“Less does not necessarily lead to more.”

The impact of COVID-19 on Health-related quality of life among the general population of seven European countries

(EBSCO, 2020; Feder, 2021)

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Abstract

Background

The SARS-CoV-2 virus shocked the world when the virus first emerged in Wuhan, China, at the end of 2019. It has put a strain on people's health-related quality of life (HRQoL) due to unprecedented disruption in people's daily lives. Gradually, countries were forced to implement lockdown measures to limit the spread of the infection, varying from social distancing, school closures, and travel restrictions to the obligation of being self-isolated. Previous studies showed significant effects on various domains of HRQoL. The primary purpose of this quantitative study is to assess the impact of the development of the COVID-19 pandemic and related measures on HRQoL among the general population of Germany, the United Kingdom (UK), Denmark, France, the Netherlands, Portugal, and Italy controlled for socio-demographic factors and unemployment rates.

Methods

A total of 12,631 adult respondents were included via the ECOS survey conducted at three data rounds: April, June, and August 2020. The online survey was used to gather information on respondents' socio-demographic factors and HRQoL measured by the EQ-5D-5L instrument. In addition, the Oxford COVID-19 Government Response Tracker was used to compare policy responses across countries. A two-part regression model and panel data regression was carried out to analyze the relationships among the different variables with a statistical significance set at $p<.05$.

Results

The results revealed a partly statistically significant difference of the stringency of COVID-19 measures on HRQoL among the European population. The two-part model showed a significant impact, while the panel data showed an insignificant effect of the stringency of measures on HRQoL. Besides, pain/discomfort and anxiety/depression were most affected during the five months study period. Gender, income, unemployment rate, and country characteristics are significant predictors of HRQoL.

Discussion/conclusion

The study provides insights for policymakers that females, older people, people with lower income, and lower educated have a significantly lower HRQoL. Therefore, to avoid further health inequalities, policymakers should pay attention to these most vulnerable groups by focusing specifically on anxiety/depression and pain/discomfort. Follow-up research could focus on the relative impact of measures on HRQoL and which vulnerable groups exactly are most affected by anxiety/depression and pain/discomfort.

Preface

Dear reader,

Before you lies my thesis for completing the Master's Degree in Health Economics, Policy & Law. However, it is also the end of a study period. Although I will look back on this beautiful time with pleasure, I am also curious about the next phase in my life: working.

This research examines the corona pandemic and its impact on quality of life. This is something we never heard of two years ago, but we are still dealing with today. Even though everyone has become "pandemic fatique," I chose to work on this topic. It is an actual and global issue and I hope to have made a small contribution to the investigation of the consequences of COVID-19.

I would like to thank Ms. D. C. Voormolen for supervising me during the first period of writing my thesis. In addition, I am grateful for the further guidance from Mr. N. J. A. van Exel. I would also like to thank Mr. M.A.J.M. Buijsen as the second reader.

I have enjoyed working on this thesis, and I hope you will enjoy reading it.

Elaine Corstiaensen

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1. Introduction

The world has turned on its head since the emergence of Coronavirus disease 2019 (COVID-19) caused by a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Johns Hopkins University, 2020). Beginning in 2019, COVID-19 has resulted in more than 107 million confirmed cases and more than 2 million deaths worldwide (Worldometer, 2021). It can cause fever, respiratory problems, and breathing problems (RIVM, 2021). The virus is spread by coughing and sneezing (RIVM, 2021). Most infected people experience mild to moderate problems, however, especially people with underlying medical problems, experience more severe problems (WHO, 2021). The pandemic has led to unprecedented medical, economic and social consequences to billions of people's lives (Ravens-Sieberer et al., 2020).

Worldwide, governments have played an important role in combating the virus. The World Health Organization (WHO) highly recommended every country to implement National Action Plans, including public health measures to control the pandemic by reducing transmission speed and mortality (WHO, 2020). While no vaccines or treatments were available, many non-pharmaceutical interventions have been developed and implemented by governments (Haug et al., 2020). Apart from public health measures such as disinfection and restricted testing, more social-related restrictions have been imposed (for example, social distancing, gathering cancelations, and individual movement restrictions) (Haug et al., 2020). Adopting the different policies varied in stringency and pace across countries (Sebat et al., 2020). Strict lockdowns were mostly implemented in hardest-hit countries, such as Italy and France. However, other countries, such as the Netherlands chose a less severe lockdown at the beginning of the pandemic, which resulted in fewer restrictions on population movements (Sebat et al., 2020).

Although government response measures are generally seen as effective in slowing down the spread of COVID-19, they also have a detrimental influence on many aspects of the lives of the general population, such as their well-being and psychological functioning (Fayers & Machin, 2013). Monitoring the health-related quality of life (HRQoL) of citizens can help identify the range of problems that people experience as a result of measures and how these measures can affect people's daily lives. HRQoL relates to the impact of an illness on various factors, such as physical, psychological, social, and occupational factors (International Society for Quality of Life Research, 2015). An instrument that captures HRQoL is the EuroQol 5 Dimensions 5 levels (EQ-5D-5L), which is a generic instrument applicable to a wide range of populations and interventions (EuroQol, 2020).

1.1 Scientific relevance

Research on various aspects of HRQoL during a global health crisis among the general population is scarce. In the past decades, several epidemic/pandemic outbreaks like SARS-CoV-1, Swine flu (H1N1), Middle East respiratory syndrome coronavirus (MERS-CoV), and the Ebolavirus have occurred (Zürcher, et al., 2020). These outbreaks led to psychological effects such as fear, stress, anxiety, and depression associated with social isolation (Yip et al., 2010). SARS even led to an increase in suicide risk among older adults (Yip et al., 2010). In the same line, previous research has also already shown a negative impact on various HRQoL aspects during the COVID-19 pandemic. Empirical evidence indicates that COVID-19 not only poses a threat to one's physical health but also caused mental health problems, such as stress and anxiety (Ozamiz-Etxebarria et al., 2020; Usher, Bhullar, & Jackson, 2020) and that being quarantined lead to more anxiety and lower HRQoL (Ferreira et al., 2020). In addition, it is stated that physical activity plays a significant role in improving HRQoL (Abdelbasset et al., 2019). However, restrictions on, for example, performing team sports and the closure of gyms might obstruct people in their physical activity. Therefore, it is conceivable that measures affecting social and physical mobility could lead to long-lasting health problems and might also lead to a lower quality of life. Moreover, prior studies already investigated the effects of COVID-19 on HRQoL in the general population using the EQ-5D-5L, but only in China, Vietnam, Morocco, and the United States (US) (Ping et al., 2020; Vu et al., 2020; Azizi et al., 2020; Hay et al., 2021) and concluded that the risk of anxiety/depression and pain/discomfort increased and HRQoL decreased due to the COVID-19 pandemic.

Aside from the HRQoL consequences, the pandemic has also led to an economic concern regarding unemployment. The unemployment rate increased during the second quarter of 2020 despite the financial scheme packages that have been implemented by governments to protect affected employers and employees (OECD 2020; Goniewicz et al., 2020). Due to COVID-19, 130 million full-time jobs were lost at the end of December 2020 (ILO, 2021) and because of this, people's daily lives have changed abruptly and unprecedentedly. As a consequence of COVID-19, the expectation is that the unemployment rate will rise even further in the coming years (Ahmad et al., 2021). Moreover, it has also been determined that unemployment leads to lower HRQoL (Norström et al., 2014). Ultimately, it is expected that (concerns about) unemployment and financial stress, caused by COVID-19, may lead to more people with a lower HRQoL.

1.2 Study aim and questions

Although previous studies in China, Vietnam, Morocco, and the US have shown that the pandemic impacts specific dimensions of the EQ-5D, there is currently limited evidence of the effect of the COVID-19 pandemic on HRQoL of the general population of European countries. Therefore, this study investigates the effects of the stringency of COVID-19 lockdown measures on HRQoL of the general adult population of seven European countries (Germany, the UK, Denmark, the Netherlands, France, Portugal, and Italy) during the months April to August 2020, in order to get insight into differences in HRQoL related to both socio-demographic factors and COVID-19-specific factors. It examines the influence of socio-demographic factors (for example, age, gender, education, and household income), country-level measures (for example, partial/complete lockdown), and the unemployment rate on HRQoL during the initial months of the pandemic. Therefore, the following sub-questions are formulated:

1. How did the COVID-19 pandemic develop across the seven countries during the months April to August 2020 regarding incidence, mortality, and hospital/intensive care admissions?
2. How did HRQoL develop across the seven countries during the months April to August 2020?
3. Which variables were related to the development of HRQoL during the COVID-19 pandemic, and how did they affect HRQoL?
4. What was the effect of the stringency of the COVID-19 measures imposed by governments on HRQoL across the seven countries?

In order to get an answer to these questions, this study uses the responses of the European COvid Survey (ECOS) conducted by Sabat et al. (2020) in France, Italy, The Netherlands, Germany, Denmark, Portugal, and the UK at three data rounds: April, June, and August of 2020 (Sabat et al., 2020). As there is less knowledge about the impact of the stringency of lockdown measures on HRQoL among the European population, the results of this study could be used for developing guidelines regarding which social groups have a lower HRQoL as a result of the COVID-19 measures. Subsequently, interventions could be developed for these most vulnerable groups (Epifanio et al., 2021).

1.3 Overview

In the next section, the theoretical background will be described, including previous literature and the concept of HRQoL. Next, the methodology will be described, which exemplifies the main characteristics of the dataset and how it is analyzed and structured. Afterward, the most important study findings will be presented. Moreover, the main findings will be linked to the current literature

and theoretical framework in the discussion. In addition, in this chapter, the strengths and limitations of this study will be addressed, including the consequences of these limitations. Additionally, recommendations are proposed for further research. After all, the main research question will be answered, and potential policy measures that need to be taken will be described.

2. Theoretical framework

This chapter describes the theoretical concepts related to the research questions and is the framework for this study. First, the concept of HRQoL is described in more detail. Subsequently, an overview of the previous research about socio-demographic factors, unemployment, and COVID-19 restrictions related to HRQoL is presented. This overview reflects on what has already been researched in the field of HRQoL before the COVID-19 pandemic. However, it also shows how the COVID-19 pandemic has already changed the lives of the general population in some countries regarding HRQoL.

2.1 The concept of HRQoL

For long, life expectancy at birth and the number and causes of death were seen as the primary indicators to measure population's health (Thacker et al., 2006; National Research Council, 2010). While these indicators give information about the health status of a country's population, they do not provide any information on the quality of the health status. As life expectancy increases, measuring and subsequently improving QoL has become more important (WHO, 2005). HRQoL measurements give information about the positive or negative impact of a disease/treatment on the perceived QoL of people (Basch et al., 2012). It is often a subjective measurement of how people rate their health (Wilson & Cleary, 1995; Ferrans et al., 2005). People's subjective health perception provides insight into the problems that people experience in daily life due to, for example, illness (Algahtani et al., 2021).

A lot of research has already been conducted into factors that influence people's HRQoL. HRQoL is a multi-dimensional concept that captures physical and mental health status and its impact on quality of life (QoL) (Palermo et al., 2008). It encompasses all aspects of health that influence the QoL (Zubritsky et al., 2013). A distinction is made between HRQoL at the individual and environmental level (Centers for Disease Control and Prevention, 2000). At the individual level, HRQoL captures the subjective physical and mental health status and their correlations, including the health risks and conditions, functional status, social support, and socioeconomic status. The social environment is strongly related to culture, which can affect people's behavior (Ferrans et al., 2005). At the environmental level, the subjective health status depends on available resources, policies, and practices (Centers for Disease Control and Prevention, 2000). Physical functioning, psychological condition, social support, and socioeconomic factors explain 91% of the variability in the overall QoL (Ferrans & Powers, 1992). The COVID-19 pandemic adversely affects the physical, social, and

psychological functioning of people (Qiu et al., 2020; Yezli et al., 2020). Therefore, the individual and environmental characteristics related to this study are discussed in the following paragraphs.

2.2 The impact of socio-demographic factors on HRQoL

Much research has been done on the impact of socio-demographic factors on HRQoL. According to these studies, the main variables associated with HRQoL are age, gender, education, and income. Socio-demographic characteristics, such as age, gender, education, and income, are significantly associated with HRQoL (Wilson & Cleary, 1995; Prause et al., 2005; Kivits et al., 2013). As previously determined in research, HRQoL decreases when age increases as the prevalence of chronic disease increases by age (Prause et al., 2005; Steptoe, Deaton & Stone, 2015). In particular, physical health declines and, thus, people cannot do what they used to do (CBS, 2020). Furthermore, on average, women report a lower HRQoL than men (Prause et al., 2005; Cherepanov et al., 2010; Arrospide et al., 2019; Fryback eta al., 2007). A lower average income seems to be one explanation for the lower HRQoL in women (Cherepanov et al., 2010; Tan et al., 2018). In line with this, household income positively influences HRQoL due to, for example, differences in lifestyle, access to healthcare services, and social networks (Zhang et al., 2015; Prause et al., 2005). Last, Charafeddine et al. (2017) concluded that low-educated people have a lower HRQoL than high-educated people. Even when controlled for age and sex, a lower education level could decrease HRQoL in all aspects- mobility, self-care, usual activities, pain, and anxiety (Mielck et al., 2013; Hoeymans, van Lindert & Westert, 2005).

