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# **Housing conditions and changes in professional activity during lockdown and the risk of prevalent and incident depression: Findings from the CONSTANCES Cohort**

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## **Introduction**

The COVID-19 pandemic has been an unprecedented upheaval regarding public health in the modern history. The World Health organization characterized the outbreak as a pandemic on March 11, 2020<sup>1</sup>. To limit the spread of the virus, different public health measures have been taken. Numerous governments chose to recommend or impose general lockdown, changing the way of living of hundreds of millions of people, throughout different dimensions like socializing, or working for several months in some cases. The French government applied confinement strategy measures from March 17, 2020 to May, 11 2020. People were only allowed to go out for a limited amount of time and essential tasks. Distance working was encouraged to promote the maintenance of professional activities and to limit the economic impact of the crisis.

Among the numerous public health outcomes potentially associated with the pandemic, it has been documented that the impact was particularly important on mental health<sup>2,3</sup>. In the general population, a meta-analysis of studies from the early phase of the pandemic estimated the pooled prevalence of depression to be up to 31.4%. The prevalence of anxiety and insomnia was 31.9% and 37.9% respectively<sup>4</sup>. An increase of 27.6% of cases of major depressive disorder was estimated to be attributed to the COVID-19 pandemic<sup>2</sup>. Beyond personal suffering, depression is of particular concern in a public health perspective, resulting in functional impairment and suicide risk<sup>5,6</sup>. Indeed, the Global Burden of Diseases, Injuries and Risk Factors Study 2019 presented depressive disorders as one of the top leading causes of burden worldwide<sup>7</sup>. Furthermore, in the context of a global pandemic, mental health

consequences and risks, should be carefully considered as potential side effects of lockdown on global health.

This impact on mental health could be linked to different factors. Increased distress could for example be linked to worries about one's own or relatives' health and the risk of dying or being impaired<sup>8</sup>. Conditions of lockdowns could also have negative impacts on mental health. Restricting social contacts and daily routine in functioning can contribute to greater psychological distress. The literature regarding previous epidemics already highlighted the impact of quarantine measures<sup>9</sup>. Some risk factors regarding depression during lockdown are already known to be associated with depressive disorders in general, such as female gender, low household income or loneliness<sup>10</sup>. Recent findings also showed that living alone or in crowded households, and not having access to an outdoor space were suggestively associated with worst outcomes such as lower life satisfaction<sup>11</sup>. Therefore, some risk factors may be specific to the COVID-19 pandemic and lockdown conditions. For example, high levels of anxiety, depression and poor sleep quality were observed among full-time teleworkers during lockdown<sup>12</sup>. However, more specific data lack to understand the role on depression of material conditions of lockdown and imposed changes in regular functioning by these measures.

To examine the associations of different sociodemographic characteristics, housing conditions and changes in professional activity with depression during lockdown, we used data from the large population-based CONSTANCES cohort.

## Materials and Methods

### *The CONSTANCES cohort*

The CONSTANCES cohort is a national population-based cohort of randomly recruited volunteers aged 18–69 years at baseline in 21 selected health centers<sup>13</sup>. The cohort has obtained the authorization of the National Data Protection Authority (Commission Nationale de l'Informatique et des Libertés, no.910486) and was approved by the Institutional Review Board of the National Institute for Medical Research (no. 01–011 and 21-842). Written informed consent was received from all participants. Participants complete a self-administered questionnaire at inclusion between 2012 and 2019 and every year for follow-up. Additionally, participants followed using online questionnaires were invited to participate to the “Santé, Pratiques, Relations et Inégalités Sociales en Population Générale Pendant la Crise COVID-19” (SAPRIS)<sup>14</sup> survey, and were requested to complete questionnaires at different time periods of the pandemic. A first questionnaire covered the lockdown period (sent from April 6 2020 and returned before May 4, 2020), and a second questionnaire covered the immediate post-lockdown period (sent from April 30 2020 and returned before June 15, 2020).

### *Measure of depression (second questionnaire, covering the immediate post-lockdown period)*

Participants completed the Center of Epidemiologic Studies Depression Scale (CES-D) as part of the second questionnaire, covering the immediate post-lockdown period. This 20-item scale evaluates the frequency of depressive symptoms during the previous week. Internal consistency is high (Cronbach's alpha=0.90 in the CONSTANCES cohort)<sup>15</sup>. A score  $\geq 19$  is generally considered the validated cutoff to identify depression, using the French Version<sup>16</sup> (sensitivity/specificity for the diagnosis of major depression: 0.853/0.859), so this threshold

was used to identify participants with significant levels of depressive symptoms, henceforth referred to as ‘depression’.

Another outcome was built to estimate incident depression. For this purpose, we used data from the last questionnaire of the CONSTANCES cohort prior to the COVID-19 pandemic with available data on the CES-D (i.e. the follow-up questionnaire of 2018 or the inclusion questionnaire of 2018 or 2019). Therefore, we defined new cases of depression as participants who had a CES-D score  $<19$  prior to the COVID-19 pandemic and a CESD-score  $\geq 19$  at the immediate post-lockdown period questionnaire. These new cases were compared to all other participants (i.e. by using a binary variable). The sample size was slightly different: the CES-D score in 2020 was available for 22,097 participants and among them, 20,582 also had a previous CES-D score available.

#### *Housing conditions and changes in professional activity (first questionnaire, covering the lockdown period)*

We used variables depicting housing conditions: participants were asked to describe 1) the number of rooms in their dwelling (without taking into account the kitchen and the bathroom) and 2) how many people (including themselves) were living in this dwelling.

Another variable depicted changes in professional activity since the start of the lockdown, categorized in 7 different modalities: 1) Maintained work with no distance working 2) Started distance working; 3) Started a new job; 4) Was already distance working; 5) Temporary layoff since the start of the first lockdown; 6) Other (being inactive); 7) Other (being employed).

