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Impact of Climate Change on Medical Emergency Incidents and Responses

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Abstract

Climate change has and will create new patterns of emergency incidents and burden the existing patterns. These patterns will be created by the predicted changes in meteorological and hydrological disasters, particularly extreme events. At the most direct level, extreme events are more likely to cause death and injury, and it is possible to predict what changes in the incidence of various health outcomes would occur. An example of prediction methodology is using the change in the incidence of heat-related health outcomes as a function of the magnitude and timing of climate change. Heat and/or sudden changes in temperature levels are more complex to predict the effect, yet the increased variance of greater frequency and intensity of high-temperature events will cause a higher incidence of acute events such as myocardial infarction and chronic events with rapid decompensation such as decompensated heart failure. Temperature change can also amplify the severity of many of today's most common disasters. An example of this is the predicted increase in flash floods due to the increased incidence of heavy rainfalls and convective rainstorms, which are often associated with a rapid rise in local precipitation and can cause catastrophic damage to life and society. Wildfire is another health-damaging event that is certainly set to increase in incidence, being very dependent on temperature and soil moisture. This event is predicting the change in the global distribution of wildfires and possible health outcomes. Yet, it is widely known that the effects in many MEDCs will burden the resources of local health services without having to consider global impacts. An example of this is wildfires in Southern France. It is known to cause mass respiratory casualties, yet the lack of studies means it is unclear as to the exact consequences and proper allocation of prehospital care.

Climate change is increasingly recognized as an important aspect of human health because the health of communities is affected by physical, chemical, and biological changes. These changes impact systems, communities, and individuals differently. The impacts are distributed in geographical areas that are already burdened by disease and poor health. This study attempts to understand a range of

impacts of climate change on medical emergency incidents and responses in terms of epidemiology, changes in the location and frequency of various emergencies, and the consequences of prehospital care. Paris and the remainder of France are used as case studies due to the presence of detailed databases and the range of climate seen in this one country.

Keywords: *Climate change, medical emergency.*

Introduction

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Global warming is one aspect of climate change and is often used interchangeably with the term climate change. However, global warming refers to only the Earth's rising surface temperature, while climate change includes changes in temperatures and precipitation, as well as the effects of global warming. Scientists have shown that the planet's climate can change naturally in a very short space of time. Ice core samples taken from Greenland have shown that in the space of 50 years, the temperature can decrease by 15°C and then increase by 20°C in just a few decades. Climate change has and will always continue to happen with or without man's intervention. For example, the discovery of the remains of tropical plants in the ice on Greenland has suggested that at one point, Greenland was once very warm. So why is it a concern now? The current rate of warming is much quicker than most events in the past, and there is no indication that it will slow down. The cause of the rapid increase is most likely due to the impact of humans. Today, many things we do are, to put it simply, bad for the environment. The use of fossil fuels has shown to be the largest contributor to the increase in greenhouse gases. The three main gases are carbon dioxide, methane, and nitrous oxide, which trap heat in the lower atmosphere, enhancing the greenhouse effect. A number of other factors have shown to increase global warming, such as the destruction of forests. In the last 50 years, human populations have doubled, and demands for resources have tripled. Forests are being cut or burned to make way for development. The decay of the wood releases CO2, and without trees to absorb the gas, there is an increase in the greenhouse effect. Peat, which is partially decayed plant material from waterlogged areas, is also a huge store of carbon, and draining the water causes the peat to dry, decay, and release CO2. The increase in farming has also raised the amount of nitrous oxide released by soil. This has all led to a prediction made in 1992 that if emissions continue to increase at the rate they are, then global temperatures would be somewhere between 1.9 and 5.2°C higher in 2100. This is extremely important to make clear—it is not just a matter of hotter weather. An increase in temperature can cause a change in climate and alter weather patterns, changes which could be catastrophic for the planet. (Lasher et al.2020)

1.1. Definition of climate change

Climate change is normally the increase in temperature in the Earth's lower atmosphere, which can be measured with a high level of accuracy from the middle of the 20th century. This being a rise of 0.6 ± 0.2 degrees Celsius. This has caused changes in global weather and climate patterns, and there is now greater scientific consensus and understanding that this will continue further.

