



# Health, work, and contributing factors on life satisfaction: A study in Norway before and during the COVID-19 pandemic<sup>☆</sup>

Nan Zou Bakkeli

Consumption Studies Norway, Oslo Metropolitan University, Postal Address: P.O. Box 4, St. Olavs Plass, 0130, Oslo, Norway

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## ABSTRACT

**Background:** The COVID-19 outbreak has posed considerable challenges for people's health, work situations and life satisfaction. This article reports on a study of the relationship between self-reported health and life satisfaction before and during the COVID-19 pandemic in Norway, and examines the role of work in explaining the health–life satisfaction relationship.

**Method:** The study was based on survey data collected from 3185 Norwegian employees in 2019 and 3002 employees in 2020. Propensity score matching techniques were used to assess the mediating effects of work situations and income loss on the health–life satisfaction relationship. Skew-*t* regression models were further applied to estimate changes in life satisfaction before and during the pandemic, as well as to explore different underlying mechanisms for the health–life satisfaction association.

**Results:** The study found a negative association between ill health and life satisfaction. Compared to the healthy population, people with poor health were more likely to experience worsened work situations. A negative work situation is further associated with lower life satisfaction, and the pandemic aggravated life satisfaction for those who had worsened work situations. When exploring central contributing factors for life satisfaction, we found that health-related risks and work-life balance played predominant roles in predicting life satisfaction before the pandemic, while different types of household structure were among the most important predictors of life satisfaction during the pandemic.

**Conclusion:** A reduction in life satisfaction is explained by ill health, but different underlying mechanisms facilitated people's life satisfaction before and during the pandemic. While work situation and health risks were important predictors for life satisfaction in 2019, worries about more unstable work situations and less access to family support accentuated worsened life satisfaction in 2020. The findings suggest the necessity of labour market interventions that address the security and maintenance of proper and predictable work situations, especially in these more uncertain times.

## 1. Introduction

The WHO has described the ongoing coronavirus (COVID-19) pandemic as the 'defining global health crisis of our time' (WHO, 2020b). The threat posed by coronavirus has been rising, and a substantial body of evidence suggests that the pandemic not only threatens people's physical and mental health, but also reduces life satisfaction levels (IGHI, 2020; Rajkumar, 2020). Scholars have found that the pandemic has a strong socioeconomic gradient concerning its social outcomes, with the most vulnerable populations—people with lower

education, income and class background—facing the most severe consequences (Adams-Prassl et al., 2020; Alstadsæter et al., 2020). Furthermore, there has also been a gradient of socioeconomic inequality in life satisfaction. The reduction of life satisfaction due to the COVID-19 pandemic is much more severe for people with poor health, lower work performance, who live alone, and those who have less confidence in the healthcare system's ability to respond to COVID-19 (IGHI, 2020; Pedraza et al., 2020).

It is, therefore, important to study how the pandemic has affected vulnerable social groups and their life satisfaction. Scholars have paid

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E-mail address: [Nan.Bakkeli@oslomet.no](mailto:Nan.Bakkeli@oslomet.no).

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much attention to the unemployed population and people with lower socioeconomic status in the existing pandemic literature (e.g. Adam-Prassl et al., 2020; Alstadsæter et al., 2020). However, relatively few studies have explicitly examined those who are employed but have poor health. Employees with poor health in a more protective welfare state do not necessarily have lower income or lower education when they are in a more stable economic situation. Compared to other countries, the Scandinavian welfare regime is 'more able to protect against non-employment in the face of illness', especially for individuals with low socioeconomic status (van der Wel et al., 2012). However, people in ill health may face greater risks of job insecurity in more uncertain times, such as economic hardship and crises (see e.g. Bartley & Owen, 1996; Urbanos-Garrido & Lopez-Valcarcel, 2015), and this might also be the case for Norway during the pandemic. The anxiety over worsened work situations due to the economic recession caused by the pandemic may lead to mental distress and lower life satisfaction for those with poor health, and illness may in return accentuate the negative relationship between ill-health and job security.

This study examined the relationship between health, work and life satisfaction before and during the COVID-19 pandemic. We asked whether the level of life satisfaction varied for people with different health statuses, and explored the role of work situation in explaining the health–life satisfaction relationship. In this paper, we use the term 'life satisfaction' and 'wellbeing' interchangeably. Work situation is addressed by asking whether a person has faced a worsened work situation due to workplace restructuring and cutbacks, and whether one has experienced income loss caused by the pandemic. Our analysis controlled for core contributors that might be correlated with both health and life satisfaction, such as work-related physical and mental health risks and work-life conflict.

The study contributes to the existing pandemic literature in several ways. First, we know relatively little about how pandemics impact the relationship between life, work and life satisfaction. The study increases such crucial knowledge. Second, the study investigated inequalities in life satisfaction among employees of various health statuses. Previous studies have mainly examined disparities between the employed and unemployed. The current study focused on employees, viewing them as a heterogeneous social group whose life satisfaction varies according to their health status and work situation. Third, the current study took into account that the underlying mechanisms for the health–life satisfaction association may vary across time. By using one of the richest longitudinal datasets on working life in Norway, we compared changes in the relationship between health and life satisfaction before and during the pandemic.

## 2. Theories, previous studies and research questions

### 2.1. Theories of life satisfaction

Subjective wellbeing is defined as 'a person's cognitive and affective evaluation of his or her life' (Diener, 2000), and a key indicator is the self-reported measure of life satisfaction. Psychologists have, for example, looked at subjective wellbeing as a broad category that contains different components, including emotional responses (positive or negative affect), domain satisfaction, and life satisfaction (see e.g. Diener et al., 1999, 2003). In sociology, there has been increasing interest in subjective wellbeing, but from somewhat different perspectives. The terms are often used interchangeably with 'life satisfaction', 'happiness' and 'quality of life' (Veenhoven, 1984, 2008, 2012). Veenhoven (2008) drew upon important sources of information when considering life satisfaction, namely 'affective information from how one feels most of the time [hedonic level of affect]'. Adopting from this perspective, life satisfaction refers not only to a cognitive evaluation, but also to an overall appraisal of life. This is similar to the core of the *life satisfaction theories of wellbeing* (LST), which considers wellbeing explicitly as an overall judgement of life (e.g. Diener et al., 1999;

Helliwell, 2020; Plant, 2020).

Haybron (2008) suggested three main determinants of wellbeing and life satisfaction: physical health, emotional health, and success in defining one's identity. Physical health constitutes the fulfilment of one's subpersonal nature, and mental health of an emotional nature refers to a person's sense of happiness and affective dispositions that are central to who we are. The identity-defining feature is comprised of 'narrative role fulfilment', which is firmly interrelated with the meaningfulness of one's life. This implies the importance of social dimensions in the health–wellbeing association. For example, in the literature on subjective wellbeing, wellbeing is defined as subjective experience of life satisfaction that is related to one's socioeconomic status and life events (Fisher, 2019; Kahneman et al., 1999). Similarly, theories of psychological wellbeing consider wellbeing as self-acceptance and autonomy, affected by an individual's mental health through biomedical, behavioural and social factors (cf. Ryff & Singer, 2008). Focusing on social determinants of health, social epidemiologists and medical sociologists have suggested that socioeconomic factors, to a large extent, contribute to the incidence of mental or physical (ill)health in the population, resulting in substantial disease burdens, health inequalities and lower life satisfaction (Fisher & Baum, 2010; Marmot and Wilkinson, 2005).

The current study focused on people's life satisfaction and investigated how it may be influenced by health before and during the ongoing COVID-19 pandemic. Two components are involved in the question we asked. First, it concerned the individuals' subjective perceptions of their overall life situation, instead of an objective measure of their standards of living. Drawing upon definitions from Veenhoven (2012), this paper refers life satisfaction to people's comprehensive evaluations of their lives as a whole. Second, the relationship between life satisfaction and health may depend on the mutability of one's illness and whether the status of health has a long-lasting effect on one's wellbeing. Quality of life and health statuses depend to a large extent on job involvement as it encourages a strong sense of social integration, independence and ability to decide (Hammell, 2014). Therefore, instead of only looking at an individual's self-reported health at a fixed point of time, this study took into account a linked health assessment in which one's health status was evaluated with regard to one's future labour market performance. This concern implies dynamic comparison between different time periods. As COVID-19 has greatly altered our lives, the mechanisms that explain the health–life satisfaction linkage may also differ before and during the pandemic.

### 2.2. Life satisfaction and health

Life satisfaction is known to be positively associated with health. Using six waves of the European Social Survey, a positive correlation between self-reported health and life satisfaction was detected in 32 European countries (Kööts-Ausmees & Realo, 2015). Indeed, self-rated health was identified as the most predominant variable for life satisfaction, compared to influences of other social factors, as well as organisational activity and belief in internal control (Palmore & Luikart, 1972). Based on Swedish microdata, Gerdtham and Johannesson (2001) found that the probability of being happy most of the time was 0.42 with a bad health status and 0.60 with a good health status. Similarly, using data collected from 6576 Norwegian twins, Røysamb et al. (2003) found that subjective wellbeing is substantially related to perceived health and that self-reported health has a much stronger effect on health compared to objectively-measured physical health status.

Moreover, the relationship between an individual's life satisfaction and health status varies with different structural circumstances. Life satisfaction increases in countries with lower income inequality (Verme, 2011) and within a stronger welfare state (Kotakorpi & Laamanen, 2010; Veenhoven, 2000). A more equal distribution of economic resources also weakens the tie between wealth and self-reported health (Diener & Biswas-Diener, 2002; Semyonov et al., 2013). The strength of

the satisfaction–health association varies according to the degree to which economic resources have been distributed to public health spending; in countries that spend less on healthcare services, life satisfaction depends to a greater extent on one’s health status, compared to countries with more healthcare spending (Kööts-Ausmees & Realo, 2015).