#### *Adjustment variables*

The following socio-demographic characteristics were considered as adjustment variables: age, gender, educational level, household income and marital status. Educational level was based on the 2011 International Standard Classification of Education: 1) Early childhood education to post-secondary non-tertiary education, 2) Short-cycle tertiary education to Bachelor's or equivalent and 3) Master's or equivalent level and Doctoral or equivalent level. Household income was categorized: 1) <2100 euros/months; 2) From 2100 to 2800; 3) From 2800 to 4000 and 4) >4000. We also considered a "recent resident" variable, by identifying participants who had resided in France for less than 10 years at inclusion. All variables were collected within the first questionnaire covering the lockdown period, except for educational level and household income that was collected from the CONSTANCES inclusion questionnaire.

We also adjusted our analyses on history of depression, this variable being a well-known risk factor. It was computed considering self-reported history of depression at the inclusion and during the subsequent follow-up questionnaires.

To explore potential confounding factors regarding working conditions, we also used variables depicting physical activity and social interactions with coworkers.

### *Statistical Analysis*

We performed several multivariable binary logistic regression models, with depression as the outcome. Results are presented as Odds Ratios (ORs) with their 95% confidence intervals (95% CIs). First, we explored the association of depression with housing conditions (i.e., number of people and number of rooms, Model 1). Second, we explored the association with changes in professional activity (Model 2). Third, we included both housing conditions and changes in professional activity (Model 3). Then, we adjusted this latter model on changes in physical activity and in social interactions with coworkers (Model 4). All models were

adjusted on socio-demographic characteristics and history of depression. Of note, in logistic regression models, age is presented as “age by 10 years” to ease the reading of associated Odds Ratios years (obtained by dividing age by 10 for every participant). This way, the odds ratios would depict the increase in risk of depression for an increase in age by 10.

We also performed post-hoc analyses searching for interactions between gender and housing conditions or changes in professional activity.

We conducted sensitivity analyses. First, we replaced household income by a subjective assessment of income, collected at the first questionnaire covering the lockdown period (Likert scale of 6 points; 1 being great and 6 being the worst). Second, we replaced household income and educational level by occupational status (farmer/blue-collar worker/craftsman/”clerk” (clerical or commercial employee, childcare worker, service agent)/intermediate worker (e.g. school teacher, nurse, technician, foreman, supervising officer)/executive and other). Occupational status is a useful proxy for socio-economic status as it integrates the educational achievements, the skills required to obtain a job, the long-term associated rewards, and several job characteristics. Third, to limit selection bias, we repeated the analyses, removing variables with high number of missing data.

All the analyses were performed using Stata 15.0 (StataCorp, College Station, TX)



## Results

### *Participants' characteristics*

A total of 22,042 participants were included in the analyses. Figure 1 presents the flow of participants for this study. There were 53.2% women and median age was 46 [38-54] years. Table 1 presents detailed participants' characteristics. A total of 3,516 participants (16%) presented with depression at the time of the second questionnaire. Considering incident depression, 1,902 out of 20,534 participants had a CES-D score <19 before the pandemic, and a CES-D score  $\geq 19$  (9.26%) in the immediate post-lockdown period.

When comparing our study sample with the population of participants at the first questionnaire, we found that our population was slightly younger (median age 52[41-64] years) and with higher educational level (ISCED 1-4 17.5% and 27.1% respectively). The proportion of women was quite similar (50.9%) as well as the number of participants with a CES-D  $\geq 19$  (14.8% respectively).

**Table 1 : Participants' characteristics (N=22,042)**

<b>CONTINUOUS VARIABLES</b>		<b>Median</b>	<b>IqR</b>
<b>Age</b>		46	38-54
<b>CATEGORICAL VARIABLES</b>		<b>n</b>	<b>%</b>
<b>Gender (women)</b>		11,727	53.20
<b>History of depression</b>		1,682	7.63
<b>Educational level (ISCED)</b>	1-4	3,796	17.22
	5-6	9,202	41.75
	7-8	8,917	40.45
	Missing	127	0.58
<b>Household income</b>	<2100 euros	2,723	12.35
	2100-2800	2,549	11.56
	2800-4200	7,165	32.51
	>4200	9,019	40.92
	Others (does not wish to answer)	586	2.66
<b>Recent resident (<math>\leq 10</math> years)</b>		107	0.48
<b>Marital status</b>	Single	5,453	24.74
	Married	14,944	67.80
	Divorced	1,452	6.59
	Widowed	193	0.87
<b>Housing: number of people</b>	1	2,993	13.58
	2	6,092	27.64
	3	4,454	20.21
	4	6,114	27.74
	5	1,945	8.82
	$\geq 6$	444	2.01
<b>Housing: number of rooms</b>	1	416	1.89
	2	1,954	8.86
	3	3,480	15.79
	4	4,721	21.42
	5	5,248	23.81
	6	3,442	15.62
	$\geq 7$	2,781	12.62
<b>Changes in professional activity</b>	Not distance working	3,193	14.49
	Started distance working	13,014	59.04
	Has a new job	68	0.31
	Was already distance working	603	2.74
	Temporary lay-offs	1,568	7.11
	Other (inactives)	1,587	7.20
	Other (employees)	949	4.31
	Missing	1,060	4.81

### *Univariable analysis*

Table 2 presents the Odds Ratios (OR) estimating the crude association between depression within the immediate post-lockdown period and the different variables of interest assessed at baseline (i.e. sociodemographic factors, housing conditions and changes in professional activity assessed in the first questionnaire covering the lockdown period). Depression was associated with younger age, being a woman, living in France for less than 10 years at inclusion, having a history of depression and a lower household income. Number of rooms in the dwelling was associated with depression and the estimated ORs presented a gradient (p for linear trend <0.001), lower number of rooms in the dwelling being associated with higher odds of depression. Living alone was also associated with depression. Changes in professional activity were associated with depression: every modality was associated with a greater risk, as compared to those who were still working but not distance working, (except for those who were already distance working).