The above definition of climate change is important and relevant to this study because it gives a broad view of the topic of climate change. It doesn't just define climate change as being man-made but also mentions natural causes. This is important to note as the study into

climate change and weather-related incidents is to decide what impact climate change has or has not had on increasing these events. An examination into this may help us determine the actual causes of these events.

Climate change is the alteration in Earth's climate over time. This change can be brought on naturally or by human activities. It is usually a change in weather patterns, which are manifested by certain characteristics and weather-related phenomena. These include a shift in temperature, usually to higher levels. Climate change can be identified by changes in seasons, amount of rainfall, frequency of weather-related events, and their strength. Climate change is different from usual weather patterns in its amount of activity and the time at which the change occurs. Climate change can be catastrophic. Research from the World Health Organization and World Meteorological Organization has suggested that it could lead to a loss of life greater than deaths from infectious diseases. (Gaythorpe et al.2020)

1.2. Importance of studying its impact on medical emergencies

In order to mitigate and prevent any increase in negative health outcomes due to acute weather events, it is vital to understand what the changes in risk are, which elements of the population are most at risk, and what current systems are in place to deal with these eventualities.

Weather significantly affects human health by changing patterns of disease. Climate change may also affect an individual's medical decision making and therefore their risk of complications or death. Understanding how climate and weather influence emergency health issues can allow for better coping/adaptation strategies. This information is important for anticipatory resource allocation from both an emergency services and public health perspective.

There are many resources and funding given to the study of how climate change impacts human health in a broad sense. However, little is known about how increasingly frequent acute weather events affect the prevalence and type of emergencies seen in the community and the subsequent needs for emergency services and health systems.

2. Climate Change and Medical Emergency Incidents

Before examining the ways in which climate change can affect medical emergency incidents, it is important to define what constitutes a medical emergency in this context. It can be described as an acute episode of illness or injury that is severe or life-threatening, with sudden onset or rapid progression, requiring urgent intervention in order to prevent serious health implications. The need for urgent medical attention forms the basis of the incident's response in this context, which involves providing out-of-hospital or hospital care in order to treat the illness or injury. This may involve a medical procedure, simple advice, or information giving with the aim to prevent further injury, illness, or trauma. Given that this is a broad term, for the purpose of this work, the acute health impacts of climate change on the incidence and emergency response to specific diseases and injuries will be considered. (Watts et al.2021)

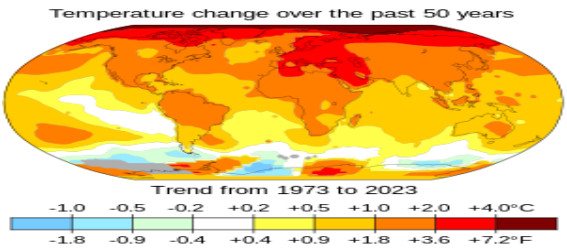
Human-induced climate change and global warming are now widely accepted as major threats to human health and well-being. There is increasing evidence to show that the Earth's climate is changing more rapidly now than at any other time in recent centuries. This is having a potentially serious impact on human health, particularly in lower income countries, through more extreme weather events and changing distributions of climate-sensitive infectious diseases. In developed countries, while the direct health impacts of climate change are more modest, they are still significant, occurring through effects such as more frequent and intense heatwaves, flooding, and wildfires. (Baker et al.2022)

2.1. Increase in heat-related illnesses

Impact of heat-related illnesses on the community Heat-related illnesses have a significant impact on the health sector and on the community as a whole. As the severity of heat-

related illnesses ranges from mild to fatal, they account for a large number of deaths. The 2009 heat wave in Victoria resulted in a 62% increase in the daily number of deaths. To measure the impact of non-fatal heat-related illnesses, a study in Adelaide examined the number of ambulance attendances for heat stress to estimate the overall increase in morbidity. On the hottest days, the rates of ambulance attendances for heat stress increased by as much as 17 times compared with days of average temperature. This demonstrates that increased temperatures result in an increase in the incidence of heat-related illnesses. The increase in demand from both mortality and morbidity due to the effect of climate change on heat-related illnesses will have flow-on effects to other areas of the health sector. This includes an increase in demand for primary care, pharmaceuticals, and hospital services. It will also require interventions to minimize the impact of heat on vulnerable populations, with particular emphasis on the elderly and those from lower socioeconomic backgrounds. (Espinosa et al., 2020)

