

**Impact of flooding on health-related quality of life in England: results from the National Study of Flooding and Health.**

Charlotte Robin<sup>1,2, \*</sup>, Charles Beck<sup>1,2,3</sup>, Ben Armstrong<sup>4</sup>, Thomas David Waite<sup>5</sup>, G. James Rubin<sup>6</sup>, English Study of Flooding and Health Study Group<sup>7, †</sup>, Isabel Oliver<sup>1,2,3</sup>

<sup>1</sup>Field Epidemiology, Field Service, National Infection Service, Public Health England, Bristol BS1 6EH, UK

<sup>2</sup>NIHR Health Protection Research Unit in Evaluation of Interventions, University of Bristol, Bristol BS8 2BN, UK

<sup>3</sup>Population Health Sciences, Bristol Medical School, University of Bristol, Bristol BS8 2PS, UK

<sup>4</sup>NIHR Health Protection Research Unit in Environmental Change and Health, London School of Hygiene and Tropical Medicine, London WC1H 9SH, UK

<sup>5</sup>Global Public Health, Field Service, Public Health England, Wellington House, London SE1 8UG, UK

<sup>6</sup>NIHR Health Protection Research Unit in Emergency Preparedness and Response, King's College London, London SE5 9RJ, UK

<sup>7</sup>Public Health England, London SE1 8UG, UK

†Group members: Thomas David Waite, Charles R Beck, Richard Amlôt, Sari Kovats, Ben Armstrong, Giovanni Leonardi, G James Rubin and Isabel Oliver

\*Corresponding author: Charlotte Robin, Field Epidemiology, Field Service, National Infection Service, Public Health England, Bristol BS1 6EH, UK. Email: [charlotte.robin@phe.gov.uk](mailto:charlotte.robin@phe.gov.uk). Tel: +44(0)117 9689248

## **Abstract**

Background: Flooding can have extensive effects on the health and wellbeing of affected communities. The impact of flooding on psychological morbidity has been established, however the wider impacts of flooding exposure, including on health-related quality of life (HRQoL) have not been described.

Methods: Using data from the English National Study of Flooding and Health cohort, HRQoL two and three years post-flooding was assessed with the EuroQol Group EQ-5D-5L tool. Associations between exposure groups (flooding and disruption from flooding) and HRQoL were assessed, using ordinal and linear regression, adjusting for *a priori* confounders.

Results: For both two and three years post-flooding, the median HRQoL scores were lower in the flooded and disrupted groups, compared with unaffected respondents. A higher proportion of flooded and disrupted respondents reported HRQoL problems in most dimensions of the EQ-5D-5L, compared with unaffected respondents. In year two, independent associations between exposure to flooding and experiencing anxiety/depression (adjusted odds ratio [aOR] 7.7; 95% CI 4.6–13.5), problems with usual activities (aOR 5.3; 95% CI 2.5–11.9) and pain/discomfort (aOR 2.4; 95% CI 1.5–3.9) were identified. These problems persisted three years post-flooding; associations between exposure to flooding and experiencing anxiety/depression (aOR 4.3; 95% CI 2.5–7.7), problems with usual activities (aOR 2.9; 95% CI 1.5–6.1) and pain/discomfort (aOR 2.5; 95% CI 1.5–4.2) were identified.

Conclusions: Exposure to flooding and disruption from flooding significantly reduces HRQoL. These findings extend our knowledge of the impacts of flooding on health, with implications for multi-agency emergency response and recovery plans.

## **Keywords**

Flood, health, quality of life

## **Introduction**

In Europe, the most common natural hazard is flooding; over the last decade, 50 of the 53 countries in the European Region have experienced floods, with the United Kingdom (UK) being one of the most severely affected (1). It has been estimated that around 2.4 million properties in England are at-risk of flooding (2). In addition to the potential impact of climate change on increasing the frequency and severity of flooding (3), human activities such as changes to land use and rural land management may increase the impact of floods (4).

In the winter of 2013/14, England experienced a rapid succession of storms. In addition to the damaging winds, there was an exceptionally high level of rainfall resulting in widespread flooding in the south of England. In response, to better understand the public health impact of the flooding, Public Health England, in collaboration with academic partners, established the English National Study of Flooding and Health (NSFH).

