Midwifery 30 (2014) 50–59

Contents lists available at ScienceDirect

Midwifery

journal homepage: www.elsevier.com/midw

High environmental temperature and preterm birth: A review of the evidence

Mary Carolan-Olah, PhD (Associate Professor Midwifery)*, Dorota Frankowska MNSce (Masters of Nursing Science) (Lecturer)

School of Nursing and Midwifery, St. Alban's Campus, Victoria University, PO Box 14228, Melbourne 8001, Australia

ARTICLE INFO

Article history:
Received 24 June 2012
Received in revised form
4 January 2013
Accepted 20 January 2013

Keywords:
Preterm birth
Environmental temperature
Pregnancy

ABSTRACT

Objective: to examine the evidence in relation to preterm birth and high environmental temperature.
Background: this review was conducted against a background of global warming and an escalation in the frequency and severity of hot weather together with a rising preterm birth rate.
Methods: electronic health databases such as: SCOPUS, MEDLINE, CINAHL, EMBASE and Maternity and Infant Care were searched for research articles, that examined preterm birth and high environmental temperature. Further searches were based on the reference lists of located articles. Keywords included a search term for preterm birth (preterm birth, preterm, premature, <37 weeks, gestation) and a search term for hot weather (heatwaves, heat-waves, global warming, climate change, extreme heat, hot weather, high temperature, ambient temperature). A total of 159 papers were retrieved in this way. Of these publications, eight met inclusion criteria.
Data extraction: data were extracted and organised under the following headings: study design; dataset and sample; gestational age and effect of environmental heat on preterm birth. Critical Appraisal Skills Programme (CASP) guidelines were used to appraise study quality.
Findings: in this review, the weight of evidence supported an association between high environmental temperature and preterm birth. However, the degree of association varied considerably, and it is not clear what factors influence this relationship. Differing definitions of preterm birth may also add to lack of clarity.
Key conclusions: preterm birth is an increasingly common and debilitating condition that affects a substantial portion of infants. Rates appear to be linked to high environmental temperature, and more especially heat stress, which may be experienced during extreme heat or following a sudden rise in temperature. When this happens, the body may be unable to adapt quickly to the change. As global warming continues, the incidence of high environmental temperature and dramatic temperature changes are also increasing. This situation makes it important that research effort is directed to understanding the degree of association and the mechanism by which high temperature and temperature increases impact on preterm birth. Research is also warranted into the development of more effective cooling practices to ameliorate the effects of heat stress. In the meantime, it is important that pregnant women are advised to take special precautions to avoid heat stress and to keep cool when there are sudden increases in temperature.

Introduction

Global warming is one of the fastest emerging concerns for the 21st century and environmental temperatures have risen by approximately 0.5–1 °C since the middle of the 20th century (McMichael et al., 2006; Bureau of Meterology, 2010). This warming of the planet results in an increasing incidence of high environmental temperatures, or very hot weather, and heatwaves (Robinson, 2001; Frich et al., 2002; Filippidou and Koukouliata, 2011; WHO/WMO, 2012). Experts predict the incidence of very hot weather and heatwaves will increase both in frequency and severity as the impact of global warming escalates (Meehl and Tebaldi, 2004). This is of concern as high environmental temperature has serious health impacts and can trigger the onset of acute conditions, including heat stroke and dehydration (Hajat et al., 2010). It can also exacerbate a range of underlying conditions such as asthma, respiratory conditions (Filippidou and Koukouliata, 2011) and mental health disorders (Khalaj et al., 2010). Vulnerable populations such as babies, children

* Corresponding author
E-mail addresses: Mary.carolan@vu.edu.au (M. Carolan-Olah), dorota.frankowska@vu.edu.au (D. Frankowska).

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http://dx.doi.org/10.1016/j.midw.2013.01.011

and pregnant women are thought to be the most at risk of these heat related effects (Balbus and Malina, 2009; Filippidou and Koukouliata, 2011).

Although it is clear that global warming has serious health consequences (Hajat and Kosatky, 2010; Hajat et al., 2010), the full extent of those consequences is still largely unknown. This is especially the case for pregnancy and birth and, to date, research on the impact of very hot weather, on mothers and babies, is very limited. Anecdotal evidence supports an association between high environmental temperature and earlier gestation, and this association appears likely, as factors such as raised maternal body temperature and stress are linked to preterm labour (Goldenberg et al., 2008; Hellgren et al., 2011). Both of these features result from heat exposure (Hajat et al., 2010).

Preterm birth is defined as the birth of an infant prior to 37 weeks gestation (Keller and Nugent, 1983) and the rate of preterm birth in developed countries such as Australia, the UK and the US is roughly 8–13% (Keller and Nugent, 1983; Ventura et al., 2006; ABS, 2009).