Definition of heat-related illness With the predicted temperature increase, there is an expectation that the incidence of heat-related illnesses will increase in Australia. Heat-related illnesses occur on a spectrum with the less severe end including heat stress and heat fatigue, and the more severe end resulting in heat stroke and death. There are two types of heat-related illnesses: classic and exertional. Classic heat-related illnesses occur when an individual is exposed to high environmental temperatures and is unable to dissipate metabolic heat. This inability to dissipate heat results in a rapid rise in body core temperature. Classic heat-related illnesses primarily affect the elderly and young children, as well as those with pre-existing illnesses. In comparison, exertional heat-related illnesses occur when an individual is participating in physical activity. The onset of these illnesses is often rapid and they can occur in fit and healthy individuals. With the expected increase in temperature and the likelihood of more extreme heat events, the incidence of both classic and exertional heat-related illnesses is likely to rise.



2.2. Changes in vector-borne diseases

Several important diseases are considered to be vector-borne diseases: malaria, dengue fever, yellow fever, Japanese encephalitis, and bancroftian filariasis. All are transmitted via vectors such as mosquitoes and flies, with the exception of the "kissing bug" that transmits Chagas' Disease. Life cycles of vectors are heavily influenced by the environment, particularly by temperature and precipitation. Development rates, survival, and biting rates of mosquitoes and other insects are highly temperature-dependent. As a result, minor increases in temperature can have major impacts on transmission of these diseases. A recent effort to estimate the effects of climate change on a range of infectious diseases suggests that by the 2050s, an additional 2-3 billion people will be put at risk of dengue fever. Models developed for the impact of climate change on malaria suggest a wide range of outcomes. Malaria in Africa is expected to decrease significantly due to the expected drying and warming of the continent. Warmer temperatures will allow transmission in areas that are currently just below the transmission threshold, but also shorten the lifespan of the Anopheles mosquito, thus reducing the total amount of transmission. In South Africa, temperature increases are expected to allow transmission in areas that are currently too cold and malaria is likely to increase in the highland regions. Outside of Africa, malaria is expected to increase and large populations in the highland regions of Asia will be put at risk. (Lansbury and Crosby2022)

2.3. Impact on respiratory conditions

Next, in terms of weather patterns that greatly affect the occurrence of respiratory problems, flooding and aeroallergens are of significant quality. Flooding is increasing in many areas, whether it be from an increase in rainfall or

increased severity of tropical cyclones. When there is flooding, especially when accompanied by river overflow, there is increased growth of mold in houses, which can have serious effects on children's respiratory health. The WHO has shown that an increase in allergic and asthma-type respiratory problems were significantly greater in children exposed to moldy dwellings during a flood in the USA. This can have irreversible effects when taking into account the impact of childhood respiratory problems on adult lung function. High and sustained levels of mold over many diseases will vastly increase the prevalence of asthma and allergy sufferers and also cause increased risk and incidences of other respiratory diseases.

The number of people suffering from asthma in the whole world is right around 15 million, with some countries experiencing an increase in the rate of tenfold. This can drastically impact public health costs and also the economy to a certain extent. Epidemiological studies have shown that the incidence of symptoms of asthma and allergies are closely associated with specific weather changes. For example, increases in the amount of rainfall can stimulate the growth of indoor biological pollutants, which can exacerbate allergies and asthma. An increase in temperature can also increase levels of ground-level ozone and other air pollutants that are linked to serious health problems. Longer ragweed pollen seasons and higher CO2 levels can aggravate asthma symptoms and other respiratory conditions. Finally, more frequent dust storms, a symptom of changing weather patterns, can pose serious health risks to people with respiratory problems. One study in Taiwan related to the prevalence of asthma in school children and another comparing children in Poland had both found significant increases with certain symptoms of weather change. Long-term changes in climatic conditions can have real effects on the spread and incidence of respiratory problems. (Bloom et al., 2022)

3. Climate Change and Emergency Response Systems

To understand the potential impact of climate change on emergency response, it is critical first to understand the nature of the challenges. When climate change influences an increase in the frequency and severity of natural disasters, there will be a subsequent increase in the demand for emergency response due to the fact that climate change relates to an increase in vulnerable communities and infrastructure. Additionally, higher temperatures can directly cause an increase in certain types of emergencies, such as heatstroke. Extreme weather events lead not only to more moving of medical materials, but also to more of a need to supply medical care for emergency responders themselves who are affected by the conditions. All of these factors increase the demand for emergency response services and increase the complexity of the tasks required to respond. Emergency responders are likely to face an increase in the severity and frequency of the types of situations that they are already facing, combined with a higher frequency of situations that are unfamiliar or more difficult to manage. This places a significant amount of stress on emergency response systems that are already facing limited resources and funding.

