

Climate change and mental health: a causal pathways framework

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Abstract

Objectives Climate change will bring more frequent, long lasting and severe adverse weather events and these changes will affect mental health. We propose an explanatory framework to enhance consideration of how these effects may operate and to encourage debate about this important aspect of the health impacts of climate change.

Methods Literature review.

Results Climate change may affect mental health directly by exposing people to trauma. It may also affect mental health indirectly, by affecting (1) physical health (for example, extreme heat exposure causes heat exhaustion in vulnerable people, and associated mental health consequences) and (2) community wellbeing. Within community, wellbeing is a sub-process in which climate change erodes physical environments which, in turn, damage social environments. Vulnerable people and places, especially in low-income countries, will be particularly badly affected.

Conclusions Different aspects of climate change may affect mental health through direct and indirect pathways,

leading to serious mental health problems, possibly including increased suicide mortality. We propose that it is helpful to integrate these pathways in an explanatory framework, which may assist in developing public health policy, practice and research.

Keywords Climate change · Mental health · Public health · Adaptation

Introduction

Our world is facing potentially catastrophic climate change (Intergovernmental Panel on Climate Change 2007) and this has the capacity to damage human health in multiple ways (Costello et al. 2009). Human life has evolved within a temperature, humidity and solar radiation environment that has not varied much over thousands of years; we, and the flora and fauna with which we share our planet, have limited capacity to adapt to rapid or extreme climatic changes (McMichael 1993). However, as climate science advances, it is becoming evident that we may have to prepare for dramatic changes, mostly for the worst (McMichael et al. 2006b). We have begun to consider some of the ways in which our health may be affected: our greatest challenges may come from lack of food and drinkable water, wider spread of certain vector-borne diseases and increased heat exposures (McMichael et al. 2004). However, little consideration has been given to how climate change may affect mental health, perhaps due to its ‘neglected’ (Horton 2007) status as the poor relation of health (Hickie 2002). Although it is important not to pathologise normal psychological reactions to adversity and disaster (Horwitz and Wakefield 2007), we do need to consider the mental health implications of climate change

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and why this aspect of health has received so little attention. The aims of this paper are to highlight the importance of the possible impacts of climate change on mental health and to propose a framework for better understanding on how climate change may affect mental health.

Climate change and health

The latest evaluation by the Intergovernmental Panel on Climate Change (2007) has concluded that greenhouse gases from human activity are a major cause of continuing global climate change. Global temperature will increase, perhaps between 1.8 and 4.0°C, by 2100 (Intergovernmental Panel on Climate Change 2007), depending on which actions are taken to mitigate greenhouse gas emissions. This will mean more variable and extreme weather conditions (mainly extremely hot or violent weather but, in some places, also extremely cold weather). It is essential to note that estimates of average global climate change mask the variability of impacts and extremes that some locations will experience (Kjellstrom 2009a). For instance, in Cairo and Athens, at 4.8 and 5.3°C per century, respectively, temperatures are rising more rapidly than the global average (Fig. 1).

Extreme heat exposure will be associated with substantial fatalities and injuries (Kovats and Hajat 2008), particularly where other extreme weather events also occur, such as floods and droughts (Huq et al. 2007). Cases of diarrheal and vector-borne diseases, and famine, will increase with rising temperatures (Intergovernmental Panel on Climate Change 2007; McMichael 2003); and increasing temperatures in combination with high air humidity will lead to heat exhaustion, heat stroke and fatalities during heat waves, especially among the elderly (Kovats and Hajat 2008) and among younger people undertaking heavy labour (Kjellstrom 2009b). An important concern is that the effects of climate change may be stronger for those

populations at socioeconomic disadvantage (Commission on Social Determinants of Health 2008) exacerbating the already inequitable distribution of health challenges (Friel et al. 2008), particularly among indigenous peoples (Salick and Byg 2007).

