Health impacts of flooding in Lewes: a comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households

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Summary: Severe flooding may become more frequent due to global warming. A historical cohort study was conducted by telephone interview for new episodes of illness in all age groups, and for psychological distress in adults, following severe river flooding on 12 October 2000 in the town of Lewes in Southern England. Two hundred and twenty-seven residents of 103 flooded households and 240 residents of 104 non-flooded households in the same postal district were recruited by random selection of addresses from a post flooding survey and a commercial database respectively. Having been flooded was associated with earache (RR 2.2 [1.1,4.1] $p = 0.02$), and a significant increase in risk of gastroenteritis with depth of flooding (RR 1.7 [0.9,3.0] $p = 0.09$, p for trend by flood depth = 0.04). Adults had a four-times higher risk of psychological distress defined as a score of ≥ 4 in response to the 12-item General Health Questionnaire (GHQ-12) (RR 4.1 [2.6, 6.4] $p < 0.0005$, p for trend by flood depth = 0.01). Associations between flooding and new episodes of physical illness in adults diminished after adjustment for psychological distress. Flooding remained highly significantly associated with psychological distress after adjustment for physical illnesses. Psychological distress may explain some of the excess physical illness reported by flooded adults and possibly by children as well. Policies to promote population resilience to flooding where flood prevention has failed must include practical support for flood victims and provision of appropriate psychological support. Associations with physical illnesses affirm the need for advice and assistance with individual, household and environmental hygiene and access to medical services.

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Introduction

Floods account for approximately forty per cent of natural disasters and may become more frequent and severe due to global warming[1,2]. In the UK, warmer, wetter and stormier weather and rising sea levels are anticipated, increasing riverine and coastal flooding[3,4]. The health impact of flooding may vary substantially according to the severity and whether riverine or coastal, the time of day flooding occurred, the timeliness of any warning, emergency preparedness and existing social and economic structures[3,5,6]. The recognised immediate and medium health effects of flooding include drowning, injury, exposure, acute asthma, skin rashes and clusters and outbreaks of gastroenteritis and respiratory infection[1,3,7].

Knowledge of the longer-term health impacts of flooding is less complete[3,8-10]. In the year following the 1968 floods in Bristol UK, increase in visits to health providers, in psychiatric symptoms in women and in all cause mortality were reported in those who had had to leave their homes compared with those who did not[9]. A study following flooding in Brisbane, Australia in 1974 reported increased rates of hospital and primary care attendance and increased rates of psychological symptoms in flooded compared to non-flooded individuals at approximately one year, but no increase in mortality[10]. It has therefore been suggested that psychological distress may be associated with being flooded[3,8-10]. The Bristol and Adelaide studies were undertaken before standardised tools to assess psychological symptoms or multivariable regression methods were available[9,10]. It also remains unclear whether psychological distress from flooding is associated with increased rates of treatable mental illness in the long term or whether the psychological symptoms suffered by flood victims offer an explanation for their increased rates of reporting physical illness or attending health services.

In the autumn of 2000, England and Wales experienced widespread flooding[3,8]. Lewes in the South East of England was one of the worst affected locations and, following multiple breaches to flood defences on the river Ouse at approximately 1:00 pm on Thursday 12 October 2000, its town centre was completely flooded. Hundreds of people were stranded and had to be rescued by emergency services in boats. By the time the floodwaters peaked at about 9:30 pm, some parts of Lewes were under 3.6 m of water[11]. No deaths from drowning or trauma were reported and local surveillance of infectious diseases showed no discernible upward trend in the aftermath of the floods.

The Health Protection Agency's Communicable Disease Surveillance Centre (CDSC) was invited by local government and health authorities in Lewes to evaluate the longer-term health impacts of the floods. This provided an opportunity to gain contemporary UK data using a well validated instrument to measure psychological distress as well as physical illness, and to use modern multi-variable regression methods to investi-gate independent association between flooding, psychological and physical health.

