Loneliness in the Time of COVID-19: an analysis of Risk Factor Evolution during the Pandemic

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Abstract

Loneliness is a growing concern for public policy in the United Kingdom. The effects of COVID-19, both directly and as a result of responses such as lockdowns, further increase the need for a timely understanding of loneliness. This paper analyzes how COVID-19 is changing the landscape for loneliness in the UK, looking at risk factors of age, sex, and location over the course of the pandemic. The study draws on weekly surveys of 1500-5000 UK residents collected from the start of the first lockdown in March 2020 through the end of October 2021 asking how often they feel lonely. A fixed effects linear model of categorical variables is used to examine the significance of the risk factors and their interactions with phases of the pandemic response. A pairwise differences test was used to compare the overall levels of loneliness throughout the pandemic and after the removal of most restrictions. The interaction models found that women were more likely than men to be lonely, and increasingly so in later stages of the pandemic. Younger respondents, under 30 years old, were also more likely to be lonely, though no change in this relationship was identified during the pandemic. In comparison with the pre-pandemic baseline, overall loneliness was elevated in each stage of the pandemic, and did not return to baseline levels even after the end of the 'Roadmap out of Lockdown'. Resources directed towards reducing loneliness will need to specifically consider women and young people as vulnerable populations. Additional support may also be necessary even after the end of the pandemic since increases in loneliness have not reversed.

1 Introduction

Over the past two years, the UK has been under continuous restrictions in response to COVID-19, including most of a year spent in and out of lockdowns. Studies have shown that lockdown and containment policies are effective in saving lives and reducing the spread of the disease [9, 21]. At the same time, lockdowns incur serious costs, economically and socially, and living through a pandemic with high rates of infection and casualty is itself a massive source of stress [11, 20]. To offset the costs, the UK government has taken substantial steps to provide both economic stimulus and social support, including a targeted initiative to combat loneliness [5]. Most of the loneliness funding is being channeled through existing organizations which combat loneliness, but it is possible that the people most impacted by the lockdown are not the ones who would ordinarily be most at risk for loneliness. This paper examines reported levels of loneliness throughout the pandemic to determine whether he social changes of the pandemic have structurally changed which people are most vulnerable to loneliness. To the extent that this is the case, loneliness organizations will need to adapt their strategies to best serve the UK population.

Prior to the first lockdown, loneliness had already been identified as a growing area of concern for public policy, and in 2018 a commission was established to combat loneliness in the UK through better resourcing, data collection, and policy [6]. Being lonely is associated with a number of other well-being issues, including depression, poor job performance, and even heart disease and heightened risk of mortality, making it a serious public health challenge [7, 8, 15, 22]. Loneliness is a subjective experience, most commonly understood in social science literature as an 'unwelcome feeling of lack or loss of companionship [which] happens when we have a mismatch between the quantity and quality of social relationships that we have, and those that we want' [16]. A further distinction can be made between predisposing factors and precipitating events, with a combination of the two resulting in loneliness [16]. In the case of COVID-19, lockdowns are certainly a precipitating event, but the broader changes to society may also have shifted the landscape of predisposing factors. This possibility motivates studying the risk factors associated with loneliness over the past two years and how they have changed.

Because loneliness depends on the desires of each individual, it cannot necessarily be measured or predicted simply by looking at the frequency of social contacts. However, a dramatic change in the frequency of social contact as seen in lockdowns could certainly constitute the sort of 'loss of companionship' which is loneliness. Within a few months of the first implementation of physical distancing requirements, researchers found that loneliness levels had risen, particularly in groups which had previously been identified as 'high-risk' [4]. However, these studies relied upon data collected in the first six weeks of the first lockdown in 2020. At that point, people had relatively optimistic views of how long the pandemic would last, with most of the population expecting their lives to return to normal

within six months or less, and nearly 90% expecting the pandemic to last a year or less [10]. As such, it is possible that people were able to adapt their short-term expectations for social relationships early on in the pandemic with confidence that things would get better. As we approach two years living with estranged social conditions, we do not have more recent research of whether the prior 'high-risk' categories for understanding loneliness will still apply. Over the latter half of 2021, many of the restrictions also lifted for an extended period of time, allowing a potential look at how lasting the effects of the lockdowns will be even after they are eventually removed. With new restrictions once again potentially on the horizon due to the Omicron variant, an up-to-date consideration of how the key risk factors for loneliness may have shifted during COVID-19 will be a timely tool for directing support to those most in need.

2 Methods

Data in this paper are taken from the UK Office of National Statistics' Opinions and Lifestyle Survey [10]. The Opinions and Lifestyle Survey is an ongoing battery of questions covering many aspects of life in the UK with questions being added and removed based on the interests of government researchers. In a desire to keep a timely pulse on wellbeing in the UK during the pandemic, the survey began being conducted weekly on March 20, 2020, and continued to run weekly until August 25, 2021, when it was reduced to a bi-weekly cadence to reduce costs. In the years prior to COVID-19, the ONS also released annual loneliness levels from a less frequent version of the same survey, so those are also useful as a benchmark for 'normal'. The responses are primarily collected online, although phone surveys are available upon request and about 1% of respondents choose this option. For loneliness, the primary question asked was simply "How often do you feel lonely?", with answers provided on a five-point scale from 'Often/Always' to 'Never', with respondents also allowed to decline the question, although selecting this option was not common.

