Indicators and trends

Monitoring climate change adaptation

climate change

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Indicator name				**Version**
CRS9 Number of hospital admissions due to extreme weather events				**31/03/16**

Indicator type:	**Risk/opportunity**	**Impact**	**Action**
		X	

SCCAP Theme	**SCCAP Objective**	**CCRA risk/opportunity**
Climate Ready Society	S1: Understand the effects of climate change and their impacts on people, homes and communities S2: Increase the awareness of the impacts of climate change to enable people to adapt to future extreme weather events	HE2: Summer morbidity due to higher temperatures HE6: Decline in winter morbidity due to higher temperatures HE7: Extreme weather event (flooding and storm) injuries

At a glance

- Increased mean winter temperatures may be beneficial with respect to health impacts associated with prolonged exposure to cold.
- The impact of short-term exposure to very low temperature extremes (cold snaps) – hypothermia, cardiac and pulmonary diseases – is unlikely to change.
- Short-term exposure to high temperature extremes (heat-waves) – heatstroke, syncope and fatigue – is likely to increase.
- The warming atmosphere will likely lead to greater precipitation outdoors and higher humidity indoors in winter, the former increasing the likelihood of flood; the latter increasing incidence of respiratory infection and allergic reactions.
- While the number of hospital admissions directly attributable to flooding and other extreme weather events is unlikely to be high (less than 1,000 p.a. from all causes), the effect of these events on society, the environment and the economy will be substantial.

Latest Figure	**Trend**
2013/14 hospital admission figures: Hypothermia: 307 Other exposures to excessive natural cold: 179 Heat stroke and heat exhaustion: 17 Exposure to excessive natural heat: 14 Flooding: 0	The trend in hospital admissions as a result of hypothermia or other prolonged exposures to excessive natural cold is downward. Such admissions are likely to continue to fall with increasing mean winter temperatures. Hospital admissions as a result of heat: No meaningful trend as the absolute numbers are too low.

High winds and storms: 1	There is no meaningful trend currently for injuries (and deaths) from storms and floods. The combined number of hospital admissions from these sources has not exceeded 10 since 2000/01.

Why is this indicator important?

One of the direct effects of climate change on public health will be changes in the mortality and morbidity rates associated with exposure to extreme weather events. This indicator considers morbidity, measured in terms of changes in the number of hospital admissions associated with a range of health conditions related to specific weather events.

Extreme weather events include floods, high winds and storms and extreme cold (including impacts of ice and snow), as well as extreme heat (including drought and heat-waves). Future changes in climate will almost certainly alter the frequency of extreme weather events and their severity.

A significant increase in mean summer temperature is likely in the second and third reference periods (2050/2080) with an increase in heat-related hospital admissions. In the shorter term, there may be localised effects in certain urban building types as a result of the urban heat island effect. Incidents of extreme heat at or exceeding the temperatures of the 2003 heat-wave are projected to become more common. On the other hand, increasing mean winter temperature may be potentially beneficial (HR Wallingford, 2012), leading to a decline in winter morbidity. At the same time, increased precipitation and (less certainly) storm intensity is anticipated (see Patterns of Change below) with consequent injuries from flooding, high winds and storms. In general the decline in hospital admissions in winter due to increasing mean temperature is likely to be offset by the increase in admissions in summer due to extreme heat by the second reference period (2050s).

The findings have implications for climate change health adaptation policies. Different Health Boards will be affected differently, depending on the vulnerability of their catchment to different weather events. At the moment, this is best understood for flood risk as a result of SEPA’s hazard maps, the resolution of which continues to improve with each release. However, the numbers are (very) low – less than 1,000 admissions per annum in total for all morbidity and injury. Health protection measures including advice and guidance and treatment strategies will need to be developed to respond effectively and efficiently to a change in risk (UK Government, 2008; Scottish Government, 2008; Scottish Government, 2011; NHS Health, 2010; Hames & Vardoulakis, 2012). We would expect the priority to be commensurate with the perceived public health risk; disruption of service from extreme weather events is considered elsewhere.