**Table 2: Association between each variable and risk of depression in univariable binary logistic regression models (N=22,042)**

		<b>OR (CI95%)</b>	<b>P</b>
<b>Age (by 10 years)</b>		<b>0.91 (0.98-0.95)</b>	<b>&lt;0.001</b>
<b>Gender (women)</b>		<b>1.88 (1.74-2.03)</b>	<b>&lt;0.001</b>
<b>History of depression</b>		<b>4.48 (4.03-4.97)</b>	<b>&lt;0.001</b>
<b>Educational level (ISCED)</b>	1-4	1.09 (0.98-1.21)	0.10
(reference: ISCED 7-8)	5-6	<b>1.10 (1.02-1.19)</b>	<b>0.018</b>
	Missing	0.80 (0.47-1.36)	0.413
<b>Household income (euros)</b>	<2100 euros	<b>2.34 (2.10-2.61)</b>	<b>&lt;0.001</b>
(reference: >4200)	2100-2800	<b>1.82 (1.62-2.04)</b>	<b>&lt;0.001</b>
	2800-4200	<b>1.33 (1.22-1.46)</b>	<b>&lt;0.001</b>
	Others (does not wish to answer)	<b>1.60 (1.29-2.00)</b>	<b>&lt;0.001</b>
<b>Recent resident (<math>\leq</math>10 years)</b>		1.87 (1.22-2.89)	0.004
<b>Marital status</b>	Single	<b>1.94 (1.79-2.10)</b>	<b>&lt;0.001</b>
(reference: married)	Divorced	<b>2.03 (1.78-2.32)</b>	<b>&lt;0.001</b>
	Widowed	<b>2.18 (1.56-3.04)</b>	<b>&lt;0.001</b>
<b>Housing: number of rooms</b>	1	<b>2.74 (2.20-3.42)</b>	<b>&lt;0.001</b>
(reference: 5)	2	<b>2.02 (1.78-2.30)</b>	<b>&lt;0.001</b>
	3	<b>1.40 (1.25-1.57)</b>	<b>&lt;0.001</b>
	4	<b>1.13 (1.02-1.26)</b>	<b>0.025</b>
	6	<b>0.75 (0.66-0.86)</b>	<b>&lt;0.001</b>
	$\geq$ 7	<b>0.72 (0.63-0.83)</b>	<b>&lt;0.001</b>
<b>Housing: number of people</b>	1	<b>2.24 (2.01-2.49)</b>	<b>&lt;0.001</b>
(reference: 2)	3	0.96 (0.86-1.07)	0.511
	4	<b>0.83 (0.75-0.92)</b>	<b>&lt;0.001</b>
	5	0.89 (0.77-1.04)	0.139
	$\geq$ 6	0.99 (0.76-1.30)	0.945
<b>Changes in professional activity</b>	Started distance working	<b>1.19 (1.06-1.33)</b>	<b>0.002</b>
(reference: not distance working)	Has a new job	<b>2.51 (1.46-4.31)</b>	<b>0.001</b>
	Was already distance working	1.15 (0.90-1.47)	0.262
	Temporary lay-offs	<b>1.40 (1.19-1.65)</b>	<b>&lt;0.001</b>
	Other (inactives)	<b>1.59 (1.36-1.87)</b>	<b>&lt;0.001</b>
	Other (employees)	<b>1.38 (1.14-1.68)</b>	<b>0.001</b>
	Missing	<b>1.49 (1.24-1.79)</b>	<b>&lt;0.001</b>

### *Multivariable analyses*

Table 3 displays the results of the multivariable binary logistic regression models for prevalent depression. Being a woman and having a history of depression were still associated with depression, while age was not across all models (1 to 4). Having a lower income was also associated with depression, across all statistical models (1 to 4). Being single, divorced or widowed were all associated with a greater risk of depression (as compared to being married) (models 1 to 4). Living in France for less than 10 years at inclusion was still associated with depression after adjusting for working conditions alone (model 2), but this significant association was no longer observed across other models, while adjusting for housing conditions.

Housing conditions were also associated with depression (Model 1, 3 and 4). The adjusted Odds Ratios (aOR) associated with number of rooms still showed a gradient by multivariable analysis. This gradient was observed across all statistical models with similar aORs and was consistently significant ( $p$  for trend  $<0.001$ ). Regarding the number of people in the same dwelling, being alone was positively associated with depression, but a positive association was also observed for a higher number of people living in the same household, suggesting a U-shape relationship, when accounting for the other variables. These associations were observed across all models adjusting for housing conditions (Model 1,3 and 4)

Changes in professional activity were associated with depression (Model 2, 3 and 4). Compared to participants that were still working but not distance working, all other modalities presented greater risks of depression: participants who started distance working, who were already distance working, who had a new job, who mentioned other changes, who were inactive, who experienced temporarily lay-offs and who had missing data regarding changes.

These associations were consistently observed across all models and adjusting for housing conditions did not significantly change the estimations (model 3). Similarly, when adjusting for physical activity and interactions with coworkers (model 4), changes in professional activity were still associated with depression with a similar magnitude. Less frequent physical activity and less frequent interactions with coworkers were also independently associated with greater risks of depression.

