Impact of heat waves on hospitalisation and mortality in elderly homes

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Abstract

Context

De klimaatverandering en daaraan gerelateerde opwarming van de aarde is één van de grootste problemen waarmee de wereld vandaag kampt. Ten gevolge van het toenemende aantal warme dagen, zullen onze gezondheidssystemen de komende jaren worden uitgedaagd. Analyses van hittegolven toonden in het verleden reeds een stijging in mortaliteit. De relatie tussen extreme temperaturen en morbiditeit werd echter minder frequent onderzocht. Ouderen met leeftijd boven 65 jaar behoren tot de meest kwetsbare groep tijdens hitteblootstelling. Weinig studies beschrijven echter de impact van hitte op het deel van deze populatie die in een rust- en verzorgingstehuis verblijft.

Onderzoeksvraag

In deze studie willen we de relatie tussen hittegolven en mortaliteit nagaan in rust- en verzorgingstehuizen in Vlaanderen. Daarnaast onderzoeken we of warm weer leidt tot een toegenomen aantal hospitalisaties in de onderzochte populatie.

Methode

Een retrospectieve analyse van mortaliteit en ziekenhuisopnames in de periode van 1 januari 2013 tot en met 31 december 2017 werd uitgevoerd. Tien rust- en verzorgingstehuizen werden opgenomen in de studie. Data omtrent de exacte datum van opname in het rusthuis, periodes van opname in het ziekenhuis en overlijdensdata werden opgevraagd en anoniem gecodeerd in een databestand. Een descriptieve analyse werd uitgevoerd, gevolgd door een case-crossover analyse om de korte termijn impact van hittegolven op mortaliteit en ziekenhuisopnames te beoordelen.

Resultaten

In de referentieperiode werden er 3048 ziekenhuisopnames en 1888 overlijdens geregistreerd. Er waren 23 hittegolfdagen in deze periode. De case-crossover analyse toonde voor mortaliteit en hospitalisaties respectievelijk een odds ratio van 1.61 (95% betrouwbaarheidsinterval 1.10 – 2.37) en 0.96 (95% betrouwbaarheidsinterval 0.67 – 1.36). Het resultaat voor mortaliteit was statistisch significant (P-waarde 0.02). Voor de hospitalisaties werd de drempel van statistische significantie niet bereikt (P-waarde 0.80).

Conclusie

Hittegolven tonen een negatief effect op de mortaliteit in Vlaamse rust- en verzorgingstehuizen. Verder onderzoek is noodzakelijk om de gevonden discrepantie tussen ziekenhuisopnames als proxy voor morbiditeit en mortaliteit te verklaren. De impact van extreme hitte wordt voorspeld toe te nemen als een resultaat van de opwarming van de aarde en verdere vergrijzing van de bevolking. De aandacht moet daarom worden gevestigd op kwetsbare groepen die een grote kans hebben om nadelige effecten van hitte te ondervinden. Daarnaast moeten we in rusthuizen anticiperen op hittegolven en in deze setting zorgprotocollen testen op hun effect bij extreme weersomstandigheden.

Abstract

Rationale

Climate change and the related global warming are the greatest problems faced by the world today. Due to an increasing number of days with extreme hot temperatures, our health care systems are going to be challenged in the next couple of years. Previous analyses of heat waves have documented a short-term rise in mortality. Less research has been done on the relationship between high temperature and morbidity. Although, elderly aged over 65 years old belong to the group most vulnerable to the effects of heat, limited studies were performed in elderly homes.

Objective

In this study, we want to assess the effect of heat wave days on hospitalisation and mortality in elderly homes in Flanders.

Methods

A retrospective analysis of mortality and hospitalisations between 1 January 2013 and 31 December 2017 was conducted in 10 elderly homes. Obtained data included exact date of admission to the home, periods of hospital admissions and date of death. These were anonymously encoded in a data-file. Descriptive analysis was done, followed by case-crossover analyses to investigate the short-term impact of heat waves.