Methods

Survey sample

A survey of flood damage was conducted by Lewes District Council between 22 October and 15 November 2000 (figure 1). Two hundred and fifty-eight flooded residential addresses were identified and details of housing damage and the contact telephone numbers of residents were sought and entered into a database. Two hundred and forty seven (96%) of the flooded addresses were located in postcode area BN7 2, of which 160 had a contact telephone number, and from which a sample of 115 addresses was selected using a series of random numbers. A list of non-flooded addresses was created by identifying and deleting flooded addresses from the total list of addresses in postcode area BN7 2 present in a commercial database (UK-INFO Disk 2000, I-CD publishing [UK] Ltd). Of 4,847 addresses, 2,126 (44%) had telephone numbers, from which a sample was taken using a series of random numbers from random number tables. Nine non-flooded addresses from the total list of randomly selected non-flooded addresses with telephone numbers were assigned to interviewers to be approached in association with each flooded household. This arrangement was for administrative clarity and did not result in matching between flooded and non-flooded households. Interviewers replaced non-flooded households if contact had not been successful after five attempts at different times of the day including evenings and weekends, or if a household declined to participate.
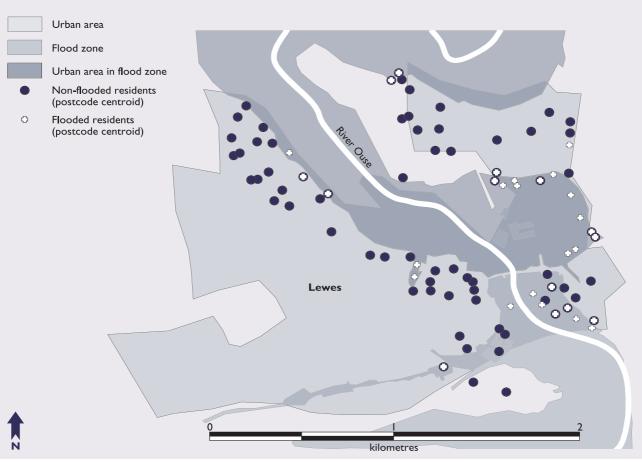
Interview and consent

Five staff was trained to conduct telephone interviews according to a written protocol using questionnaires, which were piloted and refined prior to study enrolment[12]. Interviews were conducted between 10 July and 16 August 2001 (nine months following the floods). An adult aged 18 years or over was sought at the contact telephone number and informed consent was requested and recorded. An adult completed a questionnaire measuring flood impacts on the house and episodes of physical illness arising between the floods of 12 October 2000 and the date of interview for each resident. The 12-item General Health Questionnaire (GHQ-12) was administered separately for each adult[13].

Definition of a flooded address

Flooding was defined as entry of floodwater to the level of the floor or deeper, of the lowest habitable room at the address associated with the floods that occurred on 12 October 2000. A habitable room was defined as a living space heated and furnished to a level to allow continuous occupation for at least four hours per day at any time of year. Respondents were informed that flood water entering non-habitable areas such as cellars, basements, halls, landings and stairs, or below

FIGURE 1   Maximum extent of flood waters in Lewes, Sussex, 12 October 2001, and postcode centroid locations of study participants

Source: Lewes District Council

the floor level of the lowest habitable room, did not meet the definition of flooding for this survey.

Definition of exposure to flooding
A person was considered to have been exposed to flooding if they were normally resident at the flooded address and had been at the address at any time between 11 pm on Wednesday 11 October and 1.00 pm on Thursday 12 October 2000.

Housing and household census questionnaire
A housing and census questionnaire was completed confirming the presence or absence of flooding at the address. If flooded, the maximum depth of water above the floor of the lowest habitable room was obtained. A census of individuals who were normally full-time residents at the address and present there at any time between 11pm on Wednesday 11 October and 12 noon on Thursday 12 October 2000 was taken.

Definition of flood-associated displacement from home address
Respondents were asked for each resident whether that resident had been obliged to move for one or more nights from the flooded address because of flooding or the threat of flooding on 11 and 12 October 2000, and the number of days so displaced.

Measurement of physical health
Health status questionnaires were completed for each resident identified by the household census recording new health events between 12 October 2000 and the date of interview (July-August 2001). Information was recorded for injuries; worsening of pre-existing asthma; respiratory illness (cough, bronchitis, sore throat or flu-like illness requiring a medical consultation); earache; gastroenteritis (vomiting and/or diarrhoea (three or more loose stools in a 24-hour period); and skin rash[1,7-10,14].