During the COVID-19 pandemic, there has been a sharp drop in healthcare spending on other types of medical treatment, and much non-urgent care has been cancelled or delayed (EIU, 2020; WHO, 2020a). Hospital admissions have fallen precipitously (Mahmud et al., 2020; Solomon et al., 2020). There has also been a clear reduction in patients with acute medical illness seeking healthcare services, either because of fear of contagion or concerns about access at COVID-19-overrun hospitals (Birkmeyer et al., 2020; Siegler et al., 2020). Disrupted healthcare has led to an increase in depressive symptoms (Ahn et al., 2020), worsened mental health and increased psychological distress (Qiu et al., 2020; Sibley et al., 2020), as well as decreased life satisfaction (Zacher & Rudolph, 2020; Zhang et al., 2020). Infection control measures, such as quarantine and physical distancing, have also led to increased feelings of uncertainty and loneliness and worries about health, job insecurity and work–family conflict (cf. Restubog et al., 2020; Rudolph et al., 2020).

People with ill health are more vulnerable during the pandemic. They may be more susceptible to severe symptoms of the coronavirus disease and may face greater challenges in terms of lower job security and worsened work circumstances, due to unstable labour market situations. The COVID-19 pandemic may therefore have a stronger correlation with their life satisfaction and wellbeing compared to others with good health. Therefore, we may expect that:

**H1.** Life satisfaction is lower for those with ill health compared to the healthy population. The differences in life satisfaction between people with various health statuses have also been accentuated by the COVID-19 pandemic.

### 2.3. Work as mediator between health and life satisfaction

The condition of health is a predominant factor in job security, and the status of employment plays an important role in an individual’s psychological wellbeing and life satisfaction. Work and occupation are regarded as a synthesis of doing and belonging, which are delineated as part of psychology’s field of concern (Hammell, 2014). Health is identified as a process through which people become who they want to be, and it contains fundamental human needs and universal values that underlie human activity (Hammell, 2004; Kluckhohn & Strodtbeck, 1961, p. 421735; Wilcock, 1999). According to occupational therapy literature, the need to belong and connect through work are important dimensions of quality of life (Duncan, 2004). The sense of belonging through occupational engagement contributes to life satisfaction through social interaction, connections, mutual support, and feelings of being valued, socially included, and the ability and opportunity to contribute to others (Diener & Biswas-Diener, 2008; Hammell, 2004, 2014).

The relationship between health, work and life satisfaction has been confirmed in empirical research. Previous studies have shown that ill health is correlated with reduced work participation, poor job performance, earlier labour force exit and unemployment (Bartley, 1994; Schuring et al., 2013). Lower labour market participation may, in turn, lead to psychological distress and reduced life satisfaction (Clark et al., 2001; Flatau et al., 2000). Furthermore, people with poor health may have a higher risk for worsened work situations in uncertain times, and the impact of illness on employment increases in times of economic stagnation (Bartley & Owen, 1996). Such shocks have been proven to widen health inequalities and increase unemployment risk (Stuckler et al., 2009). As work is often perceived as the basis for belonging, job loss during a crisis may, to a greater degree, lead to feelings of isolation and hopelessness, lack of self-esteem, reduced wellbeing and lower life

satisfaction (Hiswåls et al., 2017).

These connections between health, work and life satisfaction in times of instability may also be applicable to the pandemic situation. The COVID-19 outbreak has significantly affected the labour market structure. Job replacement has fallen sharply, work hours have been reduced, employment rates have declined and the most vulnerable social groups have been hit the hardest (Eurostat, 2020; OECD, 2020). During the second week after the coronavirus disease reached Norway, from 17 to 24 March, the Norwegian Labour and Welfare Administration (NAV) reported 159,560 new cases of job lay-offs. Among this, 144,983 people were or would be temporarily suspended, 6077 became unemployed and 3276 had uncertain job situations. In total, by 24 March, 291,483 people were registered as temporarily or permanently laid-off, and 29,328 people were registered with sickness absence. In comparison, the corresponding numbers right before the outbreak (on March 10) were 65,344 and 1661 respectively (NAV, 2020a, b).

Among employees who faced a more uncertain situation, people with poor health were even more vulnerable. Employees in ill health are more likely to be suspended in uncertain times, and they may compare their own work situation to that of their healthy colleagues, causing lowered wellbeing for the sick (cf. social comparison theory). The unequal chances for a worsened work situation due to varied health status, in combination with greater challenges of finding another job during the pandemic, may lead to even lower life satisfaction in 2020. Therefore, we may expect that the pandemic reinforced the negative association between ill health and life satisfaction through a more uncertain job market and worsened work situation for employees with poor health in Norway. Following these arguments, we hypothesised:

**H2a.** Compared to those who do not have health problems, employees with poor health have higher risks of a worsened work situation, which contributes to lower life satisfaction. This is more severe in 2020 than it was in 2019.

**H2b.** Compared to those with good health, people with ill health are more likely to experience income loss due to the COVID-19 pandemic, which is associated with lower life satisfaction.

### 2.4. Determinants of life satisfaction

Work is a part of the social distribution of behavioural risks; it involves important mediating stressors for the health–life satisfaction relationship including inequalities in socioeconomic status, financial strain, work-life conflict and disaster-induced mental illness (e.g., Brunner, 1997; Greenhaus & Beutell, 1985; Makwana, 2019; Marmot and Wilkinson, 2005). However, the underlying mechanisms for life satisfaction may be different in 2019 compared to 2020. While the pandemic and lockdown situations may accentuate worsened life satisfaction in 2020, there might be other factors that facilitate the employee’s wellbeing in 2019. For example, high risk occupations and manual work may increase physical health risks (Pedersen et al., 2020), and chronic stress from home and work (e.g. high tempo work and low levels of control in the workplace) may lead to mental illnesses (Fisher & Baum, 2010). The health-related risk stressors might be important underlying factors for the health–life satisfaction association in a normal life circumstance, as for example before the pandemic. Nevertheless, at a time of crisis and economic recession, increased disaster-induced distress and worries for an unstable labour market situation may be more important in explaining the relationship between health and life satisfaction (cf., Makwana, 2019). Therefore, the health-related risk stressors may not be as powerful confounders during the pandemic as in 2019.

Work-life conflict is another central element for a person’s wellbeing. Previous studies reported that employees who have often experienced work-family conflict are more likely to suffer from clinical mental health problems, depression, poor physical health and lower life satisfaction, compared to those who reported no conflict (Frone, 2000; Frone et al.,

1997). Work-life conflict can be both a confounder and a mediator for the association between health and life satisfaction. On the one hand, poor work-life balance may cause both health problems and low life satisfaction (Haar et al., 2014; Knecht et al., 2011). On the other hand, employees with poor health and higher levels of stress are more likely to experience greater conflict between work and family (cf. Kelloway et al., 1999). Social distancing and remote work during the pandemic may increase the level of work-life conflict, and lead to greater challenges in wellbeing.

Therefore, we hypothesised that when controlling for health-related risk stressors and work-life conflict, the relationship between health and life satisfaction will be weakened. Moreover, we expect that:

**H3a.** Physical and mental health-related risks were particularly important for life satisfaction in 2019, compared to 2020.

**H3b.** Work-life conflict is negatively associated with life satisfaction, and the association is more important in 2020, compared to 2019.

Although health and its related labour market consequences may have a large impact on a person's wellbeing and happiness, life satisfaction may also be influenced by many other factors. Earlier studies have shown that better life satisfaction is related to higher socioeconomic status and social capital (Barger et al., 2009; Helliwell, 2001), such as income (Diener & Biswas-Diener, 2002; Diener et al., 2010) and education (Melin et al., 2003; Salinas-Jiménez et al., 2011). Other important determinants can be diverse demographic characteristics such as age, gender and ethnic origin (George et al., 1985; Melin et al., 2003; Moksnes & Espnes, 2013) as well as family and community support (Diener & Diener, 2009; Helliwell, 2001). The final research goal was more exploratory; we identified other underlying factors that are essential for people's life satisfaction during the COVID-19 pandemic.

### 3. Methods

#### 3.1. Data and variables

##### Data

The study used the 2019 and 2020 survey waves from the Working Life Barometer (*Arbeidslivsbarometeret*) to examine the relationship between health problems and life satisfaction before and during the COVID-19 outbreak in Norway. The data contained 3185 respondents in 2019 and 3002 respondents in 2020. The Working Life Barometer consists of annual, repeated cross-sectional surveys targeting the working population aged 18 to 67. It contains rich information about working life in Norway, including working conditions, work-related stress and coping, work-life participation, job security and attachment in the workplace, competence and skills, and union support and wage formation.

The 2020 survey was collected between 24 March and 20 April when the first COVID-19 outbreak struck Norway. The data collection started 12 days after the lockdown in Norway (12 March) and stopped on the same day when the Norwegian Government started their gradual opening before the second wave of COVID-19 later in the summer of 2020. Therefore, the respondents answered the survey questions during the peak of the pandemic burden in the first wave of COVID-19. The 2020 survey contained an additional module concerning the outbreak, including questions on interventions, exposure and morbidity risks, social distancing and pandemic consequences for labour market outcomes. The response rates in 2019 and 2020 were 35% and 38%, respectively (see Ingelsrud & Steen, 2020).