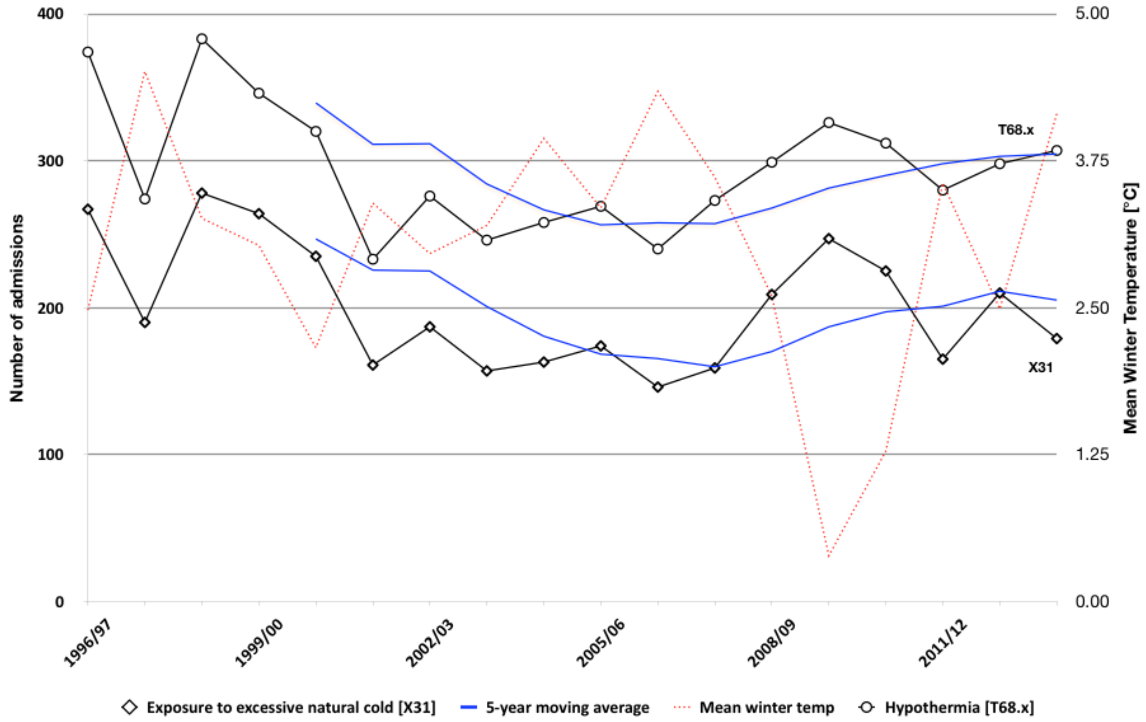
Scottish Morbidity Record 01 [SMR01] captures general acute inpatient and day case episodes at the time of transfer or discharge using the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10).* This provides a systematic, internationally understood classification scheme for recording diseases. For this indicator ICD-10 codes have been grouped into six categories. These codes are further described in *Methodology*. Other ICD-10 codes are introduced in the narrative for reference.

Related indicators:
CRS8: Excess deaths due to extreme temperatures
CRS54: Off-grid water supplies at risk of flooding
CRS61: Number of households in fuel poverty.

What is happening now?
The number of hospital admissions associated with extreme weather events can be broken into three groups across which the number of hospital admissions are two orders of magnitude apart. The first is associated with extreme cold where the number of admissions for exposure to excessive natural cold (ICD-10 code X31) is in the hundreds annually, with 179 cases in 2013/14[1]. Hospital admissions due to hypothermia (T68.x) are also in the hundreds with 307 reported cases in 2013/14, 122 of which were the direct presenting symptom while the remaining 185 were secondary conditions. The second group is associated with heat related admissions covering both heatstroke/exhaustion and other effects, primarily syncope (T67.1) and cramp (T67.2). There were 17 admissions as a direct result of heatstroke/exhaustion (T67.0, T67.3, T67.4 and T67.5) and 14 for other causes (T67.1, T67.2 and T67.7). The third group is associated with flooding and cataclysmic storm[2] where hospital admissions are even lower. Admissions as a direct result of injury sustained through flooding (X38) were zero in 2013/14. There was one admission in 2013/14 as a result of an injury sustained directly in a cataclysmic storm (X37).
What has happened in the past?
Hospital admissions as a result of exposure to excessive natural cold (X31) have been falling slowly over the last eighteen years (Figure 1): admissions in 2013/14 were a third less than 1996/97. The extremely cold winters in 2009/10 and 2010/11 established an upward trend that is still apparent in the 5-year moving average. A very similar pattern emerges for admissions for hypothermia (T68.x) over this same period (Figure 1).

[1] Injuries sustained from exposure to excessive natural cold include exposure to weather conditions; chilblains; immersion and other non-specific exposures to cold.

[2] *Cataclysmic Storm* is ICD terminology, defined to include hurricane, tornado, blizzard, tidal wave (due to storm and due to landslide) and other or unspecified storms.