Some research has been done on previously mentioned socio-demographic factors and their influence on HRQoL during the COVID-19 pandemic. In contrast with studies conducted before the pandemic, Pieh et al. (2020) demonstrated that younger adults have higher stress and anxiety levels due to lockdown measures during COVID-19. On the other hand, Algahtani (2021) stated that middle-aged people scored lower one HRQoL due to concerns about income and relationships with friends and family. Mostly, males are the main earners of their families and were, thus, more likely to report more stress and anxiety because of being afraid of losing their job (Algahtani, 2021). By contrast, other studies show that being female is a predictor of having a lower HRQoL (Vu et al., 2020; Epifanio, 2021). There are also contradictory results concerning the impact of education. Whereas Vu et al. (2017) said that low-educated people have a lower HRQoL, Huang et al. (2020) stated the opposite direction during the pandemic (especially in physical and emotional functioning), but this differs between men and women. Notably, women's health state is more sensitive to education than

men's health state (Gil-Lacruz et al., 2020). Regarding income, the correlation is consistent with studies conducted before COVID-19 (Hay et al., 2020; Ping et al., 2020).

2.3 The impact of unemployment on HRQoL

Previous research has determined that unemployment has a negative impact on HRQoL (Norström et al., 2014). It negatively impacts recently unemployed people and has long-term effects on people who have been unemployed for a longer time (Norström et al., 2014). A Swedish study showed that unemployment leads to more anxiety and depression and that unemployed people score 7.5 points (out of 100) lower than employed people on the EQ Visual Analogue Scale (EQ-VAS) (Norström et al., 2019). Moreover, there is also variation in gender and education (Åhs & Westerling, 2006). Men experience a lower HRQoL due to unemployment than women (Norström et al., 2014). However, lower HRQoL due to unemployment differs across countries (Cooper et al., 2008). Southern European countries, such as Italy and Portugal, have a strong and negative effect of being unemployed on physical and mental health. In contrast to this, there are no substantial negative effects of unemployment on health in the Netherlands and Denmark. This might have to do with the unemployment benefit systems in these countries (Cooper et al., 2008).

The average European unemployment rate was 7.3 at the beginning of April 2020 (Trading Economics, 2020). However, this increased to 8.3 at the end of October 2020. Of the countries included in this study, Spain (16.2%), Italy (9%), and France (8.9%) have the highest rates, whereas Germany (4.6%) and the Netherlands (3.9%) have the lowest rates during the initial months of the pandemic (Trading Economics, 2020). It is expected that unemployment during COVID-19 has an impact on HRQoL among the European population. Employment has a central place in the lives of most people because it contributes to people's material needs (income) and social needs (interaction with colleagues, time structure, and participating in the society), but these needs could be limited through lockdown measurements (Epifanio et al., 2021). A recent study conducted in Saudi Arabia demonstrated that job loss due to the COVID-19 pandemic leads to a higher risk of anxiety and depression (Alyami et al., 2020). Contrary to this, another study conducted in Italy found that the employment status during lockdown does not predict HRQoL (Amit Aharon, Dubovi & Ruban, 2021). If people lose their job, this does not necessarily lead to a lower HRQoL. Partially coverage of unemployment and the fact that it was temporary in many cases are seen as reasons for these findings (Endeweld, Heler & Karandi, 2020).

Regarding this study, the ECOS survey did not directly ask about the respondents' labor force status. However, the unemployment rate of a country is expected to affect HRQoL during the pandemic. Namely, research shows that the unemployment rate affects not only people who lose their job but also the employed people (Ochsen, 2011; Tay & Harter, 2013; Tay et al., 2014; Chen & Hou, 2018). This is called the "spillover effect." The unemployment rate tends to have negative spillover effects on the employed by reducing their quality of life (Chen & Hau, 2018). Since the study sample consists of the general population, it is also likely that spillover effects occur in the study sample during the pandemic.

The unemployment rate at the country level affects employees' well-being due to the increasing uncertainty about keeping one's job and the workload (Tay & Harter, 2013; Chen & Hou, 2018). In addition, it can also give a feeling of guilt or shame. As a consequence, people experience lower job optimism and, in turn, lower quality of life. Even when studies controlled for demographic factors, income, and type of job, a negative effect of high unemployment rates on employed life satisfaction was seen (Tay & Harter, 2013). On the other hand, when the unemployment rate is high, the impact on wellbeing is smaller for unemployed people (Chen & Hau, 2018). The effect is reduced because more people are in the same boat, which lead to less stigmatization or being unemployed gives other advantages such as not having to keep up with the speed of life (Ochsen 2011; Chen & Hau, 2018). On the other hand, the unemployment rate can also positively correlate to the life satisfaction of working people (Chen & Hau, 2018). For instance, in Canada, employed people are more satisfied if the unemployment rate is high. One possible explanation for this is that the employed are less afraid of losing their job (Chen & Hau, 2018).

2.4 Government strategies

Government strategies include imposing strategic measures to limit the spread of the COVID-19 virus. Due to the seriousness of the situation and the absence of vaccines, governments responded quickly by introducing lockdowns (complete restriction of movement through penalties), social distancing, self-isolation, and quarantines, etc. Other measures such as office closures and working from home became more common. In the US, half of the workforce worked strictly from home, whereas in Europe, 37% of employees during the first wave of the pandemic (Rock et al., 2020). This varies across countries, from approximately 22% in the Netherlands to 48% in Italy (Eurofound, 2020). In addition, many children were at home as they were unable to go to school or childcare centers due to the measures (Yerkes et al., 2020).

Of the countries participating in this study, the policies of Italy, the Netherlands, and the UK stand out at the start of the pandemic in Europe. Although Italy and the Netherlands first introduced local measures and then national measures, their policy considerably differed (Rijksoverheid, 2020; Moreira et al., 2021). Italy was the first European country to be significantly affected by the virus (Ghislandi et al., 2020), and as a consequence, the first country to take measures (Plümper & Neumayer, 2020). From mid-March, the Italian government applied a hard lockdown that precluded the freedom of people's movement. The Italian government implemented, among others stay-at-home orders, a ban on public gathering, closed schools, universities, and non-essential businesses, and prohibited travel within Italy. Italians were only allowed to leave home with a printed-out declaration with the reason for leaving the house, even though they went outside to do groceries or visiting the doctor (Moreira et al., 2021).

The policy of the Netherlands also catches the eye since it deviated from the policy of surrounding European countries at the time of the first COVID-19 wave. Their policy was relatively mild/lenient and, therefore, strongly internationally criticized and was known as the "intelligent" lockdown (De Voogd, 2020). The emphasis was on individual responsibility and had the intention to limit the economic, social, and psychological consequences as much as possible (Yerkes et al., 2020). The Dutch government launched educational campaigns on hand hygiene and the adoption of social distancing measures (Rijksoverheid, 2020a). Despite its soft character, strict measures had also been introduced by the government. The closing of childcare centers, schools, and universities was seen as a strict measure. Furthermore, public gatherings and events were prohibited, and bars, restaurants, hairdressers, gyms, and saunas had to close. Other measures were less strict. For example, retailers and companies (who could guarantee the 1.5-meter distance) could decide at their discretion to continue their work, and, unlike Italy, the Dutch did not need written permission for being away from home. In addition, it was strongly advised, but not required, to work from home as much as possible and only use public transport when necessary. Dutch families were also allowed to spend time with one non-household member outside or three non-household members at home as long as social distancing was possible (Rijksoverheid, 2020b).

The UK stands out because, unlike other European countries, it hardly took any measures to contain the virus at the start of the corona crisis in Europe, despite an increase in cases (Flanders Trade, 2020). This was because the government wanted to cultivate herd immunity that would be gained through widespread exposure (Colfer, 2020). The government slowly imposed precautions, and restrictions on the freedom of movement of the British were introduced as one of the last countries in Europe (Colfer, 2020). For instance, social distancing was only required in crowded places

(Flanders Trade, 2020), but there were no further restrictions on movement, economic activities, and public gatherings (Gov., 2020). As already introduced in other European countries, the UK imposed a lockdown (including among others school closure and restrictions on public gatherings) only on March 22, 2020.

2.5 The impact of COVID-19 restrictions on HRQoL

Due to the rapid spread and threat to global public health posed by the virus, governments have implemented strict measures to mitigate the outbreak. Although little research has been done on specific imposed public measures during COVID-19 on the various dimensions of HRQoL, there is already evidence that some measures have a negative impact on people's quality of life. Even before the pandemic, it has been established that a reduction in physical activity leads to higher stress levels, which is strongly associated with a lower HRQoL (Bize, Johnson & Plotnikoff, 2007). Physical activity stimulates the production of endorphins that improve your mood and reduce stress hormones, such as adrenaline and cortisol (Basso & Suzuki, 2017). Several measures during COVID-19, such as being quarantined, have shown a reduction in physical activity during the pandemic and an increase in sedentary time (Qin, 2020; Qi et al., 2020). On average, the sedentary time of European people increased from five to eight hours per day (Ammar et al., 2020). The decrease in physical activity and increase in sedentary time led to higher stress levels, which strongly negatively affects people's HRQoL during the pandemic (Qi et al., 2020). Other similar studies support this, where physically active people reported higher HRQoL levels (Nayak et al., 2021; Rajoo et al., 2019; Meiring et al., 2021). Sufficient physical activity levels can help people to cope with COVID-19 related stress and its impact on HRQoL (Cheval et al., 2021).

Most countries have social distancing as the primary measure in reducing new corona cases (Khan et al., 2021). Social distancing disrupts regular activities and limits the freedom of movements due to limiting people's interactions (Kaufman et al., 2020). It influences relationships with friends due to reduced physical contact with friends and family. Although social distancing is an effective measure in controlling the spread of the virus, it also leads to loneliness, boredom, and anger (Cénat et al., 2021). It has a negative psychological impact on COVID-19 patients and healthy non-infected people (Brito de Oliveira et al., 2020; Zhang et al., 2020). Moreover, people with comorbidity report significantly lower HRQoL scores (Algahtani et al., 2021; Brito de Oliveira et al., 2020). People with comorbidity often need medical treatment and check-ups. However, medical visits were limited due to COVID-19 restrictions. This increased stress among these people and indirectly lowered the HRQoL. Anxiety, depression, and stress lead to a higher risk of having lower HRQoL scores (Algahtani

et al., 2021; Tsamakis et al., 2020), but also pain/discomfort has increased significantly during the COVID-19 pandemic (Ping et al., 2020).

As far as known, few studies have investigated the relationship between partial lockdown and complete lockdown on HRQoL, but no research compares between countries. Brivio and colleagues (2021) investigated the impact of the lockdown imposed in Italy in March 2020 on the behavioral and psychological condition of the general Italian population and focused on post-traumatic stress symptoms. They concluded that the population suffered high levels of distress and PTSD symptoms. An increase in COVID-19 patients and associated deaths led to a feeling of loss of control and feeling of forcefully confined (Brivio et al., 2021). Like this study that focuses on HRQoL captured by the EQ-5D-5L, Hay et al. (2020) examined the impact of COVID-19 among the US population. They showed that increasing age and income were correlated with a higher HRQoL which is in contrast with Prause et al. (2005). However, In general, the overall HRQoL has decreased during the pandemic and younger adults in the age of 18-24 were most affected as younger people are more frightened about their future careers. Moreover, they are in a critical life stage where it is important to build friendships and networks that have been hampered by lockdown measures (Hay et al., 2020). In contrast to the study of Hay et al. (2020), the Vietnamese government implied strict lockdown measures to some restrictions (physical distancing policy, mandatory precautious quarantine) to mitigate the spread of COVID-19 (Vu et al., 2020), but this did not affect people's HRQoL. People being self-isolated/quarantined showed a slightly lower EQ5D HRQoL index than people not needing isolation, but this was insignificant. They stated that it seems that the quarantine measures imposed may not have a negative impact on Vietnamese people's quality of life. Financial policies supporting most affected people, like lay-off workers and poor households, are given as a possible explanation for this (Vu et al., 2020).

3. Data and Methodology

This chapter describes how the data was collected and analyzed. The first part is about the study design and participants. In the second part, the dependent and independent variables are defined. Finally, the statistical analyses are described in detail.

3.1 Study design and participants

This research is based on the online ECOS survey conducted in the Netherlands, Denmark, France, Germany, the United Kingdom, Portugal, and Italy (Sabat et al., 2020). The questionnaire contained items measuring socio-demographic factors (for example, age, gender, education, and income) and people's HRQoL (using EQ-5D and EQ-VAS). It was partly designed by Sabat et al. and partly by the WHO COVID-19 Snapshot Monitoring project (Sabat et al., 2002; WHO, 2020). In order to get a representative sample of the populations, the researchers used multi-sourced panels obtained from the global online market research firm Dynata. The questionnaire was administered in six languages. First, a pilot was conducted by using the Qualtrics platform, and afterward, a large-scale survey was implemented. Data were collected at the beginning of April, June, and August 2020, which resulted in the data set to consists of three time points (Sabat et al., 2020). Over 7,000 respondents were included in the study per time point, made up of 1,000 representative respondents for each country. The authors included 500 additional respondents during the first data round from the region Lombardy, Italy. This region was one of the hardest-hit areas and was included to get essential insights into people's attitudes and perceptions. However, the additional sample from Lombardy is excluded from this study, because the Italian sample is representative of their population and also includes people from Lombardy. The overall samples were representative of the population in terms of region, age, gender, and education (Sabat et al., 2020).

The original dataset consisted of 21,975 observations, of which 13,310 different respondents. As said before, 500 respondents from Lombardy are excluded from the study sample. Moreover, two respondents were excluded because they were not classified into an age category. In addition, duplicates (168) and young people under the age of 18 (11 respondents) were removed. According to the dictionary, being 18 years of age is considered an adult (APA, 2020). Table 1 shows the distribution of the respondents who conducted the online surveys and are included in this study. In total, 12,631 respondents have filled out the online survey for at least one-time point. For 2,589 respondents, there is information for all three data rounds. What also emerged from the data cleaning, ninety-two respondents reported a different gender several times. For example, some who conducted the survey three times changed gender. Their gender was not always the same at all three data rounds. Some who completed the survey three times have changed back to the gender they

filled in during the first survey. Therefore, it is likely that this is inconsistent, and as a solution, these genders are randomly adjusted. As a result, their gender currently matches at all three time points.