3.1. Challenges faced by emergency responders

Challenges of working as a responder: The report "The Impact of Climate Change on Emergency Medical Service in Fujisawa City" states that medical responses operate under specific conditions which press the importance of time and transportation. The ability of EMS to effectively deliver care under changed climate conditions in which incidents are increasing is contingent on the ability to adapt to the new conditions and maintain effective interventions. Whether the impacts are indirect (such as needing to respond to a flood evacuation center to care for an increase in skin infections) or whether they are responding to a direct climate-change related medical problem, EMS must be prepared. Inability to adapt may lead to inefficient resource use and fosters unwarranted liabilities for both the patient and the EMS agency. Increased frequency and severity of

extreme weather events has tremendous implications for the safety of both emergency responders and the general population. In agreement with the research mentioned earlier, the report "Challenges Facing the Health Services" reconfirms that in terms of natural disasters, vulnerability is compounded in such groups as people living in marginal areas, those without resources, and the infirm or elderly. This is an issue which is often forgotten in consideration of on-paper disaster plans. It is important to understand that the ability to "deal with it on our own" may not necessarily be feasible when the event actually takes place. If we take the example of an ambulance service hit by an electrical blackout, of course the ability to react will depend on the type of event and the damage done, however, the severe dependence on modern technology for fast and effective care would render most situations very problematic. In another global consensus, the potential health effects and need for patient evacuation in the event of a hot or cold weather incident are sure to be a significant future problem. Impacts of climate change on infectious disease are a significant issue. The ability to effectively track and monitor the changes in disease patterns and thereby maintain effective intervention will determine the weight of this issue on EMS. Though it is all very good to say that modern global surveillance is effective in public health action regarding emerging infectious diseases, the reality is that inter-country surveillance and information sharing is often a sensitive political issue. The result may be added pressure on local public health services to deal with a problem which has come as a surprise. High influxes of immigration or refugees may also add to this pressure. (Sanderson & Alexander, 2020)(Linares et al.2020)

3.2. Adaptation strategies for emergency response systems

Current policies have failed to address the effective integration of EMS in disaster management and public health systems. This is because prehospital and emergency medical care are often overlooked or undervalued compared to other resources in the health and medical sector. A weak integration would be problematic because hospital care is considered a high-cost and high-tech service that largely focuses on tertiary prevention. It is an inappropriate setting for the treatment or prevention of injury and illness in the general population. To this extent, EMS agencies are part of a public health-oriented system. They provide preventive and public health services and education, primary and secondary prevention, and basic to comprehensive emergency and medical care at various points in the healthcare continuum. The influence of climate change on the increased frequency and severity of disasters is expected to affect overall populations, including at-risk and vulnerable populations, which are the focus of public health services. Hence, the integration of EMS systems into disaster management and public health systems is more vital than ever.

During a disaster, a chaotic situation can occur, especially when a real disaster strikes and the number of casualties increases. In situations like this, emergency medical services (EMS) and relevant healthcare professionals are assigned to provide immediate medical and public health care to disaster survivors. They cater to the immediate needs of injured or ill victims and also provide support for ongoing chronic diseases, mental health, and public health services. Preparation for specific needs inside a shelter or housing, environmental health, and recovery phase services are also included. In order to improve the emergency response during a disaster, there are a few strategies available for adaptation.