The impact of exposure to flooding on mental health is becoming increasingly recognised as a public health priority, with considerable evidence for the short-term impact of flooding on psychological morbidity (5–8). To date, the NSFH has made an important contribution to the evidence on the association between flooding and longer-term psychological morbidity, demonstrating that exposure to flooding resulted in an increased risk of experiencing depression, anxiety and post-traumatic stress disorder (PTSD) (9).

It is also important to consider the effect of flooding more broadly on individuals' health and wellbeing. One holistic measure of overall health and wellbeing is health-related quality of life (HRQoL). This has been defined as how individuals perceive their physical and psychological health, independence and social relationships (10). Studies from different countries have identified that exposure to disasters such as earthquakes (11–13) and wildfire (14) can reduce HRQoL. Research in England on the effect of flooding on HRQoL remains limited (15).

There are several tools available for measuring HRQoL, one of which is the EQ-5D-5L, developed by the EuroQol Group (16). The EQ-5D-5L tool has been validated for common mental health disorders (17) and population health surveys (18), however to date it has not been used as a tool to measure HRQoL following exposure to flooding in higher income countries.

Considering HRQoL following a disaster such as a flood is important, not just because it makes a significant contribution to overall health and wellbeing, but also because higher HRQoL has been associated with better engagement with health-protective behaviour and receptiveness to health-related communications (19). This association may impact responsiveness to flood resilience strategies, particularly for communities at-risk of repeat flooding. Evaluating the HRQoL impact of flooding also forms the basis for enabling a health economic evaluation of the impact of flooding, an essential component of developing policies to reduce the impact of flooding in future.

The aim of this study was to describe the HRQoL of individuals exposed to flooding following the 2013/14 winter storms in England, using data from the NSFH, two and three years post-flooding.

## **Methods**

### *Study design*

This is a cross-sectional analysis of data from the NSFH; a cohort study of individuals affected by flooding in the south of England, between 1 December 2013 and 31 March 2014. The study commenced in 2015, one year post-flooding, with two subsequent annual follow-up questionnaires (9,20). The EQ-5D-5L tool (16) was not included in the first data collection exercise, therefore data are presented from the two subsequent years of follow up, 2016 (two years post-flooding) and 2017 (three years post-flooding).

### *Study population*

The process for recruiting the original cohort is described in detail elsewhere (9). Briefly, each residential address in affected postcode areas in Gloucestershire, Wiltshire, Sedgemoor, South Somerset and Tonbridge and Malling were contacted by post and invited to participate in the study. In addition, because of the large number of people affected in Surrey, 4110 addresses were randomly selected from the Royal Mail Postcode Address File. Participants who consented to follow-up at year one were contacted in years two and three, where they had not withdrawn consent and remained contactable. The English National Study on Flooding and Health was granted ethical approval by the Psychiatry, Nursing and Midwifery Research Ethics Subcommittee at King's College London (Reference PNM 1314 152).

#### *Data collection*

A bespoke 21-item questionnaire was developed and participants were invited to return their questionnaire either by email or post (9). A copy of the year two questionnaire is included in supplementary file 1. Respondents were assigned one of three exposure categories; “unaffected”, “disrupted” (no floodwater in liveable rooms in the home, but flood-related disruption to daily life) or “flooded” (floodwater in at least one liveable room in their home). The questionnaire also collected information on sociodemographic characteristics and long-term health conditions.

#### *Health-related quality of life measure*

HRQoL was assessed using the EuroQol Group EQ-5D-5L tool (16). The tool consists of two components; the descriptive system and the EQ Visual Analogue Scale (VAS). The descriptive system defines health status over five dimensions (mobility, self-care, usual activities, pain/discomfort and anxiety/depression), with five levels in each dimension, ranging from no problems to severe problems, to create a five-digit dimension profile for each respondent. Each dimension profile is

converted into a country-specific index value, providing a single value representing the respondent's health state, ranging from -0.594 for a profile of 55555 (severe problems in all dimensions) to 1.0 for a profile of 11111 (no problems for any dimensions). The VAS records respondents' self-rated health on a vertical scale from 0, 'the worst health you can imagine' to 100, 'the best health you can imagine'.