Results

For the reference period, we counted 3048 hospital admissions and 1888 deaths. There were 23 heat wave days. Case-crossover analyses showed that odds ratios of mortality and hospitalisations during heat waves were 1.61 (95% confidence interval 1.10 – 2.37) and 0.96 (95% confidence interval 0.67 – 1.36) respectively. The increase of mortality was statistically significant (P-value 0.02). The result of hospitalisations did not reach statistical significance (P-value 0.80).

Conclusion

Heat waves seem to have an adverse effect on mortality in Flemish elderly homes. Further research is needed to explain the discrepancy between hospital admissions as a proxy for morbidity, and mortality of aged people. The impact of extreme heat events is expected to increase as a result of global warming and population ageing. Our attention must be directed to high-risk groups, including elderly, anticipating the heat waves and testing health protection strategies in elderly homes during extreme weather conditions.

Keywords

Heat wave – elderly home – hospital admissions – morbidity – mortality

Introduction

Climate is changing. Greenhouse gas emissions generated by human activity are partly responsible for global warming. (1) Further heating at Earth's surface will cause an increase in the number of warm days. Moreover, the Intergovernmental Panel on Climate Change (IPCC) forecasts a rise in extreme hot temperature (heat wave) frequency and severity. (2, 3)

Human health will be affected in many ways, inducing more challenges to our health care systems. (3-5) Numerous studies have shown a short-term rise in mortality due to prolonged periods of hot weather. (6-9) The 2003 heat wave in Western Europe was one of the most severe events that led to a substantial number of deaths. (1, 8, 9) Elderly, children, persons who are unable to care for themselves, mentally ill people and others with pre-existing illness were identified as most vulnerable to the effects of heat. (1, 6, 10-13) Physiological ageing processes, potential side effects of medication and limited mobility are factors that contribute to the higher risk of aged people. (11, 13, 14)

There is a limited number of studies examining the relationship between high temperature and morbidity, and published results are inconsistent. (4, 5) Most scientists agree on the adverse effect of heat waves on renal health and heat-related diseases like dehydration, heat oedema, heat cramps, heat syncope, heat exhaustion and heat stroke. Varying outcomes have been found among studies on hospital admissions. Nevertheless, there is a discrepancy between findings on heat-related mortality and morbidity. Mortality has been shown to increase, whereas results on morbidity were inconsistent. (5)

Since results on morbidity are unclear, we decided to further examine this topic. Considering the health impact of heat waves and the vulnerability of old people, this study wants to focus on this target group. Limited studies were performed in elderly homes. The aims of the study were (i) to assess the relationship between heat waves and mortality in elderly homes and (ii) to investigate the effect of hot weather on hospitalisation as a proxy for morbidity in elderly homes. Before doing the research, we expected to find a rise in the number of deaths and hospitalisations due to heat waves.

Methods

Data collection

This research concerns a retrospective analysis of daily mortality and hospitalisation between 1 January 2013 and 31 December 2017. Twenty-four elderly homes in Flanders, Belgium, were contacted, asking for their support to this study. Eleven of them agreed to participate and provided data on the observed period. One was excluded because it had its first residents in 2016 and could not offer information on the past years. As a result, 10 retirement homes were included. Residents' data obtained from the elderly homes contained date of admission to the home, periods of hospital admissions and date of death. Furthermore, general data on age distribution and number of beds of the elderly home were requested. All collected data were anonymously encoded in a data-file. Due to General Data Protection Regulation, information was handed on paper and manually converted into a digital format. The Royal Meteorological Institute of Belgium (RMI) offered records on daily maximum temperature (Tmax) and periods of heat waves, observed at the weather station of Ukkel.

In this research, we defined a heat wave as a period of minimum five consecutive days with a Tmax ≥25°C of which minimum three days with a Tmax ≥30°C.

Approval for this research was given by the University of Leuven, Faculty of Medicine on February 27, 2018.