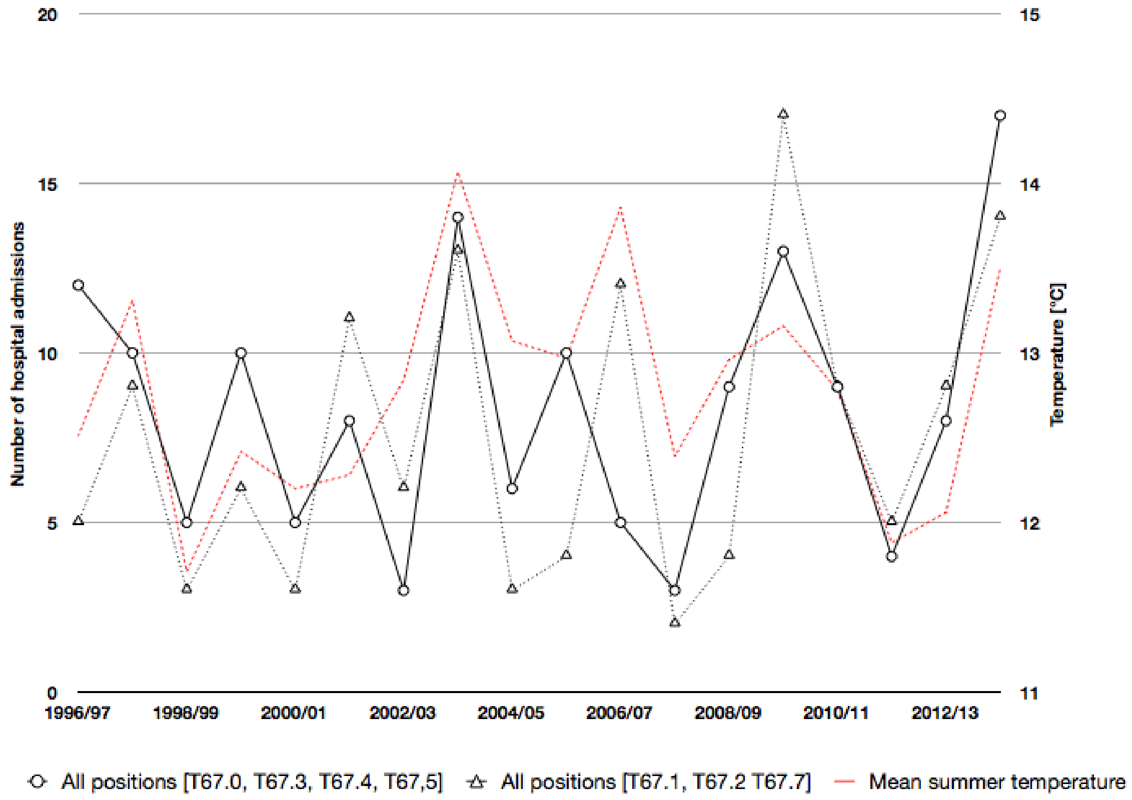


(derived from NHS SMR01 data[3])

Figure 1: Hospital Admissions for Exposure to Extreme Cold (X31) & Hypothermia (T68.x) 1996-2013

The number of hospital admissions for heatstroke/exhaustion (T67.0, T67.3, T67.4 & T67.5) has been reasonably constant over the last eighteen years from 1996, averaging 8 against a peak of 17 in 2013/14 and a minimum of 3 in 2002/03 and 2007/08 (Figure 2).

[3] www.ndc.scot.nhs.uk/National-Datasets/data.asp?SubID=2



(derived from NHS SMR01 data[4])

Figure 2: Heat-related Hospital Admissions 1996 - 2013

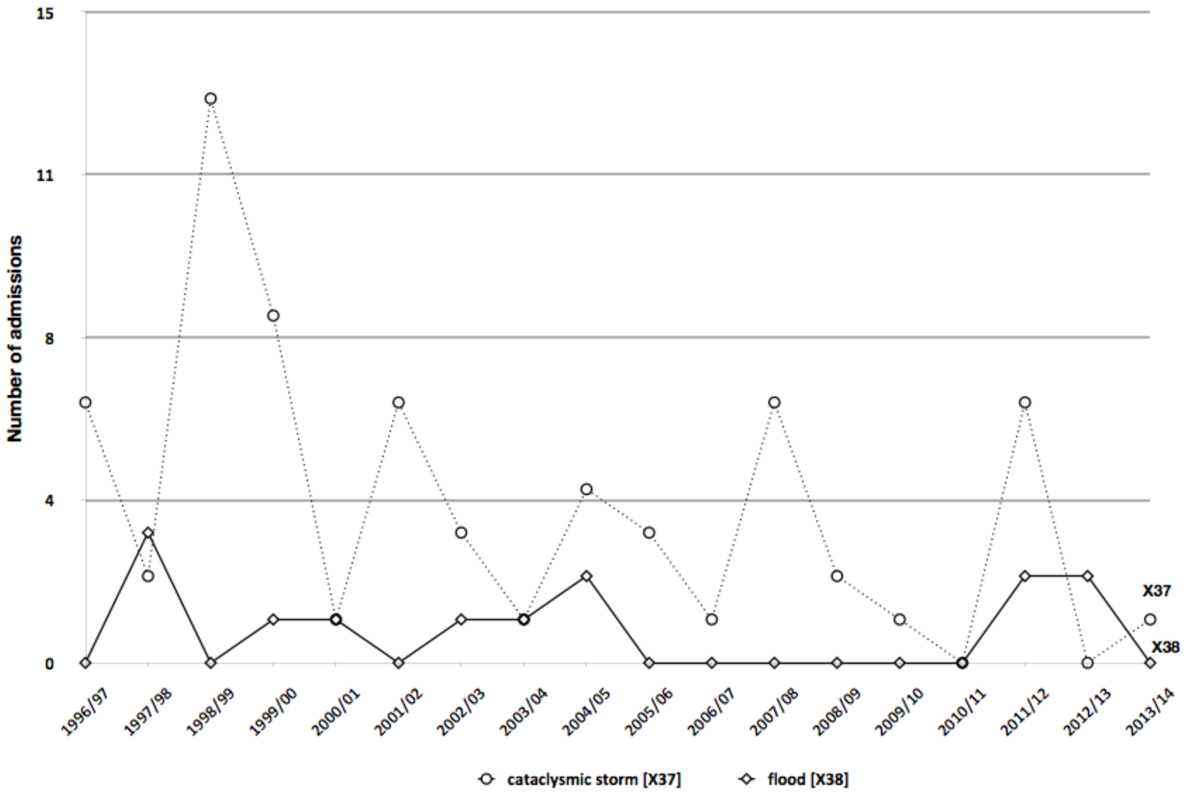
A similar pattern emerges for other heat related exposures (T67.1, T67.2 & T67.7) – syncope, cramps and fatigue (Figure 2). The highest numbers of admissions for both series have occurred in the last 5 years

Hospital admissions from cataclysmic storm (X37) are generally less than ten annually (Figure 3). The storm in early January 1998 injured 13 and caused damage estimated at over £300M, a fraction of the £1.4Bn estimated damage from the extratropical cyclone in October 1987 or the £2bn of damage caused by the Burns Day Storm in 1990[5].