### *Statistical analysis*

For the EQ-5D-5L descriptive system, data from the severe/unable or severe/extreme categories were combined because of low numbers of respondents in each category, producing a four-level ordinal outcome variable. The continuous outcomes (EQ-5D-5L index value and VAS score) were both left-skewed, therefore presented as medians with interquartile range (IQR).

Associations between exposure and outcomes were analysed using ordinal logistic regression for the ordinal outcomes (EQ-5D-5L descriptive system) and linear regression with robust standard errors for the continuous outcomes (EQ-5D-5L index value and VAS score). Correlations between the different health status dimensions were assessed using a Spearman's rank correlation matrix.

Change in HRQoL between years was assessed using a Wilcoxon signed-rank test, to determine the statistical significance of changes in prevalence of HRQoL problems in each dimension and for index values and VAS scores, two and three years post-flooding.

*A priori* confounders were age, sex, ethnicity, marital status, employment status, education level, previous illness, quintile of deprivation and local authority. All *a priori* confounders were adjusted for in subsequent multivariable analysis, except ethnicity, because of the low numbers per group. The proportional odds assumption in the ordinal logistic regression was assessed using the Brant test. All data were cleaned and analysed in R version 3.5.0 (R Foundation for Statistical Computing, Vienna,

Austria). Linear regression with robust standard errors were calculated in Stata 13 (StataCorp 2013, College Station, USA).

## **Results**

### *Response rate*

Of the 1408 participants contacted at year two, 1064 (75.6%) responded. Overall, 76 exclusions were made, including 20 duplicates, 18 respondents who experienced a new flooding episode and 38 who did not provide adequate information to assign an exposure group. Respondents with missing data for either the dimension score (n=31), or missing (n=12) or invalid (n=2) data for the VAS score were excluded, giving a total of 957 respondents with complete data for the dimension score (34.4% flooded and 51.8% disrupted) and 974 respondents with complete data for the VAS score (34.5% flooded and 51.5% disrupted).

In year three, of the 1361 participants contacted, 896 (65.8%) responded. Overall, 77 exclusions were made, including 9 duplicates, 3 respondents who experienced a new episode of flooding, 29 who returned a blank questionnaire and 36 who were not assigned to an exposure group. In addition, respondents with missing data for either the dimension score (n=24) or missing (n=19) or invalid (n=2) data for the VAS score were excluded, giving a total of 795 respondents with complete data for the dimension score (33.8% flooded and 51.4% disrupted) and 798 respondents with complete data for the VAS score (34.2% flooded and 51.3% disrupted).

A total of 708 respondents had complete data for the dimension score and 724 respondents with complete data for the VAS score for both years of the study. Demographic characteristics of respondents are summarised in supplementary tables 2a and 2b.

### *Prevalence of HRQoL problems*

High scores for mobility and activity problems ( $r=0.69$ ) often occurred together. Moderate correlations were identified between mobility and pain/discomfort ( $r=0.55$ ) and pain/discomfort and activity problems ( $r=0.53$ ). There were no strong associations between any of the other dimension scores ( $r=0.19-0.48$ ).

Extent of reported problems varied depending on the specific dimension; for both years of the study only a small proportion of respondents reported any problems with self-care (Supplementary Table 1). In both years of the study, problems with pain/discomfort and anxiety/depression were the most frequently reported HRQoL-related problems in respondents who were exposed to flooding and disruption from flooding (Figure 1).

For most dimensions at both years, a higher proportion of flooded and disrupted respondents reported HRQoL-related problems to varying extents, compared with those who were unaffected (Figure 1). The exception to this was self-care, where in year two more unaffected respondents reported slight problems and in year three more unaffected respondents reported moderate problems, compared with flooded and disrupted groups (Supplementary Table 1). In addition, in year two, more disrupted respondents reported slight problems with mobility, compared with flooded respondents. The median VAS scores and index values were lower in respondents who were exposed to flooding and disruption from flooding, compared with unaffected respondents (Figure 2, Table 2).

The prevalence of reported mobility and pain/discomfort problems changed little between follow-up years. In the flooded group, the prevalence of reported anxiety/depression problems decreased between years, from 59.8% in year two to 50.9% in year three ( $p=0.029$ ).