The respondents were selected from the Kantar Gallup Panel, and the response rates for the Working Life Barometer vary from 32% in 2013 to 49% in 2009. The discrepancies were mainly caused by the maintenance of the Kantar Panel, since Kantar frequently included new respondents and deleted people who had stopped responding. The dropout rates in the surveys are often higher among young people. However, most of the dropouts in such surveys are random (Hellevik, 2016). Analysing

Norwegian surveys that used the same sampling method as Kantar, Hellevik (2016) argued that the sampling methods in collecting survey data were robust, the nonresponse often happened by chance and results based on such data should not be biased.

##### Dependent variable

The dependent variable in this study was *subjective wellbeing*, measured by an individual's perception of his or her overall life satisfaction. Participants were asked: 'All things considered, how satisfied are you with your life as a whole these days?' They were to choose a number from 1 to 10, where 1 was 'completely dissatisfied' and 10 was 'completely satisfied'.

##### Independent variables

The key independent variable in this study was *self-reported health*. The respondents were asked: 'How likely is it that your state of health will lead to reduced work effort for you over the next five years?'. The response scale ranged from 1 to 5, where 1 denoted 'not at all likely' and 5 denoted 'extremely likely'. A dummy variable of *ill health* was constructed based on the original health variable, where people who rated their self-reported health as 4 or 5 were defined as having relatively ill health (=1).

Two central intermediate risk variables were *worsened work situation* and *income loss due to corona*. For the former, respondents were asked: 'Do you feel that you are in danger of having a less satisfactory work situation due to restructuring or cutbacks?' Respondents were asked to provide an answer from 1 ('most unlikely to happen') to 5 ('most likely to happen'). The study used both the original quantitative variable and a dummy variable where 1 corresponded to values 4 and 5 from the original variable. The variable concerning income loss was operationalised by asking respondents: 'As an employee, have you experienced income loss as a consequence of the coronavirus outbreak? (Choose from Yes/No)'. This question *only* appeared in the 2020 survey.

The data did not contain objective health measures or health behaviours. However, we have approximated work-related physical and mental health risks by constructing two indicators. The indicator of *mental health risks* was constructed using three variables, each containing five values ranging from 'never' to 'always': (1) 'Is it necessary to work at a high pace?', (2) 'Are you exhausted when you get home from work?' and (3) 'Does the work feel stressful?'. The indicator of *physical health risks* was constructed by two 5-scaled variables ranging from 'never' to 'always': (1) 'Do you have to do hard physical work?' and (2) 'Do you work under hazardous conditions?'. Both indicators were constructed using principal component analysis. Higher values for the two indicators imply higher risks for health problems.

The indicator of *work-life conflict* was constructed by using seven variables, each ranging from 'never' to 'always': (1) 'The work demands often interfere with family life', (2) 'The family responsibilities often interfere with job', (3) 'It is difficult to combine job with an active social life', (4) 'It is difficult to combine job with leisure activities you want to do', (5) 'There is time pressure for doing the job and/or meeting other obligations after work', (6) 'It is difficult to combine work with caring responsibilities for elderly family members' and (7) 'The employer shows little understanding for your family and care responsibilities'. Principal components analysis was applied to generate the indicator, and a higher value indicated higher level of work-life conflict.

Other control variables were: *age* (18–67 years), *gender* (female = 1), *education* (higher education at college/university = 1), *individual income* (personal gross annual income in Norwegian kroner (NOK) categorised within nine income intervals), *household types* and *employment sectors*. Household types contains couple (spouse/cohabitant) without children, couple with children, single parent with children, people living with parents, people living alone, shared housing, and other. Employment sectors were comprised of seven categories: the specialist health service; state sector (exclude health services); municipality and county sectors; industry, construction and energy; tertiary sector (hotels, glossary

shops, tourism and other service industries); banking insurance and financial sector; transport; and other private services.

### 3.2. Analytical strategy

The analytical procedure is as follows. First, using propensity score matching techniques, we explored the relationship between self-reported health, work situation (in danger of worsened work situation and income loss due to coronavirus) and life satisfaction. Second, we used skew-*t* regressions with propensity score weightings to model life satisfaction. Potential confounding variables were controlled in the regression models, and interaction terms were included to examine time variations in life satisfaction predicted by health and work.

#### Propensity score matching

We used the propensity score matching technique to study the relationship between health, work situation and life satisfaction (H1&H2). First, we examined the relationship between health and life satisfaction (H1) by matching those with good and poor health based on a series of socioeconomic background variables. The basic idea of matching was to construct a matched control sample that corresponded as closely as possible to the sample of ill health with respect to all relevant covariates (see e.g. Guo & Fraser, 2015; Morgan & Winship, 2014). Ideally, this would result in two very similar samples with the only difference being that people in the treatment group were in ill health, while those in the control group were not. The logit models were used to estimate propensity scores. Standardised differences were assessed by calculating the mean difference in the covariate between the treatment conditions. The same procedure was performed separately for the 2019 and 2020 data sets.

To examine the role of the risk variables, we incorporated worsened work situation and income loss as two intermediate variables connecting health and life satisfaction (see Fig. 1). Two matching procedures were performed separately following the arrows in the illustration. To test H2a, we first estimated the mean degrees of worsened work situation between subjects with good and poor health for both 2019 and 2020. Afterwards, the mean life satisfaction levels between people with good and poor work situations were calculated for both 2019 and 2020. To test H2b, we first compared mean differences in corona-related income loss between people with and without ill health, and then examined the mean differences in life satisfaction between people with and without coronavirus-related income loss. Note that income loss variable was operationalised by its definition to measure the pandemic consequences directly; the variable was only available in 2020.

#### The skew-*t* regression models

We used skew-*t* regressions to study model changes when adding controls for health risks and work-life conflict (H3). The regression analysis also made it possible to examine interaction effects between year and, respectively, health and work, in order to test whether the correlations changed across the years (H1&H2).

Skew-*t* distribution (ST) is a skewed version of the Student's *t*-distribution. The skewness of the skew-*t* distribution is determined by an additional shape parameter ( $\nu$ ) and the degree of freedom ( $\alpha$ ). When the sample is assumed to follow the skew-*t* distributions, we may expect  $y_i \sim ST(\xi_i, w^2, \alpha, \nu)$  for the skew-*t* distribution, where  $\xi_i = \beta_0 + \beta_1 x_{1i} + \dots +$

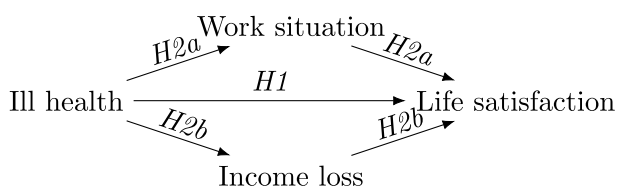


Fig. 1. Intermediating mechanisms between health and life satisfaction.

$\beta_n x_{ni}$ ,  $w$  is a scale parameter,  $\alpha$  is a part of the shape parameter and  $\nu$  is the degree of freedom. In this way, the skew-*t* regressions are linear regressions with errors from  $\varepsilon_i \sim ST(0, w^2, \alpha, \nu)$ . See, for example, Marchenko and Genton (2010) and Moser et al. (2015) for detailed information about the skew-*t* regression.

The skew-*t* model in this part of the analysis was further weighted by propensity scores in order to reduce bias. The baseline model included self-reported health, intermediating work variables and socioeconomic background controls:

$$y = \alpha + \beta X + \sum_{i=1}^p \gamma_i I_i + \sum_{i=1}^q \lambda_i S_i + U, \tag{1}$$

where  $X$  denotes self-reported health;  $I_i$  represents the two intermediate variables, namely worsened work situation and income loss.  $S$  is a vector of socioeconomic control variables,  $\beta$ ,  $\gamma$  and  $\lambda$  are the regression coefficients, and the random error  $U$  is independent of  $X$ ,  $I$  and  $S$ . The regressions were weighted for the conditional probability of ill health  $X$  given  $I_i$ , and this minimised the weighted sum of squares. The model was run separately using 2019 and 2020 datasets.

The next step was to add controls for physical health risks, mental health risks and work-life conflict. The three variables are denoted by vector  $C$  in equation (2). The new model was also run separately with the 2019 and 2020 data in order to examine how health, work and the controls were associated with wellbeing before and during COVID-19 (H3aH3b).

$$y = \alpha + \beta X + \sum_{i=1}^p \gamma_i I_i + \sum_{i=1}^q \lambda_i S_i + \sum_{i=1}^m \theta_i C_i + U \tag{2}$$

Finally, using pooled data, we included interaction terms to investigate H1 and H2. The model explored whether or not the correlation between life satisfaction and, respectively, health and work situation ( $I$ ) vary significantly across the two survey-years ( $T$ ). Robust standard errors were applied in all models in order to avoid confounding effects of the two years.

$$y = \alpha + \beta X + \sum_{i=1}^p \gamma_i I_i + \sum_{i=1}^q \lambda_i S_i + \sum_{i=1}^m \theta_i C_i + \sum_{i=1}^n \delta_i I_i T_i + U \tag{3}$$

## 4. Results

Table 1 shows descriptive statistics and mean life satisfaction scores for the subgroups. The descriptive statistics are based on data before propensity score weighting. The mean score of life satisfaction is 7.26 on a scale from 0 to 10. Relatively low scores (column to the right) may be observed for people with poor health, worsened work situation, who experienced income loss, have lower income, work in a tertiary sector, adults living with their parents and those who live alone or in shared housing. The mean life-satisfaction score was also lower in 2020, compared to in 2019. The average levels of life satisfaction were the same for all variables. This suggests that the missing values were random. Note that the variable 'income loss' was only available in 2019, causing lower sample size for this variable.