Statistical analysis

The anonymous data-file was used for descriptive analysis. We calculated both the number of hospitalisations over 1000 residents per year in each elderly home and the mean number of hospitalisations over 1000 residents per year across the 10 homes. Hospitalisation rate and heat data were plotted in Microsoft Office Excel 2007. The same analyses were performed for the mortality rate.

Study design

The study design was a case-crossover analysis. This design is best suited if the exposure is intermittent, if there is an immediate and transient effect, and a sudden outcome. It is usually used to assess the short-term effect of an exposure. The exposure during a window just before outcome onset (hazard period) is compared with exposure during control times (referent periods) within the same person. The ratio of exposed (exposure in hazard period, but not in referent period) to unexposed (exposure in referent period, but not in hazard period) discordants is an estimate of the relative risk. If the exposure is related to the outcome, it will be higher in the hazard period compared with the referent periods. It controls for time-invariant patient characteristics by design, since the person is compared with himself. In addition, the design is efficient, because each case can provide multiple referent periods. (15)

A time-stratified approach was used to select the referent periods. The day of death or hospitalisation was defined as the hazardous day, and the same day of the week in the same month as referent period. For example, if someone was hospitalised on 21 July 2013, then the referent periods were 7, 14 and 28 July 2013. This approach helps controlling for confounding by personal characteristics and other factors that could change with time. (15) In this analysis, three referent periods were matched to each hazard period.

The association between heat waves and hospital admissions was investigated using conditional logistic regression. The same was done for the heat wave – mortality relationship. RStudio (version 3.4.2) software was used to obtain the results.

Results

Ten elderly homes were enrolled in the study. Average age of residents was 80 years old and above in each home on December 31, 2017 (table 1). The number of inhabitants differed between homes and is presented in table 1.

From 1 January 2013 until 31 December 2017, 1888 residents living in the included elderly homes died. For the reference period, we counted 3048 hospital admissions, spread across 10 homes. Average number of deaths and hospitalisations calculated per 1000 residents alternated between elderly homes (table 2). Heat waves occurred every year, except in 2014. There were 23 heat wave

days during the reference period (table 3). The average number of hospitalisations stayed stable throughout the years (table 3). So, there were no important differences in annual hospitalisation numbers between years with and without a heat wave. On the contrary, mortality numbers increased during the five investigated years (table 3).

Rest home	Province	Number of beds	Average age
1	Flemish Brabant	D	80y, 3m, 2d
2	Antwerp	A	86y, 6m, 23d
3	Antwerp	C	86y, 4m, 4d
4	Antwerp	A	87y, 6m, 11d
5	Antwerp	A	85y, 10m,11d
6	Antwerp	A	86y, 0m, 10d
7	Antwerp	C	84y, 5m, 27d
8	Antwerp	A	85y, 2m, 27d
9	Antwerp	B	86y, 7m, 17d
10	Flemish Brabant	B	88y, 8m, 8d

Table 1 General data of the elderly homes. Number of beds are divided in categories: A) 50-100, B) 101-150, C) 151-200 and D) > 200. Average age on 31 December 2017.

Elderly home	Hospitalisations	Deaths
1	374	218
2	692	443
3	415	281
4	420	302
5	644	339
6	429	299
7	407	249
8	340	235
9	317	207
10	416	228

Table 2 Average number of yearly hospital admissions and deaths calculated per 1000 residents per elderly home, across 5 years of reference period.

Year	Heat wave	Hospitalisations	Deaths
2013	21/7 - 27/7	431	152
2014	None	428	232
2015	30/6 - 5/7	469	301
2016	23/8 - 27/8	457	328
2017	18/6 - 22/6	441	388

Table 3 Average number of yearly hospitalisations and deaths calculated per 1000 residents per year, across 10 homes.

Figure 1 presents the annual distribution of daily hospitalisations, daily deaths and Tmax. The mortality curve shows a seasonal pattern when looking at the number of deaths on cold and hot days. A smaller effect is seen for hospitalisations.