Climate change and pathways to mental health

Mental health is a key component of the World Health Organization's (WHO) definition of health as 'a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity' (World Health Organization 1948). More elegantly and pragmatically, mental health may be considered a person's ability to think, to learn, and to live with his or her own emotions and the reactions of others (Herrman 2001). The first definition views mental health as a stable state of positive wellbeing while the second more properly implies a dynamic continuum. Mental health problems are part of this continuum of mental health. They differ in their causes, symptoms, effects and treatment, but are all characterized by alterations in thinking, mood or behavior, and associated distress or impaired functioning. Some mental health problems are uncommon (such as schizophrenia, other psychoses, bipolar disorder and some anxiety and personality disorders), some are common (including depression and other mood disorders, some anxiety disorders, psychological distress, substance use and eating disorders, dementia and other forms of cognitive decline), and all may be severe and/or enduring (Berry et al. 2007a).

Different types of extreme weather events appear to relate to somewhat different mental health impacts, particularly at onset. The link between extreme anxiety reactions (such as post-traumatic stress disorder, or PTSD) and acute weather disasters, such as floods (the most common disasters at global level), forest fires, heat waves and cyclones, is

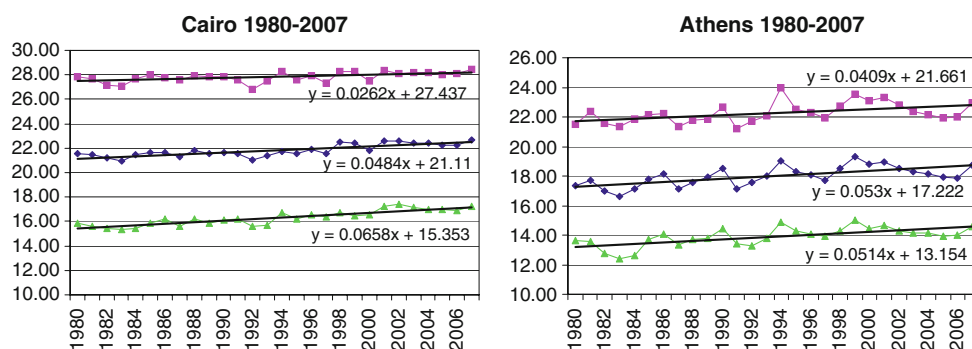


Fig. 1 Temperature (°C) time trends in two cities, Cairo and Athens, based on the daily weather station data, and including linear regression equations (from Kjellstrom and Lemke, unpublished). Each plot shows annual average of daily averages; middle line is

average temperature, and the other two lines are averages of maximum and minimum temperatures in daily data for each year; the equations describe the fitted linear trend as change per year, since 1980: $x = \text{year} - 1980$, $y = \text{temperature}$

well established (e.g. [Salcioglu et al. 2007](#)), as are the emergency and other response procedures that are deployed when they occur. However, not much research has been conducted into their long-term effects. However, long-term anxiety and depression, as well as PTSD, increased aggression (in children) and perhaps even suicide, have been found to be associated with floods ([Ahern et al. 2005](#)).

There is almost no quantitative epidemiological evidence for the mental health effects of sub-acute weather disasters, such as long-term drought ([Berry et al. 2008](#)). But it may be expected that the same loss of people, property and possessions, dislocation from community and disruption of key social connections that precede or amplify the development of mental health problems following acute disasters would apply in response to chronic disasters of equivalent magnitude. Symptomatology related to chronic loss and failure, such as helplessness depression, chronic psychological distress and generalized anxiety may be expected ([Coelho et al. 2004](#)). This is because, commonly, these mental health problems develop following multiple adversities ([Brugha and Cragg 1990](#)), and slow-creeping climate change-related weather events, such as drought, tend to accumulate adversities.

[Fritze et al. \(2008\)](#) have also proposed that climate change will have significant mental health implications noting the psychological distress and anxiety about the future that may result from acknowledging climate change as a global environmental threat. They describe the immediate (direct) mental health impacts of climate change: the disruptions that vulnerable communities, in

particular, face with regard to the social, economic and environmental determinants of mental health; and the future distress and anxiety that climate change may create on an individual level ([Fritze et al. 2008](#)).