Measure of psychological health
Adults aged 18 years and over were contacted individually and asked to indicate which of four responses to the 12 items of the GHQ-12 best indicated the way they had recently been feeling[13]. Psychological distress was defined as a score of four or more on the GHQ-12.

Data management and statistical analysis
Questionnaires were double entered, checked for differences and corrected, and individual and housing records linked using Epi Info software[15]. The main exposure variable was having been exposed to flooding. Secondary exposure variables were: interruption of mains tap water supply; changed

taste, smell or colour of mains tap water supply; and sewage backflow and spillage. Associations between exposure to flooding and risks of reported injury, physical illness and psychological distress were explored in single variable and multivariable analyses using Stata version 8.1 software (Stata Corporation, Texas). Adjusted risk ratios were estimated using generalised linear models from the binomial family. This method is similar to logistic regression but uses a log link function instead of a logit link function. Confidence intervals and significance tests used the modified sandwich estimator of variance and allowed for the clustering of the sample of individuals within households[16]. Age and sex adjusted risk ratios were estimated in separate models for each category of reported physical illness in all subjects. This was repeated in adults for whom the risk of psychological distress was also determined. Finally, the risk ratio of each category of physical illness adjusted for age, sex and psychological distress was calculated. Tests for trend of risk ratios by height of flooding were based on flooded individuals only.

Results

One hundred and fifteen flooded households were contacted, of which 90% (103/115) consented to participate and were recruited. Contact was made with 188 non-flooded households of which 55% (104/188) consented to participate and were recruited (table 1). This represents 42% (103/247) of total flooded addresses and 2% (104/4,847) total non-flooded addresses in postcode area BN7 2. Participating flooded households accommodated 227 flood-exposed individuals and non-flooded households 240 individuals (table 1). Ninety-one per cent (161/177) of flooded and 83% (160/192) non-flooded adults completed the GHQ-12. Flooded and non-flooded groups were comparable with respect to the number of residents at each address, age and sex (table 1). Most flooded individuals were displaced from home for more than ten days with a median of six months.

In subjects of all ages, having been flooded was significantly associated with earache (RR 2.2 [1.1,4.1] $p = 0.02$) (table 2). A less marked association was seen with gastroenteritis (RR 1.7 [0.9,3.0] $p = 0.09$) but risk was significantly associated with depth of flooding (p for trend = 0.04) (table 2). Weaker associations were observed for skin rash (RR 3.4 [0.8,15] $p = 0.1$), respiratory illness (RR1.3 [0.8,2.1] $p = 0.32$) and all categories of injury (RR 1.6 [0.9,2.8] $p = 0.14$) (table 2). Sprains, broken bones, burns or scalds, and inhalation of gas, smoke or vapours were reported by flooded and non-flooded individuals (table 3). In the small number of subjects with pre-existing asthma, a non significant association was observed (RR 1.9 [0.8, 4.2] $p = 0.13$) and a significant test for trend, but this showed decrease in risk with increasing depth of flooding (table 2).

In adults aged 18 and over, the risk estimates of physical illnesses compared to subjects of all ages,

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TABLE 1 Composition of flooded and non-flooded study groups

		Flooded		Non-flooded	
Address		Number		Number	
Number of residential addresses		103		104	
Mean number of participants at each address		2.20		2.31	
Total subjects		227		240	
Participants					
Sex	Male	104	46%	105	44%
	Female	123	54%	135	56%
	Total	227	100%	240	100%
Age group	0-17	50	22%	46	19%
	18-39	54	24%	46	19%
	40-49	38	17%	48	20%
	50-64	50	22%	48	20%
	65+	34	15%	49	21%
	Total	226	100%	237	100%
Days displaced due to flooding	0	19	8%	219	91%
	1-10	35	15%	21	9%
	>10	173	76%	0	0%
	Total	227	100%	240	100%

TABLE 2 Risk ratios for reported physical illness and psychological distress after flooding

