PEER REVIEW HISTORY

BMJ Open publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form (**http://bmjopen.bmj.com/site/about/resources/checklist.pdf**) and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below.

ARTICLE DETAILS

TITLE (PROVISIONAL)	An evaluation of a heat warning system in Adelaide, South Australia, using case-series analysis
AUTHORS	Nitschke, Monika; Tucker, Graeme; Hansen, Alana; Williams, Susan; Zhang, Ying; Bi, Peng

VERSION 1 - REVIEW

REVIEWER	Scott Sheridan Kent State University USA
REVIEW RETURNED	18-Apr-2016

GENERAL COMMENTS	I feel that the manuscript is a timely contribution to the literature, with overall well executed statistical tests that follow well the researchers' previous publications. The manuscript reads well and flows logically. I only have minor concerns, largely related to the contextualization of the results. In the researchers' previous works, particularly Nitschke et al. (2011), they cite the 2008 and 2009 heat waves as being fundamentally different than all those before, and document well why this is the case. However, in this paper, only the 2009 event is cited. While it certainly is clear that the 2014 temperatures are more similar to 2009 than 2008, in which extreme temperatures were somewhat lower, nevertheless the three heat events seem to stand out well across the record. It's unclear to me why 2008 isn't mentioned, since looking at the results in the other paper, it looks as though in several of the morbidity categories the 2008 and 2014 events are similar, thus making me wonder if 2009 is the outlier. I don't think this needs to be changed with further statistical analyses, but I'm always a bit nervous when too many conclusions are drawn for what effectively amounts to n=2. I think some additional text talking about the uniqueness of 2009 vs. previous events, including 2008, should be included, and also provide broader context beyond these two events in Adelaide, particularly since the research has been done. Minor: There should be more clarity between the 32° threshold cited (p6, l12) and the 35° threshold (p7, l22)

REVIEWER	Sam Toloo Queensland University of Technology, Australia
REVIEW RETURNED	28-Apr-2016

GENERAL COMMENTS	METHOD 1) P 5, L 38: It is stated that data "from 1993 to 2014 were obtained". Again, on P 7, LL 54-56, it is claimed that long-term trends for 1993-

2014 have been analysed. However, only 2009 and 2014 data have been analysed and reported. Please explain or correct the discrepancy.

2) P 7, L 22: The heatwave definition is unclear. What does "3 or more days of =>35C" mean? Is the 35C the average daily temp (ADT) or maximum temp (Tmax)? If it is ADT, then most of the selected days do not qualify as heatwave (see Suppl Table 1), but if that is Tmax, then this definition does not conform to the BoM's definition on P 6 (L 10-13 & Table 1), which states that the HWS is triggered when an ADT =>32C is forecast.

3) The two heatwave periods (2009 and 2014) are not comparable (see Suppl Table 1). While the 2009 hw period is a single 13-day period, the 2014 hw is comprised of two shorter periods separated by a 9-day non-hw period. The Tmin and Tmax ranges vary by several degrees between the hw periods, e.g Tmin= 16.9–33.9 (2009), 16.6–29.9 (2014a), and 17.6–28.7 (2014b). Similar variations exist for Tmax. It is likely that the improvement in health outcomes in 2014 was simply because of the cool temperature relief between the two hw periods, or better adjustments following the 1st hw, hence reducing the adverse health effect thereafter. There is literature that shows "higher mortality risk from heat waves that were more intense or longer, or those occurring earlier in summer" (Anderson & Bell, 2011, EHP. doi: 10.1289/ehp.1002313). Since the results do not distinguish the health outcomes of the 2014's 1st hw period from the 2nd, it is not possible to draw a conclusion as to the HWS' effectiveness.

RESULTS
1) P 9, Table 2: The mean number of Hospital Admissions (HA) and Emergency Presentations (EP) during the 2014 hw were lower than non-hw days. This is counter-intuitive and requires some explanation.

2) There seem to be serious miscalculations in tables 3-5 & Suppl Table 2. I recalculated the excess reductions and differences between 2009 and 2014 in accordance with the instructions on P 8 and above Table 3. However, I found many discrepancies (some small and some large) between my calculations and the ones reported in the mentioned tables. For instance, in Table 4 (P 13), I came up with 253.5 excess (instead of 301.7, total 2009), –402 (instead of –439.8, total 2014), and 124.3 (instead of 125.2, Renal 2009). Only the results of my calculations for the Heat-related conditions (Table 4 and Suppl Table 2) were identical to the ones reported in the paper. Please explain the discrepancy or correct the results and the interpretations.