Table 1. Distribution respondents who conducted ECOS

Data round	Respondents	Percent	Cum.	Observations
1..	2,742	21.71	21.71	2,742
123	2,589	20.50	42.21	7,767
..3	2,226	17.62	59.83	2,226
.23	1,656	13.11	72.94	3.312
.2.	1,589	12.58	85.52	1,589
12.	1,275	10.09	95.61	2,550
1.3	554	4.39	100.00	1,108
Total	12,631	100.00	100.00	21,294

Note: data rounds refer to the months in which the ECOS survey was conducted: April, June, and August, where 1 stands for April, 2 for June, and 3 for August. For example, 554 respondents conducted the first and third survey.

3.2 Variables and measurement instruments

In order to study the impact on HRQoL and test the hypotheses, data about socio-demographic factors, unemployment, and measurement stringency is used.

3.2.1 Health-related quality of life

The EQ-5D-5L, which is a validated and widely used instrument, is used in this study to measure HRQoL and is the dependent variable (Euroqol, 2020). The EuroQol Group developed this instrument to measure, compare and value HRQoL (Devlin, Parkin, & Janssen, 2020). The tool consists of five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. For every dimension, five levels of severity are used: no problems, slight problems, moderate problems, severe problems, and extreme problems. The five dimensions' responses represent an individual's health state, with 11111 representing the best possible health state and 55555 representing the worst imaginable health state. Each health state can be converted in a utility score from 0 (death) to 1 (perfect health) (Euroqol, 2020). The utility scores can be used to calculate quality-adjusted life years (QALYs) and are often used in economic evaluations of interventions (Gerlinger et al., 2019). In this study, the utility scores range from -.758 to 1, where below 0 is evaluated as worse than death (Lamers, 2007). In addition to this, participants were also asked to self-rate their health according to the Visual Analogue Scale (VAS), ranging from 0 (bad health) to 100 (good health). Notwithstanding this range, there are some inconsistencies in the dataset. Two hundred thirty-eight respondents filled in a VAS score below zero, above 100, or did not fill in the VAS score. VAS scores below zero (46) and

above 100 (11) are considered missing values to get a more representative sample and to use the other (non-biased) answers of these respondents in the analyses.

In this study, population norms for the EQ-5D-5L will be used to compare HRQoL across countries. The population norms represent the EQ-VAS scores or EQ-5D utility values (Stavem et al., 2018). These population norms are based on literature and included as a new variable in the dataset. The EQ-5D-5L value set could be used for almost every country to calculate the utility score during COVID-19. It is recommended to use the standardized valuation study protocol (EQ-VT) that the EuroQol Group developed to set up value sets (EuroQol, 2021). Almost every country included in this study has its own value set with different population norms. This means that every domain with corresponding levels of severity has a value that adds up to a utility. The adjusted hybrid model corrected for age and sex is the preferred value set for France (Andrade et al., 2020). This was also the case for Germany and Portugal, in which they combined time trade-off and discrete choice experiment in a hybrid model (Ludwig, Von der Schulenburg & Greiner, 2018; Ferreira et al., 2019). Italy does not have an EQ-5D-5L value set or “cross-walk” value set based on the EQ-5D-3L. The EQ-5D-3L value set is based on three levels instead of five levels of severity. However, the Italian EQ-5D-3L value set is, on average similar to the German EQ-5D-3L value set (Scalone et al., 2013). Therefore, it is supposed that this is also the case for the EQ-5D-5L value set. This also applies to the UK. As it is likely that the English value set is consistent with the UK’s value set, the English EQ-5D-5L value set is used for the UK (Devlin et al., 2017). The Tobit model was examined as the preferred model for the Dutch tariff (Versteegh et al., 2016). Last, The Danish EQ-5D-5L value set is based on the hybrid model using the time trade-off and discrete choice data (Jensen et al., 2021). The time-trade off, Tobit model, and discrete choice model are tools used to determine EQ-5D-5L value sets (Janssen et al., 2013; Webb et al., 2020). The validity and reliability of the EQ-5D-5L have been widely determined in disease-specific and general populations (Kontodimopouos et al., 2008; Kim et al., 2013; Hernandez et al., 2019).

3.2.2 Government response measures

Every country responded differently to the development of the COVID-19 pandemic. Therefore, a Stringency index was developed to compare different policies across countries (Hale et al., 2020). The stringency index is the main independent variable. In this study, "*The Oxford COVID-19 Government Response Tracker (OxCGRT)*" will be used to compare policy responses. This tool provides information on 19 indicators about containment and closure policies, economic policies, health system policies, and vaccination policies. These indicators are converted into a value between 0 (not strict) and 100

(most stringent) (Hale et al., 2020). The OxCGRT is a global panel database of pandemic measures that is continuously updated and makes it possible to compare policy measures across countries (Hale et al., 2021).

Along with the ECOS, the OxCGRT index is measured on the fifteenth of April 2020, the fifteenth of June 2020, and the fifteenth of August 2020. The indicators are measured in 180 countries and at the subnational level (Hale et al., 2021). However, only the general stringency index for the whole country is captured for countries included in this research. The indicators captured with the OxCGRT are school closing, workplace closing, cancel public events, restrictions on gathering size, close public transport, stay-at-home requirements, restrictions on internal movement, restrictions on international travel, public information campaign, facial coverings, and vaccination policy (Hale et al., 2021).

There is less evidence about the validity and reliability of this measurement instrument. Hale et al. (2021) tested the reliability and validity of the OxCGRT, and they concluded that there is significant internal consistency within the indices. The robustness check in which they used the item response theory model reinforced the validity. The item response theory used individual policy levels as observable variables and the policy index as the unobservable variable to test the correlation. The reliability of the instrument could be biased because mistakes can be made quickly by human actions. The OxCGRT is based on human judgment rather than automatic data collection. Each indicator includes various policies. These policies should be carefully interpreted by intensively trained countries' data collectors. For instance, it could be that governments force companies to close down temporarily. However, the types of closed companies could differ across countries. As a result, the data contributors should assess this policy measure alongside *"detailed guidance material"* to assign a code to the indicator. Nevertheless, the data contributors are mostly specialized in one country's culture, language, and legal system and are weekly taught to standardize interpretations (Hale et al., 2021).

3.2.3 Unemployment

Unemployment statistics during the COVID-19 crisis are used to compare unemployment data across countries and the effect on HRQoL (OECD, 2021). Monthly unemployment rates as a percentage of the labor force are based on the International Conference of Labour Statisticians (ICLS). This guideline states who is considered to be unemployed or employed. Moreover, an additional criterion in which people whose duration of absence during the COVID-19 crisis is unknown is classified as

"unemployed" (OECD, 2021). The unemployment rates are based on labor force surveys (OECD, 2021). This survey is conducted among households to obtain information on people's job situation (Eurostat, 2021). Along with the ECOS and the OxCGRT index, the unemployment rate of April 2020, June 2020, and August 2020 are used separately for each country.

3.2.4 Socio-demographic variables

A single question assessed the socio-demographic variables household income, education level, age, and gender in the ECOS for each of the variables. The variable "household income" was based on the monthly income of a household and financial status (whether they could make their ends meet) and measured by the following items: "with great difficulty," "with some difficulty," "fairly easily," and "easily." These items are included in the dataset on a four-point Likert scale. Concerning education, respondents were asked how many years of full-time education they have completed. Gender is a nominal variable (male or female).

3.3 Data analysis

Statistical analyses were performed by using Software for Statistics and Data Science (Stata). First, the mean and standard deviations were calculated for age, household income, education level, gender, and unemployment in percentages (see Table 3). Descriptive statistics for stringency, utility, country characteristics, and time points are presented in a figure (see Figure 2).

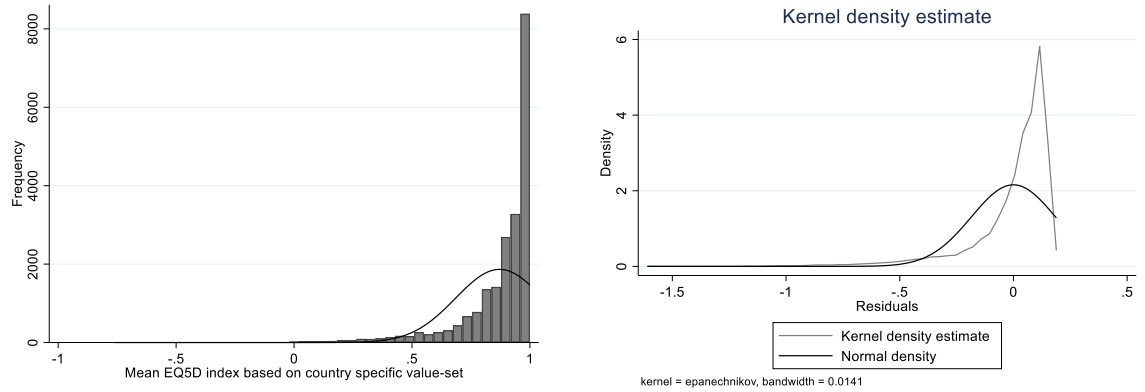
3.3.1 Assumptions and two-part model

Before the regression analyses, the following assumptions will be briefly discussed below: linearity, normality, homogeneity, independence of residuals, and multicollinearity.

To start with the assumption of linearity (see Appendix A1). A two-way graph was used to inspect the linear relationship among the variables. Multicollinearity among predictors is detected by using tolerance and the variance inflation factor (VIF). VIF represents the presence of multicollinearity between two or more variables if the value exceeds 10. If the tolerance is lower than 0.2, there is multicollinearity (Kim, 2019). If the independent variables are highly correlated, this may lead to incorrect outcomes in the regression analysis (Kim, 2019). None of the independent variables included in the different models of the analyses are highly correlated. Thus, this assumption is not violated. Last, the assumptions for the examination of residuals. Residuals (differences between the actual and predicted dependent variables) should be normally distributed, linear, and the variance should be the same for all predicted outcomes (Tabachnick & Fidell, 2013). The assumption of

homoscedasticity (variance of the residuals) is violated (see Appendix A1). Consequently, "robust" standard errors from Huber/White were used to get unbiased standard errors for the regressions. Otherwise, heteroscedasticity leads to non-constant variance (Hayes and Cai, 2007). As regards the normality assumption, Figure 1 shows the non-normal distribution of the EQ5D index.

Figure 1. Non-normal distribution of the EQ5D index



The distribution is highly skewed to the left, and more than 25% of the respondents scored a utility score of 1.0. Regression analyses are performed to examine the impact of the independent variables (age, gender, income, education, unemployment, and policy measures) on HRQoL. As the EQ5D index score is far from being normally distributed, a two-part model is used and examined as a suitable approach in case of a non-normal distribution (Li & Fu, 2009). The first part of the model consists of a logistic regression model for the probability of reaching the maximum score of 1.0. The second part is a least square regression done on the respondents whose EQ5D index score was below 1.0, which reduced the sample size to 9,473 respondents. The interpretation of the first part model is about whether and how the independent variables affect the respondent's likelihood of achieving the maximum score. In contrast, in the second part, the focus is on whether and to which extent the independent variable impacts the EQ5D index score for respondents scoring no full health (Li & Fu, 2009). The equation for the least-squares regression with the Huber/White robust standard error is: $Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k$, where Y is the predicted value on the dependent variable (EQ5D index score), β_0 represents the constant that tells what the Y value would be if all the X's are zero, the X's are the independent variables, and the betas are the coefficients corresponding with the independent variables (Tabachnick & Fidell, 2013). The independent variables were stepwise included in the regression models. Model 1 included all the socio-demographic factors. Country characteristics were additionally included in Model 2, followed by time points in Model 3. The unemployment rate was only included in Model 1 and Model 4 as this independent variable highly correlated with variables

country and time points (Appendix A1). The last model consisted of the stringency index after adjusting for socio-demographic factors.

3.3.2 Fixed effects regression model

In order to analyze changes in HRQoL over time across countries, this study performed a panel data regression. This method combines the time series characteristics with the cross-sectional data (Harrison, 1996). To decide whether to use the fixed or random-effects model, a Hausman test was performed. The null hypothesis was that the $E(u_{it} | X_{it}) = 0$ (Hausman, 1978), which suggests that the unique errors (u_{it}) are not correlated with the regressors (Hausman, 1978). The null hypothesis could be rejected, and, thus, the fixed effects model was most appropriated.

The fixed-effects model can be used to control for omitted variables by capturing unobserved time and country effects (Allison, 2009). Omitted variables are variables that cannot be observed but might have an impact on the dependent variable (Allison, 2009). There are many variables affecting health-related quality of life, but not measured during the survey, like motivation or culture (Gu et al., 2019). In the fixed model, the unobserved variables are fixed. They cannot be controlled for if changes happen over time. Two basic assumptions should be met before using the fixed-effects model (Allison, 2009). First, the dependent variable should for each respondent be measured on at least two time points. However, returns are missing in the time series as not every individual conducted the survey two or three times. Moreover, the region Lombardy is only included in the first data round of the study. Therefore, the panel dataset is unbalanced, meaning that not all the observations are measured at every time point. As a result, Lombardy is excluded from the panel data regression on account of the incompleteness of the data. The panel data sample consists of 12,631 respondents.

The second assumption consists that the independent variables must change over time for a substantial part of the sample (Allison, 2009). The basic equation for the fixed effects regression model is:

$$Y_{it} = \beta_1 X_{1,it} + \ldots + \beta_k X_{k,it} + \alpha_i + \varepsilon_{it}$$

Where the dependent variable health-related quality of life (Y_{it}) is measured for individual *i* at time *t* in months. X_{it} represents the independent variable (Stringency index, unemployment rate, and income) with the corresponding coefficient (β) that influences the dependent variable Y_{it}, α_i is the

intercept that captures the heterogeneity between the individuals, and ε_{it} is the error term. Income, stringency, and unemployment are time-varying variables and, thus, included in the panel data to get a controlled effect. Last, coefficients were interacted with country dummies to compare differences between countries in the effect of stringency on HRQoL.