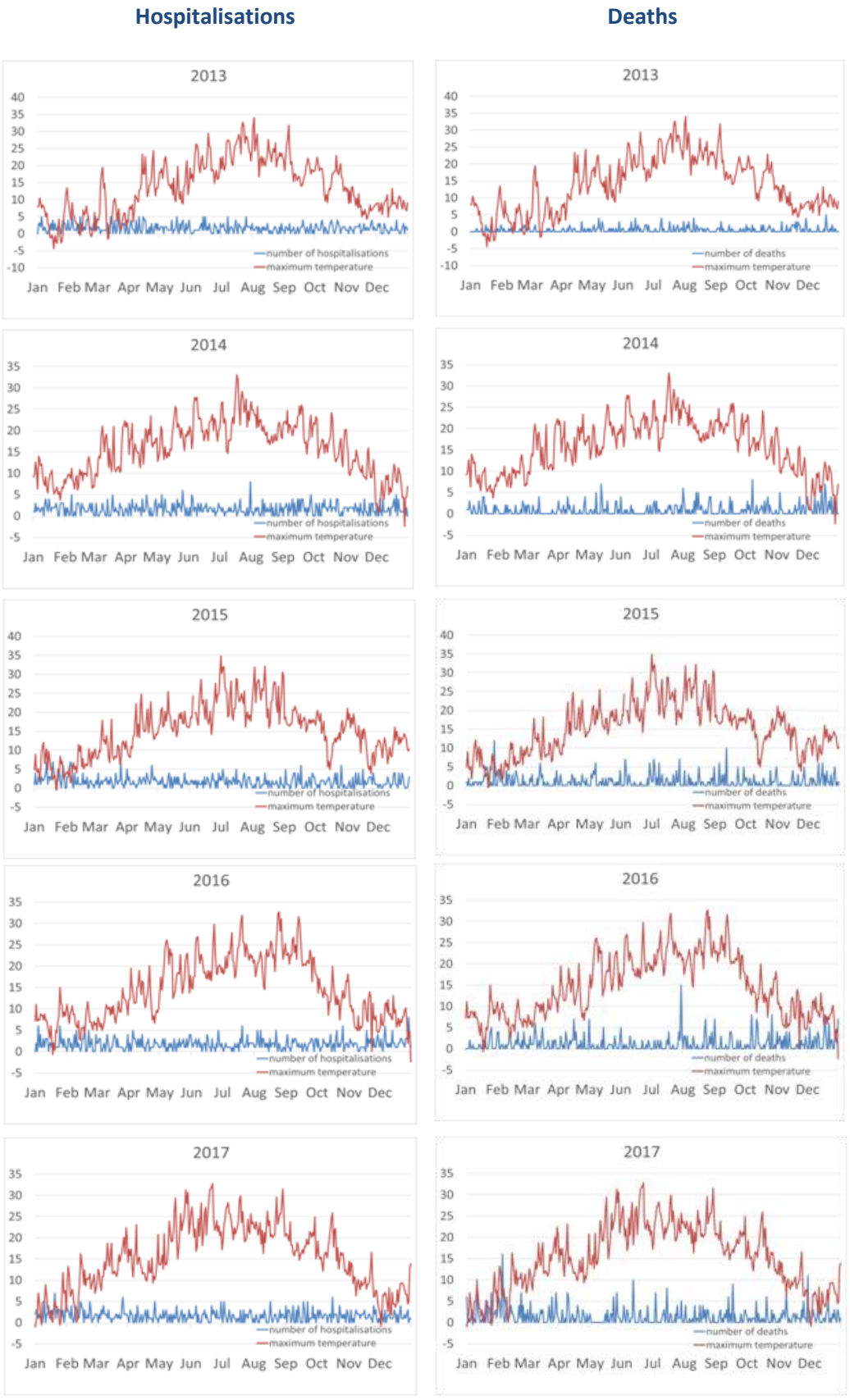

Figure 1 Annual distribution of daily maximum temperature, daily hospital admissions and daily deaths.