3) P 12, L 21-23: It is stated that "Heat-related IRRs were reduced by one-third". However, the data in Table 4 do not support this claim. The All ages IRRs were 12.03 and 5.27 for 2009 and 2014, respectively (2014:2009 ratio= 0.44). None of these suggest a reduction by one-third.

DISCUSSION & CONCLUSION
1) Study limitations should more comprehensively examine the in/comparability of the two (or better say, three) heatwave periods. It seems like the authors are trying to mask the differences by highlighting the similarities.

	2) Furthermore, the study only analyses the total number of cases or specific conditions without controlling for the severity (e.g. triage category) and other conditions such as time of the day or potential lag effects. It is important to discuss such limitations in detail. 3) The conclusions should be revised in light of the limitations mentioned above.

VERSION 1 – AUTHOR RESPONSE

Response to reviewer 1: Professor Scott Sheridan
Comment: Why was 2008 not used in the context of the comparison to 2014?
Response: The 2008 heatwave was just relevant because of the length (15 days ≥35°C) and not because of the intensity of temperature. In 2008, temperatures did just skim the 40°C mark and only on 2 days. It was later found in our heat health threshold investigation that significant increases in mortality and morbidity in Adelaide only occur in conditions of
3+ days of 40 & ADT 32
(3 or more days of >40 and minimum temperature >=24C.
Therefore the comparability is not between 2008 and 2014, but only between 2009 and 2014 where temperatures in the mid-forties occurred.
We have included a description of the 2008 heatwave into the discussion.
Additional text has been included on page 16:
"There was only one other notable heat event in recent years occurring in March 2008, with 15 consecutive days of 35°C and over, but temperatures merely skimmed the 40°C mark. The heatwave was therefore not comparable with the 2009 and 2014 events which all included consecutive days well over 40°C including high overnight temperatures, a heat health threshold pattern that is now recognised as being associated with considerable risks in Adelaide's population.2, 13-14"

Comment: N=2 shortage of numbers of studies for comparison purposes
We accept this criticism and have included additional text on page 18

"It is essential to continue evaluating future extreme heatwaves considering that the 2014 heatwaves are so far the only ones comparable in severity to the pre-intervention 2009 heatwave. The evaluation of the effectiveness of the HWS and interventions in Adelaide are therefore at an early stage and this study has explored the effect of the intervention on health outcomes only."
Comment: There should be more clarity between the 32° threshold cited (p6, l12) and the 35° threshold (p7, l22)
Response: For analytic purposes, our definition of a heatwave was 3 or more days with maximum temperatures ≥35ºC. A heat warning is issued by the SES during extreme heat events – i.e. when there is a forecast of 3 or more days with average daily temperatures of ≥32ºC based on empirical threshold investigations.
The following text has been included on page 6 under the heading heat health interventions:
"A HWS is triggered during extreme heat events in conjunction with the Bureau of Meteorology (BOM) when an average daily temperature (ADT) of ≥32ºC is forecast for three or more days (average of daily maximum and minimum = ADT; for example 40°C + 24°C/2=32). This temperature threshold is based on retrospective analysis of health and temperature data.13-14"
See also page 7 in temperature data:
"The definition (3 or more days with maximum daily temperatures of ≥35ºC) for heatwave impact assessments in Adelaide was used to compare the health impacts during the 2014 heatwaves to those in 2009.1-2"

Response to Dr Sam Toloo, reviewer 2
Comment P 5, L 38: It is stated that data "from 1993 to 2014 were obtained". Again, on P 7, LL 54-56,

it is claimed that long-term trends for 1993-2014 have been analysed. However, only 2009 and 2014 data have been analysed and reported. Please explain or correct the discrepancy:
Response: Data from 1993 to 2014 was analysed. Since the model was a fixed effect model within years, the results are the same for the 2009 and 2014 heatwaves for a poisson model regardless of whether all years were included in the analysis, or if just the 2009 and 2014 years (i.e. the 2008/09 and 2013/14 financial years) were analysed. The coefficient for heatwaves other than 2009 & 2014 is different however. For the model including all data this term represents the effect of heatwaves other than during the two specified over the full period. When there was overdispersion in the model, a negative binomial model was fit. When the model is adjusted for overdispersion in this way, the standard errors estimated for the parameters are more accurate using the full dataset.
Additional text has been included on page 7:
"The analysis was conducted within years, therefore implicitly adjusting for long-term trends for the years 1993-2014 which provides more accurate standard errors when the data are over dispersed.20"