Hospital admissions as a direct result of injuries sustained in a flood [X38] are even lower, a maximum of 3 having been recorded in any one of the last twenty years and a total of 13 over the entire time series (Figure 3).

[4] www.ndc.scot.nhs.uk/National-Datasets/data.asp?SubID=2. *All Positions* includes those situations where heat effects are considered as a subsidiary cause for admission.

[5] Wikipedia http://en.wikipedia.org/wiki/List_of_European_windstorms :: http://en.wikipedia.org/wiki/Great_Storm_of_1987.



(derived from NHS SMR01 data[3])

Figure 3: Hospital Admissions due to injuries from flood & cataclysmic storm 1996-2013

What is projected to happen in the future?

The risks associated with prolonged exposure to excessive cold – the most significant cause of extreme weather hospital admissions - are likely to decrease. Higher temperatures in winter will result in a reduction in cold-related deaths (premature deaths avoided) and a reduction in hospital admissions for respiratory and cardiac disease. Higher temperatures are also likely to lead to less reliance on heating, helping to alleviate fuel poverty (see indicator *CRS61 Number of households in fuel poverty*). The risks associated with people's ability to adapt to sudden cold snaps such as those in the winters of 2009 and 2010 remain, leading to on-going cardiac and pulmonary incidents and of (some cases of) hypothermia, where there is little time to adapt to sudden changes in temperature.

While summer temperatures similar to those seen in the 2003 UK heat-wave will likely become more common, excessive heat is not considered a significant climate change risk in the current assessment. In Scotland, 100 heat-related (premature) deaths per year are estimated by 2050 based on projections of population growth and 200 by the 2080s: "these projected increases in deaths are very small in relation to the number of deaths likely for all causes in any particular year" (HR Wallingford, 2012). Projected increases in mean summer temperature may also have some impact on public health as a result of elevated levels particulates [$PM_{2.5/10}$] and tropospheric ozone with corresponding deterioration in air quality although these effects may be mitigated by less frequent temperature inversion. Impacts on health and well-being from increased temperatures indoors are likely to be highly localised (urban heat island effects). Some increase in allergic response to elevated of dust mites can be expected.

More intense although less frequent storms (Slingo et al, 2014) and more frequent heavy rainfall events[6] increase the likelihood of injuries (and deaths) from airborne and waterborne hazards. The projections on storminess are highly uncertain though (Met Office, 2010; Hartmann 2014).

Patterns of change

In June 2013, Scotland's population was 5.3 million. This is projected to rise by 9% over the next 25 years to around 5.78 million by 2037 although there will be distributional differences (NRS, 2014). The demographic trend is to an older population across all local authority regions with an additional 300,000 citizens of pensionable age overall, with the largest increases in West Lothian (+47%) and the Shetland Islands (+44%). Policy will therefore need to consider the effects of temperature on older urban and rural populations.

Changing climate is very likely to alter the frequency, intensity, spatial extent, duration and timing of extreme weather events.

Mean annual winter and summer temperatures are expected to continue to increase for all regions under all emissions scenarios during each of the three 30-year reference climate periods to 2080. The distributional differences range quite widely (CXC, 2015; UKCP09, 2009[7]). Wetter and milder winters are likely with maxima for the central estimate of between 24% (North) and 30% (West) more precipitation by the third reference period (2080) of the A1F1 (high emissions) scenario with a maximum increase of nearly 4°C (A1F1, 2080, p.0.9) in the coolest day expected in the South. By contrast hotter, drier summers are likely with increased temperatures in the range of 5.9°C (North) to 6.8°C (South) again at the high end (A1F1, 2080, p.0.9) with a mean summer temperature for the central estimate somewhere in the 18°C and 22°C range across the country with 9% less precipitation in the North and perhaps as much as 20% less in the South.

Data from and cited by the Met Office and the Centre for Ecology and Hydrology following the floods and storms during the winter of 2013 suggest the likelihood of rising sea levels, contributing to both coastal and fluvial flooding; increasing intensity, but not frequency of strong winter cyclones; and more frequent heavy rainfall events (Slingo et al., 2014).

Historically, Met Office data shows that there has been a slight increase in average annual precipitation in all regions of the UK between 1961 and 2006, however this trend is only statistically significant above background natural variation in Scotland where an increase of around 20% has been observed. The best evidence available at the moment for considering the detail of the differential and distributional impacts is based on the flood hazard maps created by SEPA whose resolution continues to improve with each release (SEPA, 2009). No equivalent evidence exists for the other extreme weather events under consideration here.

Changes in weather patterns will likely have mixed outcome with respect to morbidity and injury associated with extreme weather events: increases as a result of some (heat) being offset by decreases in others (cold). Quantifying that impact will be difficult not least as adaptive capacity will be increasing at the same time as the effects of environmental change are being felt. Further, differential and distributional impacts (east/west splits in particular) will require different regional responses in NHS service planning and delivery (Health Protection Scotland, 2012).

[6] More than 25mm in 24 hours

[7] http://ukclimateprojections.metoffice.gov.uk/23894?emission=low : http://ukclimateprojections.metoffice.gov.uk/23894?emission=high

Data sets are complete, given that the National Health Service implements a standardised recording system. However, low numbers of cases and high variability mean that the data are unlikely to gain the level of statistical evidence usually acceptable for trends and relationships (i.e. low statistical power) unless effect sizes are very large. Even so, the impact on society, the environment and the economy is likely to be very substantial indeed.