We expected a rise in the number of deaths and hospitalisations due to heat waves. This assumption could be confirmed for mortality, but not for morbidity. ORs for mortality and hospital admissions during heat wave days compared to non-heat wave days were respectively 1.61 (95% CI 1.10 – 2.37, P-value 0.02) and 0.96 (95% CI 0.67 – 1.36, P-value 0.80).

Discussion

The health effects of heat have reached a lot of public attention. This research focused on the consequences for elderly, living in homes. Retrospective analyses showed differences in mortality and hospitalisations between retirement homes. The annual average of hospital admissions remained stable, while the annual number of deaths was increasing over the years. We found a statistically significant increase in mortality due to heat waves, although results for hospital admissions did not achieve statistical significance.

Annual mortality and morbidity

No important differences in the annual number of hospitalisations between years with and without heat wave could be found. This finding is in accordance with what we expected. The consequences of heat must be rather extensive to affect the average annual measurement data. The annual mean of deaths increased during the investigated period. This observation can be attributed to the ageing of our population and a change in inclusion criteria towards more disabled persons of the elderly homes in the observed time period. (1, 13) Kenney et al. reported that the number of people aged 80 or above is expanding at the rate of 3.8% per year. (13) Consequently, the proportion of elderly is rising in retirement homes.

The annual mortality curve showed a seasonal pattern including a rise in mortality during cold and hot days. Numerous studies have described temperature to be U-shaped associated with mortality. Populations typically have been found to show an optimal temperature at which the daily death rate is the lowest. Within certain temperature extremes, thermoregulatory responses can preserve thermal comfort. Mortality and morbidity rate rise at temperatures outside this zone. (1, 4, 11) Song et al. documented an elevated risk of mortality associated with cold exposure. (4) Bunker et al. reported an increased risk of respiratory and cardiovascular mortality, and respiratory morbidity in elderly due to temperature reduction. (12) Potential mechanisms like the association between transmission of influenza and cold weather were proposed. In addition, high rates of respiratory syncytial virus infection were observed with cold temperatures. (4) Our further research was limited to the effects of heat exposure, but these findings suggest the necessity to investigate the cold-mortality relation in retirement homes as well.

Heat related mortality

A rise in mortality due to heat waves has been described in numerous publications. (4, 7-9, 16-19) In this research, a statistically significant increase in mortality was found in elderly homes. Fouillet et al. conducted an analysis about the August 2003 heat wave in France. They found a relative increase in mortality of 91% in retirement homes. (18) Borst et al. reported an increase of 50% in mortality rate in Dutch nursing homes, when the maximal weekly temperature exceeded 25°C. (17) Baccini et al. identified a stronger association between heat and mortality in people aged above 74 years than earlier in life. (20) Various publications described cardiovascular mechanisms as underlying cause of

the excess of deaths. (4, 13, 19, 20) Song et al. and Mastrangelo et al. also stated that heat exposure was associated with increased risk of cerebrovascular mortality. (4, 19) Besides, respiratory mortality due to heat waves was declared by Song et al and Baccini et al. (4, 20) However, Wichmann et al. observed an inverse association between apparent temperature and cardiovascular disease. They could not find an association with cerebrovascular and respiratory mortality. (21)