The sample data are aggregated into weekly statistics, which are reported as the percentage of the population which give each response to the question, broken down by various demographic traits. For this study, the three demographic groupings with the best data coverage are used: age, country and sex. An income breakdown is also available for the first year of the pandemic, and other variations are occasionally provided but not with enough regularity to study over time. Previous studies have shown differences in loneliness across sex and age breakdowns, making these good cases to consider [4]. Geography has also been studied, but usually in the context of urban/rural rather than UK countries [1]. All of the samples were drawn from the Royal Mail's address files representing the whole of the UK, and weighted to account for non-response and representation biases in the sample. Less represented groups, such as younger people, are additionally over-sampled to produce more precise measurements. For the weeks of March 20 - October 21 2020, the sample consisted of 1,500 respondents per week, which was subsequently raised to 3,000-3,500 per week to increase the statistical power of the results for the granular breakdowns.

The data quality is generally expected to be good, with minimal avoidable bias or error. There is a potential source of bias in the selection of the survey question. In most research, a multi-question test is preferred for assessing loneliness relative to directly asking subjects to report how often they feel lonely because some age and gender groups tend to under-report [19]. If this does induce a bias, it should only appear in difference within age, country, and sex, not over time, and there should not be an impact on the significance of the interaction terms between time periods and the other factors. The upside to this form of question is that it allows a natural interpretation of the data: 'x% of people feel lonely sometimes'. This choice of question is also consistent with pre-pandemic data, making it easier to compare to the baseline.

The data for this study are accessed as downloadable Excel files from the ONS website. Aside from the pre-pandemic annual March releases from 2018-2020, there are two separate series of weekly data releases one spanning the period from March 2020 to April 2021, and the other from March 2020 through November 2021. For simplicity, I will refer to the one which ends first (April 2021) as the 'first' or 'former', and the other as the 'latter'. The latter source has complete coverage for the grand total, but does not include breakdowns by age or country prior to November 2020, making a combination of the two necessary. The two releases make different choices in how to group the data by age, making it impossible to construct a continuous series of observations for the age groupings across the entire pandemic. The former source also does not release the number of observations in each age group, which prevents aggregating up the age groups into larger buckets where they would align. As such, the final data for this study consist of nearly-weekly measures of loneliness spanning from March 2020 to October 2021, with the exception of the age data, which starts in November 2020, and three observations of loneliness by sex from the three years before the pandemic.

In order to combine the five category survey responses into a single measure of population loneliness, I combined the percentage of people responding 'Never' and 'Hardly ever' and subtracted from 100%. This series conceptually represents the percentage of people who are lonely with some regularity in the UK. It also comes from two practical necessities: the former dataset already aggregates 'Hardly ever/never' and 'Some of the time/Occasionally' together, and the 'Always/often' and 'Don't know' categories have a lot of missing values due to low response rates before the sample size was increased. By working from subtraction, the loneliest people are definitely included in

the measure. Also including 'Don't know' may introduce some noise, but it is a small percentage of the data in periods where it is reported, and too small to report when it is missing.

For the effects of the pandemic and response measures, I broke down the time period into six phases corresponding to the major lockdowns and easings of the pandemic in the UK, plus the baseline. Although the data is stored as a timeseries, the factor of interest is not the amount of time passing, but the state of the UK on each date. Two neighboring dates may have far more different pandemic response policies than two separated by several weeks. As such, it makes more sense to assign periods under the same pandemic controls as treatments. Based on key dates when UK government policies changed, I created five phases corresponding to the first lockdown (March - July 2020), first easing of restrictions (July - November 2020), second and third lockdowns together (November 2020 - March 2021), second easing of restrictions (March -July 2021), and after the end of the roadmap to lift restrictions (July - October 2021). The three years before the pandemic are treated as one period, which is longer than the others but also has more consistency in situation and between observations.

The first research question in this paper is whether shifts in loneliness due to prolonged COVID-related restrictions fit within previous frameworks for risk-factors. To test this, I model levels of loneliness as a function of the standard risk factors (age, sex, country) and phase of the pandemic. Since the regressors are each categorical and observations are only broken up across one risk factor at a time, I create three separate models, one for each factor, each taking the form of a two-way ANOVA model:

$$Y_{ijk} = \mu + \alpha_j + \beta_k + \gamma_{jk} + \epsilon_i \tag{1}$$

In the equation above, Y_{ijk} is an observation of the level of loneliness in group j during a phase of the pandemic, k. The general mean of Y is μ, the α_j's and β_k's are the main effects parameters of the risk factors and pandemic phases respectively, and the γ_{jk}'s are the interaction terms, with ϵ_i's as the errors from the linear model. These model account for the variation in loneliness due to each factor individually, as well as due to changing phases of COVID-19 responses, and the interaction between the two. If the changes in loneliness during COVID-19 fit within the previous frameworks, the impact of adding in COVID-19 and responses would only shift the overall level of loneliness, it would be attributable to the main effects of the phases variable. If instead, COVID-19 has changed how risk factors relate to loneliness, this would result in the interaction term being significant as well. As such, the null hypothesis that the pre-pandemic framework still applies well to loneliness during COVID-19 is equivalent to saying that the γ_{jk}'s are uniformly zero. To test this, I use the F-statistics from the sum of squares of the regression models.

