

PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Heat stress, health, and wellbeing: findings from a large national cohort of Thai adults
AUTHORS	Tawatsupa, Benjawan; Yiengprugsawan, Vasoontara; Kjellstrom, Tord; Seubsman, Sam-ang; Sleight, Adrian

VERSION 1 - REVIEW

REVIEWER	Yuk Yee Yan (Professor) Department of Geography Hong Kong Baptist University Kowloon Tong, Hong Kong I have no conflict of interests with the authors.
REVIEW RETURNED	29-May-2012

GENERAL COMMENTS	<p>This is an original study that provides important information on the impact of heat stress on daily activities, health and wellbeing outcomes in a tropical country. However, I would like the authors to include the following:</p> <ol style="list-style-type: none"> 1. The study examined the impact of heat stress in the hot season in Thailand. When is the hot season in Thailand? What are the maximum, mean, minimum temperatures and relative humidity? Is there any spatial variations? I would suggest the authors to have a brief description of the climate in Thailand. 2. The subjects of the study came from all areas of Thailand. Were the subjects evenly distributed geographically (i.e. were the number of subjects from various parts of Thailand the same)? If there is geographical variations in climate, responses of the subjects may also be different. I would like the authors to address these questions.
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REVIEWER	Prof. S. Tong School of Public Health and Social Work Institute of Health and Biomedical Innovation Queensland University of Technology Kelvin Grove, Qld. 4059 AUSTRALIA No competing interests
REVIEW RETURNED	15-Jun-2012

THE STUDY	This paper attempted to examine the association between hot season heat stress interference with daily activities and some health
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	<p>and wellbeing outcomes. A cross-sectional survey was conducted among 60,569 Thailand university students. They found that there already are substantial heat stress impacts on health and wellbeing in Thailand, and unmitigated climate change as well as the growing urban population could significantly worsen the situation. It is an interesting and well-written paper which addresses an important research question. However, a number of issues need to be clarified. For example, about one third of the participants were lost to follow-up in 2009 and what is the potential for loss to follow-up bias? A table should be provided to compare the characteristics of the participants and those who were lost to follow-up in 2009. More details are needed for the Methods section. For instance, it is unclear how valid the questions used in the survey instrument are. They stated that "Questions related to heat stress were as follows: "How often did the hot period this year interfere with the following activities? 1) sleeping; 2) housework..." However, there is no description about how they defined the interference. It could lead to over- or/and under-estimates of heat impacts if the definition is unclear. Similarly, it may be unreliable for just using two questions from SF8 to measure the physical and mental health impacts of heat. Discussion should be expanded. Some relevant studies have already been conducted in Thailand (e.g., refs 0, 18-20 and Guo et al, 2012), and the authors should discuss if their results are consistent with previous findings, even though different studies focused on different health outcomes.</p> <p>Reference: Guo Y, et al. Effects of temperature on mortality in Chiang Mai city, Thailand: a time series study. Environ Health. 2012 May 21;11(1):36. [Epub ahead of print]</p>
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REVIEWER	Patrizia Schifano Department of Epidemiology Lazio Regional Health Service - Rome - Italy
REVIEW RETURNED	09-Jul-2012

THE STUDY	<p>The study is a cross-sectional study, based on a self administered questionnaire. The questionnaire contains questions on "perception of the effect of heat on daily activities" and on health outcomes. I would suggest to reformulate the objective of the paper, specifying they are measuring the association between the perceived interference of health stress on daily activities and health outcomes. No direct measure of the exposure is taken. Furthermore the question on the interference between heat stress and daily activity is referred to the whole year. Why didn't they restrict the reference period to the hot season? Alternatively they could have repeated the question referring it separately to the hot season and the cold season.</p> <p>Also questions revealing the health status are referred to a different period (one is referred to the all-life time period, and the other two to the last month, and we don't know if this "last month" was in the hot season or not. Assuming that heat stress can influence the perception of their status, this might be important.</p> <p>- It is well known that some subjects are more susceptible than others to heat. In many studies the elderly represents the part of the population more susceptible to the negative effect of heat on health.</p>
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	The studied cohort is composed mainly by very young. This should be stressed more in the paper.
RESULTS & CONCLUSIONS	The objective of the paper will be re-written and the problem of the different time periods of the questionnaire items addressed