**Table 3: Variables associated with depression in multivariable binary logistic regression models (N = 22,042)**

		Model 1		Model 2		Model 3		Model 4	
		aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI
<b>Age (by 10 years)</b>		0.98	0.94-1.02	0.98	0.94-1.02	0.97	0.93-1.02	0.99	0.94-1.03
<b>Gender (women)</b>		<b>1.80</b>	<b>1.67-1.95</b>	<b>1.74</b>	<b>1.61-1.88</b>	<b>1.79</b>	<b>1.66-1.94</b>	<b>1.86</b>	<b>1.71-2.01</b>
<b>History of depression</b>		<b>4.00</b>	<b>3.58-4.45</b>	<b>3.96</b>	<b>3.56-4.41</b>	<b>3.96</b>	<b>3.55-4.41</b>	<b>3.70</b>	<b>3.31-4.13</b>
<b>Recent resident (≤10 years)</b>		1.47	0.93-2.34	<b>1.66</b>	<b>1.05-2.62</b>	1.46	0.92-2.32	1.42	0.88-2.28
<b>Educational level (ISCED)</b>	1-4	0.96	0.85-1.08	0.92	0.82-1.04	0.98	0.87-1.11	0.95	0.84-1.08
(reference: ISCED=7-8)	5-6	0.99	0.90-1.08	0.95	0.87-1.04	1.00	0.91-1.09	0.99	0.91-1.08
	Missing	0.76	0.44-1.31	0.75	0.43-1.29	0.76	0.44-1.32	0.74	0.43-1.29
<b>Household income (euros)</b>	<2100	<b>1.26</b>	<b>1.10-1.44</b>	<b>1.54</b>	<b>1.35-1.76</b>	<b>1.25</b>	<b>1.09-1.44</b>	<b>1.22</b>	<b>1.06-1.40</b>
(reference: >4200)	2100-2800	<b>1.26</b>	<b>1.11-1.44</b>	<b>1.42</b>	<b>1.25-1.62</b>	<b>1.25</b>	<b>1.09-1.43</b>	<b>1.19</b>	<b>1.05-1.36</b>
	2800-4200	<b>1.15</b>	<b>1.05-1.27</b>	<b>1.22</b>	<b>1.11-1.34</b>	<b>1.15</b>	<b>1.05-1.27</b>	<b>1.13</b>	<b>1.02-1.25</b>
	Others	1.25	0.99-1.58	<b>1.30</b>	<b>1.03-1.63</b>	1.23	0.98-1.55	1.24	0.98-1.58
<b>Marital status</b>	Single	<b>1.13</b>	<b>1.01-1.26</b>	<b>1.55</b>	<b>1.42-1.70</b>	<b>1.13</b>	<b>1.01-1.27</b>	<b>1.15</b>	<b>1.03-1.29</b>
(reference: Married)	Divorced	<b>1.34</b>	<b>1.15-1.56</b>	<b>1.61</b>	<b>1.39-1.85</b>	<b>1.34</b>	<b>1.15-1.55</b>	<b>1.40</b>	<b>1.20-1.62</b>
	Widowed	<b>1.55</b>	<b>1.09-2.21</b>	<b>1.79</b>	<b>1.27-2.53</b>	<b>1.52</b>	<b>1.07-2.16</b>	<b>1.60</b>	<b>1.12-2.28</b>
<b>Housing: number of rooms</b>	1	<b>1.59</b>	<b>1.23-2.04</b>	-	-	<b>1.57</b>	<b>1.22-2.02</b>	<b>1.55</b>	<b>1.19-2.00</b>
(reference: 5)	2	<b>1.40</b>	<b>1.19-1.65</b>	-	-	<b>1.39</b>	<b>1.18-1.64</b>	<b>1.39</b>	<b>1.18-1.64</b>
	3	<b>1.17</b>	<b>1.02-1.33</b>	-	-	<b>1.15</b>	<b>1.01-1.32</b>	<b>1.15</b>	<b>1.01-1.31</b>
	4	1.06	0.95-1.19	-	-	1.06	0.94-1.19	1.05	0.94-1.18
	6	<b>0.78</b>	<b>0.68-0.89</b>	-	-	<b>0.78</b>	<b>0.68-0.89</b>	<b>0.78</b>	<b>0.68-0.90</b>
	≥7	<b>0.75</b>	<b>0.64-0.87</b>	-	-	<b>0.75</b>	<b>0.64-0.87</b>	<b>0.76</b>	<b>0.65-0.88</b>
<b>Housing: number of people</b>	1	<b>1.61</b>	<b>1.42-1.83</b>	-	-	<b>1.63</b>	<b>1.43-1.85</b>	<b>1.62</b>	<b>1.42-1.84</b>
	2 (ref)	-	-	-	-	-	-	-	-
	3	1.05	0.93-1.18	-	-	1.05	0.93-1.17	1.01	0.90-1.14
	4	1.03	0.92-1.16	-	-	1.03	0.91-1.15	1.01	0.89-1.13
	5	<b>1.23</b>	<b>1.05-1.46</b>	-	-	<b>1.22</b>	<b>1.04-1.44</b>	<b>1.19</b>	<b>1.01-1.41</b>
	≥6	<b>1.43</b>	<b>1.07-1.91</b>	-	-	<b>1.43</b>	<b>1.07-1.91</b>	<b>1.44</b>	<b>1.07-1.92</b>
<b>Changes in professional activity</b>	Started distance working	-	-	<b>1.27</b>	<b>1.13-1.44</b>	<b>1.28</b>	<b>1.14-1.45</b>	<b>1.33</b>	<b>1.17-1.50</b>
(reference: not distance working)	Has a new job	-	-	<b>1.89</b>	<b>1.06-3.36</b>	<b>1.90</b>	<b>1.06-3.41</b>	<b>1.97</b>	<b>1.10-3.52</b>
	Was already distance working	-	-	<b>1.31</b>	<b>1.02-1.70</b>	<b>1.30</b>	<b>1.01-1.68</b>	<b>1.32</b>	<b>1.02-1.72</b>
	Temporary lay-offs	-	-	<b>1.36</b>	<b>1.14-1.61</b>	<b>1.37</b>	<b>1.16-1.63</b>	<b>1.29</b>	<b>1.08-1.55</b>
	Other (inactives)	-	-	<b>1.45</b>	<b>1.22-1.71</b>	<b>1.49</b>	<b>1.26-1.76</b>	<b>1.45</b>	<b>1.22-1.73</b>
	Other (employees)	-	-	<b>1.29</b>	<b>1.05-1.58</b>	<b>1.29</b>	<b>1.05-1.59</b>	<b>1.29</b>	<b>1.05-1.59</b>
	Missing (employees)	-	-	<b>1.52</b>	<b>1.26-1.84</b>	<b>1.50</b>	<b>1.24-1.82</b>	<b>1.56</b>	<b>1.28-1.91</b>
<b>Physical activity</b>	Daily	-	-	-	-	-	-	<b>0.78</b>	<b>0.72-0.85</b>
(reference: Frequently)	Never	-	-	-	-	-	-	<b>1.28</b>	<b>1.15-1.41</b>
<b>Interactions w/coworkers</b>	Less frequently/Never	-	-	-	-	-	-	<b>1.29</b>	<b>1.17-1.42</b>
(reference: Daily/Regularly)	Not concerned	-	-	-	-	-	-	1.17	0.93-1.47