The second research question of interest is whether any changes resulting from the pandemic restrictions reversed as the restrictions were lifted. This question focuses more directly on the differences between the periods, and especially how the last period compares with the previous ones. If the levels of loneliness are lower in the easing periods than the lockdowns, and in particular lowest in the final period, then the effects are reversing. For this question, the null hypothesis is that the final period does not have lower levels of loneliness than the others. This is tested with Tukey's Honestly Significant Difference test, which performs a significance test of the pairwise means and adjusts the alpha value appropriately to account for the large number of tests performed.

3 Results

3.1 Interactions

In Table 1 and Figure 1 below, the subgroups by sex and phase contained 144 observations split evenly into pairs between Male and Female. During the pandemic, the subgroup means for female respondents ranged from 54.0 to 59.1, higher than the 51.0 average in the years prior. The means for male respondents were lower, ranging from 43.1 to 45.2, though still higher than the pre-pandemic average of 41.0. The standard deviations for both were similar, ranging from 1.2 to 3.3.

Table 1: Descriptive Statistics by Sex and Phase

		Phase					
Sex		Baseline	Lockdown I	Easing I	Lockdown II	Easing II	Easing III
Female	Y_{ij}	51.0	54.0	55.5	59.1	57.2	56.3
	S_{ij}	-	3.0	2.1	2.4	1.2	1.5
	n	3	12	15	19	13	10
Male	Y_{ij}	41.0	44.1	43.1	45.2	43.6	44.5
	S_{ij}	-	3.3	3.0	1.5	1.8	1.7
	n	3	12	15	19	13	10

Figure 1: Mean Reported Loneliness by Sex and Phase

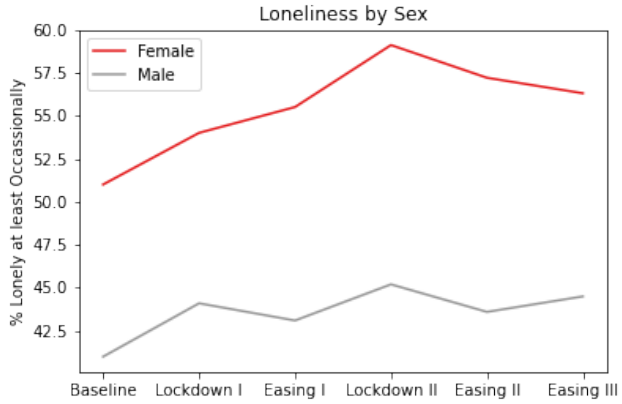


Table 2 shows that the two-way ANOVA test for sex and phase rejected the null hypothesis that the interaction terms are uniformly zero at the $p = 0.05$ significance level. The assumptions of the linear model were satisfied. (See Appendix A). Since the interaction effects are significant, we follow the principle of marginality by not interpreting the main effects.

Table 2: ANOVA Test by Sex and Phase

	Sum of Squares	df	F-Statistic	p-value
Phase	303.4	5	12.3	$\ll 0.01$
Sex	5525.4	1	1117.3	$\ll 0.01$
Sex x Phase	79.3	5	3.2	0.01
Residual	652.8	132		

As shown in Table 3 and Figure 2 below, the subgroups by age and phase contained 126 observations split evenly across the three age categories. No observations were available for this age breakdown in the first two phases of the pandemic or the baseline. The subgroup means for respondents under 30 years old ranged from 68.8 to 65.5, with standard deviations in the range of 2.6 - 3.3. The means for respondents between 30–59 years old were lower, and ranged from 49.0 to 50.3, with standard deviations in a narrower band of 0.7 to 2.0. The respondents 60 years old and older reported levels of loneliness between the other two groups, ranging from 50.6 to 54.8 with standard deviations similar to the 30–59 year–old group.