3.4 Sensitivity analysis

Sensitivity analyses are conducted in order to test the robustness of the results on the EQ5D index scores. As in the two-part model, the dependent variable is predicted based on the country-specific value set. Although country-specific tariffs reflect better populations' health states (Zhao et al., 2017), there are clear differences between countries in their valuations (Norman et al., 2009). In France, for example, people score much higher on quality of life using their value set than using the Dutch value set. Therefore, the first sensitivity analysis will use one (the Dutch) value set for all respondents. This also makes it possible to compare between countries. Moreover, a second sensitivity analysis is performed for the EQ-VAS score as the dependent variable. The EQ-VAS score was not as skewed distributed as the EQ5D index (see Appendix A1). Therefore, an OLS regression is conducted in which all 12,631 respondents are included.

4. Results

In this section, the results of the study are presented. The first part describes the development of COVID-19 across countries over the study period. Second, the descriptive statistics of the study sample. Afterwards, the outcome results of the two-part regression model are discussed to test which variables are related to HRQoL and to which extent. Moreover, the results of the sensitivity analyses are reviewed. Last, the panel data regression outcomes are shown to show the effect of the measures on HRQoL over time controlled for unobservable time-varying variables.

4.1 Development of COVID-19

4.1.1 The Health crisis

At the end of January 2020, COVID-19 first appeared in Europe, particularly in France (Spiteri et al., 2020). The virus spread across Europe in a few weeks. In July, the UK (44,517), Italy (34,914), and France (29,965) were affected most in terms of COVID-19 deaths (Lupu, Maha & Viorica, 2020). This is also illustrated in Table 2 for the countries included in this study, where the confirmed deaths per 1,000,000 people are the highest for these countries. The number of COVID-19 deaths is remarkably low in Germany and Denmark. Note that not every corona death may have been registered. The table below also shows that the number of infections, deaths, and admissions has fallen sharply during the summer, with a marked decline visible in France. At the end of the summer, the number of infections increased again, starting the COVID-19 second wave.

Table 2. Development COVID-19 over time

	Incidence			Deaths			Hospital admissions			ICU admissions		
Country	T1	T 2	T 3	T 1	T 2	T 3	T 1	T 2	T 3	T 1	T 2	T 3
DE	256.1	18.77	90.53	17.37	1.34	0.41	37	3.0	4.0	32.49	5.18	2.72
UK	443.07	105.06	114.47	94.72	10.77	1.3	272	44.0	10.0	47.64	5.67	1.12
DK	220.81	44.02	192.67	15.71	0.86	0.69	48	5.0	3.0	.	1.55	0.00
NL	445.52	70.62	301.84	51.94	2.86	0.76	75	1.0	4.0	76.04	5.08	2.28
FR	1,203.9	49.83	260.33	92.89	3.35	1.24	243	10.0	12.0	97.67	12.11	5.22
PT	485.45	210.95	141.61	21.48	3.43	2.45	46	13.0	7.0	21.38	7.16	3.63
IT	425.61	33.28	55.16	65.76	6.73	3.13	107	7.0	8.0	52.69	3.42	0.91
Mean	496.19	79.18	171.45	496.19	4.04	1.47	117.64	11.58	6.85	54.31	5.61	2.26

Note I: Confirmed cases, deaths, and hospital admissions per 1,000,000 people over the previous week
Note II: ICU admissions based on daily new admissions
Note III: Data are from Ritchie et al. (2020)

Although Italy is considered one of the hardest-hit countries, compared to other severely-hit countries (France, UK, Portugal, and the Netherlands), the infection rate in Italy did not increase at the same pace in August (T3). The main reason for this is the effectiveness of the policy measures

imposed by the Italian government (Bontempi, 2021). Aside from the Netherlands and Denmark, which had a less strict lowdown (see Figure 2.1) and high incidence rate in August, the UK, France, Portugal, and Italy saw a slight and comparable drop in the stringency index, suggesting that some policies are more successful in limiting the spread of the virus (Bontempi, 2021).

Regarding the hospital and ICU admissions, in April 2020, there was enormous pressure on hospital care. There were major differences across countries: Italy, France, and the UK had significantly more hospitalized COVID-19 patients per million inhabitants than the other countries. The number of ICU admissions reflects the most urgent bottleneck in the healthcare system (de Klerk et al., 2021). Once again, we see a peak in April 2020 in the number of ICU patients. Note that the Netherlands had relatively more ICU patients than the number of hospital admissions and that the UK had relatively few patients. Nevertheless, there is a visible convergence between the countries at time point three, and the differences are relatively small.

4.1.2 Evolution of the stringency of measures and EQ5D utility index by country

In April 2020, the stringency of the measures and the speed with which governments imposed them differed significantly across countries (see figure 2.1). Whereas Denmark imposed the least stringent measures, Italy imposed the strictest measures. From May, the COVID-19 measures were relaxed, except in the UK, which continued a stricter policy. A possible explanation that the Netherlands and Denmark had a more flexible policy compared to the other countries is that these countries initially placed the responsibility on the citizen (Devine et al., 2021). Devine (2021) also indicated that higher political trust leads to slower policy responses, possibly because of the belief that the pandemic can be suppressed without stricter policies by holding citizens accountable and that citizens are able to self-regulate. The less severe restrictions in Denmark and The Netherlands may justify the sharp increase in infections, starting from mid-June. In general, an increase in infections, deaths, and admissions leads to a stricter policy (see Appendix A5). The stringency index is not fully related to the rise in infections in some countries (Bontempi, 2021). Although The UK and Portugal have the highest stringency index compared to other countries in August, the infection rate increased sharply. On the contrary, Italy showed a slight increase in infections even though a less strict lockdown. Bontempi (2021) suggests that this results from the effectiveness of the measures and the social acceptance of these measures. Teleworking and travel restrictions are established as effective measures to limit the virus. However, before summer, teleworking measures were relaxed by the government of the UK and France. Teleworking reduces people's mobility and indirectly the social interactions. Another fundamental measure that declares the differences in the development of COVID-19 can be

attributed to when wearing facemasks became compulsory. The UK made it mandatory only in July, whereas Germany and Italy had already adopted this rule in April 2020. Moreover, in the Netherlands, face masks were only mandatory in public transport. Italians (90%) and French (90%) were more likely to accept this rule and thus wear a face mask than Germans (65%). Despite one of the highest death rates in Europe, the English population was also less inclined to wear facemasks (75%) (Bontempi, 2021).

Figure 2. Evolution of the COVID-19 stringency index and EQ5D index by country

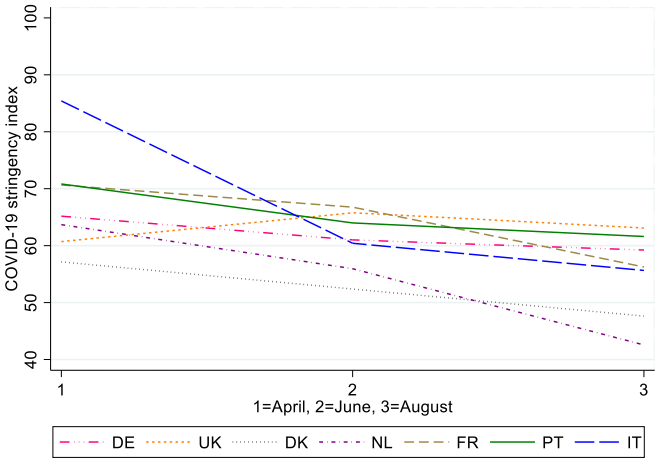


Figure 2.1

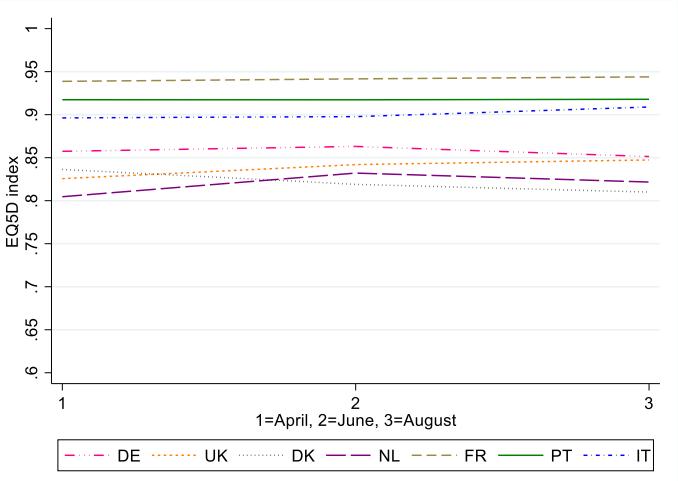


Figure 2.2

It can also be seen from figure 2 that the development of the EQ5D index differs across countries over time. The mean utility score for every time point was 0.87, 0.88, and 0.87, respectively. The lowest EQ5D index was reported for the Netherlands at T1 (0.80) and the highest for France (0.94) and stayed constant over time (see also Appendix A2). Notably, the differences in utility over time are small, and only the Danish EQ5D index decreased during five months. In summary, in terms of health impacts, France and UK were the hardest hit during these five months, and Germany and Denmark were the least hit in terms of incidence, deaths, and hospital admissions. In terms of the EQ5D index, Denmark has the lowest score and France the highest score.

4.2 Descriptive statistics

Table 3 provides the descriptive statistics of the socio-demographic variables used in the regression models. Summary statistics for the different time points, countries, stringency indices, and utilities are depicted in Figure 2. The total sample consisted of 13,310 respondents, which are reduced to 12,631 after correcting for missing values on the outcome or explanatory variables and scores for

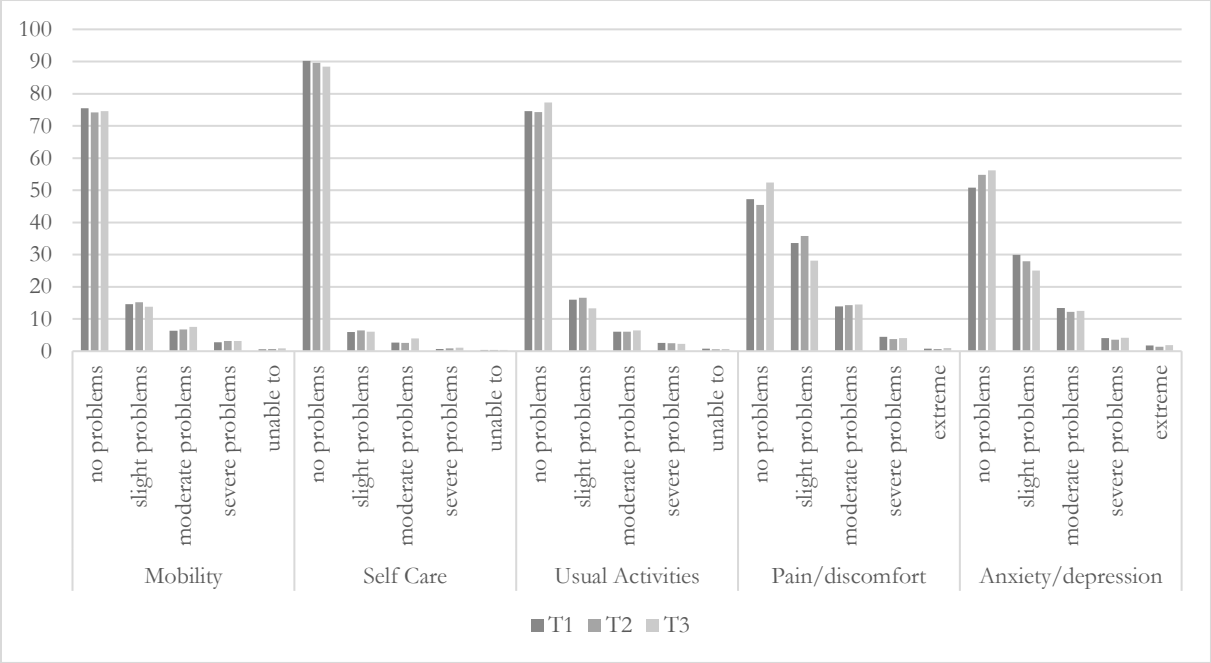
VAS. The mean number of respondents per country is 1804, ranges from 1672 to 1990 for the study period (see Appendix A3). The mean age for the total sample was 43.9 years old, with 39.9 for Portugal, which has the lowest average age, and 47.2 for the UK with the highest average age. Most respondents were female (52%), had limited difficulties with income (40%), had attained 13.7 years of education on average, and lived in a country with an average unemployment rate of 6.08.