Model 1 is adjusted for age, gender, history of depression, recent resident status, educational level, household income and marital status (A) and number of rooms and number of people in the dwelling (B).

Model 2 is adjusted for (A) and changes in professional activity (C).


Model 3 is adjusted for (A), (B) and (C).

Model 4 is adjusted for (A), (B), (C) and physical activity and interaction with co-workers.

When incident depression was considered the outcome (table 4), most of the significant associations were similar. Household income and marital status were no longer associated with depression, except for model 2. The association between a lower number of rooms and higher odds of depression was no longer statistically significant, but a lower risk was still observed for higher number of rooms, with a significant gradient ( $p$  for linear trend  $<0.001$ ) (Model 1, 3 and 4). For “changes in professional activity”, some of the observed associations were no longer statistically significant (Model 2,3 and 4). Nevertheless, some categories were still associated with a greater risk of incident depression: participants who started distance working, employees who experienced “other changes” in their professional activity, inactive participants and employees who had missing data.

Considering our findings, we conducted post-hoc analysis, searching for interactions between gender and housing conditions or changes in professional activity in model 3. We identified a significant negative interaction between having a smaller dwelling and female gender ( $p=0.030$  for one room) and a significant negative association between the number of people and female gender ( $p=0.035$ ). Finally, a significant negative interaction between female gender and starting distance working was also identified ( $p=0.040$ ). These results suggest that the effect of leaving alone, in a smaller dwelling and of distance working might be less important among women. Nevertheless, when stratifying on gender, all the observed associations remained significant for both men and women, although, the estimated effect sizes of leaving alone, in a smaller dwelling and starting distance working were smaller in





women than in men (Supplemental table 1). Noteworthy, living in France for less than 10 years at inclusion was significantly associated with depression in women, even after full adjustment, whereas this association was not observed in men.

**Table 4. Variables associated with incident depression in multivariable binary logistic regression models (N = 20,534)**