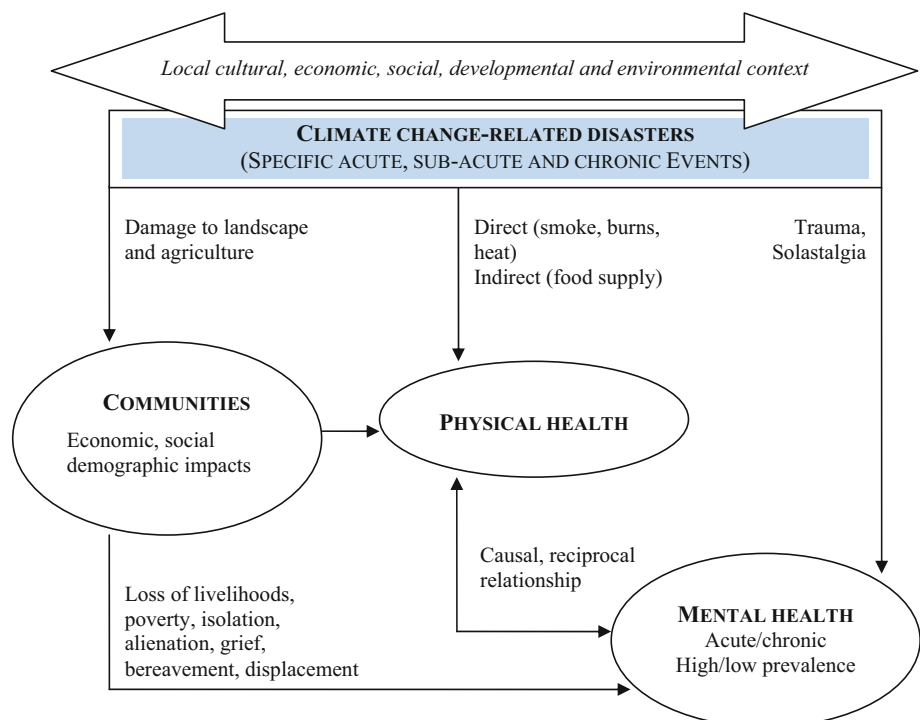
[Berry et al. \(2008\)](#) and [Fritze et al. \(2008\)](#) concur that climate change will have both direct and indirect effects on mental health but there is, currently, no integrative framework to guide research or policy making. Figure 2 illustrates putative direct and indirect relationships among factors. Climate change may affect mental health directly by exposing people to the psychological trauma associated with higher frequency, intensity and duration of climate-related disasters, including extreme heat exposure ([Kjellstrom 2009a](#)), and also by destroying landscapes, which diminishes the sense of belonging and solace that people derive from their connectedness to the land ([Higginbotham et al. 2007](#)). In addition, indirect effects may occur via two further pathways. Climate change may affect (1) physical health, through increased heat stress, injury, disease and disruption to food supply, and (2) community wellbeing, through damage to the economic and, consequently, the social fabric of communities.

Direct effects of climate change on mental health

Acute weather events

Most research into the mental health impacts of weather events has concentrated on acute events such as,

Fig. 2 Framework showing putative causal pathways linking climate change and mental health



earthquakes, floods, fires and hurricanes, and associations with the onset of PTSD. Because climate change is associated with an increase in the frequency and severity of these acute weather events, people will be increasingly exposed to the precursors of PTSD—danger, injury and death, including harm to significant others. Consistent with pathways models of mental health, PTSD is sensitive to a range of exposure and predisposing social and emotional factors, with young people particularly vulnerable (Salcioglu et al. 2007). In addition to the development of severe anxiety disorders, traumatic exposures can also cause reactions ranging from general somatic and mental health problems, followed by resilient recovery to several types of enduring, severe psychopathology (Norris et al. 2002), as well as loss of resources (Freedy et al. 1994) and substantial psychological distress (Beaudoin 2007; Wickrama and Wickrama 2008).