Comment P 7, L 22: The heatwave definition is unclear. What does "3 or more days of =>35C" mean? Is the 35C the average daily temp (ADT) or maximum temp (Tmax)?
Response: As both reviewers had asked for more clarity, additional text has been included on page 6 and 7 under the heading heat health interventions and under the heading temperature data.
Comment: The two heatwave periods (2009 and 2014) are not comparable:
Response: While the 2014 heatwaves had some differences in the temperature constellation compared to the 2009 heatwave, they were considered to be the most significant by the BOM since the 2009 heatwave (see special climate statement 48).
It is almost impossible to find identical meteorological conditions for comparison purposes. This was an issue pointed out also in the review paper about planned adaptation and reduction of heat illnesses by Boeckmann and Rohn (number 10 in our reference list). This does not mean that a direct comparison for the purpose of evaluation should not be attempted considering the importance of feedback necessary to the policy makers. The additional discussion points make this clear.
We have added the following text on page 18:
"It is essential to continue evaluating future extreme heatwaves considering that the 2014 heatwaves are so far the only ones comparable in severity to the pre-intervention 2009 heatwave. The evaluation of the effectiveness of the HWS and interventions in Adelaide are therefore at an early stage and this study has explored the effect of the intervention on health outcomes only."

Results section
Comment 1. Mean number of hospital and emergency admissions were lower than during non-heatwave periods.
Response: This is true. ED and hospitalisation totals comprise all health outcomes, not only those related to heat. Therefore, there are inevitable decreases during extreme heat for other health outcomes. Number of health outcomes where the IRRS indicate a reduction during heatwaves compared to non-heatwave periods (for example respiratory health outcomes or sports related ambulance call-outs).
Even with heat-related health-outcomes such as renal disease, there was a higher incidence during non-heat wave days compared to heat wave days in 2014. This may be due to the intervention measures which emphasized the need for drinking sufficient water and other precautions. These warnings are not broadcast during non-heatwave periods, albeit temperatures can still be warm requiring increased water intake.
It is possible that once these messages are not any more in the public focus, people may forget. This could lead to the counter intuitive effect, and is now addressed in the article in the discussion section. The following addition has been made on page 17:
"An apparent protective effect of heatwaves on renal emergency presentations in 2014 (and hospital-related; in supplementary file) is counter-intuitive considering our previous renal results and evidence from other studies.24-27 It may have been due to people being particularly cautious about

maintaining hydration in response to heat warnings, but overlooking the importance of fluid intake throughout summer."
Comment 2. There seem to be serious miscalculations in tables 3-5 & Suppl Table 2.
Response: It is not encouraged to have more than 2 decimal points in tables. Hence, the IRRs have been rounded and this will incur some differences to the real results when trying to re-calculate from rounded results.
All calculations have been checked and no mistakes have been detected.
Comment 3. P 12, L 21-23: It is stated that “Heat-related IRRs were reduced by one-third”. However, the data in Table 4 do not support this claim.
This was a mistake. There is 1/3 reduction in heat-related outcomes for total hospital admissions, but not for emergency outcomes.
We apologise.
The following change has been made on page 12: "by more than half"
Discussion and conclusion:
Comment 1 Discuss study limitations
Response: We acknowledge this and have added limitations into discussion and conlusions
Additional text on Page 18:
It is essential to continue evaluating future extreme heatwaves considering that the 2014 heatwaves are so far the only ones comparable to the pre-intervention 2009 heatwave. The evaluation of the effectiveness of the HWS and interventions in Adelaide are therefore at an early stage and this study has explored the effect of the intervention on health outcomes only.
And page 18/19 see under conclusion
Comment 2 Controlling for severity etc. lags
Response: This study was an ecological design at the population level and therefore it did not take into account any individually based patient information such as severity and triage level. This would be an entirely different study.
Potential lag effects were not considered at this stage because the reason for this paper was a comparison to the 2009 heatwave.
Suggestions for further studies have been added in the discussion
Additional text has been included on page 18:
"Further studies requiring more detailed information about severity and sub-categories of the critical health outcomes studied, co-existing diseases and other risk factors will enhance future evaluations."
Comment 3. Limitations have been included in the conclusions
"Monitoring population health outcomes during extreme heat events is essential to inform the ongoing development of public health interventions. This comparison of extreme heat events in metropolitan Adelaide, five years apart, has provided initial evidence of improvements in health outcomes, possibly associated with the introduction of a heat warning system and public health intervention measures. Notwithstanding some differences between the two heatwaves, they represent the most significant recent heat events recorded for this population. Our findings showed there were marked reductions in renal and heat-related morbidity in 2014 compared to what was expected in relation to hw2009 suggesting that awareness of warnings and advice during the heatwave may be a contributing factor."

VERSION 2 – REVIEW

REVIEWER	Scott Sheridan Kent State University, USA
REVIEW RETURNED	19-May-2016

GENERAL COMMENTS	Thank you for addressing my concerns