Table 3. Descriptive statistics (total sample)

Variable	Obs	Resp.	Mean	Std. Dev.	Min	Max
Age category						
18-24	21,294	12,631	.10	.30	0	1
25-34	21,294	12,631	.16	.37	0	1
35-44	21,294	12,631	.19	.39	0	1
45-54	21,294	12,631	.18	.39	0	1
55-64	21,294	12,631	.16	.37	0	1
65+	21,294	12,631	.21	.41	0	1
Gender						
Male	21,294	12,631	.48	.50	0	1
Female	21,294	12,631	.52	.50	0	1
Education	21,294	12,631	13.71	4.71	0	25
Income						
With great difficulty	21,294	12,631	.10	.29	0	1
With some difficulty	21,294	12,631	.37	.48	0	1
Fairly easily	21,294	12,631	.40	.49	0	1
Easily	21,294	12,631	.13	.34	0	1
Unemployment rate	21,294	12,631	6.08	1.95	3.4	10

Furthermore, concerning the responses to the EQ-5D-5L domains, Figure 3 illustrates the frequency distribution in percentage for the three time points on the five dimensions. These results show that the percentage of respondents who selected “no problems” during T1 from the EQ-5D-5L dimensions were 75.5 % for mobility, 90.2% for self-care, 74.6% for usual activities, 47.2% for pain-discomfort, and 50.8% for anxiety/depression. The largest proportions of respondents with severe and extreme problems were noted for the domain “anxiety/depression” with 5.9% for T1, 5.0% for T2, and 6.1% for T3. Respondents had the least problems in “self-care” with 90.2%, 89.6%, and 88.4% over the different time points. On the contrary, only 47%-52% of participants reported having had no problems in the domain “pain/discomfort.” So, more than half of the sample reported different from “no problems.” A relatively similar distribution of answers across the data rounds was observed for “anxiety depression”. However, the longer the pandemic lasted, the more a shift was visible from slight to having no problems.

Figure 3. Frequency distribution (%) EQ5D domains



Moreover, there are no big differences in most domain scores between countries on average. However, most problems were reported on pain/discomfort and anxiety/depression with large differences between the worst and best scoring countries (see Appendix A4). Whereas Denmark scored best on anxiety/depression (62.5% having no problems), they scored worst on pain/discomfort (40.9% having no problems). The UK scored worst on anxiety/depression (47.9% having no problems), and the general population of Portugal reported the least problems in pain/discomfort (54.5% having no problems).

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4.3 Results regression analyses

Table 4. Correlation matrix

Variable	Utility	VAS
Utility	1.000	
VAS	0.532	1.000
	(0.000)	
Gender	-0.057	-0.026
	(0.000)	(0.000)
Age_cat	-0.009	-0.034
	(0.174)	(0.000)
Education	0.065	0.059
	(0.000)	(0.000)
Income	0.186	0.221
	(0.000)	(0.000)
Unemployment	0.192	0.038
	(0.000)	(0.000)

A first inventory of the correlations between the different variables is presented in Table 4 between utility and VAS and the socio-demographic factors. The most correlated attributes were income (r=.186) and unemployment (r=.192) for utility, and only income (r=.221) for VAS. In Appendix A5, the correlations between the remaining variables are presented- incidence, deaths, and admissions. The self-rated health scores (VAS) are sensitive for the number of deaths, hospital admissions, and ICU admissions which are also positively correlated with pain/discomfort and anxiety/depression. The utility is less correlated to the characteristics of the pandemic but stronger to stringency index and incidence rate.

4.3.1 Two-part model: Logistic regression for the probability of reaching the maximum utility

Table 5 presents the results of the first part of the two-part model that consists of four models. Both the coefficients and p-values from the logistic regression are presented. Most variables are categorical variables for which the reference category is coded as 0. In all models, being older and female are strong factors that decrease the likelihood of having perfect health. Being 55+ years old leads to a significantly lower likelihood of having perfect health relative to ages 18-24. On the contrary, a higher income and living in the Netherlands are associated with a higher likelihood (p=.000) of having perfect health. Respondents with great difficulty in making their ends meet were least likely to report full health, followed by some difficulty (β=0.325), fairly easily(β=0.832), and easily (β=1.316), which was visible in all models. Unlike model 2 that does not correct for different time points, model 3 shows that living in the Netherlands and Italy leads to the highest likelihood of

being in perfect health. This implies that country characteristics lead to a higher or lower probability of reaching the maximum EQ5D utility score. Model 3 also shows that the time of the year 2020 decreased or increased the likelihood of reporting full health by respondents. In August, people had a significantly higher likelihood of being in perfect health (β=0.245; p=.000) than in April. Model 4 shows that the stringency index leads to a significantly lower likelihood of having perfect health if controlled for socio-demographic factors. Additionally, higher education does not significantly lead to a lower likelihood of reporting full health in all models. By contrast, the unemployment rate statistically significantly increases the likelihood of reporting perfect health.

Table 5. Logistic regression for the probability of reaching EQ5D index 1

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Age category	.	.	.	.	.	.	.	.
18-24	0	.	0	.	0	.	0	
25-34	0.089	.145	0.091	.136	0.090	.143	0.091	.137
35-44	0.117	.049	0.117	.049	0.113	.059	0.116	.051
45-54	0.001	.986	0.003	.955	-0.003	.96	-0.002	.978
55-64	-0.338	.000	-0.334	.000	-0.343	.000	-0.343	.000
65+	-0.458	.000	-0.457	.000	-0.465	.000	-0.463	.000
Gender								
Male	0	.	0	.	0	.	0	
Female	-0.365	.000	-0.362	.000	-0.366	.000	-0.367	.000
Education	-0.003	.315	-0.002	.564	-0.003	.397	-0.003	.325
Income								
With great difficulty	0	.	0	.	0	.	0	
With some difficulty	0.325	.000	0.326	.000	0.318	.000	0.317	.000
Fairly easily	0.832	.000	0.847	.000	0.837	.000	0.825	.000
Easily	1.316	.000	1.324	.000	1.312	.000	1.297	.000
Unemployment	0.038	.000		.			0.041	.000

Table 5 (extended). Logistic regression for the probability of reaching EQ5D index 1

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Country								
DE			0	.	0	.		
UK			-0.028	.634	-0.026	.648		
DK			-0.075	.202	-0.073	.211		
NL			0.195	.001	0.196	.001		
FR			0.165	.004	0.165	.004		
PT			0.039	.502	0.041	.481		
IT			0.194	.001	0.196	.001		
Data round								
1					0	.		
2					-0.003	.929		
3					0.245	.000		
Stringency index							-0.007	.000
Constant	-1.374	.000	-1.246	.000	-1.301	.000	-0.948	.000
Resp.	12,631		12,631		12,631		12,631	
Obs.	21,294		21,294		21,294		21,294	

4.3.2 Two-part model: least squares regression with robust standard errors

The results from the least squares regression analysis of people scoring below 1.0 on the EQ5D utility-scale are presented in Table 6. The results for gender, income and unemployment are consistent with Table 5 as it decreases or increases the likelihood and the mean of EQ5D. Upon more detailed evaluation, in general, men have a higher probability of reaching the highest utility score; however, table 6 shows that the differences in HRQoL between men and women are small among the group of people scoring a lower utility. Regarding income, a higher income (having less difficulty making ends meet) is associated with a higher level of HRQoL. The effect is almost not affected when more variables are included in the model or become even stronger. The correlation between unemployment and the EQ5D index in model 1 is 0.027, implying that if unemployment increases by one unit, EQ5D utility increases by 0.027, taking other socio-demographics constant. The higher the unemployment rate, the higher the utility score. However, it is a small significant correlation and reduces when controlled for stringency index (β=0.025).

Contrary to the logistic regression, being 25+ differs non-significantly ($p \geq .192$) from 18-24 years old in all models. The magnitude of the scores is lower than those in the logistic regression analysis, indicating that age does not significantly affect the EQ5D index of people scoring less than 1.0. This suggests that being older does not predict a lower utility score, rejecting the hypothesis of a predictive relationship. Overall, the results imply that age only influences HRQoL in the higher age groups in respondents with full health and has no effect on respondents reporting no full health. On the other hand, education is statistically significantly correlated in every model for people with an EQ5D index below 1.0, while it did not significantly affect utility in those who reported EQ5D index 1.0. The correlation is small; respondents with higher educational attainment tend to have higher scores. In summary, the number of years of education does not affect the probability that you are completely healthy, but for anyone who is not completely healthy, the more years of education, the higher the HRQoL.

There are more factors associated with HRQoL among the general population during the first wave of COVID-19. The association between living in a specific country and the EQ5D index is significant but differs from the logistic regression. People living in France have a higher utility score in comparison to the reference group, which was also visible in Figure 2, indicating that country characteristics have a higher significant impact on HRQoL in some countries than others. Regarding the time of the year, people had an insignificant higher EQ5D utility in June and a significantly lower utility in August compared to April. Hence, the time of the year affects HRQoL. Concerning the stringency index, the

stringency of the COVID-19 measures has a small significant effect on utility. Whereas table 5 showed a negative correlation (β=-0.007; p-value=.000), table 6 shows a positive effect (β=0.003; p-value=.000). If the stringency index increases by one unit, the utility score increases by 0.003.

Table 6. Least squares regression results with robust standard error for those with EQ5D index less than 1

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Age category		.		.		.		.
18-24	0	.	0	.	0	.	0	.
25-34	-0.000	.904	-0.001	.878	-0,001	.875	-0.002	.739
35-44	0.006	.383	0.006	.328	0.006	.318	0.005	.417
45-54	0.003	.597	0.005	.463	0.005	.459	0.003	.625
55-64	0.006	.335	0.008	.201	0.008	.186	0.007	.255
65+	0.007	.272	0.007	.209	0.008	.192	0.006	.285
Gender								
Male	0	.	0	.	0	.	0	.
Female	-0.007	.038	-0.007	.035	-0.006	.037	-0.007	.034
Education	0.001	.001	0.002	.000	0.002	.000	0.001	.001
Income								
With great difficulty	0	.	0	.	0	.	0	.
With some difficulty	0.066	.000	0.070	.000	0.070	.000	0.070	.000
Fairly easily	0.110	.000	0.113	.000	0.113	.000	0.114	.000
Easily	0.117	.000	0.132	.000	0.132	.000	0.126	.000
Unemployment	0.027	.000		.			0.025	.000

Table 6 (extended). Least squares regression results with robust standard error for those with EQ5D index less than 1

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Country								
DE			0	.	0	.		
UK			-0.037	.000	-0.038	.000		
DK			-0.055	.000	-0.056	.000		
NL			-0.073	.000	-.0073	.000		
FR			0.122	.000	0.122	.000		
PT			0.074	.000	0.074	.000		
IT			0.064	.000	0.064	.000		
Data round								
1					0	.		
2					0.003	.400		
3					-0.014	.000		
Stringency index							0.003	.000
Constant	0.552	.000	0.694	.000	0.697	.000	0.352	.000
Resp.	9,473		9,473		9,473		9,473	
Obs.	14,811		14,811		14,811		14,811	

4.4 Sensitivity analyses

With the aim of checking the robustness of the previously presented results, two sensitivity analyses are conducted. The Dutch EQ5D value set is used in the first sensitivity analysis instead of country-specific value sets (see Appendix A6). Results demonstrate that the impact of the stringency of measures during COVID-19 on the EQ5D index remains the same. The stringency index has a significant positive impact on the utility score of the general population. However, the effect is even more reduced (β=.001 p<.001). In comparison to the main regression analysis, being 65+ differs significantly (β=.013; p<.05) from people at the age of 18-24 years old in all models. Income is slightly stronger in all models in the least square analysis based on one value set. Regarding countries, in models 2 and 3, the impact of country characteristics on utility reduces compared to Germany. France stands out here, with the general population score significantly higher (β=.122; p<.001) than Germany in model 2, but reduces in the sensitivity analysis (β=.028; p<.001). This might implicate that the French value set is set more positively.

A self-rated health scale (VAS) is used as the dependent variable in the second sensitivity analysis instead of the EQ5D index (see Appendix A7). As with previous findings, women experience a lower HRQoL than men, which also applies to income. This remains relatively stable when adding other variables. Stringency is also positively correlated to HRQoL (β=.102; p<.001), indicating that if the stringency index goes up with one unit, the VAS score of the general population increases by 0.102. The most striking feat is that age is significantly negatively correlated to VAS, meaning that the higher the age, the lower the VAS score. This is the opposite result of the least-squares regression for people scoring less than full health, where there was a positive correlation on the utility score. What stands out in model 2 is that for the majority, a positive utility also applies to a positive VAS compared to Germany, except for the UK, Denmark and the Netherlands. Whereas in the least square model, France scored the highest utility compared to Germany, this is Portugal for the VAS score.

4.5 Panel data analysis

Table 7 shows the fixed effect panel regression model of HRQoL with stringency index, unemployment, and income as explanatory variables. The effect of the stringency index on HRQoL becomes insignificant and negligibly small. An insignificant effect is also visible when one value set was used. Having problems with income is positively and significantly associated with utility in the fixed-effects model. In general, a higher unemployment rate leads to a higher quality of life, but this effect is insignificant (β=.001, p>.05). This is not in line with the EQ-VAS model in which a negatively

insignificant effect was found. Further, whether the relationship between HRQoL and stringency was influenced by country was also investigated (see Appendix A8). In comparison to Germany, all the other countries have a smaller effect of stringency on HRQoL. However, the differences are not significant and small. Therefore, the association between HRQoL and stringency of the measures was strongest for Germany (β=.006), p>.05). As mentioned before, tariffs of different value sets differ. Therefore, it is better to compare countries with the use of one value-set. It becomes clear from Appendix A8 that in most countries, the stringency of the measures have a significantly lower impact on utility of a population compared to Germany. Denmark saw the smallest effect in comparison to Germany (β=-.043).

Furthermore, as mentioned before, previous literature shows that the domain anxiety/depression is most affected in some countries during the pandemic. Imposing strict measures leads to statistically significantly higher levels of anxiety/depression (Norström et al., 2019; Ping et al., 2020; Ferreira et al., 2020). Therefore, model 4 presents the results on anxiety/depression for this study. The dimension has been dichotomized as the distribution is highly skewed and used as dependent variable. Notably, the effect of the stringency of the measures on anxiety/depression is small, but insignificant. Unemployment rate and less difficulty with making ends meet show a significant relationship with anxiety and depression.