Extreme heat events will be especially common as global temperatures rise and these events may also be associated with a general increase in aggression (Anderson and Anderson 1998). Increasing temperatures (especially lengthy spells of hot weather) have been associated with higher rates of criminal and aggressive behavior (Brearley 1929; Cheatwood 1995; Cohn et al. 2004) and higher suicide rates (Maes et al. 1994). Extreme heat events may also be linked to suicide and psychiatric and other hospital admissions. In a recent meta-analysis, Bouchama et al. (2007) concluded that pre-existing mental health problems tripled the risk of any-cause mortality during a heat wave. In Adelaide, Australia (Nitschke et al. 2007), heat wave-related hospital admissions increased for mental and behavioral disorders, including organic illnesses, dementia, mood disorders, anxiety, stress-related and somatoform disorders, disorders of psychological development and senility (Hanson et al. 2008). A related issue is the physical and psychological exhaustion caused by extreme heat exposure (Parsons 2003), which will be a more common feature of already hot regions of the world (Global Humanitarian Forum 2009). Humidity has also been associated with mental functioning. For example, it is related to poorer concentration and elevated fatigue (Howarth and

Hoffman 1984). However, the relationships among heat, humidity and mental health may be sensitive to local context or confounded by research methods (Berry et al. 2008). For instance, decreasing temperatures have also been associated with increasing aggression (Howarth and Hoffman 1984), suggesting perhaps that significant temperature deviations up or down from local norms may be related to increasing mental health problems.

A recent review of the mental health impacts of climate change in rural and remote Australia identified an urgent need to understand the likely consequences of climate change (particularly drought and long-term drying) on mental health and wellbeing (Berry et al. 2008). The review drew attention to a spectrum of chronic to acute (fast onset) climate change-related adverse weather events (see Table 1): acute events include heat waves, floods, storms and fires, while drought is an example of a sub-acute event. Long-term underlying drying and warming are chronic events. The occurrence of such events is associated with increased mental health problems. In emergencies generally, the number of people with mental disorders is estimated to increase by 6–11% (World Health Organization).

Sub-acute weather events

Climate change will also be associated with an increase in sub-acute adverse weather events, most notably with more frequent, longer and more severe periods of extreme heat and/or drought. At its worst, this may dislocate people permanently from their land, creating cohorts of displaced persons who will experience depression and trauma (Campbell and Campbell 2007; Haq et al. 2007) associated with loss of home, place and social networks (McMichael et al. 2009). The IPCC has estimated that there may be 150 million such displaced persons by 2050, due primarily to coastal flooding, shoreline erosion and agricultural degradation. In addition to too little (or too much) rain, rain may fall outside the periods in which it is needed for particular agricultural purposes, especially for cropping, exacerbating the underlying difficulties associated with inadequate

Table 1 Nature of weather events (acute vs. chronic) and putative pathways to effects on mental health (direct vs. indirect)

	Acute weather event (e.g. increased frequency of cyclones)	Sub-acute weather event (e.g. more extremely hot days, droughts)
Direct effects on mental health	More frequent exposure to physical danger due to storms or floods; elevated rates of acute anxiety disorders	More frequent exposure to chronic stress, e.g. from long periods of extremes of heat or lack of (clean) water; elevated rates of violence and aggression
Indirect effects on mental health	More frequent and/or severe damage to homes and physical infrastructure, including community buildings (halls, churches, schools); physical injury to self or significant others; elevated rates of anxiety and mood disorders	More frequent and/or severe physical health impacts and damage to livelihoods and soft social infrastructure (disruption of networks, lack of time to socialize); elevated rates of chronic mood disorders and suicide ideation and attempts

precipitation (Intergovernmental Panel on Climate Change 2007).