Interpretation of indicator trends

The total number of hospital admissions directly attributable to flooding and other extreme weather events is very likely to remain low (less than 1,000 p.a. from all causes).

Extreme Cold

The number of hospital admissions as a result of exposure to excessive natural cold and hypothermia is currently of the order of hundreds, a figure that has been reasonably constant over the last 20 years (standard deviation [σ]= 43). The average of mean winter temperatures over the same period has been around 3°C, although mean winter temperatures are likely to rise over the three 30 year reference periods to the end of the century (UKCP09, 2009).

Extreme cold can result in respiratory infection, increased blood pressure and a greater incidence of coronary and cerebral thrombosis. The optimum temperature for both old and young groups when sitting and wearing 1 clo[8]. of insulation is 21.1°C ± 2.9°C. A *satisfactory heating regime* – broadly in the range 18°C - 24°C (see Methodology) – must be maintained to ensure that the indoor climate is optimal with respect to warmth and relative humidity (Bytchenko & Giroult, 1987).

Indoor temperature above 15°C is considered to be sufficient to prevent secondary infections following colds and influenza. With air temperatures below 15°C cardiovascular reflexes can lead to changes in heart rate and blood pressure and an increase in cardiovascular strain, the more pronounced the lower the temperature falls. Additionally, platelet and red blood cell concentrations and viscosity increase when exposed to mild surface cooling for longer than an hour, which may explain the marked increase in coronary and cerebral thrombosis, which occur in the first few days after a cold period (Keatinge et al., 1984, cited in Bytchenko & Giroult, 1987).

Body temperature drops to hypothermic level (35°C) within 7 hours in an ambient temperature of 10°C and within 4 hours in an ambient temperature of 5°C. Adaptation through repeated exposure to cold particularly amongst the elderly is unproven although there is evidence of adaptation when induced by significant repeated falls in body core temperature.

Many of the adverse health effects on the elderly are also apparent in the young with increased risk of asthma in children and hypothermia in the very young. The significance of hypothermia in the elderly and whether it is a cause or effect of cold related illnesses is difficult to assess. *Secondary* hypothermia is generally the more common cause of hospital admissions amongst the elderly, which is not always directly related to the temperature of a dwelling (Collins & Exton-Smith, 1983, cited in Bytchenko & Giroult, 1987).

In sub-zero outdoor air the temperature of the respiratory airways can fall, impairing the function of the bronchial epithelium and encouraging respiratory infection. Cold is also seen to be a primary cause of exercise-induced asthma in young people (Deal et al., cited in Bytchenko & Giroult, 1987).

[8] A unit of clothing insulation based on heat transfer rate equivalent to 0.155 K m^2/w, the same unit of measure used for insulation in construction

In the 18°C - 24°C range, a relative humidity between 20% and 70% is regarded as being compatible with health although, at the upper end, mould growth will be sustained once it has started, increasing the risk of respiratory and allergic reactions. At low and moderate temperatures, variations in atmospheric humidity have little influence on thermal exchanges and are unlikely to contribute significantly to thermal stress at normal indoor temperatures in Europe.

High relative humidity encourages the growth of house mites that cause allergic reaction in asthma sufferers. The occurrence of mites is partly related to water vapour content of indoor air, with concentrations highest in situations where humidity is above 40% at 22°C.

Projected increases in mean winter temperature should see reductions in hospital admissions associated with cold-related health risks over the medium (2050) to long (2080) term.

Extreme Heat

Scotland has no agreed temperature or temporal threshold values defining heat-waves[9] nor any standard definitions of heat-related health outcomes, with significant gaps in epidemiological evidence on the health effects of excessive heat events.

People are likely to be able to adapt to long-term, gradually increasing temperatures so hospital admissions attributable to excessive heat - both heat stress and heat stroke - generally follow sudden rises in ambient temperature. Extreme heat increases physiological demand on cardiac function and those with renal disease are particularly vulnerable. In many cases sustained night-time temperature is more important in terms of adverse health impacts than maximum day-time temperature. These impacts are frequently exacerbated in urban areas due to the urban heat island effect, 34% of Scotland's population lives in *large urban* areas with a population of 125,000 or more[10].

The extended growing season – five weeks longer than in 1961 on average in all regions (Sniffer, 2014) - lead to elevated allergen levels (pollen, spores) increasing the incidence of asthma (ICD10 J45), vasomotor and allergic rhinitis (ICD10 J30) and hay fever and other non-specific allergies (ICD10 J78.4).

Increased *indoor* temperature may lead also to elevated levels of dust mite allergens.

Flood and Storms

The number of hospital admissions due to injury from flooding or as a result of high winds and storms is practically negligible. This is likely to remain the case although the evidence on projections of storminess is uncertain.

The projected rise in sea-level will likely lead to increased incidence of flooding at the coast while increased precipitation is likely to result in increased pluvial and fluvial flooding more generally. Flooding will likely increase the risks of mould and algal and fungal growth, exacerbating respiratory diseases, particularly asthma (HM Treasury, 2012).

Some evidence for increased storm intensity (Slingo et al., 2014) is at odds with Met Office storm projections (Met Office, 2010) and IPCC AR 5 (Hartmann et al., 2014). Any increase in the intensity of storms, particularly winter cyclones, is likely to result in higher levels of injury not least as a result of airborne debris although this has a high level of uncertainty (Slingo et al., 2014).