Heat related morbidity

Our analysis could not prove a significant relation between heat waves and hospital admissions in elderly. Inconsistent results were found among studies examining the impact of heat waves on the hospitalisation rate. Kovats et al. reported an increase of hospital admissions for adults as well as for the elderly due to heat exposure. (9) In 2004, the same author published an analysis of hot weather and heat waves in the United Kingdom (UK). Hospital admissions did not show a significant rise during the UK heat wave of 1995. (8) However, during the Chicago heat wave of 1995, a rise of 11% in hospital admissions was seen by Semenza et al. (22) In addition, Liss et al. documented in 2017 an enlarged effect of the first seasonal heat wave on heat-related hospitalisation in older adults. In addition, they suggested to focus on first heat wave to intensify preventive measures. (11) Among studies that explored morbidity, there was consensus on the unfavourable health effects of heat waves on heat-related and renal diseases. (5, 8, 16, 22) Most of the studies postulated absence of impact of heat exposure on cardiovascular morbidity. (4, 16) Bunker et al. described a heat-related association with respiratory disease in elderly. (12) Other studies confirmed these findings. (7, 8) However, meta-analysis showed ambivalent results for cardiovascular and respiratory morbidity. (5, 23)

Knowledge gap

The impact of hot weather on mortality in elderly homes was not proportional to the effect on hospital admissions. Because of these contrasting patterns, the question was raised why the number of deaths augmented with increased temperature. Some studies postulated a knowledge gap hypothesis: During heat waves, many deaths occur rapidly before patients reach hospital. (7, 8, 19) According to some authors, the presence of an increase in cardiovascular mortality and the absence of an effect of heat on cardiovascular admissions suggest a sudden death due to circulatory disease. (7, 19) Further research is needed to confirm this hypothesis in elderly homes. Another possible explanation can be found in the fact that some elderly noted their will to quit hospitalisation.

Differences between elderly homes

Varying results on the average number of deaths and hospital admissions were noticed between retirement homes through the year. Further research on the origin of the observed differences is required. Various policies, housing characteristics and location could perhaps contribute to these contrasting results. For example, in summer, heat load could be different in several retirement homes. Elderly homes located in urban area could be exposed to the Urban Heat Island Effect, whereby inner urban areas reach higher temperatures than rural regions. Architectural features like isolation could contribute to the indoor heat load. (1, 6, 24, 25) The presence of best practice guidelines in retirement homes could help elderly to cope with extreme hot weather. Raised attention is needed to the hydration status of residents, use of medication and the stay in an air-conditioned area during warm days. (10, 24, 25)

Heterogeneity

Heterogeneity in the effect of heat on mortality and morbidity has been described in various studies. Different factors contributed to the discrepancies. First, there is no clear-cut definition of a heat wave in Europe. However, it is difficult to give a standard definition, because the threshold may alternate depending on which temperature the population is acclimatised to. (12, 16, 19) Furthermore, differences in the intensity of exposure, separate susceptibility of the examined populations and variation in health and social care services direct to heterogeneity. (7, 12) Methodology and choice of outcome are also counting. (5, 12) Another point of discussion is the exposure indicator. In this research, Tmax was chosen to define a heat wave. Previous studies considered a range of different exposure variables. Some authors suggested apparent temperature to be a better measure than temperature alone. This index incorporates temperature, humidity and sometimes wind speed, which could indicate relative human discomfort. (4) However, in some assessments apparent temperature was not a superior predictor of mortality than mean temperature. (16) Besides, multiple lag times are associated with extreme temperature exposure. The adverse effect of heat on health may be delayed up to a few days. (5, 7, 16, 25) Our results were for lag 0. We could also evaluate for different lags.

Vulnerability of elderly

We decided to focus on elderly, specifically those living in retirement homes. Less research on mortality and morbidity has been done in this population. A report of the Flemish Agency Care and Health declared that data derived from standby duties, home calls and elderly homes could be useful to investigate the heat-morbidity and heat-mortality relationship. General Practitioners' (GP) consultations were not suitable. This statement could be attributed to the urgent character of symptoms, through which patients are transported by themselves or by ambulance to the hospital. (25)