The main outcome variable is life satisfaction. To examine whether work situations were intermediate paths between health and life satisfaction, worsened work situation and income loss were used as both the response variables for health (health → work situation) and as the predictor for life satisfaction (work situation → life satisfaction) in the matching process (see Fig. 1). When used as the predictor, work situation was transformed to a dummy variable in order to compare mean life satisfaction scores between people with and without worsened work situation.

Appendix A shows the correlation matrix of the health and work-related variables. Appendix B shows component-loading for variables that were used to construct indicators of health-related risks and work-life conflict.

**Table 1**  
Descriptive statistics.

	Mean (s.d.)	%	Min/Max	n	LS
<b>Dependent variables</b>					
Life Satisfaction ( <i>matching&amp;regression</i> )	7.26 (1.83)	100	0/10	6168	7.26
Worsened work situation ( <i>matching, H2a</i> )	2.25 (1.13)	100	1/5	5773	7.27
Income loss ( <i>matching, H2b</i> )	0.12 (0.33)	100	0/1	2890	7.15
<b>Health-related controls</b>					
Self-reported health	0.12 (0.33)	100	0/1	5635	7.26
<i>Good health</i>	0.12 (0.33)	12	0/1	4950	7.39
<i>Ill health</i>	0.88 (0.33)	88	0/1	685	6.36
Mental health risks	3.18 (1.00)	100	0/5.74	6086	7.26
Physical health risks	1.07 (1.00)	100	0/4.10	6048	7.26
<b>Work-related controls</b>					
Worsened work situation (dummy)	0.15 (0.36)	100	0/1	4416	7.27
Stable work situation	0.85 (0.36)	85	0/1	3754	7.61
Worse work situation	0.15 (0.36)	15	0/1	662	6.43
Income loss					
<i>No income loss</i>	0.12 (0.33)	12	0/1	319	7.22
<i>Income loss</i>	0.88 (0.33)	88	0/1	2571	6.52
Work-life conflict	1.47 (1.00)	100	0/5.29	4235	7.34
<b>Socioeconomic status</b>					
Age	47.34 (11.77)	100	18/67	6187	7.26
18–35	0.21 (0.40)	21	0/1	1272	6.92
36–50	0.34 (0.47)	34	0/1	2120	7.02
51–67	0.45 (0.50)	45	0/1	2795	7.58
Gender	0.51 (0.50)	100	0/1	6187	7.26
<i>Female</i>	0.51 (0.50)	51	0/1	3164	7.20
<i>Male</i>	0.49 (0.50)	49	0/1	3023	7.31
Education	0.45 (0.50)	100	0/1	6187	7.26
<i>College/university</i>	0.45 (0.50)	45	0/1	2767	7.14
<i>Below college/university</i>	0.55 (0.50)	55	0/1	3420	7.34
Individual income	4.94 (1.84)	100	1/9	5743	7.26
<NOK 200.000	0.03 (0.17)	3	0/1	174	6.72
NOK 200.000-299.999	0.04 (0.20)	4	0/1	262	6.82
NOK 300.000-399.999	0.10 (0.30)	10	0/1	612	7.00
NOK 400.000-499.999	0.25 (0.43)	25	0/1	1521	7.16
NOK 500.000-599.999	0.22 (0.41)	22	0/1	1343	7.30
NOK 600.000-699.999	0.12 (0.32)	12	0/1	738	7.44
NOK 700.000-799.999	0.07 (0.25)	7	0/1	423	7.46
NOK 800.000-999.999	0.07 (0.25)	7	0/1	403	7.64
≥NOK 1.000.000	0.04 (0.20)	4	0/1	267	7.64

**Table 1 (continued)**

	Mean (s.d.)	%	Min/Max	n	LS
Household structure		100	1/7	6187	7.26
<i>Couple without child(ren)</i>	0.32 (0.47)	32	0/1	1972	7.52
<i>Couple with child(ren)</i>	0.35 (0.48)	35	0/1	2182	7.33
<i>Single parent w. child(ren)</i>	0.07 (0.26)	7	0/1	438	7.06
<i>Adult living with parent(s)</i>	0.03 (0.17)	3	0/1	185	6.79
<i>Living alone</i>	0.19 (0.39)	19	0/1	1158	6.87
<i>Shared housing</i>	0.03 (0.18)	3	0/1	207	6.95
<i>Other household type</i>	0.01 (0.08)	1	0/1	45	7.11
No. household members	2.57 (1.29)	100	1/5	5794	7.25
Employment sector		100	1/8	5673	7.27
<i>Specialist health service</i>	0.04 (0.20)	4	0/1	235	7.07
<i>State sector</i>	0.14 (0.35)	14	0/1	785	7.24
<i>Municipality &amp; county</i>	0.27 (0.44)	27	0/1	1151	7.36
<i>Industr., construc., energy</i>	0.18 (0.38)	18	0/1	1010	7.44
<i>Tertiary sector</i>	0.09 (0.29)	9	0/1	509	6.98
<i>Bank &amp; financial sector</i>	0.03 (0.18)	3	0/1	184	7.58
<i>Transport</i>	0.04 (0.20)	4	0/1	217	7.01
<i>Other private sector</i>	0.21 (0.41)	21	0/1	1218	7.22
Year		100	0/1	6187	7.26
2019	.51 (.50)	51	0/1	3185	7.38
2020	.51 (.50)	49	0/1	3002	7.13

*Propensity score matching*

Propensity score matching techniques require balancing between treated and untreated groups, and the baseline covariates should be balanced when specifying the model to calculate propensity score. By using standardised mean differences, we have carefully chosen covariates that assessed balancing across treatment and comparison groups. These are age, gender, education, individual income, employment sector (grouping together private vs. public sectors) and numbers of household members. [Appendix C](#) illustrates the sample distribution of propensity scores before and after matching. In each of the unmatched data sets, the treatment and control groups differed clearly from each other. After matching, the distribution of the two groups overlapped closely. This suggests an improved balance between the treatment and control groups, as well as reduced biases. The statistics of Rubin’s *B* for all matched samples were lower than 0.25 (reported in the subplots in [Appendix C](#)), indicating sufficiently balanced samples and covariates.

[Table 2](#) shows the results from propensity score matching. The sample sizes were small after matching the treatment and control groups by their socioeconomic background. Despite reduced sample sizes, all results were statistically significant. Using nearest neighbour matching, we found that in 2019, the score of life satisfaction was one point lower on a scale from 0 to 10 (equivalent to -6.80 s.d.) for those with ill health, compared to people with good health. The inequality of life satisfaction was even larger in 2020; in the middle of the first corona outbreak in Norway, people in ill health, on average, scored 1.3 points lower (-7.76 s.d.) than their healthy peers. The mean difference in life satisfaction between people with poor and good health was almost one standard deviation larger in 2020, compared to 2019. Life satisfaction was considerably lower for those with ill health in both years, and the

**Table 2**  
Average treatment effect on treated. Standard errors in parentheses.

		Year	Diff. (S.E.)	t	$n_i/n_c$
H1	Ill health→ Life satisfaction	2019	-1.024 (.151)***	-6.797	342/ 506
		2020	-1.268 (.164)***	-7.757	294/ 400
H2a	Ill health→ Worsened work situation	2019	0.249 (.091) **	2.733	342/ 485
		2020	0.375 (.101) ***	3.719	294/ 385
	Worsened work situ.→ Life satisfaction	2019	-0.887 (.131)***	-6.758	411/ 520
		2020	-1.332 (.146)***	-9.146	388/ 429
H2b	Ill health→ Income loss	2020	0.044 (.017) *	2.546	636/ 512
		Income loss→ Life satisfaction	2020	-0.663 (.161)***	-4.104

Note. \*\*\*  $p < .001$ ; \*\*  $p < .01$ ; \*  $p < .05$

reduction in life satisfaction associated with poor health was even more severe during the COVID-19 outbreak (H1).

When considering the health→ work situation→ life satisfaction relationships (H2a), the results can be read from the middle rows in Table 2. In 2019, the likelihood of experiencing worsened work situation due to restructurings or cutbacks was 0.25 points higher for people with ill health compared to those with good health, on a scale from 1 to 5 (2.73 s.d.). By 2020, this difference had increased to 0.38 points (3.72 s. d.). This suggests that ill health was associated with less secure employment and work situations, and the association seemed to be stronger in the COVID-19 pandemic. These uncertainties were further associated with individuals' life satisfaction. In 2019, the average level of life satisfaction was 0.887 points (-6.76 s.d.) lower for those who had worsened work situations, compared to those with more secure work situations. In 2020, the mean life satisfaction difference between the risk and secured groups was 1.332 points (-9.15 s.d.)—an increment of almost 40% compared to only one year before.

The last two rows in the table present the links between health→ income loss→ life satisfaction (H2b). Compared to healthy people, the probability of income reduction due to the coronavirus outbreak increased by 4.4% for people with ill health (2.55 s.d.). Income loss further led to lower life satisfaction. Those who experienced coronavirus-related income reduction reported, on average, 0.663 points lower life satisfaction (-4.10 s.d.), compared to those who had not experienced income loss.

*The skew-t regressions*

The results of the skew-t regressions are summarised in Fig. 2. Models a and b (Equation (1) on page 9) analyse the 2019 dataset, Models c and d (Equation (2)) examine the 2020 dataset and Models e and f (Equation (3)) use the pooled data.