#### *The effect of exposure to flooding on HRQoL*



Exposure to flooding and disruption from flooding significantly increased the odds of experiencing problems with being able to perform usual activities, pain/discomfort and anxiety/depression. This effect was more pronounced when comparing flooded with unaffected groups, than disrupted with unaffected groups. Two years post-flooding, the adjusted odds ratio (aOR) of experiencing problems with usual activities were 5.25 (95% CI: 2.45–11.91) times higher in respondents exposed to flooding and 3.69 (95% CI: 1.77–8.17) times higher in those exposed to disruption from flooding, compared with unaffected respondents (Table 1). Follow-up three years post-flooding showed these problems persisted, although there was a smaller increase in the odds of experiencing problems with usual activities in flooded respondents (aOR: 2.92; 95% CI: 1.48–6.06), compared with the unaffected group. Similarly, the adjusted odds of experiencing problems with anxiety/depression two years post-flooding were 7.70 (95% CI: 4.56–13.49) times higher in respondents exposed to flooding, compared with the unaffected group, whereas for those who were exposed to disruption from flooding the adjusted odds reduced (aOR: 2.22; 95% CI: 1.34–3.83). Problems with anxiety/depression persisted up to three years post-flooding, although the odds reduced for those exposed to flooding (aOR: 4.30; 95% CI: 2.48–7.72) and disruption from flooding (aOR: 1.72; 95% CI: 1.00–3.03). Experiencing problems with pain/discomfort also persisted up to three years post-flooding in respondents exposed to flooding (aOR: 2.41; 95% CI: 1.50–3.92; aOR: 2.51; 95% CI: 1.53–4.17, for year two and three, respectively), but not disruption from flooding. Exposure to flooding or disruption from flooding had little effect on the odds of experiencing mobility or self-care problems, two or three years post-flooding. In the linear regression analysis (Table 2), coefficients showed that mean VAS and index scores at year two were significantly lower, in respondents exposed to flooding, compared with the disrupted or unaffected groups. Differences remained but were smaller at year three and were no longer significant for either score for the disrupted group.

## **Discussion**

Our study has demonstrated that exposure to flooding and disruption from flooding were associated with a reduction in HRQoL in this population. Exposure to flooding resulted in a significant reduction in overall HRQoL score, two and three years post-flooding. This reflects previous research that demonstrated the prevalence of probable mental health outcomes (depression, anxiety and PTSD) was higher in people who were flooded, compared with disrupted (9). That study also found an association between severity of flooding, based on depth of floodwater and flood duration, and increased risk of developing probable anxiety, depression and PTSD.

In our study, problems with anxiety/depression and pain/discomfort were the most frequently reported dimensions of the EQ-5D-5L tool. This is consistent with a previous HRQoL assessment of the English population using the EQ-5D-5L, where anxiety/depression and pain/discomfort were the most important health problems for the sampled population (21). In our study, given the prevalence of reported problems with anxiety/depression compared with the other health dimensions, it is likely this dimension of the EQ-5D-5L tool is influential in the overall changes in HRQoL observed. The prevalence of reported anxiety/depression problems in our study is unsurprising, given the evidence for the effect of exposure to flooding on psychological morbidity (5–9,20), but the association between exposure to flooding and experiencing pain/discomfort may be more complex. There is a well-established association between depression and chronic pain (22), therefore the data may be reflecting an increased sensitivity to existing pain/discomfort. Alternatively, physical symptoms following exposure to a natural disaster may arise through a process of somatisation (23). Respondents also reported experiencing problems with performing usual activities following flooding and the analysis demonstrated that exposure to flooding increased the odds of experiencing progressively severe problems with being able to engage in usual activities. This could simply be physical restrictions on accessing specific facilities or spaces, or because of physical morbidity. However, there is evidence to suggest that individuals experiencing depression or anxiety are less active (24), therefore this could be a reflection of the wider findings of the effect of flooding

on mental health outcomes, particularly anxiety and depression. One previous study revealed an increase in antidepressant prescribing in populations in closer proximity to flooded areas, who may have experienced greater disruption (25). If there is an association between level of disruption and psychological morbidity, the relationship between displacement from flooding and HRQoL would also be an important factor to consider in future studies.