3.3. Importance of preparedness and training

Training programs also play a major part in enabling effective integration of climate change considerations into emergency management and public health practices. Training sessions provide an opportunity for interdisciplinary learning and interaction by professionals working in various areas of emergency response and public health. This is particularly important given that an effective response to many weather related events will require a multi-agency approach. Unfortunately, few training opportunities currently exist. An assessment of training needs conducted with US public health officials found that while 60-70% felt that it was

somewhat or very important for them to receive training in the specific health impacts of climate change and how to address these, less than 20% had actually participated in such training. An Australian study of public health professionals found similar interest, and highlighted the importance of case-based learning, development of practical skills and access to good quality information. All of this indicates an urgent need to develop comprehensive and targeted training programs. A recent review of its responses to recent natural disasters found that it was ill prepared to deal with increasing climatic risks, and public health is no exception. In recognition of this, the World Health Organisation has developed an Implementation Plan on Climate Change and Health Capacity, which aims to build capacity at all levels to address the health impacts of climate change. This will include development of a minimum set of core competencies for public health officials, as well as specific guidance and tools for various sectors and regions.

Training and preparedness are highly important in the context of global warming. It is important to enhance the awareness and understanding of the changing patterns and frequency of extreme weather and other events which could have a potential impact on health and disease in the community. Research has found that only a relatively small number of health and emergency management professionals and decision makers from relevant government departments have a good understanding of the potential health impacts of climate change, or the means by which these can be addressed. A national survey of emergency management officials found that less than 20% of those interviewed believed that global climate change had actually led to an increase in the frequency and severity of extreme weather events. At the individual organisational level, agencies typically need assistance to better understand the potential implications of climate change for their specific service or area of care, and how they may need to adapt their practices. All of this requires education at multiple levels. Public health officials have also noted the need to better educate the wider community about climate change and its potential health impacts, to improve public support for mitigation measures and preparation for impacts.

4. Case Studies

Heatwaves have been among the most prominent events to affect health in recent years. This case study is based in South Australia in the summer of 2008. In this season, a record-breaking heatwave occurred from the 27th of January to the 15th of February. During this period, there was an increase of 5.1% in total mortality and a 23.2% increase in mortality due to ischaemic heart disease. On the 30th of January, an unprecedented emergency incident was declared at the Royal Adelaide Hospital. The Ambulance Service was on 'red alert' after being inundated with 120 extra calls a day for four consecutive days from heat exposure, dehydration, and heat exacerbation of existing medical conditions. During this period, there was a 14.6% increase in emergency ambulance attendances. The increase of ambulance calls for the above conditions in the elderly prompted SA Health to investigate setting up an elderly heat health intervention program as they are most vulnerable to heat-related illness and injury. This would involve timely advice from community workers on preventative measures to stay healthy and keep their home environment comfortable. The second study focuses on the rise of mosquito-borne diseases and the escalating threat in non-endemic countries. Europe was hit by a large outbreak of West Nile virus in 2018, with 1463 cases reported, 75% of which were neuro-invasive. This was the highest number of human cases ever reported in Europe. In the midst of this outbreak, responding to the increased threat of mosquito-borne disease and incremental spread of disease in non-endemic countries, ECDC included West Nile virus in the list of rapidly escalating threats to EU health and subsequently published evidence-based interim guidance for surveillance of human West Nile Virus infection to inform public health response. This guidance would enable affected countries to determine the significance of the disease, identify the areas and populations at risk, and assess the effectiveness of public health actions implemented. It would also provide a framework

for comparison of surveillance data between countries. (Cai et al.2021)

4.1. Case study 1: Heatwaves and their impact on emergency calls

Examining the case of a heatwave in South Australia helped to establish the impact of heatwaves on patient volume and case severity in the metropolitan area. A significant increase in patient volume was illustrated across all age groups, as well as a noticeable increase in case severity. Using a time series analysis, the increase in daily patient contacts was estimated to be 1.7% for every 1°C increase in maximum temperature, up to 35°C. During the studied heatwave, there was a 9.9% increase in all-cause mortality, with the greatest increase in deaths due to renal failure. This is consistent with the finding that in Adelaide for each 1°C increase above 27°C, there is a 7% increase in the risk of dying from renal disease within the following 3 months. These results illustrate the inherent susceptibility of the South Australian population to the effects of heatwaves, due to the climate and demographic distribution, culminating in increased demand on the medical system and resources. In the assessment of case severity, it was found that patients were more likely to be triaged as higher priority, transported to the emergency department and hospital, as well as having an increase in on-scene death, affecting the overall workload of the ambulance services. This coincides with the state of physiological strain, as people with chronic conditions and the elderly are more likely to suffer from an exacerbation of their disease, as well as heat stress and heat-related injury. The temporal and dose-response relationship between the increase in maximum temperature and the indicators of increased case severity further solidifies the impact of heatwaves on the demand for ambulance services, particularly in the transportation of patients to medical facilities. (Agache et al.2024)