Both heat-related mortality and morbidity were investigated. The importance of studying mortality in elderly homes could be questioned. Is delaying death in this population one of the world's needs today? However, aged individuals are more vulnerable to heat than younger adults. (5, 13, 25) The regulation of body temperature affects several organ systems. These apparently deteriorate with ageing. (5) Elderly respond with diminished individual sweat gland outputs, decreased skin blood flows, reduced cardiac outputs and smaller redistributions of blood flow from the splanchnic and renal circulations during heat stress, comparing to younger people. (13, 26) Attenuated possibility of evaporation leads to storage of heat. (9, 13) Due to deterioration of the brain function, sensibility of thirst is decreased. (24) Besides, insufficient physical fitness, the presence of chronic underlying disease, polypharmacy, social isolation, financial problems and dependency on others contribute to the higher risk of heat related disease. (11, 27) Subsequently, we expect to detect an effect of heat waves earlier in this high-risk group. So, it could be useful to investigate mortality in retirement homes. Furthermore, if we can prevent heat-related disease in elderly, quality of life could be raised and health care expenses could be reduced.

Limitations

Some limitations to this study should be noticed. First, we did not adjust for the concentration of outdoor air pollutants in this research. A period of extreme heat involves increased radiation, little wind and very little rain. As a result, production of pollutants like ozone occurs in the atmosphere, nearby the Earth's surface. (6) In the meantime, higher concentrations of ozone and fine dust amplify the effect of extreme heat. (6, 24, 25) However, some studies suggest that heat effects are likely to be continued after control for air pollution. (16, 28) Secondly, no delayed effects were investigated, only the hospitalisation and mortality on the heat wave days itself. We did not reflect on post heat wave period to investigate deficits in expected deaths, which is consistent with a harvesting process. It is hypothesized that the increase in mortality during heat waves reflects an excess of deaths occurring in frail individuals. Their death was only slightly accelerated by the heat wave. (16) Finally, a rather small number of elderly homes was included in this research. We could not provide any information about gender differences, co-morbidities or diagnosis of death.

Conclusion

Global warming is one of the greatest problems faced by the world today. Due to an increasing number of hot days and the ageing of our population, our health care systems are going to be challenged in the next couple of years. In this study, heat exposure seems to have an adverse effect on mortality in elderly homes. Further research is needed to explain the discrepancy between hospital admissions as a proxy for morbidity, and mortality of aged people. Our attention must be directed to high-risk groups of heat, including elderly, anticipating heat waves and testing heat health protection strategies in elderly homes during extreme weather conditions.

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Appendix

Approval for the research

KU LEUVEN SCONE

Geachte professor,
Beste student,

De verstrekte informatie toont aan dat in het kader van uw onderzoek er op geen enkel moment contact zal zijn met proefpersonen of menselijk lichaamsmateriaal. U geeft aan dat uw onderzoek een zuiver retrospectieve studie betreft en dat de reeds beschikbare data enkel niet-identificeerbare persoonsgegevens bevat. Dit betekent dat de data publieke data zijn, volledig anoniem zijn of voorafgaand aan het verwerven geanonimiseerd werden.

Dit type onderzoek vereist geen goedkeuring door een gemachtigde commissie voor medische ethiek.

Onder voorbehoud van de volledigheid en correctheid van de door u verstrekte gegevens, krijgt u hierbij het akkoord om het onderzoek in het kader van de masterproef te starten. Deze mail dient als bewijs van goedkeuring mocht u uw onderzoek wensen te publiceren.

Wij willen u erop attent maken dat u zelf verantwoordelijk blijft voor uw onderzoek. Bovendien doet elke wijziging aan de door u verstrekte gegevens omtrent de onderzoeksopzet deze goedkeuring vervallen. U dient in dat geval een amendement te maken aan uw huidig dossier.

Veel succes!

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Literature: search strategy

PubMed, the Cochrane Library and Web of Science were searched to retrieve relevant articles regarding heat waves and the impact on morbidity and mortality in elderly people. Following MeSH terms and keywords were used: “heat”, “heat wave”, “elderly”, “elderly home”, “morbidity”, “hospitalisation” and “mortality”. Besides, governmental reports about heat periods were selected.

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