[9] In England the threshold for a heat wave is defined by the Met Office as a 'daily maximum temperature grater than 30°C (greater than 32°C for inner London) and a minimum night-time temperature grater than 15°C over most of the area for at least five consecutive days'.

[10] Scottish Government Urban Rural Classification: www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification and associated datasets www.gov.scot/Publications/2014/11/2763/downloads

Summer wind speeds for the reference period centred on 2050 (p.0.5) show little or no increase at all for any region, while winter wind speeds are "quasi-symmetric about near zero change" of ± $0.7ms^{-1}$ (A1F1, p.0.5), equivalent to around 1 knot change in the observed values of 10-14 knots over the Lowlands and 18-24 knots in the Highlands (Sexton & Murphy, 2010).

A significant increase in Injuries therefore looks unlikely even allowing that this type of injury is likely to be under-estimated due to under-reporting (Health Protection Scotland, 2012).

Mental Health
More importantly perhaps we have very little understanding of the psychological impacts of flooding and the consequences of storms. Disruption due to extreme weather and indeed the threat of this type of disruption can contribute to a range of psychological impacts associated with (a) acute events - stress resulting from floods, for example - and (b) sub-acute events - aggression associated with overheating - and (c) long term environmental change - anxiety about the (inter-generational) effects of climate change. While the impacts are reasonably well understood in general terms, there is a distinct lack quantitative evidence (SMR04 in the Scottish context) and qualitative evidence where it exists tends to be localised and anecdotal (Scottish Flood Forum). There is a growing recognition of the importance of mitigating both the mental health risks and mental health impacts of EWEs (Bourque and Cunsolo Willox, 2014; Kovats and Hajat, 2008). Indicator CRS43 considers mental health episodes resulting from extreme weather events. However, data held in the Scottish Morbidity Record 04 (SMR04) - the mental health inpatient and daycare dataset - is incomplete and relatively little research has been undertaken to date – see also *Limitations (8)* below.

Other events
No consideration of air pollution or UV radiation is included in the CCRA (Scotland) or, therefore, the SCCAP; the following observations are made though.

Increased incidence of chronic respiratory diseases associated with elevated particulate levels will depend in part on the effectiveness of the Government's existing Air Quality Strategy (AQS) governing the control of 8 'priority pollutants' (DEFRA, 2007a; and 2007b). AEA's report in 2010 shows a downward trend in the number of times thresholds were exceeded across Scotland. The Department of Health consider longer term mean concentrations of NO_2 and SO_2 are unlikely to increase (Loader et al., 2010). Scottish Government's strategy Cleaner Air for Scotland was published in November 2015 (Scottish Government, 2015)

Tropospheric ozone exposures are more problematic as a 'transboundary' air pollutant requiring international intervention to prevent ozone increases. Annual mean and daily mean maximum ozone concentrations are likely to increase until 2030 resulting in increased incidence of asthma (ICD10 J45 and J46) and COPD (ICD10 J44). On the other hand, a decrease in the frequency of occurrence of temperature inversions where warmer air traps colder air near the ground may result in an improvement in air quality - $PM_{2.5/10}$ and tropospheric ozone (if trans-boundary impacts are discounted) - reducing the incidence of asthma (ICD10 J46) and chronic obstructive pulmonary disease (COPD) (ICD10 J44) (Loader et al., 2011).

The health impacts of wildfires will be considered as part of the long term wildfire risk assessment for Scotland when available.

Limitations
Low numbers of admissions and weak, though statistically significant, correlation between environmental and behavioural factors in health impacts is a challenging investigative criterion:

indicator interpretations should be regarded as indicative rather than conclusive. Increasing effort is addressing this current knowledge gap and developing an evidence base to understand the potential impacts of climate change on health and well-being (see for example the work of the Centre for Environment and Health).[11]

NHS ISD Scotland is not able to provide seasonal data for extreme weather events, as the numbers are low and would increase the risk of disclosure.

ICD-10 coding at the time of discharge/transfer could capture the climate context for disease and injuries attributable to these phenomena.

No data have been identified that would facilitate a meaningful analysis of hospital admissions as a result of increases in UV radiation (sunlight). This impact however is absent from both the CCRA (Scotland) and the SCCAP.

No consideration of the impact of extreme weather events, particularly excessive natural heat, on food contamination is included here[12]. A new agency Food Standards Scotland [FSS][13] was established in April 2015 with a remit that includes the impact that climate change and responses to it may have on food security, nutrition and food safety as well as the role of food and food waste as a driver of climate change. A suite of indicators will be derived from the FSS Strategic Plan, which is expected in 2016.

No consideration of the impact of climatic change (increased temperature) on vector-borne diseases is included here. Health Protection Scotland reviewed vulnerability to a number of the most likely vector-borne diseases in 2008. Their risk assessment of the occurrence of those transferred by (different species of) mosquito bite[14] was low based on the predicted relatively small rise in ambient temperature in Scotland, noting however that this assessment should be continuously reviewed based on surveillance data. An increase in tick-borne illnesses including Lyme Disease transmitted through the pathogen *Borrelia burgdorferi* and the more serious tick-borne Encephalitis [TBE] is likely "to result from changes in land management and leisure activities" (Reid, 2008).