4.2. Case study 2: Rise in mosquito-borne diseases and response measures

Though this is a complex scenario, best considered a "thought experiment," we are concerned that the impact of climate change will lead to a greater prevalence of vector-borne diseases from tropical infections such as dengue, chikungunya, and Zika. These infections are largely contained within the populations and geography where the diseases are already endemic, such as dengue in tropical and subtropical regions of the world. It is unlikely that there will be a significant movement in the disease to new areas, especially in Europe due to the invasive mosquito vectors limited geographic range. Nonetheless, it is expected that the intensity and duration of transmission seasons will increase with detrimental public health consequences. This is due to the mosquito's sensitivity to climate; small changes in temperature and rainfall can greatly affect their reproductive and biting rates and the development rate of the viruses within the mosquitoes. Higher temperatures may also lead to the establishment of the mosquitoes in new areas such as southern Europe. This situation closely mirrors the predicted intensification of malaria in parts of Europe, a disease which was only eradicated in the mid-20th century.

5. Policy Implications

The extreme weather events occurring will likely lead to the displacement of people. The health system will need to cater for these people and changes in patterns of infectious diseases and non-communicable diseases. An effective approach to this will involve close surveillance and research and the ability to detect and track early any adverse effects on public health. An already stretched health system will need assistance to help the most vulnerable populations, who are both more susceptible to the effects of climate change and have less capacity to adapt. From these experiences, it will be possible to further refine the health adaptation strategies.

Mitigation has clear health co-benefits but there will also be challenges to the health sector. This is because mitigation in some sectors, with the switch to renewable energy, may cause further damage to health through its effects on air quality. Planning and preparation will be needed to ensure that the health sector can adapt to these

changes. This may involve a more holistic approach to energy and health with collaboration between the health and environment sectors.

It is evident that climate change is underway and it is affecting people's health as well as causing damage to the health infrastructure. Recent extreme weather events and patterns are an indication of the changing climate. Substantial emission reductions in the coming years can reduce the probability of these events occurring and allow the health sector to adapt to some changes that are now inevitable.

Need for climate change mitigation policies

5.1. Need for climate change mitigation policies

This statistical proof that climate change will indeed increase patient numbers for the health sector is an example of a "factual cause". With this evidence, it can be said that the cause of future increased patient numbers stems from climate change effects. This is an argument that would be highly important in order to have a policy change or an increase in funding towards the mitigation of climate change effects. From a further interview with Dr. Forbes McGain, it was suggested that data on what might bring a patient to the hospital, but particularly the system factors such as access block, could be used to predict what might stress the system. Given an understanding that climate-driven increases in demand will be a great cause of stress on the system, it should be possible to best prepare the health system for these increased patient numbers. This would be in the best interests of both the health of the population and the safety of patients receiving emergency care. This issue on whether the health system is adequately prepared for an increase in demand is something that can be taken before government or hospital administrators, in a plight to best serve the interests of the public.

A need for climate change policies is advocated in this research. A study predicts an increase in extreme weather events from climate change will have severe impacts on human health. There will be an increase in people suffering physical injuries from weather-related events such as heat waves, storms, and floods. There will also be a higher incidence of illness as a result of climate change, which will elevate the demand for medical care. It is important to note that the overall health and safety of the public will be at greater risk during extreme weather events. These effects of climate change on illness and injury will result in a higher demand on the health system and will be reflected in increased utilization of emergency services.

5.2. Integration of climate resilience in emergency response planning

long-run (Rahman et al.2021)(Shaw-Taylor, 2020)

Reactive budgeting as a result of unpredictable need often leads to reduced funding for emergency services, with an assumption that it will not be needed. Currently, only 1-2% of the annual $13 billion health budget is spent on emergency management, of which little is used to prepare for future challenges. A global survey of 198 Red Cross/Red Crescent national societies conducted by McEntire et al. found that due to a lack of understanding of the costs of various hazard scenarios, the levels of preparedness were quite inadequate. One of the key barriers to increasing the integration of climate adaptation into emergency management has been identifying where climate change will actually make a difference to the natural hazards that emergency management agencies currently deal with. Often, it has been assumed that preparing for natural hazards in a changing climate means a wholesale shift in focus, resulting in inertia to act without detailed information about the projected changes' impact on local hazards.