There are limited data available on the effect of flooding on HRQoL. Previous studies have demonstrated exposure to other disasters or extreme weather events such as earthquakes reduces HRQoL (11,13,26,27). These studies were conducted in low and middle-income countries (LMIC), where the population demographics are very different from the population in the NSFH cohort. In our cohort, the majority of participants lived in affluent neighbourhoods in the lowest quintile of socioeconomic deprivation. There is a substantial body of evidence that social environment and socioeconomic status has a significant effect on HRQoL (28). Those living in more deprived areas tend to have worse quality of life and health outcomes (29), therefore the findings from our study are not comparable with studies conducted in LMIC. In addition, the demographics of the NSFH cohort means our findings are not necessarily generalisable to other, less affluent areas of England, which may also be affected by flooding. Evaluating the effect of socioeconomic status on HRQoL post-flooding in England would be particularly useful to inform decision-making for commissioning of resources following flooding events.

In addition to the previously reported limitations with the NSFH cohort (9), there are several limitations with this study. One of the main challenges of trying to measure HRQoL is that there are numerous definitions for what constitutes HRQoL. Assumptions underlying different measurements are dependent on epistemological perspectives; tensions exist about how HRQoL should be measured (30). Generic tools such as the EQ-5D-5L have been developed from the perspective of health professionals, rather than what people understand to be important to their own HRQoL (31). This constrains individuals to express their HRQoL within the limits of the tool provided and prevents

them from expressing other aspects of their lives that might be impacting their HRQoL. We have no baseline measurement of HRQoL for the study population prior to flooding. This negates being able to compare HRQoL before and after exposure to flooding. In addition, we have no HRQoL measurement for the first year following flooding.

Only a small proportion of respondents reported any problems at all; compounded by the small sample size, particularly in year three, this means that it is difficult to draw robust conclusions from the data. This is particularly relevant for the ordinal regression analysis, where data were split across four categories and several confounders, resulting in a low number of events per variable, potentially leading to sparse data bias (32). While we tried to minimise this effect by combining categories in the dimension score there was still a small number of events per variable for some of the confounders. This meant that ethnicity could not be included as a confounder.

This is one of the first studies to report the longer-term effects of flooding on HRQoL in England, extending knowledge on the health-related impact of flooding beyond associations with PTSD, anxiety and depression, identified previously. Our findings demonstrate a reduction in the HRQoL of people affected by flooding and disruption from flooding, following storms in 2013/14 in the south of England. This highlights that exposure to flooding does not just impact physical and psychological morbidity but can affect overall HRQoL. In addition, these effects are felt by wider communities, specifically those who have been indirectly affected and are not just limited to individuals whose homes have been flooded. While using a generic tool such as EQ-5D-5L to measure HRQoL may be restrictive, it provides a method of quantifying changes in HRQoL in different exposure groups and forms the basis for an evaluation of the economic impact of exposure to flooding. Including consideration of HRQoL in multi-agency response and recovery plans will strengthen how agencies respond to and support flood-affected communities. Health service providers should recognise that exposure to flooding can have significant effects on HRQoL, even in those without a clinical diagnosis

of psychological morbidity. Our research will help inform agencies to plan and provide services in flood-affected areas, both in the immediate aftermath of flooding and longer-term, to help mitigate the effect of flooding on HRQoL.

### **Funding**

This work was supported by the National Institute for Health Research Health Protection Research Units (NIHR HPRU) in Evaluation of Interventions at the University of Bristol, in partnership with Public Health England (PHE), the NIHR HPRU in Emergency Preparedness and Response at King's College London in partnership with PHE and the NIHR HPRU in Environmental Change and Health at the London School of Hygiene and Tropical Medicine in partnership with PHE. The views expressed are those of the authors and not those of the NHS, the NIHR, the Department of Health and Social Care or PHE.

### **Acknowledgements**

We thank respondents to the English National Study of Flooding and Health for providing data analysed used in our study and members of the English National Study of Flooding and Health for supporting this study and providing advice.

### **Conflicts of interest**

None declared.

### **Key-points**

- This is one of the first studies to report on the effect of flooding on health-related quality (HRQoL) of life in England.
- HRQoL was significantly reduced in people who were exposed to flooding and disruption from flooding; this effect was more pronounced in the flooded compared with disrupted group.
- Independent associations were identified between exposure to flooding and experiencing increased anxiety/depression, performing usual activities and pain/discomfort, which persisted for up to three years post-flooding.
- An assessment of HRQoL is an important consideration for the public health response to flooding for people who do not have a clinical diagnosis of psychological morbidity
- Quantifying HRQoL is the first step towards an economic evaluation of the impact of flooding; an important consideration for commissioning decisions in flood prevention.