Table 7. The effect of Covid-19 stringency (Individual fixed effects (FE) regression)

Variables	(1) Country-specifc Utility		(2) General Utility		(3) EQ-VAS		(4) Anx/depr.	
	β	p-value	β	p-value	β	p-value	β	p-value
stringency index	0.000	.651	0.001	.054	0.046	.218	0.002	.053
unemployment rate	0.001	.572	0.026	.000	-0.103	.773	-0.024	.005
Income								
With great difficulty	0	.	0	.	0	.	0	.
With some difficulty	0.023	.006	0.028	.003	1.944	.051	-0.022	.245
Fairly easily	0.031	.001	0.041	.000	2.748	.018	-0.06	.009
Easily	0.038	.001	0.053	.000	4.565	.001	-0.105	.000
constant	0.845	.000	0.597	.000	69.643	.000	0.556	.000
Fixed effects	Yes		Yes		Yes		Yes	
Observations	21,294		21,294		21,225		21,294	
Individuals	12,631		12,631		12,611		12,631	
Mean dependent variable	0.871		0.825		74.236		0.461	
SD dependent variable	0.186		0.207		21.625		0.498	
R-squared	0.003		0.027		0.003		0.011	
F-test	3.168		45.732		3.453		17.543	
Prob>F	0.013		0.000		0.008		0.000	

Note: Country-specific utility is based on the value set specific for each country
General utility is based on the Dutch value set

5. Discussion

The main aim of this study was to investigate the effects of the development of COVID-19 and the stringency of the COVID-19 measures on the general adult populations' HRQoL of seven European countries. Regarding the development of the COVID-19 pandemic (*sub-question 1*), results show that the pandemic weakened during the five-month study period regarding incidence, deaths, and admissions. In terms of quality of life, the present study found that these development measures are negatively correlated with the VAS score and positively with pain/discomfort and anxiety/depression. This correlation was weaker for the EQ5D utility score.

Furthermore, this study also presented the change in HRQoL from April 2020 to August 2020 across countries (*sub-question 2*). Overall, HRQoL did not change over time; the mean EQ5D utility was 0.87 for all time points, of which more than 30% of the sample reported full health. Younger people, men, higher educated, and having no difficulties making ends meet reported the highest HRQoL scores (*sub-question 3*). Along this line, Wilson and Cleary, 1995; Prause et al. 2005; Kivits et al. 2013; Charafeddine et al. 2017 also show that age, gender, education, and income are predictors for HRQoL. However, this was not visible in the whole sample; education does not seem to play a significant role in the likelihood of having full health. In addition, being 25+ differs non-significantly ($p \geq .192$) from 18-24 years old in all models for people reporting less than full health. As expected, the outcomes on the EQ5D domains are in line with existing literature, which has demonstrated that pain/discomfort and anxiety/depression are the most affected domains during COVID-19 (Algahtani et al., 2021; Tsamakis et al., 2020; Ping et al., 2020; Tran et al., 2020). The authors hypothesized that the fear of being infected by SARS-VOV-2 and concerns of the impact of being infected might be explanations for reporting more problems in this domain (Vu et al., 2020). Having more trust in the government and being up-to-date with all the information, on the contrary, could explain the differences between countries as these factors lead to a lower level of anxiety/depression (Bäuerle et al., 2020). More than 50% of the respondents reported having problems in April 2020. Although this positively changed over time, these remain areas of focus. In particular, the stringency index has a positive effect on anxiety/depression, although this was insignificant. However, it should be further investigated which people reported more anxiety/depression in order to set up specific intervention.

In this study, the environmental characteristics affecting HRQoL are categorized into stringency of the measures and country characteristics. Regarding the stringency index, a stricter policy leads to a lower likelihood of reporting full health ($\beta = -0.007$) (*sub-question 4*). However, under people reporting less than full health, the stringency index is significantly positively correlated to HRQoL, but

the effect is small (β=0.003). The effect becomes even insignificant and disappears in the panel data analysis controlled for time-varying factors. Therefore, it seemed that stricter policy measures of COVID-19 might not have a positive or negative impact on the European general population's HRQoL. This aligns with the findings of Vu et al. (2020) for the Vietnamese population, but is also in contrast to other previous studies (Hay et al., 2020; Brito de Oliveira et al., 2020; Algahtani et al., 2021).

There might be several explanations of finding a small effect. It may be because this study was conducted from April to August 2020. At the start of the crisis, people thought the crisis might not take a long time, and in the summer months, measures were relaxed in most countries. Most people saw the need for imposing measures, and they generally had confidence in hospitals and medical centers to combat the virus. Furthermore, governmental support to mitigate the economic impact of COVID-19 may also have contributed to the fact that economic measures (such as closing companies) may not have affected HRQoL. Besides, the acceptance of measures could have played a role in finding no significant relationship and finding a small significant correlation. According to research, wearing masks and public transport restrictions are acceptable by the general French population (Blayac et al., 2020). This is confirmed by Gollwitzer et al. (2020), who showed that the stringency of measures less affects people's compliance than the lockdown length. For instance, the Spanish were willing to comply with a strict forced lockdown if this was imposed for a short time. People were also more willing to accept the lockdown measures if the infection rates and demand for intensive care beds increased (Gollwitzer et al., 2020). However, this pattern should be investigated in future research for all countries included in this study.

Most of the respondents in this sample are of reproductive age (more than 50%) and are likely to have children, which might also explain a small effect. Parenthood appears to have a mitigating effect (Brivio et al., 2021). Brivio et al. (2021) looked at the effect of the lockdown on symptoms of Post-Traumatic Stress Disorder in which parents developed fewer symptoms. This is because efficient upbringing of children leads to less focus of parents on themselves and would discourage them from excessive reactions (Brivio et al., 2021). In line with this, regarding social-related restrictions, people spent more time relaxing during the pandemic because they were no longer "obliged" to socialize (Al Dhaheri, 2021). Additionally, Al Dhaheri (2021) also indicates that people spent more time with their nuclear families, which had a positive impact on mental health. This may have helped people to cope with the negative impacts of COVID-19, but family life should be mapped in further research.

Further analysis of the data revealed that the unemployment rate also has a positive impact on HRQoL. As described in chapter 2, the unemployment rate at the country level is included as an independent variable as the rate could influence the quality of life of both employed and

unemployed people (Ochsen, 2011; Tay & Harter, 2013; Tay et al., 2014; Chen & Hou, 2018). This study shows similar results in which the country-level unemployment rate predicts the average level of HRQoL. A positively significant correlation is found, and, thus, it is likely that the rate affects unemployed people and has some spillover effect on employed people. These findings are supported by Chen & Hau (2018) highlighting a positive correlation between the country-level unemployment rate and quality of life, explained by less stigmatizing and less job insecurity among the unemployed and employed, respectively. It might also be positively influencing HRQoL as people might have expected that unemployment was temporary (Endeweld, Heler & Karandi, 2020). However, care needs to be taken when interpreting these results. Respondents are not specifically asked whether they are employed or unemployed. Therefore, further research could investigate which people particularly are affected by the unemployment rate during COVID-19. This study only investigated whether the country's unemployment rate influences people's HRQoL during the pandemic, but it remains unclear for which people.

There might be another explanation of whether a positive correlation was found in this study. Since many young people lost their job during COVID-19 and these people were healthy in general, research showed that unemployed young people score a lower quality of life than employed young people. However, the majority still scores high levels of QOL (Axelsson et al., 2007). Moreover, the same study shows that 24% of the young people attained a higher score on QOL since unemployment started. Young adults often have good social support related to better mental health (Axelsson et al., 2007). Nevertheless, as stated before, these are speculations and should be considered in further research.

5.1 Strengths and limitations

Strengths of this study include the multi-country context in which differences across countries are included, like the health system, cultural differences, weather conditions. Secondly, the panel data analysis controlled for time-invariant unobserved heterogeneity, which was not the case in the preliminary two-part model analysis causing bigger omitted variable bias. Thirdly, this is one of the few studies that looked at the country's general population, while most of the previous studies are about people who have been infected by COVID-19 or people who already had a higher risk of getting sick, such as people with co-morbidity (Halpin et al., 2020; Lim, 2020). Moreover, as the survey was conducted in multiple countries at three-time points, a large representative sample was included. Last, as country-specific value sets are used to determine the EQ5D utility score, countries can see how they score on HRQoL. The performed sensitivity analyses allow them to see how they

score on, for example, the correlation of stringency index, unemployment, and income on the EQ5D utility and EQ-VAS compared to other countries.

This study also has a number of limitations. In particular, there is still little evidence on how HRQoL is affected by COVID-19 in the longer term. In line with this, the impact might be different after one year of pandemic. The longer the duration of a lockdown, the less acceptable the measures, which may influence HRQoL as well. Specifically, the consequences that the pandemic entailed regarding delayed regular care. Previous research has pointed out substantial decreases in hospital visits during the pandemic due to fear and scaling back by providers (Lazzerini et al., 2020; Gonzalez et al., 2021). Another limitation that should be mentioned is that even though France scores highest on EQ5D utility, the tariffs of country-value sets differ. One set is stricter than the other set. Consequently, countries can only look specifically at their results and not in comparison to other countries. In addition, this study used the self-assessed health status of respondents. The subjective health status does not always correspond with the objective measured health status (Spitzer & Weber, 2019; Bobak, 2013). Quality of life is partly determined by people's attitudes, culture, and how they deal with problems. For instance, in Southern, Central, and Eastern Europe, older people misjudge their physical and cognitive state more often than in Northern and Western European countries (Spitzer & Weber, 2019). Therefore, it is conceivable that comparisons between countries regarding self-rated health in this study are prone to be biased. The biggest limitation perhaps is that this study does not show the relative impact of measures on HRQoL. It only looks at the stringency of the measures in total, while perhaps some measures have more influence on HRQoL than others. Only the effects of social distancing and being quarantined have previously been investigated separately, and these studies showed that these measures lower HRQoL (Cénat et al., 2021; Qin, 2020). Therefore, some caution should be exercised concerning the study results, as the selection (and enforcement) of measures differs between countries. In addition, an online survey was conducted, which may not give equal opportunity to all people to be involved in the research (mainly the elderly). Most respondents were young and middle-aged. Moreover, it is necessary to carry out more research within a country as measures may also differ between regions in a country. The stringency index does not take differences in government response measures within countries into account (Financial Times, 2021). For instance, Germany has 16 federal states with their governments individually selecting and enforcing the necessary measures (Bennema-Broos, Groenewegen & Westert, 2001).

6. Conclusion

There is limited evidence of the effect of the COVID-19 pandemic on HRQoL of general populations, and so far, this is the first study that investigated and compared this relationship in several European countries focusing on the effect of the stringency of the measures. As stated before, the assessment of HRQoL is an important indicator for population's health, specifically the quality of the health status (WHO, 2005). As the pandemic has affected people in multiple ways (physical, psychological, social), this study provides insight into the most vulnerable groups of the European population (Ravens-Sieberer et al., 2020).

Among people scoring EQ5D utility below 1.0, the stringency of the COVID-19 measures had a significant positive effect on HRQoL during the months April to August 2020. If the stringency index increases by one unit, the utility score increases by 0.003. Over time, this effect reduced to a negligible effect and became insignificant. Compared to Germany, the impact was smallest for Portugal and largest for Germany itself, but the effect remained insignificant.

Although this study shows no significant impact of the stringency of measures on HRQoL, interventions could be made for those most affected people. Thus, no public health interventions should necessarily be implemented as there was no impact of the pandemic on HRQoL during the spring and summer of 2020. However, it is noteworthy to highlight the income inequality in those countries. Having less difficulty in making ends meet leads to a significantly higher level of HRQoL, specifically, self-rated health (VAS), compared to having difficulty. There is a European approach to reduce income inequality (European Commission, n.d.), but this study confirms once again that income inequality has far-reaching consequences, in this case, for people's HRQoL. Additionally, attention should be given to older, female, and lower educated people having a lower HRQoL by helping them cope with the pandemic to prevent deterioration of quality of life among those groups. This is useful information for working towards a more optimal allocation of resources.

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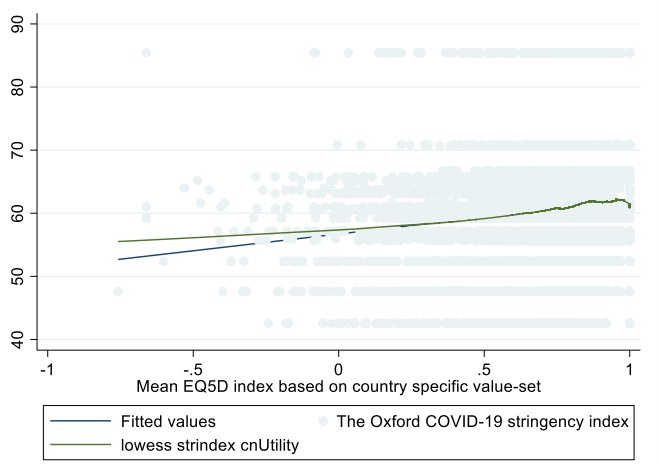
Appendices

Appendix A1: Assumptions of linear regression analysis

Linearity:

As the stringency index is the main independent variable, only the linear relationship between the stringency index and EQ5D index is showed below. This graph shows a slightly positive relationship between the two variables. It is slightly non-linear when reaching the highest utility score. A solution could be to include a squared variable of the stringency index (Scribbr, 2018). However, the two-part model showed significant correlations between stringency index and EQ5D utility. The quadratic stringency index showed an even smaller effect. That means that this is a worse fit model and, thus, not used in this study.