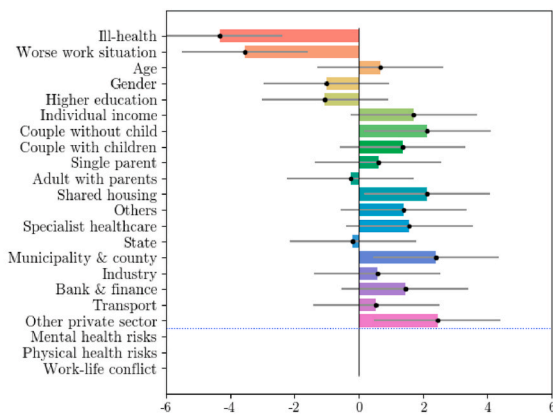
Model a (the top left figure) shows the standardised coefficients for ill health and worsened work situation in 2019 when predicting life satisfaction. The model controls for socioeconomic backgrounds were age, gender, education, income, household types (reference group: people living alone) and working sectors (reference group: tertiary sector). Life satisfaction was expected to reduce with ill health ( $\beta_{health} = -0.71, Z = -4.32$ ) and worsened work situation ( $\gamma_{work} = -0.28, Z = -3.54$ ). Compared to those who lived alone, couples without children and those living in a shared flat/house were more satisfied with their lives (satisfaction scored respectively 2.13 and 2.12 s.d. higher). Employees who worked in municipalities/counties and other private enterprises were respectively 2.40 and 2.44 standard deviation happier than those who worked in the tertiary sector. In addition, at 10% significance level, each unit increment in income corresponded to 1.71 standard deviations higher life satisfaction scores.

Model b (the top right figure) includes the same variables as Model a, but further controls for mental health risks, physical health risks, and work-life conflict. The association between worsened work situation and life satisfaction was weakened after controlling for the three additional variables, but the reduction was marginal. The coefficients remained strong and significant ( $\beta_{health} = -0.59, Z = -3.68; \gamma_{work} = -0.24, Z = -2.50$ ). At the same time, life satisfaction was reduced by mental health risks ( $\theta_{mental} = -0.23, Z = -3.07$ ), physical health risks ( $\theta_{physical} = -0.30, Z = -3.13$ ), and work-life conflict ( $\theta_{conflict} = -0.29, Z = -3.27$ ). This supports H3a. Couples without child were 2.13 s.d. happier than those who live alone, but living in a shared flat was only associated with life satisfaction at 10% significance level. Employment sector was not associated with satisfaction anymore. In this model, income turned out to be significantly associated with one's wellbeing, and the effect size has been doubled (3.22 s.d.) compared to the previous model.

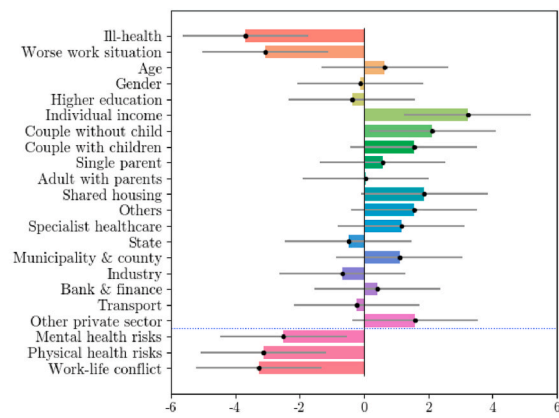
Model c (middle left) is similar to Model a, but the analysis was based on the 2020 survey wave. The new model includes income loss in addition to self-reported health, work situation and socioeconomic status. Income loss was part of a survey module that measured pandemic consequences in the Norwegian labour market. The variable was thus only included in the 2020 survey. Health ( $\beta_{health} = -0.65, Z = -3.28$ ) and work situation ( $\gamma_{work} = -0.34, Z = -2.80$ ) were still strongly correlated with life satisfaction. However, income loss due to the COVID-19 outbreak was not correlated with life satisfaction. The effect size was small ( $\gamma_{loss} = -0.29, Z = -0.89$ ), and the association was not statistically significant. Furthermore, age was positively correlated with life satisfaction (2.71 s.d.) in 2020. The standard coefficients for some of the household type variables were large, ( $\lambda_{couple} = 1.03, Z = 4.14; \lambda_{couple+child} = 0.90, Z = 3.32$ ), meaning that household structure played a greater part in explaining life satisfaction in 2020. Finally, when considering working sectors, only employees from bank and financial sectors were more satisfied than employees in the tertiary sector ( $\lambda_{bank} = 1.24, Z = 2.29$ ) in 2020.

Model d (middle right) controls for health-related risk stressors and work-life conflict, based on the 2020 data. None of the three additional indicators were significantly correlated with life satisfaction in 2020, disproving H3b. Health ( $\beta_{health} = -0.63, Z = -3.06$ ) and work situation ( $\gamma_{work} = -0.29, Z = -2.22$ ) remained strong and significant, and the coefficients reduced only marginally from the previous model. The estimates for other socioeconomic background variables were similar to Model c, but the difference in life satisfaction between tertiary and financial sectors was only significant at 10% level.

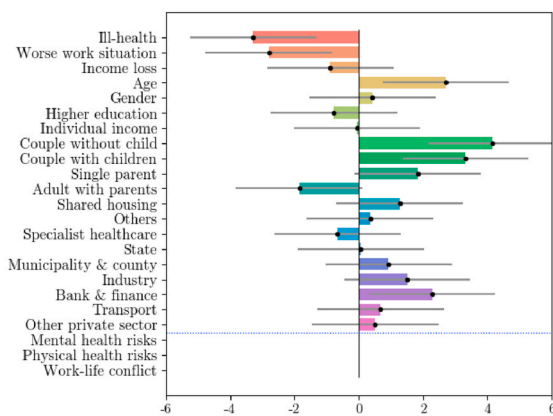
The last two models included interaction terms between time and respectively health and work situation, using pooled data. Post-estimations for the two models can be found in Appendix D, showing that the nonparametric model estimates fit well with the skew-t distribution. In Model e (bottom left), the interaction between ill health and year was significant at 10% level ( $\delta_{health*year} = -0.39, Z = -1.67$ ), suggesting a relatively stable health effect on satisfaction across the two years. The interaction between worsened work situation and year was significantly correlated with life satisfaction ( $\delta_{work*year} = -0.67, Z = -2.28$ ), indicating an even stronger negative effect of worsened work situation on a person's wellbeing in 2020, compared to 2019. The joint effects between year and work situation were also more influential in explaining differences in life satisfaction than the main effect of work situation and year. The same conclusion can be drawn from Model f (bottom right), even after controlling for health-related risks and work-life conflict ( $\delta_{work*year} = -1.03, Z = -2.96; \delta_{health*year} = -0.33, Z = -1.37$ ). Note that the multiplicative effect between work situation and year became even stronger in the last model, meaning that health risks and work-life conflict may have moderated the relationship between life satisfaction and the interaction term. See also Appendix E, which illustrates the changes in life satisfaction predicted by the interaction terms.



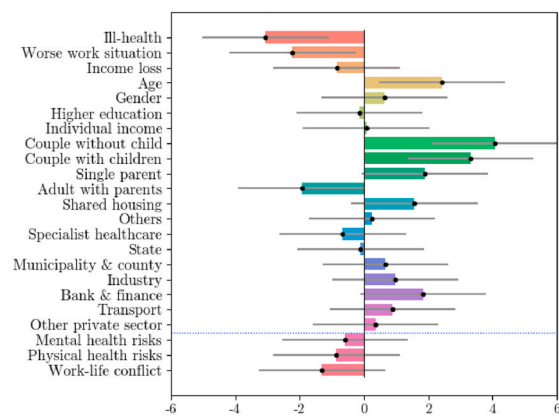
(a) Life satisfaction predicted by health and work situation, controlled for socioeconomic background. 2019. n=431



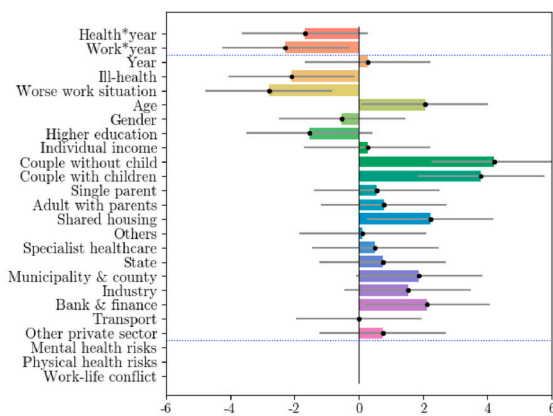
(b) Life satisfaction predicted by health and work situation, controlled for socioeconomic background, health risks, and work-life balance. 2019. n=431



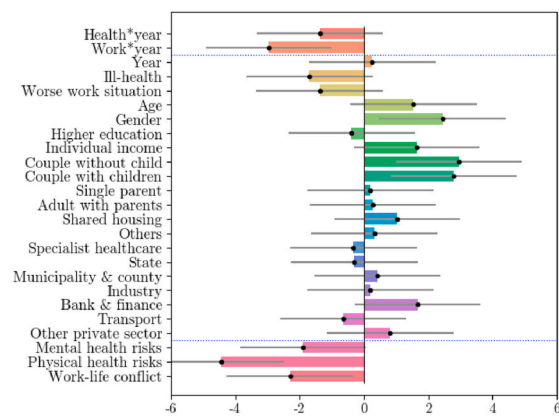
(c) Life satisfaction predicted by health and work situation, controlled for socioeconomic background. 2020. n=316



(d) Life satisfaction predicted by health and work situation, controlled for socioeconomic background, health risks, and work-life balance. 2020. n=316



(e) Life satisfaction predicted by health, work situation and interaction with time. Controlled for socioeconomic background. Pooled data. n=593



(f) Life satisfaction predicted by health, work situation and interaction with time. Controlled for socioeconomic background, health risks, and work-life balance. Pooled data. n=593

Fig. 2. Determinants of life satisfaction predicted by skew-t regressions. Plotted with standardised coefficients, 95 per cent confidence interval, and robust standard errors.