Illness	Flooded % (*n*/total)		Non-flooded % (*n*/total)		Adjusted risk ratio	95% CI	*p*	*p* for trend
Adults and children adjusted for age and sex								
Skin rash	9%	(16/173)	3%	(5/188)	3.4	[0.8, 15]	0.1	0.71
Earache	12%	(26/226)	5%	(12/236)	2.2	[1.1, 4.1]	0.02	0.26
Gastroenteritis	22%	(44/199)	13%	(27/204)	1.7	[0.9, 3.0]	0.09	0.04
Asthma got worse	48%	(16/33)	25%	(8/32)	1.9	[0.8, 4.2]	0.13	0.01†
Respiratory illness	18%	(41/223)	14%	(33/238)	1.3	[0.81, 2.1]	0.32	0.68
One or more injuries	12%	(27/227)	8%	(19/240)	1.6	[0.9, 2.8]	0.14	0.85
Adults adjusted for age and sex								
Skin rash	9%	(13/137)	3%	(4/148)	2.7	[0.5, 15.3]	0.27	0.91
Earache	10%	(18/176)	5%	(10/190)	1.8	[0.8, 3.9]	0.15	0.09
Gastroenteritis	23%	(34/150)	13%	(20/160)	1.7	[0.9, 3.4]	0.12	0.04
Asthma got worse	52%	(11/21)	21%	(5/24)	3.1	[1.2, 4.4]	0.03	0.28†
Respiratory illness	19%	(33/176)	13%	(25/191)	1.4	[0.8, 2.5]	0.24	0.5
One or more injuries	14%	(24/177)	8%	(15/192)	1.8	[0.9, 3.6]	0.07	0.27
Psychological distress	48%	(77/161)	12%	(19/160)	4.1	[2.6, 6.4]	<0.0005	0.01
Adults adjusted for age, sex and psychological distress								
Skin rash	9%	(13/137)	3%	(4/148)	1.9	[0.4, 10.5]	0.45	0.89
Earache	10%	(18/176)	5%	(10/190)	0.9	[0.3, 2.8]	0.86	0.21
Gastroenteritis	23%	(34/150)	13%	(20/160)	1.3	[0.7, 2.6]	0.44	0.06
Asthma got worse	52%	(11/21)	21%	(5/24)	2.8	[0.8, 4.3]	0.1	0.28†
Respiratory illness	19%	(33/176)	13%	(25/191)	1.1	[0.6, 2.2]	0.78	0.38
One or more injuries	14%	(24/177)	8%	(15/192)	1.6	[0.7, 3.4]	0.24	0.33

*   Test for trend in risk with maximum depth of water in feet above the floor of the lowest habitable room (based on flooded individuals only).

†   Risk of worsening asthma was estimated to decrease with increasing depth of floodwater.

were lower for skin rash and earache; and similar for gastroenteritis and respiratory illness. Risk was higher for worsening asthma (RR 3.1 [1.2,4.4] *p* = 0.03) and any category of injury (RR 1.8 [0.9,3.6] *p* = 0.07) (table 2).

Psychological distress, defined as a score of ≥ 4 in response to the 12-item General Health Questionnaire (GHQ-12), was additionally measured in adults. Psychological distress showed a four-fold higher risk in flooded compared to non-flooded subjects and a highly significant increase in risk with flood depth (RR 4.1 [2.6, 6.4] *p* < 0.0005, *p* for trend by flood depth = 0.01) (table 2).

In adults, the risk estimates for physical illnesses declined after adjustment for psychological distress (table 2). However, flooding remained strongly associated with psychological distress after adjustment for age, sex, injury, respiratory illness, earache, gastroenteritis and skin rash (RR 5.4 [2.7, 10.9] *p* < 0.0005, *n* = 207). No significant trend was apparent

for risk of psychological distress by days displaced from home (*p* = 0.32).