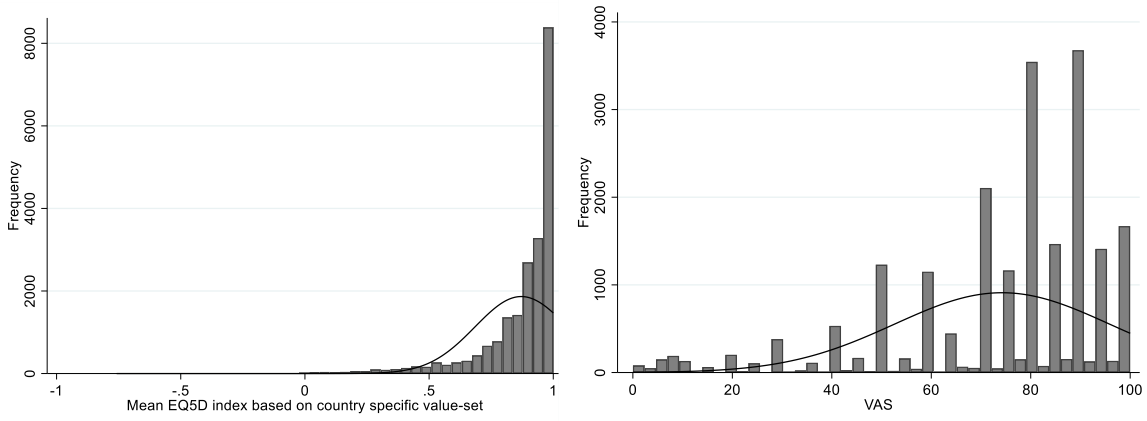
Figure 4. Linear relationship stringency index-EQ5D utility



Normality:

Figure 5 shows a non-normal distribution of the EQ5D utility. The distribution is highly skewed to the left, and more than 25% of the respondents scored a utility score of 1.0. As a solution, a two-part model is used. The figure also shows that the EQ-VAS is more normally distributed and, thus, an Ordinary Least Squares analysis is performed for the sensitivity analysis.

Figure 5. Normality outcome variable EQ5D index and EQ-VAS



The Shaphiro-Wilk test was used to test the normality assumption of the residuals. The null hypothesis is rejected as the p-value (Prob>z) is lower than the significance level of 0.05. Thus, the data is not normally distributed.

Table 8. Shaphiro-Wilk test residuals

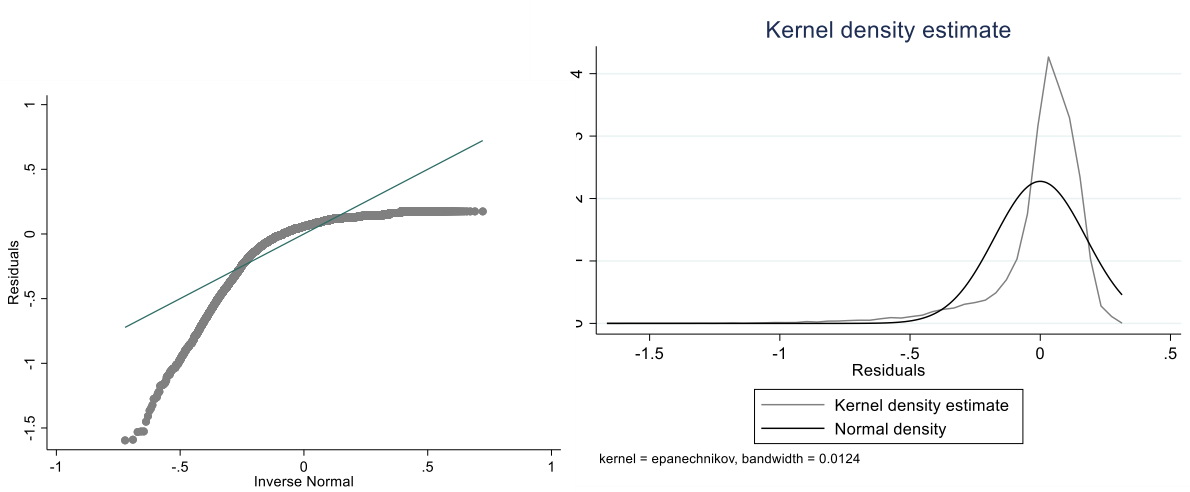
Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r	21,294	0.784	2033.868	20.775	0.000

Note: The normal approximation to the sampling distribution of W' is valid for 4<=n<=2000.

The figures below confirm that the residuals are not normally distributed. The left figure below shows a quintile-normal plot to check the normality assumption for residuals. It shows a deviation at the upper and lower tail. The right figure also shows a non-normal distribution. It is skewed to the left.

Figure 6. quintile-normal plot and Kernel density estimate



Multicollinearity:

The unemployment rate and some countries exceed a VIF value above 10, indicating that explanatory variables are correlated with each other. This is because the unemployment rate has been included for each country. As a solution, the unemployment rate is not included in every model of the regression analysis.

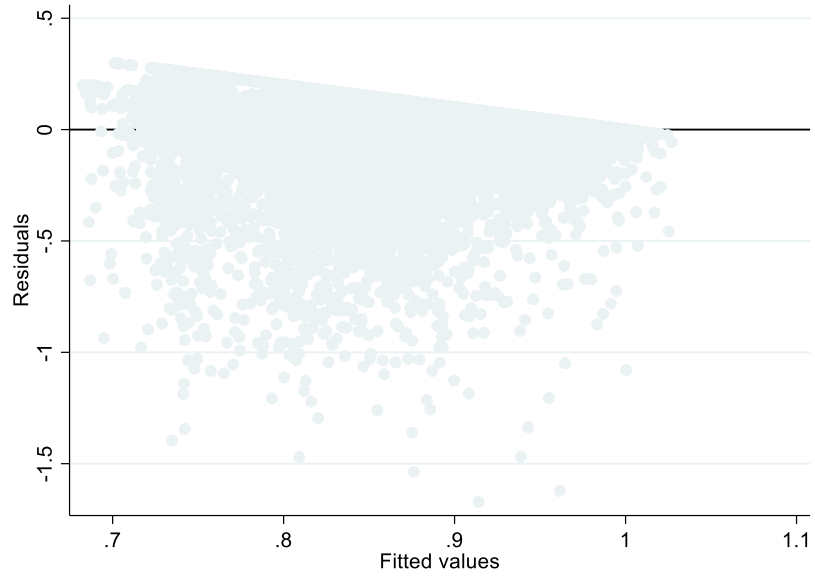
Table 9. Multicollinearity among predictors after regression

	VIF	1/VIF
Age category		
25-34	2.25	0.444
35-44	2.41	0.415
45-54	2.39	0.419
55-64	3.26	0.443
65+	2.57	0.388
Gender		
Female	1.03	0.972
Education	1.05	0.953
Income		
With some difficulty	3.07	0.326
Fairly easily	3.19	0.314
Easily	2.15	0.464
Unemployment	49.74	0.020
Country		
UK	1.83	0.546
DK	3.46	0.289
NL	2.70	0.370
FR	25.55	0.039
PT	18.59	0.054
IT	41.55	0.024
Wave		
2	2.33	0.429
3	4.47	0.224
Stringency index	6.37	0.157
Mean VIF	8.95	

Homoscedasticity

The Breush-Pagan test shows that the null hypothesis can be rejected as the p-value (Prob>chi2) is below the significance level. This means that the assumption of homoscedasticity is violated. As a solution, robust standard errors from Huber/White were used to get unbiased standard errors (Hayes & Cai, 2007).

Figure 7. Homoscedasticity




```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of cnUtility

         chi2(1)      =  4007.21
         Prob > chi2  =   0.0000
```

Appendix A2: Mean utility by country

Table 10 shows the country-specific EQ5D utility for the months April, June, and August 2020.

Table 10. Mean Utility during the COVID-19

	Utility			
Country	T1	T2	T3	Total (mean)
DE	0.86	0.86	0.85	0.86
UK	0.83	0.84	0.85	0.84
DK	0.84	0.82	0.81	0.82
NL	0.80	0.83	0.82	0.82
FR	0.94	0.94	0.94	0.94
PT	0.92	0.92	0.92	0.92
IT	0.90	0.90	0.91	0.90
Total (mean)	0.87	0.87	0.87	0.87

Note: Values are based on country-specific value sets

Appendix A3: Descriptive statistics by country

Table 11. Descriptive statistics by country

Country	Variable	Obs	Mean	Std. Dev.	Min	Max	Resp.
	Age category						
	18-24	3,055	.09	.28	0	1	1,672
	25-34	3,055	.15	.35	0	1	1,672
	35-44	3,055	.17	.38	0	1	1,672
	45-54	3,055	.18	.39	0	1	1,672
	55-64	3,055	.17	.37	0	1	1,672
DE	65+	3,055	.25	.43	0	1	1,672
	Gender						
	Male	3,055	.48	.50	0	1	1,672
	Female	3,055	.52	.50	0	1	1,672
	Education	3,055	12.70	4.74	0	25	1,672
	Income						
	With great difficulty	3,055	.09	.29	0	1	1,672
	With some difficulty	3,055	.38	.49	0	1	1,672
	Fairly easily	3,055	.39	.49	0	1	1,672
	Easily	3,055	.14	.35	0	1	1,672
	Unemployment rate	3,055	4.27	.20	4	4.5	1,672
	Age category						
	18-24	3,055	.10	.30	0	1	1,779
	25-34	3,055	.18	.38	0	1	1,779
	35-44	3,055	.19	.39	0	1	1,779
	45-54	3,055	.18	.38	0	1	1,779
	55-64	3,055	.16	.36	0	1	1,779
UK	65+	3,055	.20	.40	0	1	1,779
	Gender						
	Male	3,055	.48	.50	0	1	1,779
	Female	3,055	.52	.50	0	1	1,779
	Education	3,055	14.12	4.50	0	25	1,779
	Income						
	With great difficulty	3,055	.07	.26	0	1	1,779
	With some difficulty	3,055	.32	.47	0	1	1,779
	Fairly easily	3,055	.42	.49	0	1	1,779
	Easily	3,055	.19	.40	0	1	1,779
	Unemployment rate	3,055	4.31	.34	4.1	4.9	1,779
	Age category						
	18-24	2,992	.09	.29	0	1	1,848
	25-34	2,992	.14	.34	0	1	1,848
	35-44	2,992	.17	.37	0	1	1,848
	45-54	2,992	.19	.39	0	1	1,848
	55-64	2,992	.18	.39	0	1	1,848
DK	65+	2,992	.24	.43	0	1	1,848
	Gender						
	Male	2,992	.48	.50	0	1	1,848
	Female	2,992	.52	.50	0	1	1,848
	Education	2,992	13.92	3.81	0	25	1,848
	Income						
	With great difficulty	2,992	.08	.27	0	1	1,848
	With some difficulty	2,992	.32	.47	0	1	1,848

	Fairly easily	2,992	.40	.49	0	1	1,848
	Easily	2,992	.19	.39	0	1	1,848
	Unemployment rate	2,992	5.63	0.52	4.9	6	1,848
	Age category						
	18-24	3,016	.10	.30	0	1	1,839
	25-34	3,016	.15	.36	0	1	1,839
	35-44	3,016	.18	.39	0	1	1,839
	45-54	3,016	.19	.39	0	1	1,839
	55-64	3,016	.17	.37	0	1	1,839
NL	65+	3,016	.21	.40	0	1	1,839
	Gender						
	Male	3,016	.49	.50	0	1	1,839
	Female	3,016	.51	.50	0	1	1,839
	Education	3,016	12.96	5.31	0	25	1,839
	Income						
	With great difficulty	3,016	.09	.28	0	1	1,839
	With some difficulty	3,016	.36	.48	0	1	1,839
	Fairly easily	3,016	.37	.49	0	1	1,839
	Easily	3,016	.18	.38	0	1	1,839
	Unemployment rate	3,016	4.03	.45	3.4	4.4	1,839
	Age category						
	18-24	3,004	.10	.30	0	1	1,699
	25-34	3,004	.16	.37	0	1	1,699
	35-44	3,004	.18	.39	0	1	1,699
	45-54	3,004	.18	.38	0	1	1,699
	55-64	3,004	.16	.37	0	1	1,699
FR	65+	3,004	.22	.41	0	1	1,699
	Gender						
	Male	3,004	.47	.50	0	1	1,699
	Female	3,004	.53	.50	0	1	1,699
	Education	3,004	13.77	5.49	0	25	1,699
	Income						
	With great difficulty	3,004	.13	.34	0	1	1,699
	With some difficulty	3,004	.45	.50	0	1	1,699
	Fairly easily	3,004	.35	.48	0	1	1,699
	Easily	3,004	.07	.26	0	1	1,699
	Unemployment rate	3,004	8.00	.92	7.3	9.3	1,699
	Age category						
	18-24	3,080	.11	.31	0	1	1,990
	25-34	3,080	.21	.41	0	1	1,990
	35-44	3,080	.21	.41	0	1	1,990
	45-54	3,080	.18	.39	0	1	1,990
	55-64	3,080	.14	.35	0	1	1,990
PT	65+	3,080	.14	.35	0	1	1,990
	Gender						
	Male	3,080	.48	.50	0	1	1,990
	Female	3,080	.52	.50	0	1	1,990
	Education	3,080	14.18	4.25	0	25	1,990
	Income						
	With great difficulty	3,080	.08	.27	0	1	1,990
	With some difficulty	3,080	.29	.45	0	1	1,990
	Fairly easily	3,080	.55	.50	0	1	1,990
	Easily	3,080	.09	.28	0	1	1,990

	Unemployment rate	3,080	7.29	.67	6.4	8	1,990
	Age category						
	18-24	3,092	.08	.28	0	1	1,804
	25-34	3,092	.15	.36	0	1	1,804
	35-44	3,092	.20	.40	0	1	1,804
	45-54	3,092	.18	.39	0	1	1,804
	55-64	3,092	.14	.35	0	1	1,804
IT	65+	3,092	.24	.42	0	1	1,804
	Gender						
	Male	3,092	.48	.50	0	1	1,804
	Female	3,092	.52	.50	0	1	1,804
	Education	3,092	14.29	4.38	0	25	1,804
	Income						
	With great difficulty	3,092	.14	.34	0	1	1,804
	With some difficulty	3,092	.46	.50	0	1	1,804
	Fairly easily	3,092	.33	.47	0	1	1,804
	Easily	3,092	.07	.25	0	1	1,804
	Unemployment rate	3,092	8.90	1.06	7.5	10	1,804

Appendix A4: Frequency distribution (%) pain/discomfort and anxiety/depression

The figures below show the distribution of having problems in pain/discomfort and anxiety/depression for each country over time. In April, more than 50 percent of the people reported having problems in both domains in most countries. However, these problems diminished on average over time.