5.3. Collaborative efforts between healthcare and environmental sectors

Collaboration between the healthcare and environmental sectors is increasingly seen as a critical aspect of understanding and addressing the health impacts of climate change. At the broader policy level, addressing health and climate connections will involve collaboration between the public health and environment sectors. This includes jointly addressing research gaps and needs and the implementation of policies and programs that are beneficial to

both sectors, such as clean energy policies. However, it is at the implementation level where joint working has the greatest potential to add value to each sector. For the health sector, addressing climate change can be more effective and have the collateral benefit of reducing air pollution through joint working with the environment and other sectors to ensure that climate change considerations are taken into account in policy and planning decisions across all sectors, rather than leaving it to individual sectors to deal with in isolation. An example might be in spatial planning in the building of more climate-friendly and healthy cities. Here, health has a valuable input into the potential health co-benefits of planning decisions, through reduced vehicle use or more active transport and recreation, and thus reducing emissions. The health sector can also act as a trusted voice to the community and policymakers about the health risks of climate change and the co-benefits of mitigation measures. For the environmental sector, addressing health has the potential to add a compelling and human face to the consequences of climate change and enable easier communication on the potential risks and benefits of various mitigation and adaptation measures. This can best be done through integrating health considerations into all aspects of climate-related policies and decisions and building capacity within the environment sector to understand the health implications of climate change and have access to health expertise. An example might be in the work of climate change adaptation professionals in government or a non-government organization, who today more often than not do not consider health. In order for this to occur, the health sector must reach out and provide education and a platform for collaboration and create bridges with environment sector organizations and professional associations. Given that climate change is a global issue with local health impacts, it is likely that shared knowledge and experiences between sectors and with other countries will be highly valuable. This is exemplified by the international research collaboration on climate and health science that has been instigated through the World Climate Research Programme.

6. Future Research Directions

Developing predictive models for emergency response planning. The associations identified in this research between meteorological conditions and emergency incidents have the potential to inform predictive models of future patterns in emergency work, taking into account effects of climate change. This could assist forward planning by ambulance services, who currently are provided with workload forecasts based on little more than previous incident data and population growth. The findings can also inform public health initiatives aimed at injury prevention during meteorologically-triggered spikes in emergency incidents. Predictive models offer a cost-effective method of preparing health services for the effects of climate change, allowing resources to be allocated and interventions to be implemented in an adaptive and timely manner. In our current era of financial austerity in the developed world, propelled by global economic crisis, predictive modelling will be an increasingly valuable tool for maintaining high-quality emergency care in the face of a changing climate.

Long-term effects of climate change on emergency incidents. Currently, the International Panel on Climate Change (IPCC) is focused on the year 2100, which is unhelpful for policy makers who are considering the effects of climate change on emergency incidents over the next few decades. This research provides a quantitative prediction of the varying effects of climate change at a regional level, with the 20-year time horizon aiding policy makers and health services to adapt emergency response systems in a timely fashion.

6.1. Long-term effects of climate change on emergency incidents

Increases in extreme weather events and natural disasters associated with climate change have implications for emergency systems at local, national, and global levels. Acute events, such as storms and floods or heat waves, can cause mass trauma and injury and may overwhelm existing response systems. Studies have shown that economic damage and humanitarian crises associated with natural disasters have been

increasing globally, with a particularly rapid increase seen in climate-related disasters. Between 1995 and 2004, World Health Organization statistics show a 62% increase in climate-related weather disasters. These trends have serious implications for the allocation of resources and development of disaster response planning for emergency services. Although it is a common perception that changes such as increases in extreme weather events are likely to increase demand on emergency services, the specific implications and best strategies for response planning are not well understood. This is an area where research and modeling are needed to inform policy and practice for future global health security.