## 5. Discussion

The propensity score matching show that life satisfaction is strongly correlated with self-reported health. However, the negative association between ill health and life satisfaction is relatively stable over time when examining the time-health interaction in the skew- $t$  regression. Therefore, the findings only support part of *H1*. Some scholars have identified self-rated health as the most predominant factor for life satisfaction, compared to the influences of other social factors (Palmore & Luikart, 1972). However, the health-satisfaction relationship may be mediated by other important factors, such as work situation. When looking more closely at work as a mediator, we found that people with poor health to a larger extent reported worsened work situations compared to people with good health, which further contributed to a lower degree of life satisfaction (*H2a*).

This finding supports studies that have identified work situation as an important predictor for wellbeing (Clark et al., 2001; Flatau et al., 2000). Life satisfaction can be explained by various factors, many of which, such as identity, life circumstances, and social relation and support, are closely connected with work (Adams et al., 1996; Hammell, 2014; Haybron, 2008; Hirschi & Herrmann, 2012). A person's identity often comes from doing and belonging, and a stable work situation indicates certainty and provides access to social relations. The regression analysis also revealed that the COVID-19 pandemic reinforced the negative relationship between worsened work situation and life satisfaction. The pandemic has imposed unpredictable work situations and the threat of dismissal or temporary layoff, especially for people with a weak ties to the labour market. This has further led to a steep decline in life satisfaction.

Income has a strong and direct impact on life satisfaction (see e.g. Diener & Biswas-Diener, 2002; Diener et al., 2010; Palmore & Luikart, 1972), and loss of income is often viewed as an immediate effect of job insecurity. However, although the study detected a significant correlation between ill health and higher risks for income reduction in the matching process, the association was relatively weak. When matched with demographic and socioeconomic traits but without accounting for health status and work situation, we found that people who experienced income loss in 2020 had lower levels of life satisfaction. Nevertheless, after accounting for both health and work situation in the regression model, the effect of income loss on satisfaction disappeared. This disproved *H2b*. Although we suspect that people facing higher risks of worsened work situations are more likely to experience reduced income, the correlation between the two variables is moderately low ( $r = .21$ ). This means that income loss itself was not correlated with the level of life satisfaction.

One explanation for this is that income loss was not only affected by reduced employment but also by other factors. For example, people who worked in the commerce sector may have experienced substantial income reduction during the lockdown period because their wage was composed of a variable element that depends on the volume of sales. Income loss can also be caused by fewer working hours and reduced work performance, or by shifting to different tasks or changing workplace (Bartel & Taubman, 1979; Luft, 1975). In our survey, 11% of the survey respondents replied that they would be temporarily laid-off due to the coronavirus, 16% reported that the pandemic caused reduced working hours and both conditions were highly correlated with income loss. However, we may need to distinguish between people who experienced temporary income reduction but still had a strong tie to their workplace, and those who became unemployed during the pandemic. The fact that the survey only included people who were employed precludes the possibility of analysing such differences.

Structural implications may also contribute to reducing the

association between income loss and life satisfaction. The study was conducted in the Norwegian context, which may shed light on pandemic outcomes for individuals living in more protective welfare-state environments. The Scandinavian welfare model is characterised by its universal social support and high benefit levels. Norwegian policy has implemented several measures to reduce health inequality, including policies affecting income structure, employment opportunities and affordable childcare (van der Wel et al., 2016). During COVID-19, the Norwegian government also enacted a series of interventions to support jobs and avoid unnecessary layoffs, such as financial support for businesses and new layoff rules for faster and easier reception of benefits and income replacement, as well as government payment of most unemployment benefits (Christensen & Lægred, 2020). Such efforts have compensated for income losses due to the pandemic and may have helped reduce the negative effects of coronavirus-related income reduction on life satisfaction [1].

However, the steps taken did not reduce inequalities concerning individuals' risks of facing worsened work circumstances. Employees in ill health are still more likely to experience less favourable work situations in a more uncertain time, and stress and worries about a more uncertain future in the labour market may, to a large extent, correlate with an individual's wellbeing. The skew- $t$  regressions show that both health and work situation contribute strongly and significantly to an individual's life satisfaction, even after controlling for socioeconomic status, demographic traits, health risks and work-life conflict.

Changes in life satisfaction and work situations in 2019 and 2020 are clearly different among people with good and poor health (see Appendix F). The distribution of satisfaction for healthy employees did not differ much before and during COVID-19, nor did it change when considering their experiences of work situations; the distribution of self-reported risks for a worsened work situation due to cutbacks and reorganisations overlapped almost perfectly in 2019 and 2020. However, people with poor health have shown markedly-reduced life satisfaction during the pandemic, and their fear of less-favourable work circumstances increased considerably in 2020, compared to the year before. At the time that the survey data was collected, in late April 2020, several fiscal measures had already been introduced in Norway to support employment. However, respondents in ill health still reported a high level of fear of a worsened work situation and lowered life satisfaction. Although such uncertainties may be explained by people's insecure conjecture regarding how the situation may evolve in the future, concerns for a more perilous future are undoubtedly more severe for those with poor health compared to the healthy population. Further policies may be targeted more toward vulnerable employees with health problems in order to provide secure and equal employment climates.

The indicators of health-related risk stressors and work-life conflict had a particularly strong effect on satisfaction in 2019, supporting *H3a*. However, none of the them had a significant correlation with life satisfaction in 2020, and the effect size was relatively low. This disproves support of *H3b*. At the same time, household types were positively correlated with better life satisfaction, and their effect sizes became larger in 2020 compared to 2019. The findings suggest that important determinants of life satisfaction have changed from risk stressors and work-life conflict in normal life circumstances, to family support in the pandemic.

Previous studies identified social support, not only from work, but also from social settings and home, plays an important role in an individual's wellbeing (cf. Behar-Zusman et al., 2020; Pieh et al., 2020). Scholars also found that the COVID-19 crisis strengthened and sometimes even improved family relationships (Perelli-Harris & Walzenbach, 2020). The pandemic and lockdown may have reinforced the importance of social relationships on life satisfaction. Among all covariates in

our model, being a couple without child had the largest coefficient size predicting life satisfaction in 2020. This may explain the insignificant correlation between work-life conflict and life satisfaction during the pandemic; although one may encounter greater family demands during pandemic lockdown, to live with one's family provides a higher degree of support and care. Work-life conflict induces anxiety and depression in a more stable social setting (Haar et al., 2014). However, social isolations and worries for an unstable work situation during the pandemic seem to interfere the relationship between work-life conflict and life satisfaction.

The study had several limitations. There might have existed reversed causal paths between health, work and life satisfaction. The use of matching and regressions in this study could only have detected potential correlations but not causal directions between the variables. Moreover, matching methods and regressions with propensity score weighting largely reduced the sample size. This might be a reason for insignificant correlations between life satisfaction and several covariates. However, we conducted several robustness tests, including bootstrapping the standard errors, and the results did not differ. In addition, despite the limited sample sizes, the main factors that we examined—health and worsened work situation—were still strongly and significantly correlated with the level of life satisfaction. This strengthened the validity and reliability of the findings.

Matching techniques do not eliminate all confounding and bias, and we should be aware of other potentially important factors that were not considered in this study. One example is the correlation between ill health and severe coronavirus disease. People with underlying medical conditions are more at risk of severe COVID-19 disease, and those with poor health may worry more about being infected by the disease, hence having a lower life satisfaction. Other relevant potential confounders include household income, wealth and asset status, health-related behaviours and life style. The Working Life Barometer did not, unfortunately, include such variables. To approach more closely the causes and effects of the health–life satisfaction relationship, it may be valuable to further investigate physical health measures and how individuals' perceived fear of disease transmission affects their wellbeing.

Life satisfaction in this study was measured by respondents' evaluation of their lives as a whole. Although the measure is widely used in social sciences (see e.g. Bjørnskov, 2010; OECD, 2013), a wellbeing indicator constructed by multiple items may indicate a greater range of psychological aspects of wellbeing, compared to a single item indicator. Unfortunately, the Working Life Barometer does not contain enough variables to conduct such indicators. Future studies may construct wellbeing indicators based on, for example, the five-point satisfaction with life scale (SWLS) (Diener et al., 1985) or the 10 scale Kessler psychological distress scale (Kessler et al., 2002) to test the relationship between health, work and life satisfaction.

A related discussion may revolve around the use of self-reported health based on expected role functioning in the future. One problem is that it may induce potential endogeneity, since life satisfaction may influence feelings about future health. An ideal indicator of health may combine physical and mental health measures, such as pathological or clinical measures of health or medical certificates. Unfortunately, we did not include such variables in the dataset. However, operationalising health by exploring its related outcomes is not rare in studies of social medicine and social epidemiology, and is particularly common in labour and welfare research, such as studies of sickness, absence and retirement studies (see e.g. Anderson & Burkhauser, 1984, 1985; Bound, 1991). Conceptual and methodological contributions in this field can be found within industrial psychology, labour and health economics, healthcare studies and epidemiology (Amick et al., 2000). Moreover, Wallace and Herzog (1995) viewed 'self-attribution of work limitation to health factors' as a type of linked health assessment that is more specific to work settings and promotes easy rationalisation. In contrast, direct measurements of physical health may underestimate health effects

because they approach aspects of health that are not directly relevant to the work setting (Wallace & Herzog, 1995). Role functioning has been recognised as a fundamental aspect of generic health. An individual's social function and capacity to perform usual role activities in certain social contexts (such as work performance) reflect the person's physical health to a large extent (Ware, 1987). Existing survey designs have repeatedly used indicators of physical health based on the concept of functioning by viewing to what extent the individual is able to function normally and to carry out typical daily activities and tasks (McDowell, 2006).