The risk of earache, new episodes of gastroenteritis, skin rash and psychological distress were explored further in adults (table 4). This time the variables considered for inclusion in each model included not only age group, sex, psychological distress and the primary exposure variable of having been flooded, but also the secondary exposure variables of interruption of the mains water supply; change in taste, colour or smell of mains tap water supply; and sewage backflow and spillage. Variables which were not positively associated with these illnesses (risk ratio ≤ 1.0) were dropped from the models, whilst variables positively associated with the illness (risk ratio > 1.0) were retained. Age group and sex were retained regardless of their significance in all models. The final models showed significant independent associations between earache and psychological distress (RR 4.1[1.5,10.7] *p* = 0.005) after adjustment

TABLE 3   Injuries sustained following flooding

	Flooded n=227		Non-flooded n=240	
	Number	%	Number	%
Sprain/strain of back or limb	13	6%	15	6%
Broken bone(s)	4	2%	2	1%
Burn or scald	2	1%	1	0.5%
Electric shock	1	0.5%	0	0%
Inhalation of smoke, gas or vapour	2	1%	1	0%
Hypothermia	2	1%	0	0%

for sewage spillage and interruption of the mains water supply; between new episodes of gastro-enteritis and psychological distress (RR 1.9 [1.0, 3.2] $p = 0.05$) after adjustment for having been flooded and having disruption of the mains water supply; and for skin rash with psychological distress (RR 3.3 [1.0, 10.4] $p = 0.04$) after adjustment for being flooded and sewage spillage.

Discussion

The most striking result of our survey was the scale of psychological distress experienced by flooded adults, of whom 48% scored four or more on the GHQ-12 compared to 12% of non-flooded adults nine months after the Lewes flood (RR 4.1 95%CI [2.6,6.4] $p < 0.0005$). Risk was also significantly associated with depth of flooding (p for trend = 0.01). The GHQ-12 is a well-established instrument for measuring psychological distress in adults, which has previously been extensively used in surveys[17].

Risk estimates for physical illnesses in adults declined substantially after adjustment for psychological distress, whereas psychological distress remained strongly associated with flooding after adjustment for physical illnesses. Earache, gastroenteritis and skin rash remained signifi-cantly associated with psychological distress after adjustment for flooding and the secondary household exposures of sewage spillage and altered taste, colour or smell of mains tap water. These observations suggest that the risk of psychological distress from being flooded was independent of reported physical illness and sanitary disruption within flooded households. It is possible that psychological distress may also have been important in children, but it was not possible to measure this. These observations do not however, discount real and important associations between flooding and physical illnesses.

Increased risk of all categories of physical illness with flooding are consistent with past observations including the Bristol and Adelaide studies, although our sample size was insufficient, in most instances, to reach standard levels of significance. Risk estimates

TABLE 4   Variables selected to best model the risk of earache, gastroenteritis and rash in adults

Outcome	Variable	Adjusted risk ratio*	95% CI	p value
Earache (277 in final model)				
	Psychological distress	4.1	[1.5, 10.7]	0.005
	Sewage spillage	1.9	[0.7, 5.4]	0.21
	Water supply interruption	1.6	[0.7, 3.7]	0.28
	Dropped: flooded and changed smell, taste and/or colour of mains tap water			
Gastroenteritis (246 in final model)				
	Psychological distress	1.9	[1.0, 3.2]	0.05
	Sewage spillage	1.4	[0.6, 2.8]	0.39
	Water supply interruption	1.6	[0.6, 3.6]	0.35
	Dropped: sewage spillage and changed smell, taste and/or colour of mains tap water			
Rash (226 in final model)				
	Psychological distress	3.3	[1.0, 10.4]	0.04
	Sewage spillage	1.5	[0.2, 9.8]	0.68
	Water supply interruption	1.2	[0.3, 4.9]	0.78
	Dropped: water supply interrupted and changed smell, taste and/or colour of mains tap water			

*   Risk ratio adjusted for age group and sex, as well as for the variables shown under each health outcome; risk ratio for age and sex are not shown.

were slightly lower in adults compared to those for all subjects (adults and children) except for worsening asthma. The associations for worsening asthma should be viewed with caution because of the very small number of subjects with pre-existing asthma and because the trend with depth of flooding indicated declining risk with increasing depth of flooding. Two flooded subjects reported hypothermia, two inhalation of gas, smoke or vapour and one electric shock. Associations between being flooded and physical illnesses, other than trauma, may reflect exposure to microbiological and chemical contamination in floodwater, flooded environments and chemicals at the time of flooding and/or at refurbishment and cleaning of households in the aftermath of flooding.