Heat exposures in working environments are of great significance: they reduce people's capacity to undertake physical (Bridger 2003; Kerslake 1972; Kjellstrom et al. 2009d), mental task capacity is diminished (Ramsey 1995) and the risk of accidents is increased (Ramsey et al. 1983). The primary cause of these effects is excessive core body temperature (Leithead and Lind 1964); dehydration due to inadequate fluid intake while sweating is also important (Schrier et al. 1970). The loss of work capacity due to increasing heat exposure while working (particularly outdoors) and resulting loss of income (Kjellstrom 2009b) is also likely to cause mental health problems for many millions of people.

Indirect effects of climate change on mental health

Impacts via physical health

Physical health problems are causally and reciprocally associated with the development of mental health problems (Miller et al. 2009; Prince et al. 2007), particularly among vulnerable groups, such as older people (Katz 1996) and indigenous people (Berry 2009). Mental health problems are among the risk factors for communicable and non-communicable diseases, increasing the likelihood of their development. The reverse is also true with: for example, obesity has been associated with increase in depression, bipolar disorder and panic disorder (World Health Organization 2009).

Impacts via the physical environment

Long periods of high temperatures, heat and drought-related events (such as fires) can be expected to increase, as can flood and related events (such as landslides). These will be accompanied by consequential environmental risk factors, such as increased smoke, pollen density, dust (McMichael et al. 2006a) plant disease, and infestations. The quality and availability of water for human and livestock consumption may be compromised, with possible increases in water-borne disease (Rose et al. 2000). In developing countries, which will endure the bulk of adverse climate change, many people may be forced from land that they can no longer farm into urban slums (UN Habitat 2006); here, the additional heat exposures due to climate change and the indirect health risks (such as extended lack of clean drinking water) are much greater than in other parts of cities (World Health Organization 2008b). These threats to physical health will directly affect mental health and also compound the underlying risks to

mental health inherent in living in urban slums (Berry 2007).

Environmental relationships to health have often been narrowly articulated in terms of biophysical conditions (Horwitz et al. 2001). There is, also, an important relationship between sense of place, the environment and human wellbeing, sometimes expressed as 'biophilia' (Gullone 2000; Wilson 1984) and 'solastalgia' (Higginbotham et al. 2007). Biophilia describes the relationship between humans and their environmental conditions, while solastalgia describes the distress, the loss of solace, caused by degradation of the environment, home and sense of belonging.

Climates everywhere are characterized by daily and seasonal variations and we are acclimatized to these; but climate change-induced increases in climate variability will not be spread evenly across the day or the year. Instead, there will be increased extremes. This will increase the variability in climate-related mental health problems. For example, seasonal variation in mood has already been documented, with seasonal affective disorder, depressive symptoms, bulimia nervosa, anxiety disorders and other mental health problems usually peaking in the cold season when there is limited sunlight (Magnusson 2000). Where the climate warms, seasonal affective disorder may reduce somewhat, while it may be exacerbated in regions that receive fewer hours of sunlight. Periods of drought in rural areas over spring (a significant time for agricultural production) are associated with a reduction in life satisfaction (Carroll et al. 2009) and more of these shifts in the timing of droughts can be expected (Berry et al. 2008).

Impacts via the social environment

In communities dependent on agricultural production (which are more common in least developed countries and among Indigenous peoples; Agriculture Food Organization 2008), climate change may, in some cases, particularly in vulnerable places and among vulnerable populations reduce agricultural productivity and the viability of agricultural support industries. For example, extreme heat exposure in farm fields reduces agricultural laborers' work capacity (Kjellstrom et al. 2009d), further undermining agricultural support industries which include local businesses and services and employment brokers for casual labor (Berry et al. 2008). These losses create socio-economic hardship and subsequent poor mental health (Dohrenwend 1990; Faris and Dunham 1939; Hollingshead 1958; Leighton 1965; Srole 1962). In Australia, in the drought period from 2002 to 2003, GDP growth fell 1.0 percentage point, with gross value added falling by 28.5% compared with the preceding year (Australian Bureau of Statistics 2004). Natural disasters cost Australia A\$37.8b

between 1967 and 1999. All, but A\$5b (earthquakes) of these losses were attributable to climate factors (Intergovernmental Panel on Climate Change 2007). In long-term drought, specifically, deterioration in economic conditions over time has been associated with depression and demoralisation among parents (Conger et al. 1992) and their children. Indeed, it has been proposed that socioeconomic circumstances may be a more potent source of vulnerability to poor mental health than is the rural setting itself (Judd et al. 2002; Smith et al. 2008). Drought-prone areas are vulnerable to chronically lower socioeconomic status and educational attainment than are other areas and, consequently, to higher levels of distress and learned helplessness (Coelho et al. 2004).