The impact of extreme weather events on public supplies of drinking water and recreational water is considered in the cross cutting 'water' theme. The impact of extreme weather events, particularly flooding, on private water supply is considered in Indicator *CRS54: Off-grid water supplies at risk of extreme weather events*.

Access to primary care level data through the Practice Team Information (PTI) system would be valuable in understanding localised impacts of extreme weather events.

Our understanding and knowledge of the psychological impacts of extreme weather events is very poor (Bourque & Willox, 2014; Vardoulakis & Heaviside, 2012); where it does exist it tends to be modelled data (Hames & Vardouliks, 2012) or anecdotal in nature (Reacher et al., 2004).

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[11] Centre of Environment & Health www.lwec.org.uk/activities/environment-health

[12] campylobacter, listeria, salmonella, verocytotoxin producing *E. coli* (VTEC), *E.coli O157* (haemolytic uraemic syndrome)

[13] www.food.gov.uk/about-us/new-scotland

[14] Malaria, West Nile Virus, Eastern Equine Encephalitis, Chikungunya Fever and Dengue Fever

More generally, there are multiple gaps in the knowledge/evidence base for public health impacts of climatic change and extreme weather events in Scotland (Health Protection Scotland, 2012).

References

Bourque, F & Cunsolo Willox, A. (2014). Climate Change: the next challenge for public mental health? *Int. Rev. Psychiatry*, August 2014, 26(4): 415-422.

Bytchenko, B & Giroult, E. (1987) *Health impact of Low Indoor Temperatures*. Report on a WHO Meeting, Copenhagen, WHO Regional Office for Europe, November 1985. Available at: http://whqlibdoc.who.int/euro/ehs/EURO_EHS_16.pdf

CXC (2015) Patterns of Change: Extreme Weather Events (Scotland). Internal Briefing Paper.

DECC (2015) *Average wind speed deviations from the long term mean*, available at: www.gov.uk/government/statistics/energy-trends-section-7-weather

DEFRA (2007a) *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Volume 1*, available at: http://archive.defra.gov.uk/environment/quality/air/airquality/strategy/documents/air-qualitystrategy-vol1.pdf

DEFRA (2007b) *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Volume 2*, available at: www.gov.uk/government/uploads/system/uploads/attachment_data/file/69337/pb12670-air-quality-strategy-vol2-070712.pdf

Hames, D & Vardoulakis, S. (2012) *Climate Change Risk Assessment for the Health Sector*. DEFRA GA0204, H.R. Wallingford, Wallingford, Oxfordshire.

Hartmann, D.L., A.M.G. Klein Tank, M. Rusticucci, L.V. Alexander, S. Brönnimann, Y. Charabi, F.J. Dentener, E.J. Dlugokencky, D.R. Easterling, A. Kaplan, B.J. Soden, P.W. Thorne, M. Wild and P.M. Zhai, 2013: *Observations: Atmosphere and Surface. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA; available at: https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter02_FINAL.pdf

Health Protection Scotland (2012) *Scoping Report on Public Health Activities in Scotland related to Extreme Weather Events and Climate Change*, Health Protection Scotland, March 2012

HM Treasury (2012) *UK Climate Change Risk Assessment: Government Report*. January 2012. Available at: www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report

HR Wallingford (2012) *A Climate Change Risk Assessment for Scotland*, DEFRA Project Code GA0204, January 2012. Available at: http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=15747

Loader, A., Sneddon, S., Willis, P., Stevenson K & Yardley, R (2011) *Air Pollution in Scotland 2010*, AEA 2011, available at: www.scottishairquality.co.uk/assets/documents/reports2/309110404_AQ_scot_14_lowres.pdf

Met Office (2014) *Key Findings Summary Spreadsheet*, available at http://ukclimateprojections.metoffice.gov.uk/21708?projections=23832

Network Rail (2014) *Route Weather Resilience and Climate Change Adaptation Plans Scotland*, Network Rail, September 2014.

NHS Health Scotland (2010) *Climate Change Adaptation Consultation*, available at: www.healthscotland.com/documents/4537.aspx

National Records of Scotland [NRS] (2014) *Population Projections for Scottish Areas*; available at: http://www.nrscotland.gov.uk/news/2014/population-projections-for-scottish-areas and www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/population/population-projections/sub-national-population-projections/2012-based

Reacher, M., McKenzie, K., Lane, C., Nichols, T., Iversen, A., Hepple, P., Walter T., Laxton, C & Simpson, J. (2004) Health impacts of flooding in Lewes: a comparison of gastrointestinal and other illnesses and mental health in flooded and non-flooded households. *Commun Dis Public Health* 2004, 7(1): 1-8.

Reid, M. (2008) The Potential Health Effects of Climate Change in Scotland. *Journal of the Royal Environmental Health Institute of Scotland*, 20(1): 5-13.

Scottish Government (2008) *Public Health etc. (Scotland) Act 2008*, available at: www.gov.scot/Resource/0039/00398162.pdf

Scottish Government (2011) *Health and Well-being Sector Action Plan*, available at: www.gov.scot/Topics/Environment/climatechange/scotlands-action/adaptation/AdaptationFramework/SAP/Health

Scottish Government (2015) *Cleaner Air for Scotland*; available at: http://www.gov.scot/Resource/0048/00488493.pdf

SEPA (2009) Flood Risk Management (Scotland) Act 2009. *Appraisal Method for Flood Risk Management Strategies*. Available at: www.sepa.org.uk/flooding/idoc.ashx?docid=4681bff4-8111-4e10-905a-b2d114ff5045&version=-1

Slingo, J., Belcher, S., Scaife, A., McCarthy, M., Saulter, A., McBeath, K., Jenkins, A., Huntingford, C., Marchs, T., Hannaford, J. & Parry S (2014) *The Recent Storms and Floods in the UK*, Met Office and The Centre for Ecology and Hydrology. Exeter, 2014. Available at: http://www.metoffice.gov.uk/media/pdf/1/2/Recent_Storms_Briefing_Final_SLR_20140211.pdf.