		Model 1		Model 2		Model 3		Model 4	
		aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI
<b>Age (by 10 years)</b>		0.95	0.90-1.00	0.95	0.90-1.01	0.95	0.89-1.00	0.95	0.90-1.01
<b>Gender (women)</b>		<b>1.66</b>	<b>1.51-1.84</b>	<b>1.62</b>	<b>1.47-1.79</b>	<b>1.66</b>	<b>1.50-1.83</b>	<b>1.68</b>	<b>1.52-1.86</b>
<b>History of depression</b>		<b>1.44</b>	<b>1.23-1.68</b>	<b>1.44</b>	<b>1.24-1.69</b>	<b>1.43</b>	<b>1.22-1.67</b>	<b>1.36</b>	<b>1.16-1.59</b>
<b>Recent resident (&lt;=10y)</b>		1.57	0.91-2.72	1.70	0.98-2.93	1.57	0.91-2.71	1.54	0.88-2.72
<b>SE status (ISCED)</b>	1-4	<b>0.82</b>	<b>0.70-0.95</b>	<b>0.80</b>	<b>0.68-0.94</b>	<b>0.84</b>	<b>0.72-0.99</b>	<b>0.82</b>	<b>0.70-0.97</b>
(reference: ISCED=7-8)	5-6	0.92	0.83-1.03	0.90	0.81-1.00	0.94	0.84-1.05	0.92	0.83-1.03
	Missing	0.87	0.45-1.68	0.87	0.45-1.67	0.87	0.45-1.69	0.85	0.44-1.65
<b>Household income</b>	<2100	1.06	0.89-1.27	<b>1.27</b>	<b>1.07-1.51</b>	1.07	0.89-1.28	1.03	0.86-1.24
(reference: >4200)	2100-2800	1.10	0.93-1.30	<b>1.23</b>	<b>1.04-1.45</b>	1.09	0.93-1.29	1.06	0.90-1.26
	2800-4200	1.02	0.90-1.15	1.07	0.95-1.21	1.02	0.90-1.15	1.00	0.89-1.14
	Others	1.06	0.78-1.44	1.10	0.81-1.50	1.05	0.77-1.43	1.07	0.79-1.46
<b>Marital status</b>	Single	1.01	0.87-1.16	<b>1.33</b>	<b>1.18-1.50</b>	1.01	0.87-1.16	1.02	0.88-1.18
(reference : Married)	Divorced	1.20	0.99-1.45	<b>1.42</b>	<b>1.18-1.71</b>	1.20	0.99-1.45	<b>1.24</b>	<b>1.02-1.51</b>
	Widowed	1.25	0.78-1.99	1.45	0.92-2.28	1.22	0.77-1.95	1.27	0.80-2.03
<b>Housing: number of rooms</b>	1	1.21	0.87-1.70	-	-	1.21	0.87-1.70	1.17	0.83-1.64
(reference: 5)	2	1.21	0.99-1.49	-	-	1.21	0.98-1.49	1.21	0.98-1.49
	3	1.13	0.96-1.33	-	-	1.12	0.95-1.32	1.12	0.95-1.32
	4	1.03	0.88-1.18	-	-	1.02	0.88-1.18	1.01	0.87-1.16
	6	<b>0.80</b>	<b>0.68-0.95</b>	-	-	<b>0.80</b>	<b>0.68-0.95</b>	<b>0.80</b>	<b>0.68-0.95</b>
	>=7	<b>0.77</b>	<b>0.64-0.92</b>	-	-	<b>0.77</b>	<b>0.64-0.93</b>	<b>0.76</b>	<b>0.63-0.92</b>
<b>Housing: number of people</b>	1	<b>1.51</b>	<b>1.28-1.79</b>	-	-	<b>1.52</b>	<b>1.29-1.80</b>	<b>1.52</b>	<b>1.29-1.80</b>
(reference: 2)	3	0.99	0.86-1.15	-	-	0.99	0.86-1.15	0.96	0.83-1.12
	4	0.95	0.81-1.10	-	-	0.94	0.81-1.10	0.93	0.80-1.08
	5	1.11	0.90-1.36	-	-	1.10	0.89-1.36	1.08	0.87-1.33
	>=6	<b>1.44</b>	<b>1.02-2.05</b>	-	-	<b>1.45</b>	<b>1.02-2.05</b>	<b>1.45</b>	<b>1.02-2.06</b>
<b>Changes in professional activity</b>	Started distance working	-	-	<b>1.24</b>	<b>1.06-1.44</b>	<b>1.24</b>	<b>1.06-1.45</b>	<b>1.27</b>	<b>1.08-1.48</b>
(reference: not distance working)	Has a new job	-	-	1.45	0.68-3.10	1.44	0.67-3.09	1.47	0.68-3.15
	Was already distance working	-	-	1.14	0.82-1.59	1.13	0.81-1.58	1.14	0.81-1.60
	Temporary lay-offs	-	-	1.20	0.95-1.50	1.21	0.96-1.52	1.17	0.92-1.48
	Other (Inactives)	-	-	<b>1.31</b>	<b>1.05-1.63</b>	<b>1.33</b>	<b>1.07-1.66</b>	<b>1.30</b>	<b>1.03-1.62</b>
	Other (employees)	-	-	<b>1.33</b>	<b>1.03-1.72</b>	<b>1.33</b>	<b>1.03-1.72</b>	<b>1.34</b>	<b>1.03-1.74</b>
	Missing (employees)	-	-	<b>1.48</b>	<b>1.16-1.88</b>	<b>1.45</b>	<b>1.14-1.85</b>	<b>1.50</b>	<b>1.16-1.92</b>
<b>Physical activity</b>	Daily	-	-	-	-	-	-	<b>0.81</b>	<b>0.73-0.91</b>
(reference: Frequently)	Never	-	-	-	-	-	-	<b>1.14</b>	<b>1.01-1.30</b>
<b>Interactions w/coworkers</b>	Less frequently/Never	-	-	-	-	-	-	<b>1.25</b>	<b>1.10-1.41</b>
(reference: Daily/Regularly)	Not concerned	-	-	-	-	-	-	1.22	0.91-1.64

Model 1 is adjusted for age, gender, history of depression, recent resident status, educational level, household income and marital status (A) and number of rooms and number of people in the dwelling (B).

Model 2 is adjusted for (A) and changes in professional activity (C).

Model 3 is adjusted for (A), (B) and (C).

Model 4 is adjusted for (A), (B), (C) and physical activity and interaction with co-workers.

We also conducted additional analyses to further understand the observed association between depression and number of people in the same dwelling. Indeed, while living alone was associated either in univariable and multivariable analyses, the higher modalities were only associated with depression in multivariable analyses (resulting in the aforementioned U-shape association). Exploratory analyses identified that this U-shape association was observed after adjustment on number of rooms, that resulted in an increase of the aORs for the higher modalities.

In a sensitivity analysis, replacing household income by a subjective assessment of income did not change the observed associations. The only observed change was that the association between temporary layoff and depression was no longer significant (aOR=1.16 CI95%=0.95-1.41). Furthermore, subjective assessment of income was significantly associated with depression with a gradient ( $p$  for linear trend  $<0.001$ ).

When replacing household income and educational level by occupational status, the observed associations remained significant, except for “was already distance working” which did not reach statistical significance (yet, the estimated effect size was similar; aOR=1.28,  $p=0.06$ ).

Most categories of occupational status were not significantly associated with depression. The only categories that were significantly associated with depression were clerk and “others”.

Finally, when removing “marital status” (variable that was missing for 3,665 participants), the observed associations were unchanged as well as the estimated Odds Ratios.

## Discussion

Based on the large population-based CONSTANCES cohort, we showed that housing conditions and changes in professional activity during the first COVID-19 related lockdown in France were associated with subsequent depression just after this lockdown.