Finally, the 2020 survey was conducted during a relatively early phase of the pandemic outbreak in Norway. Future work might examine the health–work–satisfaction relationships in different virus spread phases and COVID-19 attack waves in order to get a more nuanced picture.

## 6. Conclusion

Health and work are important factors for a person's life satisfaction. The pandemic has not only demonstrated altered vulnerability patterns among different socioeconomic groups, but has also amplified inequalities in life satisfaction due to ill health and unequal risks in the labour market. The COVID-19 pandemic event can be viewed as a social experiment unlike anything the world has experienced; there is merit for further in-depth studies regarding how this affects the relationships between health, work and life satisfaction. Scholars have predicted that the COVID-19 pandemic will disparately affect more vulnerable social groups, such as those with low socioeconomic status and single parent households, in the years to come (Behar-Zusman et al., 2020). Employees with ill health face both physical health challenges and mental distress from exposure to more uncertain labour market conditions. They are also a group that has received less attention in the literature. Intervention strategies are needed to prevent and mitigate the mental health consequences of the pandemic. This could include labour market interventions that address the security and maintenance of proper and predictable work situations in uncertain times.

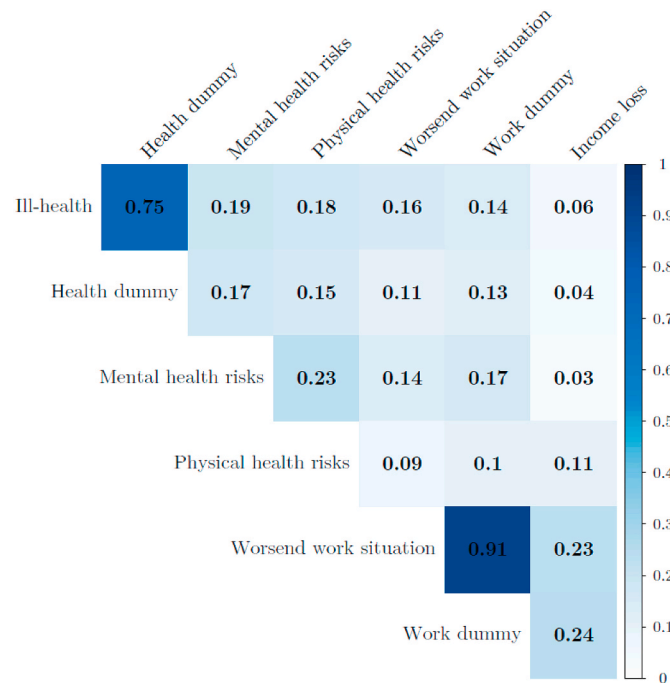
## Notes

[1] The concept of 'income' in the Norwegian context usually refers to money received from work and investment, as well as from welfare benefits and social support. The welfare system in Norway is universal; the income of the working population is highly taxed, and taxes are redistributed to the people in the form of unemployment benefits or benefits for temporarily layoffs, family-related benefits, sickness leave, healthcare, and pensions. Because of the redistributive nature of the welfare state, receiving welfare benefits in Norway is considered a rightful and conventional part of taxpayers' income. Furthermore, when a person is either temporarily or permanently laid off, a total subsidy of between 304,053 kroner and 608,106 kroner (around 80% of the person's previous annual wage) is paid by Norwegian social services twice a month for 49 weeks. This financial support is often considered a part of the person's total income. Therefore, although a laid-off person may experience reduced income, the amount of total income loss would not be as large as that for people in a similar situation in many other countries. Hence, the protective Norwegian welfare state secures the material needs of its population, which may contribute to weakening the association between income loss and life satisfaction.

## Author contribution statement

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

**Appendix A. Correlation matrix: Health- and work-related variables**

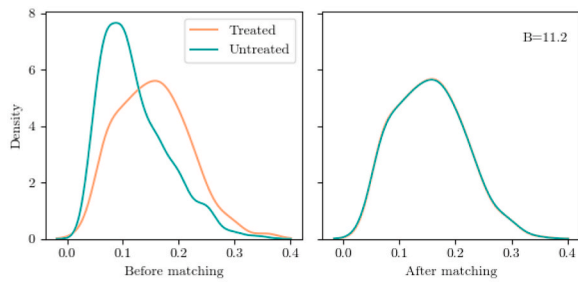


**Appendix B. Component matrix and Cronbach's alpha**

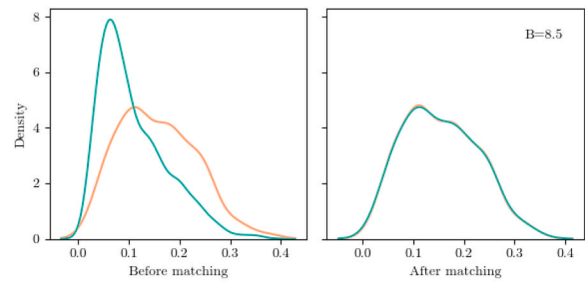
	Component loading		
	Mental Health risks	Physical Health Risks	Work-life conflict
Necessary to work at a high pace	.751		
Exhausted when get home from work	.816		
The work feels stressful	.854		
Have to do hard physical work		.880	
Work under hazardous conditions		.880	
The demand for work goes beyond family life			.810
The demands of family life go beyond work			.653
Difficult to combine job with an active social life			.854
Difficult to combine job with leisure activities			.847
Time pressure for both work and other obligations			.802
Difficult to combine work and elderly care in family			.763
Employer little understanding for family demands			.653
Eigenvalue	1.951	1.549	4.182
Cronbach's alpha	.733	.706	.878

Principal component analysis. Rotation Method: Varimax rotation with Kaiser normalization.

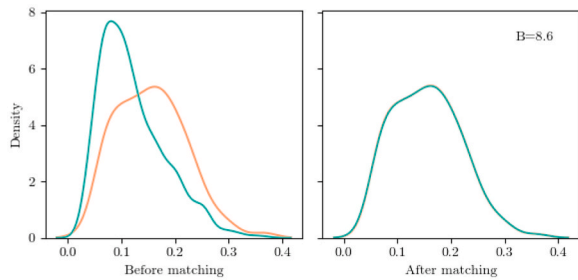
Appendix C. Sample distributions of propensity scores before and after propensity score matching



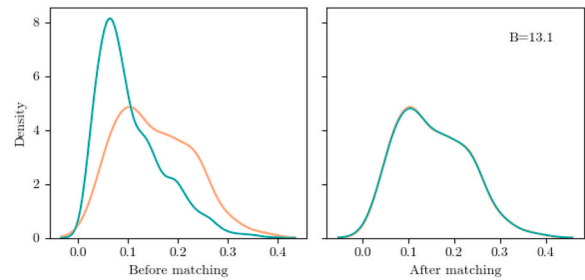
(a) *H1*, Health→Life satisfaction, 2019



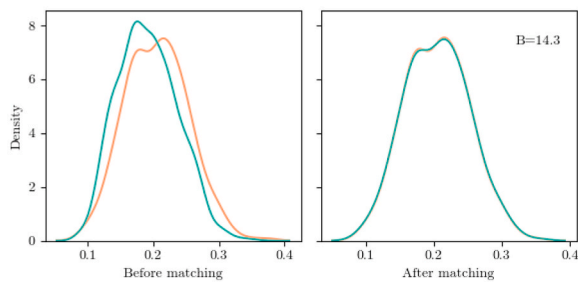
(b) *H1*, Health→Life satisfaction, 2020



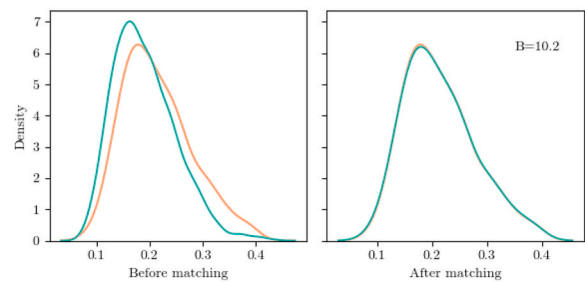
(c) *H2a*, Health→Work situation, 2019



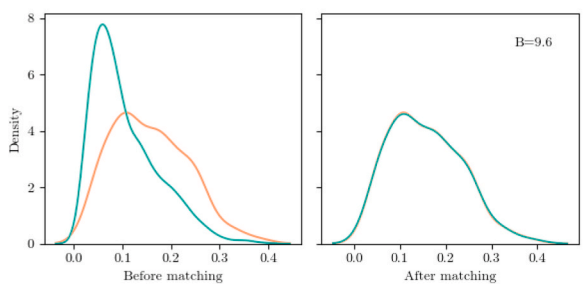
(d) *H2a*, Health→Work situation, 2020



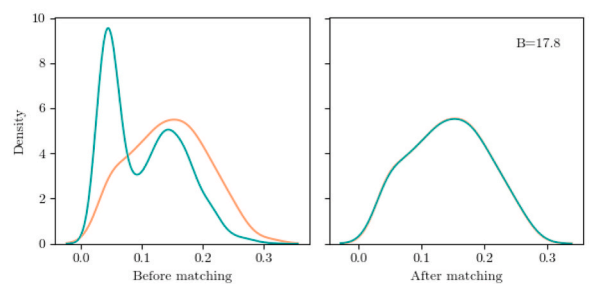
(e) *H2b*, Work situ.→Satisfaction, 2019