VERSION 1 – AUTHOR RESPONSE

Response to Reviewer comments

1. Reviewer: Prof. Yuk Yee Yan (Department of Geography, Hong Kong Baptist University Kowloon Tong, Hong Kong)

1) The study examined the impact of heat stress in the hot season in Thailand. When is the hot season in Thailand? What are the maximum, mean, minimum temperatures and relative humidity? Is there any spatial variations? I would suggest the authors to have a brief description of the climate in Thailand.

We have added information of climate in Thailand in the Introduction section (4th paragraph) in Page 5.

“...In tropical Thailand, hot and humid conditions are common, especially in the hot season (March - June). The monthly maximum, mean and minimum temperatures averaged from 1999 to 2008 were around 33°C, 27°C, and 22°C respectively with the averaged relative humidity at 75%. The monthly maximum temperatures averaged during ten years varied little by region (32-33°C) and were highest in the North region during April (40°C) and lowest in the same region during December (24°C) (Tawatsupa et al., 2012a)..”

2) The subjects of the study came from all areas of Thailand. Were the subjects evenly distributed geographically (i.e. were the number of subjects from various parts of Thailand the same)? If there is geographical variations in climate, responses of the subjects may also be different. I would like the authors to address these questions.

Regarding our response to comments No. 1, the monthly maximum temperature averaged during 1999 to 2008 varied little by geographical region (32-33°C). We are also aware of the responses to heat stress of subjects in different area of Thailand. Here (for this response to item 2) we did additional analysis to show the number of study population, number of respondents and % prevalence of often heat interference daily activities by region of Thailand (Table A, below – not for inclusion in the paper). We also added a sentence in the Result section (2nd paragraph) in page 9;

“...We noted that the prevalence of ‘often’ heat interference for each daily activity are not much different in different regions (33-42% for daily travel, 29-38% for work, 26-32% for

housework, 23-29% for sleeping, and 22-28% for exercise). Daily activities and heat interference frequency categories are summarized in Table 2....”

Table A. Study population, and % prevalence of ‘often’ heat interference daily activities by region of Thailand.

Daily activities		Bangkok	Central	North	Northeast	South	Total
Total	N	10,310	15,349	11,329	15,912	7,668	60,569
Often heat interference							
Sleeping	N	2,638	4,243	3,267	4,462	1,729	16,339
	%	26.0	28.1	29.3	28.6	23.0	27.4
Housework	N	2,903	4,634	3,525	4,787	1,922	17,771
	%	28.7	30.8	31.7	30.7	25.6	29.9
Daily travel	N	4,283	5,886	3,972	5,635	2,515	22,291
	%	42.3	39.1	35.7	36.2	33.5	37.5
Work	N	2,970	5,080	4,132	5,891	2,408	20,481
	%	29.4	33.7	37.1	37.8	32.0	34.5
Exercise	N	2,371	3,800	3,105	4,427	1,690	15,393
	%	23.5	25.3	27.9	28.4	22.5	25.9

2. Reviewer: Prof. S. Tong (School of Public Health and Social Work, Institute of Health and Biomedical Innovation, Queensland University of Technology, AUSTRALIA)

1) About one third of the participants were lost to follow-up in 2009 and what is the potential for loss to follow-up bias? A table should be provided to compare the characteristics of the participants and those who were lost to follow-up in 2009.

To respond to this item 1, we have prepared a table comparing overall socio-demographic and health characteristics of the 60,569 cohort members followed up in 2009 and those 26,578 participants who lost to follow-up (Table B). It is not necessary to include this table and we have started the Results (in Page 8) with the following inserted sentence.