## References

1. Menne B, Murray V. Floods in the WHO European Region: health effects and their prevention: <http://www.euro.who.int/pubrequest> Accessed [15 Feb 2019].
2. Environment Agency. Flood and coastal erosion risk management: Long-term investment scenarios (LTIS): [www.gov.uk/environment-agency](http://www.gov.uk/environment-agency) Accessed [4 Mar 2019].
3. Miller JD, Hutchins M. The impacts of urbanisation and climate change on urban flooding and urban water quality: A review of the evidence concerning the United Kingdom. *J Hydrol Reg Stud* 2017;12:345–62.
4. Wheeler H, Evans E. Land use, water management and future flood risk. *Land Use Policy* 2009;26:S251–64.
5. Paranjothy S, Gallacher J, Amlôt R, Rubin GJ, Page L, Baxter T, et al. Psychosocial impact of the summer 2007 floods in England. *BMC Public Health* 2011;11(1):145.
6. Tapsell SM, Penning-Rowsell EC, Tunstall SM, Wilson TL. Vulnerability to flooding: health and social dimensions. *Philos Trans R Soc* 2002;360:1511–25.
7. Reacher M, McKenzie K, Lane C, Nichols T, Kedge I, Iversen A, et al. Health impacts of flooding in Lewes: a comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households. *Commun Dis public Heal* 2004;7(1):39–46.
8. Tapsell SM, Tunstall SM. “I wish I’d never heard of Banbury”: The relationship between ‘place’ and the health impacts from flooding. *Health and Place* 2008;14(2):133–54.
9. Waite TD, Chaintarli K, Beck CR, Bone A, Amlôt R, Kovats S, et al. The English national cohort study of flooding and health: cross-sectional analysis of mental health outcomes at year one. *BMC Public Health* 2017;17(1):1–9.
10. WHO Quality of Life Group: Measuring Quality of Life: <https://www.who.int/healthinfo/survey/whoqol-qualityoflife/en/> [Accessed 12 Apr 2019].
11. Wang X, Gao L, Zhang H, Zhao C, Shen Y, Shinfuku N. Post-earthquake quality of life and psychological well-being: Longitudinal evaluation in a rural community sample in northern China. *Psychiatry Clin Neurosci*. 2000;54(4):427–33.
12. Ardalan A, Mazaheri M, Vanrooyen M, Mowafi H, Nedjat S, Naieni KH, et al. Post-disaster quality of life among older survivors five years after the Bam earthquake: implications for recovery policy. *Ageing Soc* 2011;31(02):179–96.
13. Khachadourian V, Armenian HK, Demirchyan A, Goenjian A. Loss and psychosocial factors as determinants of quality of life in a cohort of earthquake survivors. *Health Qual Life Outcomes* 2015;13(1):13.
14. Papanikolaou V, Adamis D, Kyriopoulos J. Long term quality of life after a wildfire disaster in a rural part of Greece. *Open J Psychiatry* 2012;2:164–70.
15. French CE, Waite TD, Armstrong B, James Rubin G, Beck CR, Oliver I. Impact of repeat flooding on mental health and health-related quality of life: a cross-sectional analysis of the English National Study of Flooding and Health. *BMJ Open*, 2019;9:e031562. doi:10.1136