(f) *H2b*, Work situ.→Satisfaction, 2020

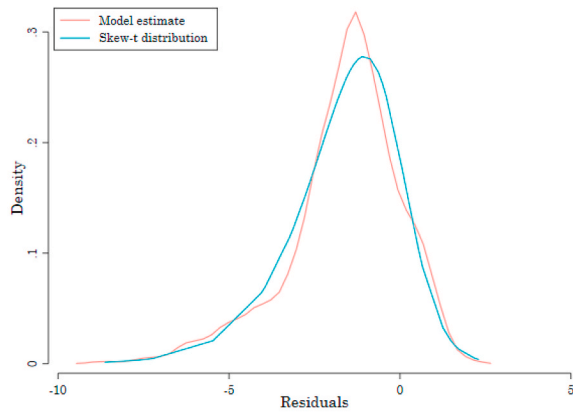


(g) *H3b*, Health→Income loss, 2020

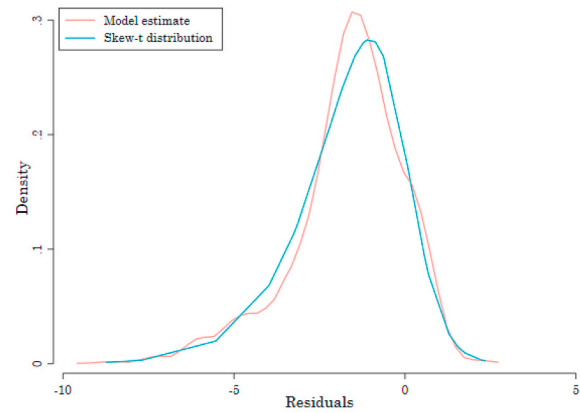


(h) *H3b*, Income loss→Satisfaction, 2020

**Appendix D. Distribution of regression residuals and skew-t distribution**

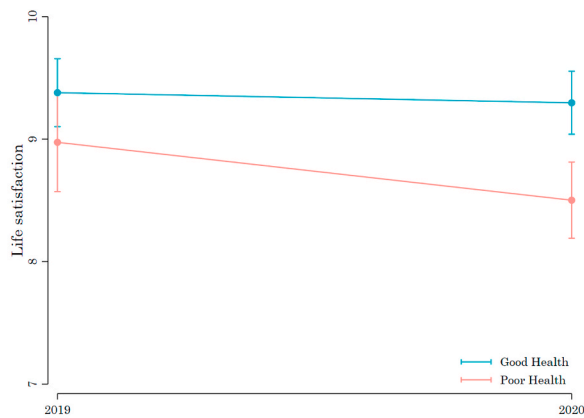


(a) Model with interaction terms. Skew-*t* distribution:  $\alpha = -2.14, df = 10.53$

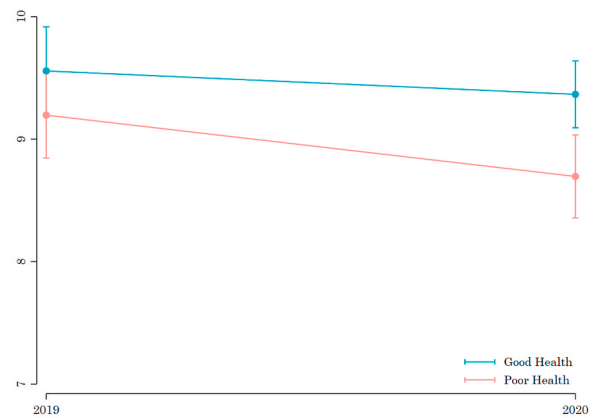


(b) Model with interaction terms controlled for health risks and work-life conflict. Skew-*t* distribution:  $\alpha = -2.32, df = 10.88$

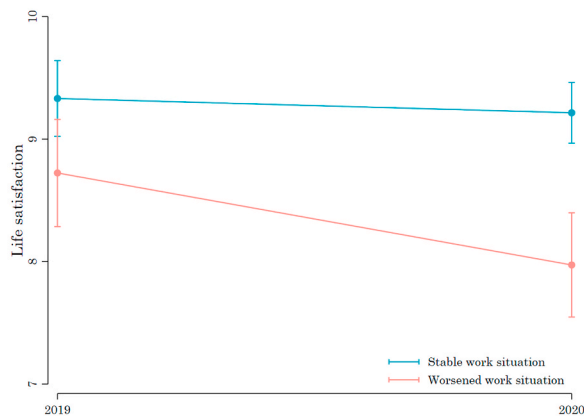
**Appendix E. Marginal effects of interaction terms on life satisfaction, 95% confidence interval**



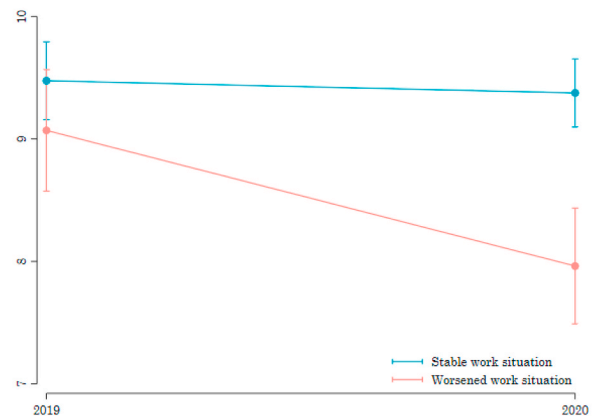
(a) Life satisfaction predicted by health\*year, based on model e



(b) Life satisfaction predicted by health\*year, based on model f

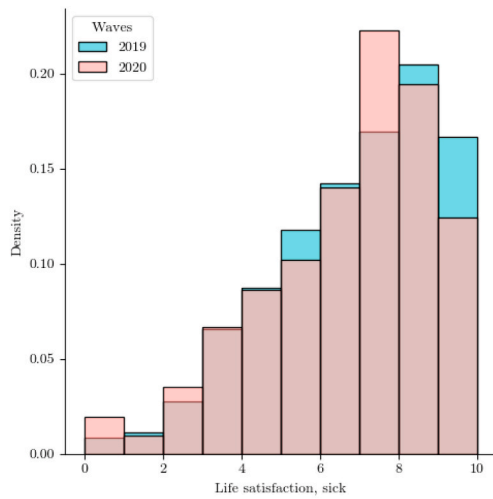


(c) Life satisfaction predicted by work\*year, based on model e

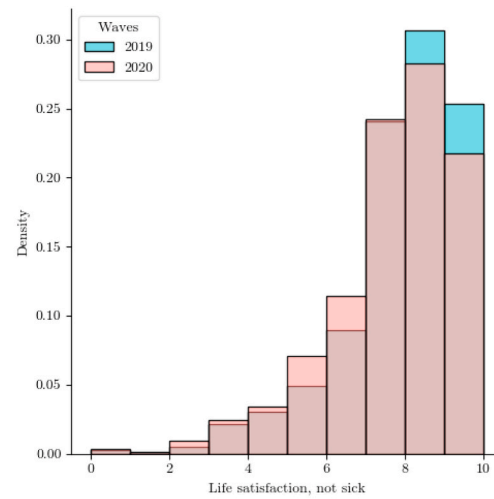


(d) Life satisfaction predicted by work\*year, based on model f

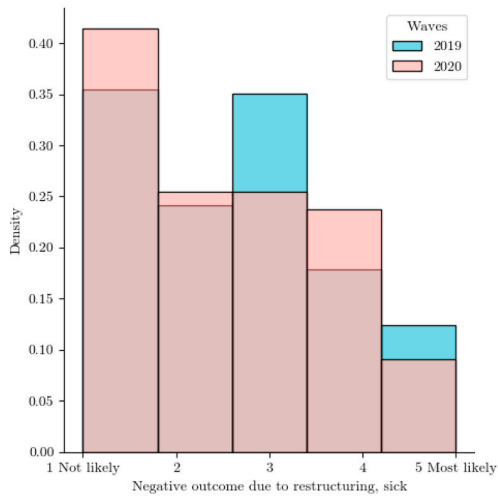
**Appendix F. Life satisfaction and work situation, by self-reported health**



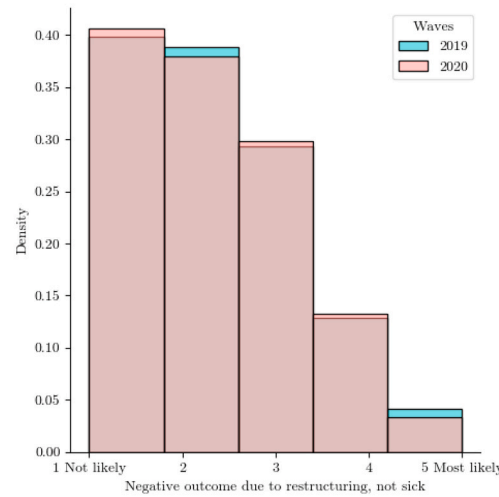
(a) Life satisfaction, ill health, N=680



(b) Life satisfaction, healthy, N=4,943



(c) Worse work situation, ill health, N=632



(d) Worse work situation, healthy, N=4,718

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