Table 3: Descriptive Statistics by Age and Phase

		Phase				
Age		Lockdown I	Easing I	Lockdown II	Easing II	Easing III
Under 30	$\bar{Y}_{ij}$	-	-	68.8	65.9	65.5
	S_{ij}	-	-	3.0	3.3	2.6
	n	0	0	19	13	10
30–59	$\bar{Y}_{ij}$	-	-	50.3	49.0	49.7
	S_{ij}	-	-	2.0	1.5	0.7
	n	0	0	19	13	10
60 Plus	$\bar{Y}_{ij}$	-	-	50.6	54.6	54.8
	S_{ij}	-	-	2.0	1.4	0.7
	n	0	0	19	13	10

Figure 2: Mean Reported Loneliness by Age and Phase

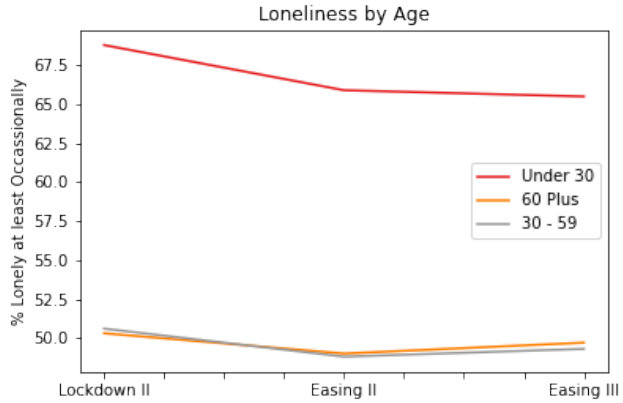


Table 4 shows that the two-way ANOVA test for age and phase did not reject the null hypothesis that the interaction terms are uniformly zero at the $p = 0.05$ significance level. The secondary null hypothesis that the main term effects, α_j and β_k were also uniformly zero was rejected. The assumptions of the model were satisfied. (See Appendix A). Appendix B re-considers this question with additional, much lower-quality, data.

Table 4: ANOVA Test by Age and Phase

	Sum of Squares	df	F-Statistic	p-value
Phase	111.7	2	11.6	$\ll 0.01$
Age	8485.0	2	884.6	$\ll 0.01$
Age x Phase	28.5	4	1.5	0.21
Residual	561.2	117		

Figure 3 and Table 5 below show the subgroups by country and phase. There were 207 observations split evenly across the three countries. No observations were available in the baseline period. The subgroup means for in England ranged from 49.6 to 52.5, with standard deviations in the range of 0.8 - 2.2. The means for respondents in Scotland were similar, and ranged from 47.8 to 52.2, with standard deviations in a wider band of 3.4 to 8.5. The respondents in Wales also reported similar levels of loneliness to the other two groups, ranging from 47.7 to 52.2 with standard deviations ranging from 4.3 to 10.0.

Table 5: Descriptive Statistics by Country and Phase

		Phase				
Country		Lockdown I	Easing I	Lockdown II	Easing II	Easing III
England	$\bar{Y}_{ij}$	49.6	49.7	52.5	50.6	50.7
	S_{ij}	2.2	2.1	1.9	1.7	0.8
	n	12	15	19	13	10
Scotland	$\bar{Y}_{ij}$	50.7	47.8	50.7	52.2	50.1
	S_{ij}	8.5	4.3	5.5	5.6	3.4
	n	12	15	19	13	10
Wales	$\bar{Y}_{ij}$	49.1	49.1	52.2	47.7	48.6
	S_{ij}	5.5	7.6	10.0	8.6	4.3
	n	12	15	19	13	10

Figure 3: Mean Reported Loneliness by Country and Phase

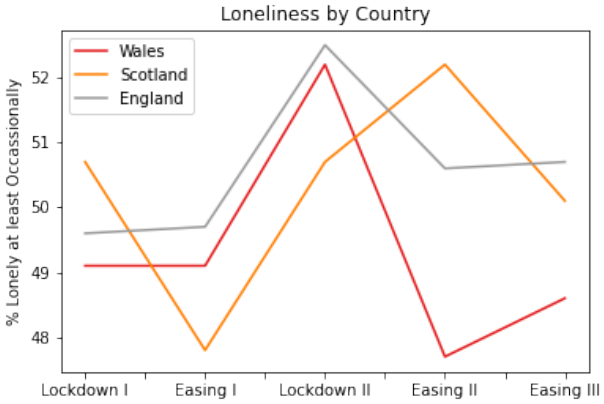


Table 6 shows that the two-way ANOVA test for country and phase did not reject the null hypothesis that the interaction terms are uniformly zero at the $p = 0.05$ significance level. The secondary null hypothesis that the main term effects, α_j and β_k were uniformly zero was not rejected either. The assumptions of the linear model were also called into question, with details in Appendix A.