16. Van Reenen M, Janssen B. EQ-5D-5L User Guide Basic information on how to use the EQ-5D-5L instrument: [https://euroqol.org/wp-content/uploads/2016/09/EQ-5D-5L\\_UserGuide\\_2015.pdf](https://euroqol.org/wp-content/uploads/2016/09/EQ-5D-5L_UserGuide_2015.pdf) [Accessed 12 Apr 2019]
17. Mulhern B, Mukuria C, Barkham M, Knapp M, Byford S, Soeteman D, et al. Using generic preference-based measures in mental health: psychometric validity of the EQ-5D and SF-6D. *Br J Psychiatry* 2014;205(03):236–43.
18. Devlin NJ, Appleby J, Buxton M, Vallance-Owen A, Emberton M, Peters K, et al. Getting the most out of PROMs: health outcomes and NHS decision-making: [www.kingsfund.org.uk/publications](http://www.kingsfund.org.uk/publications) [Accessed 12 Apr 2019].
19. Gowan ME, Kirk RC, Sloan JA. Building resiliency: a cross-sectional study examining relationships among health-related quality of life, well-being, and disaster preparedness. *Health and Quality of Life Outcomes* 2014; 12(85): doi:10.1186/1477-7525-12-85.
20. Jermacane D, Waite TD, Beck CR, Bone A, Amlôt R, Reacher M, et al. The English National Cohort Study of Flooding and Health: The change in the prevalence of psychological morbidity at year two. *BMC Public Health*. 2018;18(1):1–8.
21. Devlin NJ, Shah KK, Feng Y, Mulhern B, van Hout B. Valuing health-related quality of life: An EQ-5D-5L value set for England. *Health Econ* 2018;27(1):7–22.
22. Hermesdorf M, Berger K, Baune BT, Wellmann J, Ruscheweyh R, Wersching H. Pain Sensitivity in Patients With Major Depression: Differential Effect of Pain Sensitivity Measures, Somatic Cofactors, and Disease Characteristics. *J Pain* 2016;17(5):606–16.
23. Wahlström L, Michélsen H, Schulman A, Backheden H, Keskinen-Rosenqvist R. Longitudinal course of physical and psychological symptoms after a natural disaster. *Eur J Psychotraumatol* 2013;4(1):21892.
24. Schuch F, Vancampfort D, Firth J, Rosenbaum S, Ward P, Reichert T, et al. Physical activity and sedentary behavior in people with major depressive disorder: A systematic review and meta-analysis. *J Affect Disord* 2017;210:139–150.
25. Milojevic A, Armstrong B, Wilkinson P. Mental health impacts of flooding: A controlled interrupted time series analysis of prescribing data in England. *J Epidemiol Community Health*. 2017;71(10):970–3.
26. Liang Y, Chu P, Wang X. Health-Related Quality of Life of Chinese Earthquake Survivors: A Case Study of Five Hard-Hit Disaster Counties in Sichuan. *Soc Indic Res* 2014;119(2):943–66.
27. Ceyhan E, Aykut Ceyhan A. Earthquake survivors' quality of life and academic achievement six years after the earthquakes in Marmara, Turkey. *Disasters* 2007;31(4):516–29.
28. Drukker M, Kaplan C, Feron F, van Os J. Children's health-related quality of life, neighbourhood socio-economic deprivation and social capital. A contextual analysis. *Soc Sci Med* 2003;57(5):825–41.
29. Von Rueden U, Gosch A, Rajmil L, Bisegger C, Ravens-Sieberer U. Socioeconomic determinants of health related quality of life in childhood and adolescence: results from a European study. *J Epidemiol Community Heal* 2006;60:130–5.



30. Connell J, Brazier J, O’Cathain A, Lloyd-Jones M, Paisley S. Quality of life of people with mental health problems: a synthesis of qualitative research. *Health Qual Life Outcomes* 2012;10(1):138.
31. Hunt SM. The problem of quality of life. *Qual Life Res* 1997;6:205–12.
32. Greenland S, Mansournia MA, Altman DG. Sparse data bias: a problem hiding in plain sight. *BMJ* 2016;352:i1981.

Table 1: Adjusted odds ratios (OR) of quality of life outcomes for disrupted or flooded, compared with unaffected respondents, two (n=957) and three (n=795) years post-flooding.