Figure 8. Frequency distribution pain/discomfort

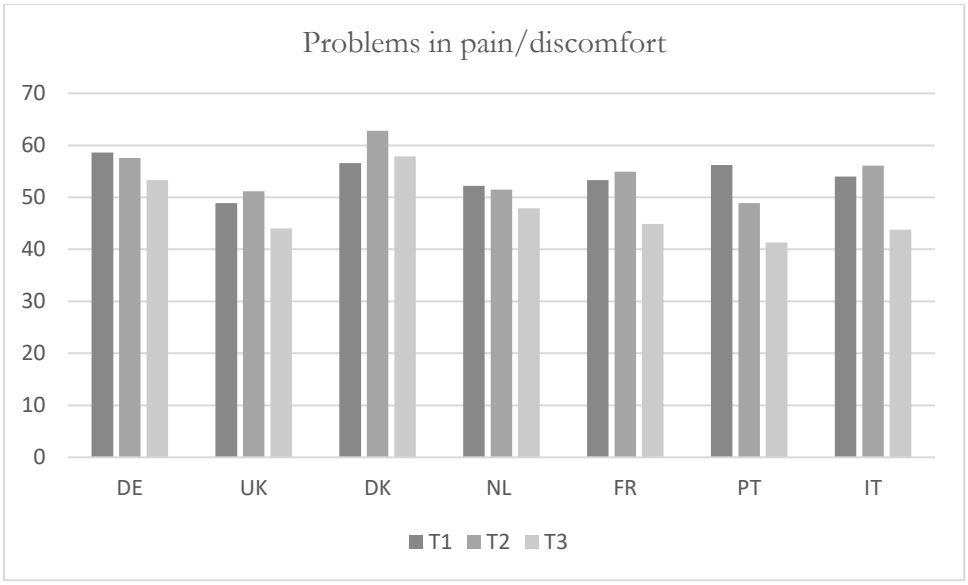
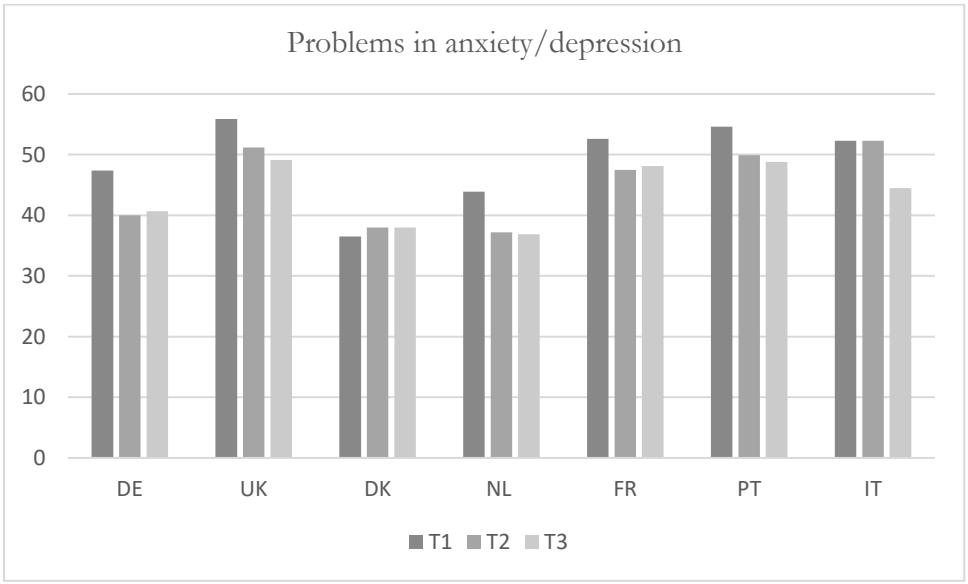


Figure 9. Frequency distribution anxiety/depression



Appendix A5: Correlation matrix remaining variables

Table 12. Correlation matrix

Variables	Strindex	Incidence	Deaths	Hospitalization	ICU	Mobility	Self Care	Usual Activities	Pain/ Discom.	Depression/Anx.	Utility	VAS
Stringency index	1.000											
Incidence	0.385	1.000										
	(0.000)											
Deaths	0.519	0.802	1.000									
	(0.000)	(0.000)										
Hospitalization	0.398	0.781	0.963	1.000								
	(0.000)	(0.000)	(0.000)									
ICU admissions	0.543	0.863	0.902	0.807	1.000							
	(0.000)	(0.000)	(0.000)	(0.000)								
Mobility	-0.077	-0.036	-0.027	-0.018	-0.021	1.000						
	(0.000)	(0.000)	(0.000)	(0.008)	(0.003)							
Self Care	-0.038	-0.023	-0.003	0.005	-0.017	0.547	1.000					
	(0.000)	(0.001)	(0.646)	(0.426)	(0.018)	(0.000)						
Usual Activities	-0.070	-0.020	0.005	0.010	0.003	0.635	0.581	1.000				
	(0.000)	(0.004)	(0.455)	(0.143)	(0.688)	(0.000)	(0.000)					
Pain/Discom.	-0.031	-0.004	0.005	0.004	0.015	0.558	0.385	0.572	1.000			
	(0.000)	(0.578)	(0.510)	(0.544)	(0.034)	(0.000)	(0.000)	(0.000)				
Depression/Anx.	0.049	0.041	0.058	0.065	0.040	0.207	0.231	0.321	0.331	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
Utility	0.114	0.056	0.007	0.009	0.018	-0.670	-0.584	-0.741	-0.734	-0.602	1.000	
	(0.000)	(0.000)	(0.337)	(0.210)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
VAS	0.031	0.006	-0.015	-0.021	-0.006	-0.426	-0.336	-0.460	-0.483	-0.395	0.532	
	(0.000)	(0.412)	(0.029)	(0.002)	(0.425)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	1.000

Appendix A6: Sensitivity analysis based on 1 value-set

Table 13. Sensitivity analysis 1. Logistic regression for the probability of reaching EQ5D index 1 based on 1 value-set

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Age category		.		.		.		.
18-24	0	.	0	.	0	.	0	.
25-34	0.089	.145	0.091	.136	0.090	.143	0.091	.137
35-44	0.117	.049	0.117	.049	0.113	.059	0.116	.051
45-54	0.001	.986	0.003	.955	-0.003	.960	-0.002	.978
55-64	-0.338	.000	-0.334	.000	-0.343	.000	-0.343	.000
65+	-0.458	.000	-0.457	.000	-0.465	.000	-0.463	.000
Gender								
Male	0	.	0	.	0	.	0	.
Female	-0.365	.000	-0.362	.000	-0.366	.000	-0.367	.000
Education	-0.003	.315	-0.002	.564	-0.003	.397	-0.003	.325
Income								
With great difficulty	0	.	0	.	0	.	0	.
With some difficulty	0.325	.000	0.326	.000	0.318	.000	0.317	.000
Fairly easily	0.832	.000	0.847	.000	0.837	.000	0.825	.000
Easily	1.316	.000	1.324	.000	1.312	.000	1.297	.000
Unemployment	0.038	.000					0.041	.000

Table 13. (extended) Sensitivity analysis 1 (extended). Logistic regression for the probability of reaching EQ5D index 1 based on 1 value-set

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Country								
DE			0	.	0	.		
UK			-0.028	.634	-0.026	.648		
DK			-0.075	.202	-0.073	.211		
NL			0.195	.001	0.196	.001		
FR			0.165	.004	0.165	.004		
PT			0.039	.502	0.041	.481		
IT			0.194	.001	0.196	.001		
Wave								
1					0	.		
2					-0.003	.929		
3					0.245	.000		
Stringency index							-0.007	.000
Constant	-1.374	.000	-1.246	.000	-1.301	.000	-0.948	.000
Resp.	12631		12631		12631		12631	
Obs.	21294		21294		21294		21294	

Table 14. Sensitivity analysis 1. Least squares regression results with robust standard error for those with EQ5D index less than 1 based on 1 value set

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Age category		.		.		.		.
18-24	0	.	0	.	0	.	0	.
25-34	-0.000	.963	-0.001	.870	-0.001	.871	-0.000	.930
35-44	0.007	.292	0.006	.328	0.006	.342	0.007	.298
45-54	0.007	.325	0.006	.351	0.006	.364	0.007	.329
55-64	0.010	.147	0.011	.093	0.011	.112	0.010	.138
65+	0.013	.035	0.015	.015	0.015	.019	0.013	.035
Gender								
Male	0	.	0	.	0	.	0	.
Female	-0.009	.005	-0.010	.004	-0.010	.003	-0.009	.005
Education	0.001	.001	0.002	.000	0.001	.000	0.001	.001
Income								
With great difficulty	0	.	0	.	0	.	0	.
With some difficulty	0.079	.000	0.080	.000	0.080	.000	0.080	.000
Fairly easily	0.133	.000	0.132	.000	0.131	.000	0.134	.000
Easily	0.148	.000	0.151	.000	0.150	.000	0.150	.000
Unemployment	0.015	.000					0.015	.000

Table 14. (extended) Sensitivity analysis 1. Least squares regression results with robust standard error for those with EQ5D index less than 1 based on 1 value set

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Country								
DE			0	.	0	.		
UK			-0.017	.015	-0.016	.017		
DK			-0.014	.034	-0.015	.030		
NL			-0.002	.765	-0.002	.750		
FR			0.028	.000	0.028	.000		
PT			0.069	.000	0.069	.000		
IT			0.062	.000	0.063	.000		
Wave								
1					0	.		
2					0.004	.293		
3					0.026	.000		
Stringency index							.001	.000
Constant	0.539	.000	0.609	.000	0.602	.000	0.497	.000
Resp.	12631		12631		12631		12631	
Obs.	21294		21294		21294		21294	

Appendix A7: Sensitivity analysis VAS-score

Table 15. Sensitivity analysis 2. Ordinary least squares regression results for VAS

VAS	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Age category		.				.		.
18-24	0	.	0	.	0	.	0	.
25-34	-0.840	.173	-0.91	.137	-0.900	.141	-0.867	.158
35-44	-1.559	.009	-1.562	.008	-1.533	.010	-1.557	.009
45-54	-2.157	.000	-2.106	.000	-2.064	.001	-2.129	.000
55-64	-2.917	.000	-2.762	.000	-2.707	.000	-2.851	.000
65+	-3.229	.000	-2.914	.000	-2.863	.000	-3.187	.000
Gender								
Male	0	.	0	.	0	.	0	.
Female	-0.714	.015	-0.682	.020	-0.665	.023	-0.693	.018
Education	0.136	.000	0.138	.000	0.145	.000	0.135	.000
Income								
With great difficulty	0	.	0	.	0	.	0	.
With some difficulty	7.221	.000	7.297	.000	7.365	.000	7.339	.000
Fairly easily	13.23	.000	12.95	.000	13.06	.000	13.37	.000
Easily	17.68	.000	17.85	.000	17.98	.000	17.97	.000
Unemployment	0.657	.000					0.599	.000

Table 15. (extended) Sensitivity analysis 2. Ordinary least squares regression results for VAS

	Model 1		Model 2		Model 3		Model 4	
	β	p-value	β	p-value	β	p-value	β	p-value
Country								
DE			0	.	0	.		
UK			-1.305	.021	-1.322	.020		
DK			1.117	.048	1.104	.051		
NL			0.943	.096	0.940	.097		
FR			1.698	.002	1.701	.002		
PT			6.424	.000	6.401	.000		
IT			3.373	.000	3.356	.000		
Wave								
1					0	.		
2					-0.469	.178		
3					-1.854	.000		
Stringency index							0.102	.000
Constant	60.38	.000	62.55	.000	63.11	.000	54.35	.000
Resp.	12631		12631		12631		12631	
Obs.	21294		21294		21294		21294	

Appendix A8: Panel data country differences

Table 16. Country differences in the effect of Covid-19 stringency (FE regression)

	(1) Country-specific Utility	(2) General Utility	(3) EQ-VAS
stringency index	.006	.036***	-.103
UK x stringency	-.005	-.037***	.475
DK x stringency	-.004	-.043***	.448
NL x stringency	-.005	-.035***	.233
FR x stringency	-.005	-.036***	-.059
PT x stringency	-.010	-.001	-1.157
IT x stringency	-.005	-.028**	-.017
Unemployment rate	.054	.495***	-5.235
UK x unemployment	-.059	-.454***	4.303
DK x unemployment	-.057	-.530***	5.519
NL x unemployment	-.024	-.465***	6.080
FR x unemployment	-.048	-.471***	3.465
PT x unemployment	-.084	-.274*	-1.976
IT x unemployment	-.037	-.369***	3.803
Income	.0086	.012	.729
UK x income	.016	.020*	2.232
DK x income	-.008	-.012	.324
NL x income	.002	-.0009	-1.431
FR x income	.005	.014	.168
PT x income	-.001	-.0004	1.926
IT x income	.004	.005	1.114
constant	.751***	-.640**	93.818**
Fixed effects	Yes	Yes	Yes
Observations	21,294	21,294	21,294
Individuals	12,631	12,631	12,631

Note: * p<.05; ** p<.01; *** p<.001. The reference country is DE.
Note: Country-specific utility is based on the value set specific for each country
General utility is based on the Dutch value set