Rates have increased over the past decade (Moss, 2006; ABS, 2007) and this increase may in part be due to older maternal age and higher numbers of multiple births (Klebanoff and Keim, 2011). Preterm birth is linked with a number of adverse outcomes and is thought to account for 20–27% of all neonatal deaths in high-income countries (Lumley, 2003; Moss, 2006). Gestation <37 weeks is also linked to poorer ongoing child health (Langridge et al., 2010) including respiratory and gastrointestinal conditions (Moss, 2006) and long-term developmental and behavioural disorders. Developmental disorders include poorer cognitive function, such as learning difficulties (Taylor et al., 2011) and neuro-developmental delays in co-ordination, communication, and social interaction (Kerstjens et al., 2011).

At present, the causes of preterm birth are not well understood (Sayres Jr., 2010) and, for more than 50% of cases, no clear cause can be isolated (Beck et al., 2010). Known risk factors include women who have had a previous preterm birth, women from low socio-economic backgrounds and the presence of infection (Anumba, 2007; Beck et al., 2010).

Although little is known about other risk factors, the literature suggests that the causes of preterm birth are complex and possibly include environmental and genetic factors (Beck et al., 2010; Sayres Jr., 2010). There is also some evidence that preterm birthrates vary according to season. Bodnar and Simhan (2008), for example, found that women who conceived in winter and spring were more likely to have preterm births, and a number of other studies have found peaks of preterm birth incidence during summer and/or winter (Matsuda and Kahyo, 1992; Flouris et al., 2009; Strand et al., 2011). This finding suggests that extremes of environmental temperature (hot or cold) may contribute to preterm birth rates. Matsuda and Kahyo (1992), for example, found that preterm births in Japan peaked in both summer and winter and these authors suggested that the associated factors might differ between the two seasons. Strand et al. (2011), who conducted a review of the epidemiological evidence around preterm birth, also concluded that extremes of both hot and cold temperatures may impact significantly on preterm birth rates. Other authors such as Keller and Nugent (1983) and Flouris et al. (2009) found an association between preterm birth and higher summer temperatures but not colder winter temperatures. Overall, the bulk of the evidence indicates a link between higher temperature and preterm birth especially. However, the exact genesis of this association is unclear and it is additionally unclear if factors other than temperature influence these peaks. Darrow et al. (2009) contend that an increased incidence of preterm births seen in summer months may simply be in proportion to a greater number of total births in the summer season. This view does not account for the overall increasing incidence of preterm birth, which is juxtaposed against a generally declining birth rate.

Against this unclear background, both preterm birth rates (ABS, 2007; Beck et al., 2010) and the incidence of high environmental temperatures are increasing (WHO/WMO, 2012), making it important to investigate if there is a relationship between these factors. Therefore, this review has sought to open the debate and to examine evidence of an association between high environmental temperatures and preterm birth. This information may prove important in preparing for likely future increasing rates of preterm births, and for ongoing global warming.

The 'evidence to date'

At this stage, the literature is limited and absolute definitions of 'hot weather' 'high environmental temperatures' or 'heat waves' are almost impossible to locate. The following represents the most recent information found.

The US National Oceanic and Atmospheric Administration Services (NOAA) base extreme heat warnings on two factors: heat index (how hot it feels), and relative humidity (moisture in the air) (NOAA, 2011). This combination is often referred to as apparent temperature, and using this classification, environmental temperatures greater than 91 °F (32 °C) are considered dangerous whereas temperatures in excess of 105 °F (40 °C) are categorised as very dangerous, and in excess of 124 °F (51 °C) extremely dangerous (NOAA, 2011). Climate experts Frich et al. (2002) use a different grading system, which links to the usual environmental temperatures in the area in question. These authors discuss 'high temperature' in terms of the number of days in excess of the 90th percentile for that period, based on records from the 1961 to 1990 base period (Frich et al., 2002).

At this time, there is no universally accepted definition of a heatwave. However, the Australian Bureau of Meteorology considers a heatwave to be a 'prolonged period of excessive heat' of 'at least three successive days of temperatures 35 °C or greater' (Bureau of Meterology, 2010) whereas the World Meteorological Organization (WMO) suggests that a heatwave is a 'period of unusually hot weather that lasts from a few days to a few weeks' (WMO, 2011). Robinson (2001), of the American Meteorological Society, considers a heatwave to consist of daytime temperatures >40.6 °C (105 °F), and night-time temperatures >26.7 °C (80 °F) for a minimum of two consecutive days.

Thermal adaptation in humans, to high temperatures, also poses some interesting questions and, for that reason, a brief overview of the process is described here. According to Brager and de Dear (1998) thermal adaptation to temperature changes consists of three aspects:

1. Physiological acclimatisation (including changes in physiological responses such as sweating and changes to skin blood flow).
2. Psychological adaptation (changes of perception of the temperature).
3. Behaviour adjustment (conscious actions such as altering clothing, drinking cold fluids/using fans).

When thermal adaptation thresholds are exceeded, heat stress occurs and manifests in physiological and haemodynamic changes, such as tachycardia, dehydration and hyperthermia (Hajat et al., 2010). In prolonged and untreated heat stress, fatal heat stroke can result (Simpson, 2012). The key to mitigating the physiological impact of heat stress, appears to be acclimatisation