We believe our study is the first to use a well-validated psychological measurement instrument and multivariable regression methods to investigate the independent association between psychological and physical health and being flooded. Our findings support the view that psychological distress is a leading adverse health outcome associated with flooding and may explain a proportion of physical illness[9,10]. The experience of physical illness in association with psychological distress is well recognised[18].

The GHQ-12 is a useful screening tool for anxiety and depression[13]. At a cut off of four, the GHQ-12 has a 0.81 positive predictive value for diagnosing International Classification of Diseases version 9 (ICD-9) depression and anxiety in those attending general practice surgeries[13]. Our participants who scored four or more on GHQ-12 therefore represent significant psychiatric morbidity in terms of anxiety and depression. It is unclear whether it was the flooding or events over the following nine months that was the reason for the increased rates of anxiety and depression. If it were the flooding, then our GHQ-12 cases would have been ill for a considerable time. Moreover, we do not know what percentage of those who did not reach psychological distress had suffered from significant anxiety and depression which resolved or was treated by the time of our study. Anxiety and depression, has a major human and economic cost when measured using the disability adjusted life years model favoured by the World Health Organization, but if identified it can be effectively treated with cognitive behavioural therapy or pharmacotherapy[19-21].

The components of the experience of flooding which contribute to psychological distress are probably varied. Flooding is a major life event, and life events, especially those that lead to loss or threat, increase the risk of the onset of a depressive illness[22]. The consequences of the life event are also important for the risk of developing a mental illness; for instance the negative impact of displacement from a stable home environment has been recognised as a stressor[23]. Loss of money, personal property and insurance matters are also important consequences of flooding[10].

A UK population study has demonstrated that financial strain is a risk factor for both the onset and maintenance of common mental disorder[24]. Those who are flooded often wait for months for insurance payments; they may be under insured or have no insurance at all.

We limited our selection of households to those with a recorded contact telephone number. Although the response rate was high in households randomly selected from these lists, it is possible that flooded individuals normally resident at addresses for which no contact telephone number was available may have been worse affected. If present, this bias could result in an under estimate of the true risk of anxiety and depression associated with being flooded in this study.

There was inevitable spatial separation between addresses that were flooded and those that were not, because flooding depends upon elevation (figure 1). We cannot therefore entirely exclude the possibility of other area-based factors such as social support being more prevalent in non-flooded than flooded areas. Relative poverty or unemployment could be area-based factors important in the risk of developing a common mental disorder. However, the British Household Survey failed to find a significant association between baseline poverty and anxiety and depression one year later[24]. We therefore think it is unlikely that area based socio-economic factors could account for the differences in risk of psychological distress between our flooded and non-flooded households.

The response rate from those who were flooded was higher than from those who were not flooded. This is analogous to the generally higher expected participation of cases than controls in case control studies[25]. This may be due to lower motivation from members of reference (here non-flooded) populations. Difference in participation rates between flooded and non-flooded households would not in itself lead to a biased estimate of risk provided the samples from the flooded and non-flooded populations were representative and that disease status was measured equally. Training and standardisation of interviews and the neutral format of questions, including the GHQ-12 instrument, should have prevented major measurement bias. These conclusions are supported by the rates of psychological distress in the non-flooded households being in line with those found in other general population surveys[17].

Loss of life could have been significant if the Lewes flood had occurred at night rather than in the day, or in winter cold when risk of exposure and hypothermia would have been far greater, or if there had been no prior warning and the flood had been greater in magnitude. Such large-scale sudden flooding occurred most recently in the great coastal floods of 1953 with catastrophic loss of life in the lowlands of England and Holland[3,26]. It is also possible that protection in Lewes was afforded by the sound infrastructure and public services available in established market economies[1,6,7].

Quantification of the burden of psychological distress from being flooded from this study suggests that prevention of such distress should be a major objective for minimising adverse health impacts of flooding should flood prevention fail.

This burden should be taken account of together with the more obvious material concerns of provision of emergency services and access to medical care, protection of the integrity of water supply and sewage services, building regulations, business impacts and insurance[4,8,27,28]. The results strongly support major efforts to improve flood protection, flood preparedness and improvements to the operation of the insurance sector by government, (particularly the Environment Agency and the Department of Health) and industry[3,28-30].

Acknowledgements

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