Importantly, economic pressures undermine social capital that is protectively related, possibly causally, to mental health and wellbeing (De Silva et al. 2005; Sartorius 2003; Whitley and McKenzie 2005). Social capital is a combination of community participation and social cohesion, with higher levels of social capital related to better health (particularly where there are high levels of inequality), and especially to mental health (Berry and Welsh 2009); where increased workloads and lack of time and money-keep people from social activities, particularly from the informal social connections that are so important for mental health (Berry et al. 2007b), or place pressure on important relationships, mental health problems are likely to increase. Women may be particularly affected, being more likely than are men (Alston and Kent 2004; Stehlik et al. 2000) to migrate for employment or for their children's education with consequent impacts on family wellbeing.

The importance of the social impacts in indigenous peoples and on those living in tropical low and middle-income countries is highlighted by the examples in Appendix.

Impacts via adaptation or mitigation

Adaptation and mitigation actions may, in themselves, increase climate change-related mental health risks via various causal pathways. For example, reduced car travel by car-reliant populations would, desirably, reduce greenhouse gas emissions and, possibly, increase physical activity. For those who may stop driving to work, instead walking or cycling, there could indeed be very substantial co-benefits for chronic disorders, such as obesity and cardiovascular disease (Besser and Dannenberg 2005; Frank et al. 2004). However, travel by alternative means, whether these are public transport, walking or cycling, may, for some people, increase travel time; where this were the case, commuters would have less time to spend at work or, perhaps more likely, at home, reducing the time available to engage with family and friends. Given that time devoted

to informal social connectedness is very strongly protectively related to mental health (Berry and Welsh 2009), increasing travel time would be related to adverse impacts on mental health. Further, as those who are most disadvantaged tend to have least access to services, such as transport, this would differentially be a disadvantage those in most need (Currie et al. 2009). Adaptation also poses health risks. For instance, when air conditioning is not available, excessive heat exposure at work may require working less in the hottest parts of the day, thus reducing daily output. For low-paid workers, especially in developing countries where occupational health systems may provide only limited protection (Kjellstrom and Hogstedt 2009), this may translate to reduced income. To compensate, these workers may find it necessary to increase their work hours, or to work more at night, with negative implications for their health (Harrington 1994) and for family life.

The role of the health system in preventing or reducing effects

Not much is being done to address physical health needs and even less to address mental health concerns relating to climate change and this is not surprising. The neglect of mental health is reflected in the inadequate level of resources made available for mental health services (Horton 2007) and also in the poor resourcing of mental health research (Jorm et al. 2002). Mental health resources are 'inadequate, insufficient and inequitably distributed' (Horton 2007 p. 806), a situation that has been called a 'silent scandal' (Thornicroft 2007). Mental health resources are catastrophically inadequate in low-income countries, which have 0.05 psychiatrists and 0.16 psychiatric nurses per 100,000 people, as compared to 200 times more in high-income countries (World Health Organization 2009). Despite strong evidence for expanding mental health services and integrating them into primary health care (Horton 2007), especially in responding to climate change (Blashki et al. 2009), worldwide, the majority of people (between 32 and 97%) usually do not receive any treatment at all for a wide range of mental health problems (Thornicroft 2007). Perhaps, there are some understandable reasons for this. It is fair to acknowledge, perhaps, that the complexity of mental health may account for why greater consideration is given to physical health. Maybe there is also a genuine lack of understanding about the importance of mental health and its interdependence with physical health (Horton 2007). Substantial continuing worldwide stigma (and associated exclusion and discrimination) linked to mental health (Sartorius 2007) may also contribute to this research and policy aversion. As Horton

(2007) writes: 'Despite the great attention western countries pay to the mind and human consciousness in philosophy and the arts, disturbances of mental health remain not only neglected but also deeply stigmatised across our societies' (p. 806).