Table 6: ANOVA Test by Country and Phase

	Sum of Squares	df	F-Statistic	p-value
Phase	237.3	4	1.8	0.13
Country	44.4	2	0.7	0.51
Country x Phase	196.5	8	0.7	0.64
Residual	6294.8	192		

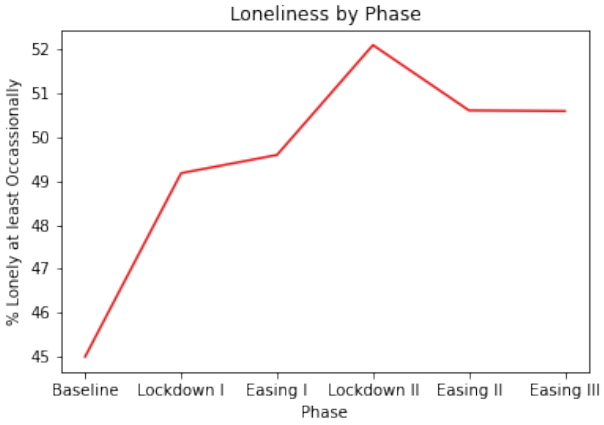
3.2 Pairwise Comparisons

Figure 4 below shows the average levels of loneliness across the entire population over the six phases. The baseline is much lower than the other values, including Easing III. Table 7 shows the adjusted p-values from the pairwise Tukey Honestly Significant Difference test performed comparing the levels of loneliness at each phase of the pandemic to the baseline. Higher numbers indicate a higher probability of similarly or more extreme differences arising between the sample means as a result of random chance, taking into account the number of comparisons being made. For every phase during the pandemic, the null hypothesis that the mean was no different than during the baseline was rejected. The null hypothesis that the means were the same was also rejected for the comparisons between Lockdown II and each of Lockdown I and Easing I, but in no other cases.

Table 7: Tukey HSD Test by Phase

	Baseline	Lockdown I	Easing I	Lockdown II	Easing II	Easing III
Easing III	<.01	.40	.69	.24	.90	-
Easing II	<.01	.31	.62	.17	-	
Lockdown II	<.01	<.01	<.01	-		
Easing I	<.01	.90	-			
Lockdown I	<.01	-				
Baseline	-					

Figure 4: Mean Reported Loneliness by Phase



4 Discussion

4.1 Findings

These findings suggest that in most cases the pandemic resulted in higher levels of loneliness without a major shift in the underlying risk factors, although there was an increase in the relative likelihood of women being lonely as compared to men. The study found that there was a statistically significant interaction between sex and the phase of the pandemic when predicting loneliness, but no such interaction between age and phase or country and phase. In the case of sex, even though the interaction was significant, the marginal effect size of the interaction was small. By the later phases of the pandemic, the relative likelihood of women being lonely to men had increased from about 1.25x to 1.33x, as compared with an overall increase in loneliness of about 10%. This impact adds to a growing body of literature describing the disproportionate impacts of the pandemic and lockdowns on women, including increased childcare burdens and risk of intimate partner violence [17, 18]. It is also possible that the relationship is causal, with caring responsibilities taking time from the limited social interaction that was available. For the purposes of coordinating resources and support, the difference is relatively small, not indicating a need to change approach.

Although there was not a interaction relationship between age and phase, the youngest age group was significantly lonelier than the older groups. This is consistent with other studies done early on in the pandemic, and shows a continuation of the same trend [2]. This study could not compare loneliness among young people to pre-pandemic levels, but earlier studies indicate that younger people are not typically so much lonelier than older people [4]. Since younger people generally have larger, more active social groups, the pandemic restrictions may have more negatively impacted their social lives [13]. The difference between groups does not meaningfully decrease during the final easing phases. At that point, most restrictions were lifted, including universities being allowed to hold classes in person, so the persistent difference is not attributable to ongoing prevention of social contact. Instead, it suggests that lockdowns may have long-term impacts which are not reversed by lifting them.

The breakdown of loneliness by country showed no significant relationship between them. Previous studies have shown a complex relationship between population density on an urban-rural spectrum and loneliness [1]. Since England generally has higher population density than the other countries, a similar pattern could have appeared. Lockdown severity also varied across the countries, but does not appear to have been different enough to produce differences in levels of loneliness.

In pairwise analysis, every period showed higher levels of loneliness than the baseline, including the final easing phase. In most cases, this is to be expected, since the pandemic reduced social contact, but the elevated levels of loneliness even during easing periods suggest that the effects of lockdowns lingers after the lockdowns are lifted. At the peak of the pandemic, more than half the UK population was lonely at least occasionally, and although the point estimates for Easing II and III are lower than during Lockdown II, the difference is not statistically significant. This is a policy concern, since an already serious issue is now impacting an additional 5% of the population.

4.2 Limitations

All of these findings must be understood in the context of the limitations of the study. In turn, the limitations raise questions for further research. Being a repeated cross-sectional study, this paper is unable to control for confounding factors in the way a randomized-controlled trial would. The most concerning confounding factor in this

case is seasonality. To my knowledge, there is relatively little research on what seasonal loneliness patterns might occur and any results would probably be highly contextualized, but that does not rule out the possibility [23].The second lockdown was correlated with higher levels of loneliness, but also occurred during winter. It is possible that people felt lonelier simply because it was colder and darker, and the lockdown just happened to coincide. The lockdown also took place during the Christmas and New Year's holidays, which could be a time of year when risk of loneliness is higher, since people have higher expectations for social relationships [3]. The lockdown could still be the proximate cause of loneliness in that case, but the effect would only be seasonally reproducible. Further investigation in seasonal patterns might help to identify more situational causes of loneliness.