More specifically, regarding housing conditions, we consistently observed a gradient between the number of rooms in the dwelling and the risk of depression. This gradient was also observed for incident depression. In addition, multivariable analyses revealed a U-shape relationship between number of people living in the dwelling and a greater risk of depression. Interestingly, post-hoc analyses identified that this U-shape relationship was specifically observed after adjustment on number of rooms. Considering professional activity, we found that changes in professional activity were robustly associated with depression. Starting distance working was positively associated with a greater risk of depression and also while considering incident depression. We also found that sociodemographic factors were consistently associated with a greater depression risk, such as being a woman, having a history of depression or a lower household income. Being a recent resident (i.e. living in France for less than 10 years at inclusion) was also associated with a greater risk of depression, but this association was no longer significant after adjusting on the number of rooms and number of people in the dwelling, suggesting that it could be partially explained by housing conditions. Of note, sensitivity analysis suggests that the role of being a recent resident could differ according to gender, as this variable was still significantly associated with greater odds of depression in women, but not in men, even after full adjustment. Nevertheless, the low sample size of recent residents warrants cautious interpretation. Regarding age, a negative significant association was found in univariable analysis, but this association was no longer significant after adjusting for housing conditions and changes in

professional activity. Indeed, it has already been highlighted that younger people could be more vulnerable to emotional distress including depression in the context of the pandemic. This greater vulnerability could be partially explained by specific social and interpersonal features (such as experiencing more life changes and presenting greater concerns about lockdown<sup>17</sup>). But our results suggest that this greater vulnerability could also be partially explained by other lockdown-related factors such as housing conditions.

Although depression was measured in the second questionnaire after the beginning of the COVID-19 pandemic (that is after the assessment of housing conditions and changes in professional activity) we considered it as a measure of prevalent depression since we didn't have a measure of depression at the first questionnaire. Nevertheless, we also built an outcome to estimate incident depression: participants who had a CES-D score <19 prior to the COVID-19 pandemic and a CES-D score  $\geq 19$  in the immediate post-lockdown period. Therefore, most of the important associations with prevalent depression were also observed for incident depression. Indeed, being a woman, having a history of depression, living alone or in a smaller dwelling, starting distance working or being inactive were associated with greater odds of (incident) depression. Some of the associations other associations, observed with prevalent depression (such as being single, having a lower household income or maintaining distance working), didn't reach statistical significance, which could be explained by small differences of the sample sizes, but could also result from a more precise estimation of the effects of recent changes on a new onset of depression.

Other studies have shown the impact of socio-economic conditions on depression during the pandemic<sup>18-20</sup>. However, most of these studies did not take into account the particular impact of changes in professional conditions due to lockdown measures. In this study, we found that changes in professional activity during the first lockdown, such as starting distance working, were associated with a greater risk of depression at the end of the lockdown, independently

from income. Furthermore, this robust association was also independent of housing conditions.

The impact of distance working on mental health has been debated in the scientific literature<sup>21-23</sup>. Previous work outside the context of the COVID-19 pandemic highlighted the role of distance working in offering autonomy and lowering conflict between work and family<sup>23</sup>. Since the beginning of the pandemic, some studies underlined a negative impact of distance working on mental health<sup>12</sup> whereas other studies has mitigated that statement<sup>24</sup>. Of note, it has been suggested that the negative impact of distance working could be explained by factors such as reduced physical activity or reduced interactions with co-workers<sup>25</sup>. Here, we found that this association was independent of changes in physical activity and social interactions with co-workers. Indeed, distance workers can experience other difficulties, such as extended work hours and difficulty identifying boundaries between work and personal or family life. Furthermore, those who were still able to work without starting distance working might have kept their occupations because of better health conditions. The characteristic of the changes due to the pandemic is also its suddenness and the lack of alternative opportunities, which may partly explain why some workers experienced more difficulties in adapting to those imposed conditions.

Other authors suggested that the impact of lockdown on mental health could be different according to gender<sup>26</sup>. In our work, exploratory analyses found significant interactions between gender and housing conditions and between gender and changes in professional activity. These results suggest that the effect on depression of lone living, in a smaller dwelling and starting distance working might be less important among women (although still significant).

Our study has several strengths. First, we took advantage of the features of the large CONSTANCES cohort, which allowed us to use a large sample with a great set of variables,

particularly regarding specific characteristics of the lockdown. Specifically, we were able to use pre-pandemic measures of depression, a unique feature of our study that strengthened the specificity of our results towards the lockdown period compared to retrospective studies. Second, several sensitivity analyses also showed the robustness of our results. Third, our study showed great external validity as some of the variables associated with depression were already known as risk factors of depression. These results are also consistent with the role of these general risk factors during the recent pandemic<sup>10,27,28</sup>.

Nevertheless, our study also has some limitations. First, our sample might not be representative of the general population and we cannot exclude selection bias. Indeed, although data were available for some participants that were professionally inactive, our sample mainly consists of workers, or people that were working before the pandemic. Second, an important proportion of our sample are persons with relatively high household income and educational level. Nevertheless, the important sample size still allows us to estimate Odds Ratios within all the different categories. Second, the observational nature of our study prevents us from concluding regarding a causal association between depression and housing and working conditions. Although we used a large set of adjustment variables, we cannot exclude the possibility of other confounding factors.

## **Conclusions**

Our study presents evidence that different characteristics of living circumstances impacted by lockdown may have contributed to the impact of the COVID-19 pandemic on depression risk. Living alone, in a smaller dwelling, and experiencing changes in professional activity (such as starting distance working) may represent risk factors of depression in this context. These results could help to improve the understanding of the impact of lockdowns on mental health and to better identify vulnerable people to promote mental health care.



## **Figure legend**

Figure 1: Flow of participants in the study



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## **Abstract for “Housing conditions and changes in professional activity during lockdown and the risk of prevalent and incident depression: Findings from the CONSTANCES Cohort”**


**Background:** Material conditions of lockdown and changes in regular functioning may have play a role on depressive manifestations. We aimed to examine the association between housing conditions and changes in professional activity and depression during the first COVID-19 outbreak in France.