Yet mental health is a major and growing global concern (Prince et al. 2007), likely constituting the second greatest burden of non-fatal disease by 2030 (Mathers and Loncar 2006), and we cannot ignore it. Within the mental health system, a graded spectrum of approaches, ranging from prevention and early intervention to treatment, is needed to properly respond to mental health needs from onset through recovery, especially for indigenous peoples. The WHO's pyramid (World Health Organization 2008a) for an optimal mix of services for mental health identifies an appropriate range: from self-care and informal community care; through mental health services via primary health care; community mental health services; and the most intensive interventions at the treatment end of the spectrum (long-stay facilities and specialist services). This pyramid is relevant and can be adapted to the needs of climate change-related mental health problems.

Conclusions

The debate about the impact of climate change on human health has, very recently, included consideration of mental health. By increasing the frequency, severity and duration of adverse weather events, climate change will affect mental health via at least three pathways. It will, first, directly affect mental health by inflicting more and worse natural disasters on human settlements which, typically, cause serious anxiety-related responses and, later, chronic and severe mental health problems. Second, it will increase the risk of injury and physical health problems which are causally and reciprocally related to mental health. Third, it will endanger the natural and social environment on which people depend for their livelihoods and wellbeing. These effects will not be felt equally by all, but will fall disproportionately on those who are already vulnerable, especially on indigenous peoples and those living in developing countries, which will bear the brunt of adverse climate change. The present paper proposes a framework showing direct and indirect pathways via which climate change may affect mental health.

The health system, broadly defined, must play an important role in identifying possibilities for preventive actions that reduce population vulnerability, and in acting to support people whose mental health has been affected. Health systems that meet WHO climate change guidelines and achieve the millennium development goals can do much to limit the health effects of climate change.

A continuum of approaches is appropriate, depending on the stage of illness, ranging from prevention through treatment and recovery. We hope that our proposed framework may encourage further debate, and contribute a perspective that may assist in the formulation of policy and services for the impact of climate change on mental health.

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Conflict of interest statement The authors have no conflicts of interest to declare.

Appendix

Two case studies illustrating how climate change may affect societal and demographic factors that may, in turn, affect mental health security

Increasing heat exposure on working people in tropical countries

There is a physiological limit to the ability of humans to carry out strenuous work in hot conditions (air temperatures above 37°C and at high humidity level). To prevent heat stroke in such conditions, workers have to reduce their work output and avoid working during the hottest part of the day. Increasing heat exposure may, therefore, reduce income, disrupt daily social activities and create psychological distress. For example, we have observed work situations at construction sites in India and shoe factories in Vietnam where the long actual working hours and heat exposure (requiring lengthy rest periods during the hottest hours) demand 15–16 h of daily presence at the workplace (Kjellstrom et al. 2009d). Increasing temperatures with climate change would make this situation worse.

Drought and long-term drying in Australia

Australia's Bureau of Meteorology has concluded that the severity of the recent drought, 2001–2007, was, in part, due to the underlying warmer temperatures caused by climate change (Nicholls and Collins 2006). The recent Kenny Review of the Social Impact of Drought in Australia (Drought Policy Review Expert Social Panel 2008) has described the increased hardships that have been experienced in rural lifestyles: livelihoods are at stake, and those who are most vulnerable, geographically or socioeconomically, appear to be worst affected. The stresses of lost income, debt and damage to property have spilled over into

mental health problems for some and to the tragedy of despair and suicide for a few (Berry et al. 2008). The severity and distribution of these mental health problems appear, also, to have been influenced by aspects of community—resources, cohesion, resilience and external supports; where community support has been strong, communities appear to have fared better than where less support has been available.

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