The online mode of data collection was necessary during the pandemic, but may have prevented some respondents from participating. However, the low uptake of the phone option suggests that the impact is minimal [14]. The overall response rate averages about 69%, which is low, but adjusted for by the ONS based on prior periods [14]. The number of computational errors in the data is expected to be very low, based on the regular quality checks and the small number of revisions published, almost all of which result from human error entering the data into the spreadsheets.

Using a single direct question as done in the ONS survey rather than an indirect panel has been found in previous studies to influence the results [12]. Potentially due to stigma, younger men were less likely to report that they were lonely directly than in the indirect surveys. Similarly, being older was found to be associated with age in indirect measures, but younger people were more lonely in direct questioning. This is a limitation for the ONS data in considering relative levels between groups, but shouldn't impact how the differences change in response to the pandemic unless the factors causing under-reporting are also changing.

4.3 Future Research

This study chose to focus on the percentage of the population who reported being lonely at least occasionally. An alternative approach might have looked at the average number of days per month a person feels lonely, which could include changes in degree of loneliness. Similarly, this study only considered the interactions between phases of the pandemic and each risk factor in a pairwise manner, but the reality may be more intersectional. An approach which builds a linear model from individual responses and demographic information might be able to uncover more complex relationships between the variables than could be considered here. Third, this study is based on new random samples each week throughout the pandemic, but a longitudinal approach would open up questions about whether it is the same people who are lonely throughout.

5 Conclusion

The last two years of pandemic have been a heavy mental burden, the final impacts of which have yet to be seen. In the UK, nearly 10% more people are lonely now than prior to the pandemic, and the lifting of lockdown measures has not corresponded to a meaningful improvement. Loneliness is a self-reinforcing condition associated with many other potentially serious conditions including depression and heart disease [7, 8, 22]. The social costs are also significant in terms of lost productivity and shorter expected life-spans [8, 15]. This paper shows that women have been particularly at risk of being lonely, alongside a continuation of previously identified increased levels of loneliness in young people [4]. Looking forward, it also suggests the need to prepare for the effects of the pandemic to last beyond the lifting of restrictions. As I only find evidence of small changes in the key risk factors for loneliness, pre-pandemic approaches to resource targeting should continue to apply, with some increased attention towards women and young people. As we try to turn the corner into a post-pandemic world, continued efforts to monitor changes in loneliness will be important to understanding the long-term effects of COVID-19.

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Appendix A: Validation of Assumptions

For the ANOVA linear model, the assumptions are similar to a standard linear regression. We need to have uncorrelated errors with a roughly normal distribution and constant variance across groups. Since the regressors are categorical, there is no concept of a linear relationship to consider. Similarly, the errors will have a mean of zero by construction. Table 8 below shows that except in the case of countries, the standard deviations of the data are similar with the categories, so the same will be true of the errors. This weakens the case for using the countries model, but since the results weren't significant, the takeaways were already limited. Figures 5, 6, 7, and 8 show the distributions as boxplots. In each case they are roughly symmetrical, supporting the case for normality. Figures 9, 10, 11, and 12 show QQ plots for each factor, which also look nearly normal in each case, thus validating the assumptions of the ANOVA test are validated.

Table 8: Standard Deviations by Factors

Sex		*Age*		*Country*		*Phase*	
Male	2.4	Under 30	3.3	England	2.1	Baseline	4.0
Female	2.9	30–59	1.8	Scotland	5.7	Lockdown I	5.4
		Over 60	1.7	Wales	7.8	Easing I	5.6
						Lockdown II	7.6
						Easing II	7.1
						Easing III	6.1