Sniffer (2014) *Scotland's Climate Trends Handbook*, available at: http://www.environment.scotland.gov.uk/climate_trends_handbook/index.html

Transport Scotland (2009) *High Wind Strategy and National Wind Management Guidelines*, available at: www.transportscotland.gov.uk/sites/default/files/documents/rrd_reports/uploaded_reports/j10783/j10783.pdf

UKCP09 (2009) Jenkins, G., Perry, M. & Prior J. *The Climate of the United Kingdom and Recent Trends*. Hadley Centre, Met Office, Exeter. Available at: http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87933&filetype=pdf.

UK Government (2008) *Climate Change Act 2008*, available at: www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf

Vardoulakis, S & Heaviside C (Eds) (2012) *Health Effects of Climate Change in the UK 2012 – current evidence, recommendations and research gaps*. Health Protection Agency, September 2012. Available at www.gov.uk/government/uploads/system/uploads/attachment_data/file/371103/Health_Effects_of_Climate_Change_in_the_UK_2012_V13_with_cover_accessible.pdf

WHO Working Group (1984) *The Effects of the Indoor Housing Climate on the Health of the Elderly*. Report on a WHO Working Group, Copenhagen, Document ICP/BSM 002 (3), WHO Regional Office for Europe, 1984.

Further information

Department of Health (2010) *Climate Change Plan*, available at: http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/documents/digitalasset/dh_114995.pdf

Scottish Morbidity Record 01: General acute inpatient and day case dataset, available at www.ndc.scot.nhs.uk/National-Datasets/data.asp?SubID=2

Scottish Morbidity Record 04: Mental Health inpatient and day care dataset, available at http://www.ndc.scot.nhs.uk/Data-Dictionary/SMR-Datasets//SMR04-Mental-Health-Inpatient-and-Day-Case/

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Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	CRS9 – Number of hospital admissions due to extreme weather events
Indicator contact: Organisation or individual/s responsible for the indicator	ClimateXChange
Indicator data source	NHS Information Services Division (ISD)
Data link: URL for retrieving the indicator primary indicator data.	Data request from NHS ISD.

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	1996 – 2013, no gaps
Frequency of updates: Planned or potential updates	On-going, on patient discharge or inter-departmental transfer
Spatial coverage: Maximum area for which data is available	Scotland
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	Attribution to climate signal is weak.
Spatial resolution: Scale/unit for which data is collected	Scotland
Categorical resolution: Potential for disaggregation of data into categories	Potentially to Scottish region - North, West and East - although concerns over deductive disclosure given the relatively low absolute numbers involved.
Data accessibility: Restrictions on usage, relevant terms & conditions	Publicly available, free of charge

Table 3 Contributing data sources

Contributing data sources
Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.

NHS ISD SMR01. Extract date 15 January 2015. Ref: IR2015-00012

Table 4 Indicator methodology

Indicator methodology

The methodology used to create the indicator data

Statistics are derived from data collected on discharges from non-obstetric and non-psychiatric hospitals (SMR01) in Scotland. Only patients treated as inpatients or day cases are included. The specialty of geriatric long stay is excluded. Data are based on date of discharge, a category that includes inter-departmental transfer.

These figures are episode based - an SMR01 episode is generated when a patient is discharged from hospital but also when a patient is transferred to a different hospital, significant facility, specialty or to the care of a different consultant.

Up to six diagnoses (one principal diagnosis and five secondary diagnoses) may be recorded per hospital episode, using the International Classification of Disease Codes, Tenth Revision (ICD-10). The main diagnosis position was used to identify cases in the 'Main Position' column and all six diagnostic positions were used to identify the relevant cases in the 'Any Position' column. The following codes were used in the analysis:

ICD-10 Code(s)	Description
T67.0	Heatstroke and sunstroke
T67.1	Heat syncope
T67.2	Heat cramp
T67.3	Heat exhaustion, anhidrotic
T67.4	Heat exhaustion due to salt depletion
T67.5	Heat exhaustion, unspecified
T67.7	Heat fatigue, transient
X30	Exposure to excessive natural heat
X31	Exposure to excessive natural cold
X37	Victim of cataclysmic storm
X38	Victim of flood
T68.X	Hypothermia

A *satisfactory heating regime* is defined as:

- For "vulnerable" households[15], 23°C in the living room (zone 1) and 18°C in other rooms (zone 2), for 16 hours in every 24.
- For other households, this is 21°C in the living room (zone 1) and 18°C in other rooms (zone 2) for 9 hours a day during the week and 16 during the weekend.

The WHO (Bytchenko and Giroult (1985)) further qualify this definition with a requirement for air movement of less than 0.2 ms^{-1}, a relative humidity of 50% and a mean radiant temperature within 2°C of air temperature.

[15] Vulnerable households are those with an occupant over 60 or long-term sick or disabled.