Outcome	Year 2		Year 3	
	Crude OR (95% CI)	aOR (95% CI)*	Crude OR (95% CI)	aOR (95% CI)*
<b>Mobility problems</b>				
Unaffected	Ref	Ref	Ref	Ref
Disrupted	1.44 (0.91–2.36)	1.35 (0.73–2.59)	1.55 (0.95–2.64)	1.14 (0.60–2.15)
Flooded	1.41 (0.86–2.35)	1.55 (0.81–3.05)	1.88 (1.12–3.24)	1.70 (0.90–3.31)
<b>Self-care problems</b>				
Unaffected	Ref	Ref	Ref	Ref
Disrupted	1.28 (0.61–3.01)	1.14 (0.43–3.40)	0.90 (0.43–2.08)	0.36 (0.13–1.04)
Flooded	1.01 (0.49–2.67)	1.23 (0.44–3.78)	0.85 (0.38–2.05)	0.37 (0.12–1.15)
<b>Activity problems</b>				
Unaffected	Ref	Ref	Ref	Ref
Disrupted	2.30 (1.37–4.10)	3.69 (1.77–8.17)	2.21 (1.30–3.97)	1.70 (0.88–3.46)
Flooded	2.59 (1.51–4.67)	5.25 (2.45–11.91)	2.87 (1.66–5.22)	2.92 (1.48–6.06)
<b>Pain/discomfort</b>				
Unaffected	Ref	Ref	Ref	Ref
Disrupted	1.52 (1.04–2.24)	1.35 (0.86–2.15)	1.75 (1.17–2.64)	1.54 (0.97–2.49)
Flooded	2.13 (1.43–3.20)	2.41 (1.50–3.92)	2.41 (1.58–3.72)	2.51 (1.53–4.17)
<b>Anxiety/depression</b>				
Unaffected	Ref	Ref	Ref	Ref
Disrupted	2.12 (1.35–3.39)	2.22 (1.34–3.83)	1.95 (1.20–3.27)	1.72 (1.00–3.03)
Flooded	6.05 (3.84–9.82)	7.70 (4.56–13.49)	4.39 (2.68–7.43)	4.30 (2.48–7.72)

\*Adjusted odds ratios (aOR) adjusted for *a priori* confounders: age, sex, marital status, employment status, education level, previous illness, quintile of deprivation and local authority. Ethnicity removed because of low numbers in each category. Brant test results  $P > 0.05$  for all outcomes.

Table 2: Univariable and multivariable linear regression analyses of EQ-5D-5L VAS scores and index values, two and three years post-flooding.

Exposure group	VAS score						Index value†					
	Year 2			Year 3			Year 2			Year 3		
	Median score (IQR)	Crude coefficient (95% CI)*	Adjusted coefficient (95% CI)**	Median score (IQR)	Crude coefficient (95% CI)*	Adjusted coefficient (95% CI)**	Median index value† (IQR)	Crude coefficient (95% CI)*	Adjusted coefficient (95% CI)**	Median index value† (IQR)	Crude coefficient (95% CI)*	Adjusted coefficient (95% CI)**
Unaffected	89 (80–90)	Ref	Ref	86 (75–93)	Ref	Ref	1.00 (0.84–1.00)	Ref	Ref	1.00 (0.84–1.00)	Ref	Ref
Disrupted	80 (70–90)	-4.56 (-7.44 to -1.68)	-2.50 (-4.87 to -0.14)	85 (75–90)	-3.74 (-6.66 to -0.83)	-0.70 (-3.35 to 1.95)	0.85 (0.74–1.00)	-0.05 (-0.9 to -0.02)	-0.04 (-0.07 to 0.01)	0.84 (0.74–1.00)	-0.05 (-0.08 to 0.01)	-0.02 (-0.05 to 0.01)
Flooded	80 (70–90)	-7.36 (-10.47 to -4.24)	-6.13 (-8.80 to -3.47)	80 (70–90)	-6.91 (-10.11 to -3.72)	-5.15 (-8.14 to -2.16)	0.80 (0.72–0.88)	-0.10 (-0.14 to 0.06)	-0.10 (-0.13 to 0.07)	0.80 (0.71–0.88)	-0.09 (-0.13 to 0.06)	-0.08 (-0.11 to 0.04)

\*Confidence intervals estimated using robust standard errors

\*\*Adjusted for *a priori* confounders: age, sex, marital status, employment status, education level, previous illness, quintile of deprivation and local authority. Ethnicity removed because of low numbers in each category.

†Index value ranged from -0.594–1.000 for UK values.

0 **Figure legends**

1 Figure 1: Dimension specific EQ-5D-5L distribution by level of problem for each exposure group, two  
2 years post-flooding (n=957) and three years post-flooding (n=795). \*Data from the severe/unable or  
3 severe/extreme categories were combined, because of the low numbers of respondents in each  
4 category.

5

6 Figure 2: Index values (n=957 and n=795, for years two and three, respectively) and VAS scores  
7 (n=974 and n=798, for years two and three, respectively) by exposure status, for (A) two years post-  
8 flooding and (B) three years post-flooding.