Figure 5: Distribution of Values by Sex

Figure 6: Distribution of Values by Age

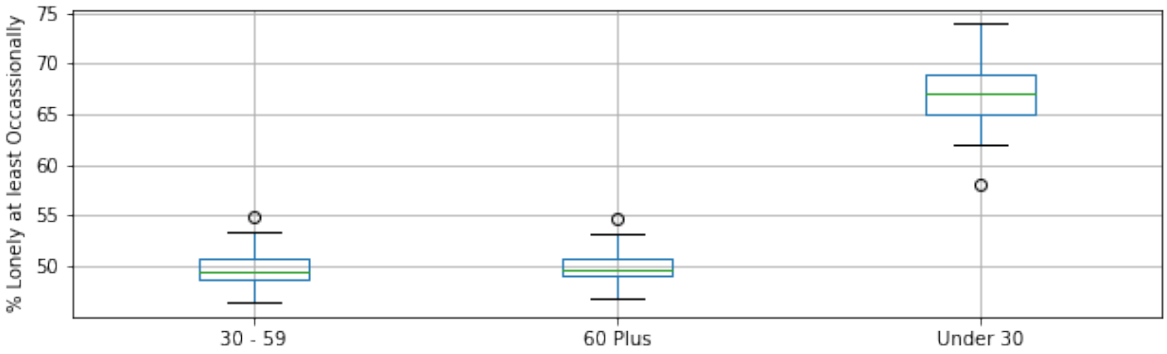


Figure 7: Distribution of Values by Country

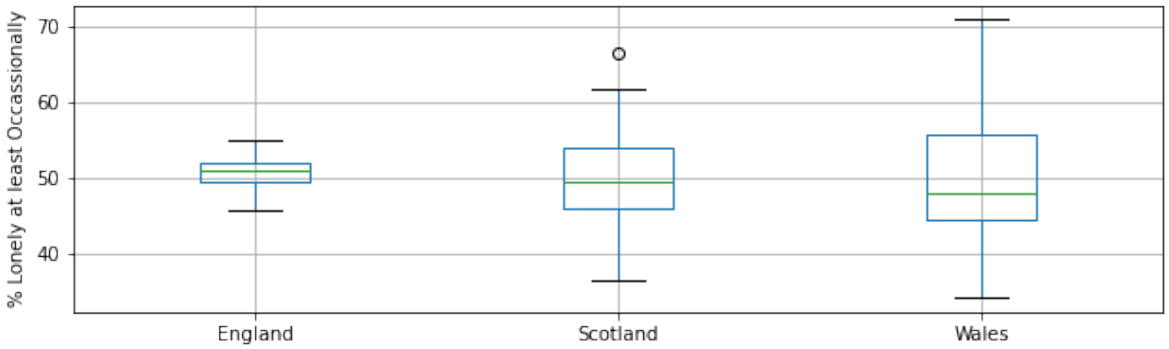


Figure 8: Distribution of Values by Phase

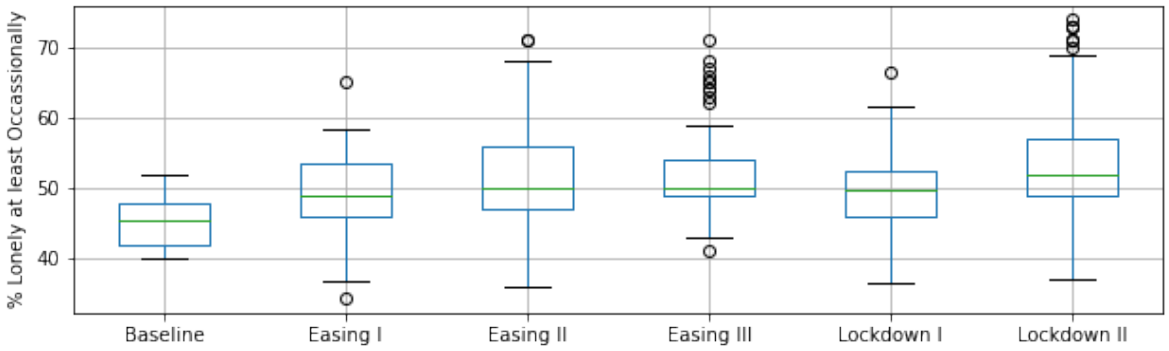


Figure 9: QQ Plot of Values by Sex

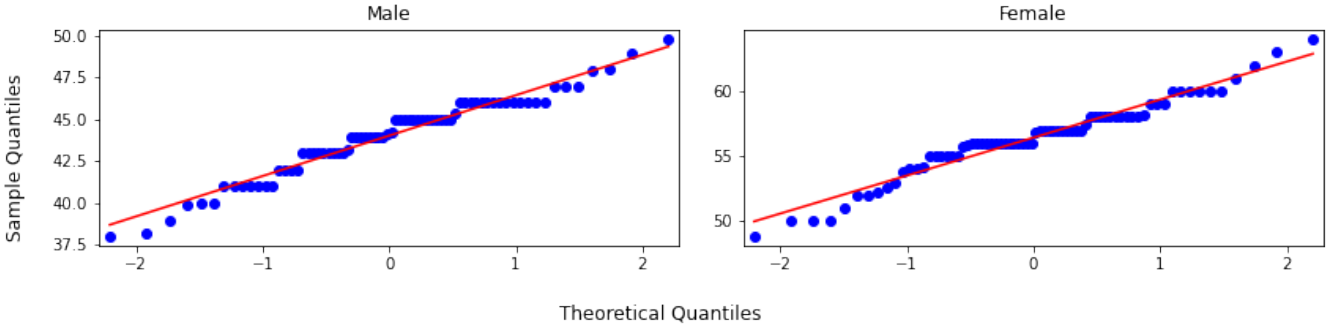


Figure 10: QQ Plot of Values by Age

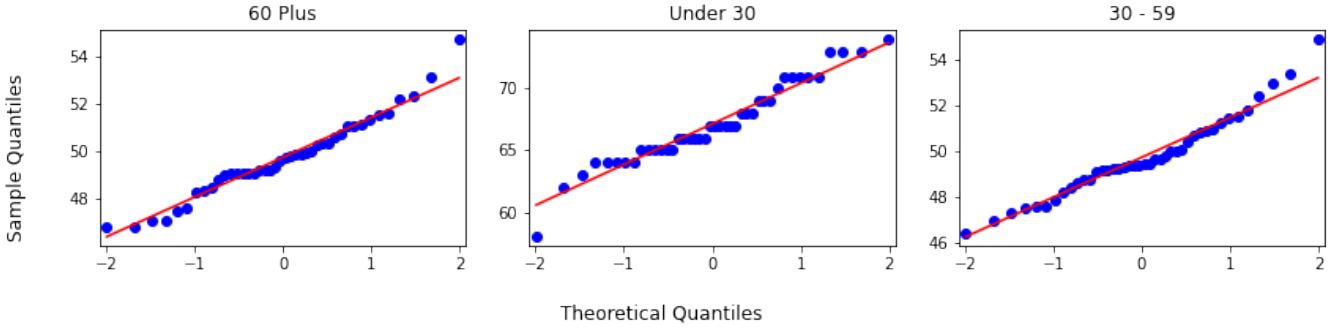


Figure 11: QQ Plot of Values by Country

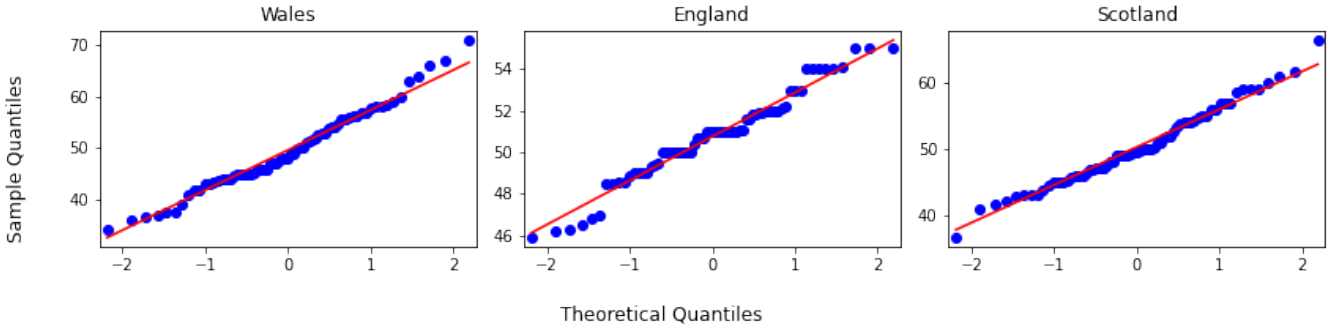
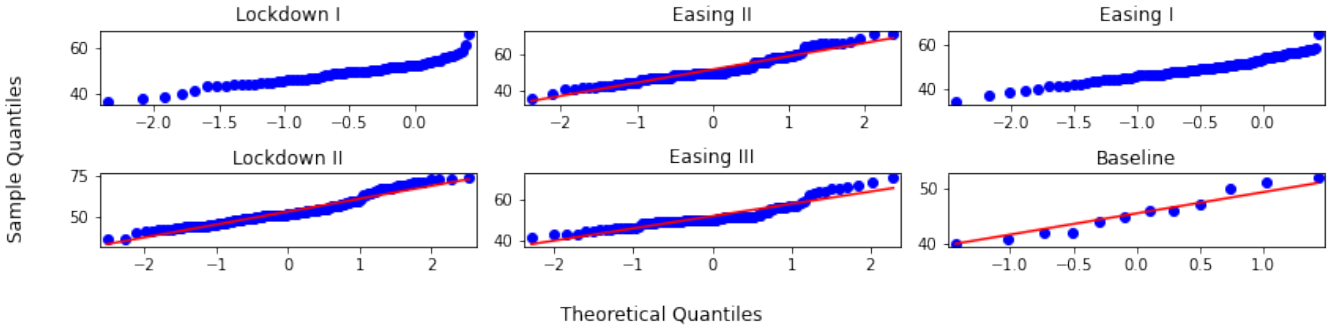


Figure 12: QQ Plot of Values by Phase



Appendix B: Approximate Age Baseline Data

Although baseline data by age was not available in broken down into the same categories as the main data set, historic data was available. As a purely indicative measure, I re-weighted the aggregates to create an approximation of the baseline levels of loneliness. As an example, the approximate loneliness of the 'Under 30' group was computed using a 9/14 weight on the value for 16-25 year olds, and a 5/14 weight on the value for 25-30 year olds. Feeding this data through the same computations as the main data does find a significant relationship between pandemic phase and age. It also supports the previous findings that younger people have increased levels of loneliness during the pandemic [4]. Interestingly, by this measure, the oldest age group is not significantly more lonely during the pandemic than prior. Not much stock can be put into this estimation, but it could be a question of interest for further research. Figure 13 and Table 9 below show the results.

Table 9: ANOVA Test by Age and Phase

	Sum of Squares	df	F-Statistic	p-value
Phase	247.6	3	17.1	$\ll 0.01$
Age	8492.5	2	881.2	$\ll 0.01$
Age x Phase	135.4	6	4.7	$\ll 0.01$
Residual	578.2	120		

Figure 13: QQ Plot of Values by Phase