**Method:** Participants of the CONSTANCES cohort were followed online. A first questionnaire covered the lockdown period (assessing housing conditions and changes in professional activity), and a second the post-lockdown period (assessing depression using the Center of Epidemiologic Studies Depression-Scale (CES-D)). Incident depression was also estimated (with a previous CES-D measure). Logistic regression models were applied.

**Results:** 22,042 participants (median age 46 years, 53.2% women) were included and 20,534 had a previous CES-D measure. Depression was associated with female gender, lower household income and past history of depression. A negative gradient between the number of rooms and the likelihood of depression was consistently observed (OR=1.55 95% [1.19-2.00] for one room, OR=0.76 [0.65-0.88] for seven rooms), while a U-shape relationship was observed with the number of people living together (OR=1.62 [1.42-1.84] for living alone, OR=1.44 [1.07-1.92] for six persons). These associations were also observed with incident depression. Changes in professional activity were associated with depression (Started distance working (OR=1.33 [1.17-1.50]). Starting distance working was also associated with incident depression (OR=1.27 [1.08-1.48]).

**Limitation:** A cross-sectional design was used.

**Conclusion:** The consequences of lockdown on depression may vary depending on living conditions and changes in professional activity, including distance working. These results could help to better identify vulnerable people to promote mental health.



**Key words:** COVID, Depression, Lockdown, cohort study, distance working.

**Highlights for “Housing conditions and changes in professional activity during lockdown and the risk of prevalent and incident depression: Findings from the CONSTANCES Cohort”**

- Housing conditions were associated with both prevalent and incident depression during the first COVID-19 related lockdown in France
- A statistical gradient was observed between the number of rooms in the dwelling and the risk of depression and a u-shape relationship was observed with the number of people living together.
- Changes in professional activity (such as starting distance working) were also associated with both prevalent and incident depression.
- Gender (women), lower household income and past history of depression were also associated with greater odds of prevalent and incident depression.

## **Author Statement for “Housing conditions and changes in professional activity during lockdown and the risk of prevalent and incident depression: Findings from the CONSTANCES Cohort”**

### **Data Availability**

Personal health data underlying the findings of our study are not publicly available due to legal reasons related to data privacy protection. CONSTANCES has a data sharing policy, but before data transfer, a legal authorisation has to be obtained from the Commission Nationale de l’Informatique et des Libertés, the French data privacy authority. The CONSTANCES email address is [contact@constances.fr](mailto:contact@constances.fr).

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**Ethics approval:**

The CONSTANCES cohort has obtained the authorization of the National Data Protection Authority (Commission Nationale de l'Informatique et des Libertés, no. 910486) and was approved by the Institutional Review Board of the National Institute for Medical Research – INSERM (no. 01–011).

**Conflicts of Interest for “Housing conditions and changes in professional activity during lockdown and the risk of prevalent and incident depression: Findings from the CONSTANCES Cohort”**

CG, EW, CO, JM, MT, GS, AD, MG and MZ have no conflict of interest to report.

GA reported speakers and/or consulting fees from Pfizer, Lundbeck and Pierre Fabre outside the submitted work.

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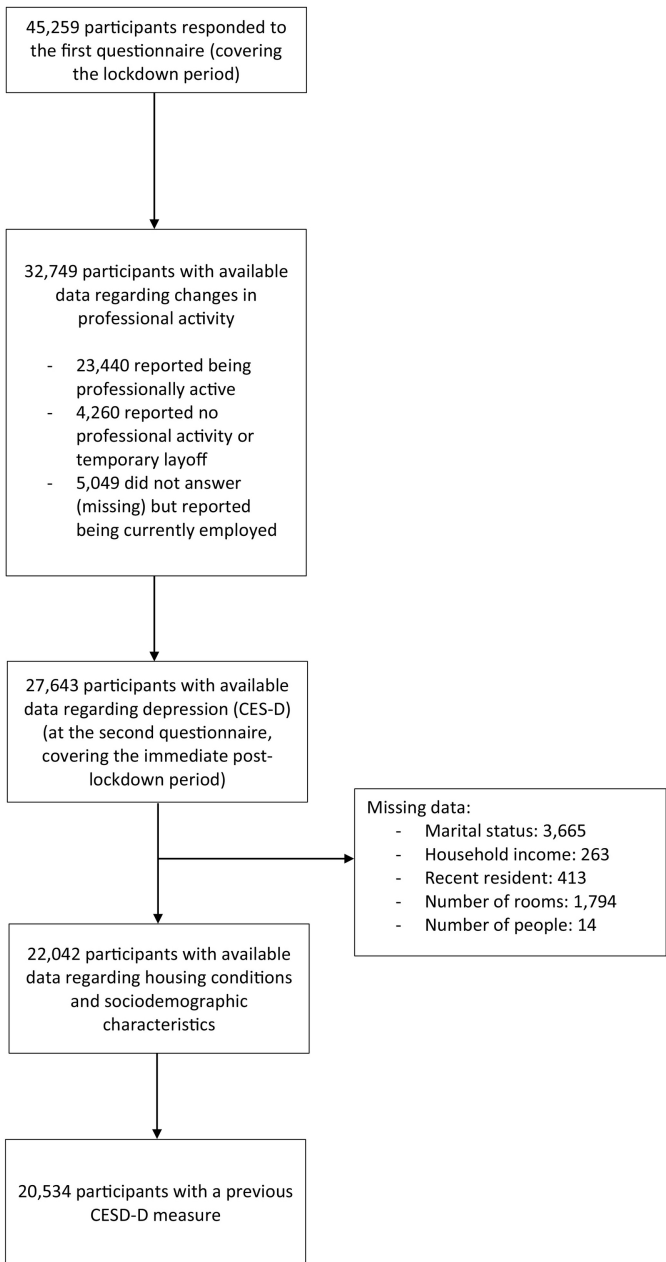


Figure 1