</sup>Model adjusted for: age, gender, number of people in the household, consider the COVID-19 regulation appropriate, mental illness, financial worries and having distress related to COVID-19 pandemic; (\*\*\*) *p*-value<0.001; (\*\*) *p*-value<0.01; (\*) *p*-value<0.05; OR = Odds ratio; CI = confidence interval.

## Résumé

**Introduction** : En période de crise et de stress, certains facteurs, comme le soutien social, semblent protéger la santé mentale contre les adversités, cependant, d'autres facteurs comme le sentiment de solitude sont rapportés comme augmentant les résultats négatifs sur la santé mentale. Dans l'étude COVID-19 en particulier, on sait peu de choses sur l'évolution du soutien social et de la solitude au fil du temps en France, et sur leur impact sur la santé mentale. Dans ce contexte, nous avons voulu (1) étudier les trajectoires longitudinales du soutien social et de la solitude en France pendant la pandémie COVID-19, (2) explorer quels facteurs prédisent ces trajectoires longitudinales afin d'identifier les groupes vulnérables dans la population, et (3) déterminer si les variations de ces trajectoires prédisent les symptômes de dépression et d'anxiété. **Méthodes** : Les données de 681 individus de l'étude COMET collectées à quatre périodes de temps de mai 2020 à avril 2021 ont été utilisées. Une modélisation de trajectoire basée sur le groupe a été utilisée pour analyser les trajectoires de soutien social et de solitude. Les facteurs sociodémographiques, de santé et liés à COVID-19 ont été explorés par régression logistique multinomiale pour identifier les prédicteurs de ces trajectoires. Enfin, des modèles de régression linéaire ont été utilisés pour tester l'association entre les trajectoires et les symptômes de dépression et d'anxiété. **Résultats** : Les trajectoires de soutien social ont révélé quatre groupes stables : faible (17,0%), modéré (42,4%), fort (35,4%) et très fort (5,1%). Les trajectoires de solitude ont également permis d'identifier quatre groupes stables : faible stable (17,8%), faible croissant (40,2%), modéré stable (37,6%) et fort croissant (5,0%). Le fait d'être célibataire était un facteur prédictif de l'appartenance à la fois au groupe à faible soutien social (OR = 3,24, IC 95 % [1,41 - 7,33]) et au groupe à forte augmentation de solitude (OR = 6,04, IC 95 % [1,10 - 33,05]). Les personnes souffrant de maladies mentales étaient plus susceptibles d'appartenir à des groupes de solitude élevée. Des niveaux plus élevés de solitude étaient associés à des symptômes élevés de dépression et d'anxiété, mais pas au soutien social ( $\beta = 7,05$ , IC 95 % [4,96 - 9,14]). **Conclusion** : Nos résultats ont montré que des niveaux élevés et croissants de solitude pendant la pandémie de COVID-19 sont prédictifs de symptômes accrus de dépression et d'anxiété. Plus précisément, les personnes seules et celles souffrant de maladies mentales sont les plus à risque. Des interventions visant à combattre la solitude sont nécessaires pendant et après la pandémie.

**Mots clés** : COVID-19, soutien social, sentiment de solitude, santé mentale.