The complex interconnections between climate variables and health are likely to cause changes in the pattern, incidence, and relative importance of different types of emergency incidents. A developing area of research with relevance to the potential health effects of climate change is the study of the connections between daily weather variability and acute health outcomes. Better understanding of these connections will enhance our ability to predict which populations are most at risk during specific weather events, and to develop targeted interventions to protect public health. This is an important consideration for emergency service agencies which may need to tailor their response systems in anticipation of changes in the prevalence of specific health conditions.

6.2. Development of predictive models for emergency response planning

Taking the first steps in this direction, researchers in Canada recently undertook a pilot study aimed at quantifying the impact of daily weather and air quality events as predictors of acute asthma exacerbations in children in a large urban center. A time-series regression model was developed using emergency department visits as a proxy for asthma attacks, and showed that a 2-day average of temperature in the summer and winter, and an 8-day average of sulfur dioxide all had significant positive associations with visit rates. This type of analysis can be applied to other specific disease/condition and event type combinations, and can be expanded to develop predictive models for changes in event frequency and severity given projected climate change scenarios.

There is a clear need to develop predictive models which will enable EMS to prepare for changes in the frequency and severity of emergency incidents due to climate change. Development of such models would allow EMS to adjust deployment strategies, optimize resource utilization, and prepare for changes in types of care needed for certain types of incidents. This area of research could also benefit similar efforts in public health and safety, and provide useful data to other health care providers and public policy experts.

7. Conclusion

High temperatures can also cause aggravation of the elderly and those with chronic illness due to their body's inability to regulate temperature. This will increase the incidence of OHCA as these are the two highest risk groups for cardiac events.

Recent studies in Japan have found a rapid association with increases in atmospheric temperature and an immediate increase in OHCA. In the same city, there was no significant association with air pollution and OHCA. This study included all patients with non-traumatic OHCA and used an hourly mean of atmospheric temperature to categorize into three tertiles. A relative risk of about 2 was found for OHCA with temperatures greater than 27 degrees centigrade. This degree of effect at this level of temperature was not seen in the case of acute myocardial infarction, so we can assume that it is at least in part due to heat-related problems with dehydration and fatigue. This Japan study has demonstrated a clear effect of heat and on a similar nature to the health problems associated with high temperature in western populations.

The health effect of hot weather is more predictable. This is important as increasing temperatures in the summer months would be a clear consequence of climate change. High

temperatures can cause heat stroke, dehydration due to loss of body salts and cramps. This may lead to dizziness and fainting, and if continued, will cause fatigue and heat exhaustion. High temperatures will also increase the concentration of ozone at ground level. This has a corrosive effect on the airways and lungs, causing respiratory problems and exacerbating pre-existing conditions such as asthma.

Cold temperatures are known to cause an increase in cardiovascular deaths within a few days of exposure. Cold affects blood pressure, viscosity, and tendency for blood to clot, which can increase the risk of heart attacks and strokes. Cold can also increase the risk of infections in the respiratory system.

Weather is an important driver of OHCA incidence and case-fatality. Both extremes of hot and cold temperatures can cause cardiac and other health problems. However, we are only considering temperature at this point as the effects of climate change on UK temperatures are unlikely to have much effect on the prevalence of extreme temperatures. The pattern of these extremes may change; however, this is difficult to predict, and a transient effect is not something that this study can easily investigate.

This paper aims to dissect a specific example of the impact of climate change on human health. Firstly, by identifying if there are any changes in the pattern of out-of-hospital cardiac arrests (OHCA), and then by investigating the weather-related factors that have caused these changes. This example provides a rather opportune case study to exemplify the impact of climate change on health. This study will also investigate the changing patterns of OHCAs in the context of urbanization. A separate but relevant issue where the effects of climate change are likely to impact. OHCA is defined as the cessation of cardiac mechanical activity, a sudden onset, and requiring immediate medical treatment.

In some situations, it is clear that there will be a negative health impact. For example, an increase in weather-related disasters is likely to result in a higher frequency of traumatic injuries, post-traumatic stress disorders, and other adverse mental health outcomes. In other situations, the impact of climate change on health is less clear.

The impact of climate change on human health is more than worrying in recent years. Many impacts have been identified and reported, ranging from extreme weather conditions to changing patterns of certain diseases. These effects are varied, complex, and often dependent on variables such as time and geographical location.

Impact of climate change on medical emergency incidents and responses

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