“...We first compared the 2005–2009 cohort to those who dropped out in 2009 (data not shown). The two groups were similar for age, sex ratio, employment, income, and health outcomes studied here (energy levels, emotional problems, life satisfaction)...”

Table B. Socio-demographic and health characteristics in 2005 of Thai cohort member in the follow-up group and who loss in the 2009

Cohort characteristics in 2005	Cohort members in 2005&2009	Participants only in 2005	Total
Total N	60,569	26,578	87,174
Sex			
Male	45.3	45.5	45.3
Female	54.7	54.5	54.7
Personal monthly incomes			
≤ 3000	9.5	14.6	11.0
3001-7000	28.7	36.1	30.9
7001-10000	23.4	23.0	23.3
10001-20000	26.5	18.8	24.2
20001-30000	7.2	4.1	6.3
>30000	4.7	3.4	4.3
Work for income			
Yes	88.4	82.4	86.5
No	11.7	17.7	13.5
Energy levels in the past 4 weeks			
Very much	17.4	17.5	17.4
Quite a lot	42.7	42.0	42.5
Some	30.0	29.8	30.0
A little or none	9.9	10.8	10.2
Emotional problems in the past 4 weeks			
Not at all	10.9	8.9	10.3
Slightly	53.0	49.2	51.9
Moderately	21.9	24.3	22.6
Quite a lot / extremely	14.2	17.6	15.2
Overall life satisfaction			
9-10 very satisfied (highest)	31.7	29.3	31.0
8 (high)	28.7	26.8	28.1
6-7 (medium)	25.9	26.5	26.1
0-5 not very satisfied (low)	13.7	17.4	14.9

2) More details are needed for the Methods section. For instance, it is unclear how valid the questions used in the survey instrument are. They stated that “Questions related to heat stress were as follows: “How often did the hot period this year interfere with the following activities? 1) sleeping; 2) housework...” However, there is no description about how they defined the interference. It could lead to over- or/and under-estimates of heat impacts if the definition is unclear.

We added a sentence describing the definition of heat interference (in Methods section, under Measures of heat stress, page 7). Also, we now have a validation study for heat stress question by calling back to the heat stress respondents in 2009. The preliminary results show that heat stress data are valid and useful to publish with the analysis and caveats as produced for this paper submitted to BMJOpen.

“...Questions related to heat stress were as follows: “How often did the hot period this year interfere with the following activities?” 1) sleeping; 2) housework; 3) daily travel; 4) work; and 5) exercise. Responses were ‘not applicable – use air conditioning’, ‘never’, ‘1-3 times per month’, ‘1-6 times per week’, and ‘every day’. In this study, heat interference means heat stress causing an uncomfortable feeling when doing those daily activities. For analysis, we grouped self-reported heat stress into ‘never’, ‘sometimes’ (1-3 times per month), and ‘often’ (1-6 times per week or every day)...”

3) Similarly, it may be unreliable for just using two questions from SF8 to measure the physical and mental health impacts of heat. Discussion should be expanded.

We expanded the 3rd paragraph of the Discussion (in page 11), including.....

“...Elsewhere we have completed detailed analyses of associations between heat stress and self-reported health outcomes in the cohort using the questions from SF8 (Tawatsupa et al., 2010). Our studied outcomes in this report were holistic fundamental measures of health.....”

4) Some relevant studies have already been conducted in Thailand (e.g., refs 10, 18-20 and Guo et al, 2012), and the authors should discuss if their results are consistent with previous findings, even though different studies focused on different health outcomes.

We added one paragraph in the Discussion section (6th Paragraph) in page 12.

“...In our study, we found that heat stress in Thailand is not only a problem at work but also heat stress interferes with other daily activities including sleeping, daily travel, housework and exercise. The results of our study complement other Thai research about adverse effects of

heat. One recent report shows that heat stress in Thailand is a very serious problem in a wide variety of work settings (Langkulsen et al., 2010). McMichael et al (2008) and Guo et al (2012) found a temperature–mortality association and Pudpong et al (2011) found heat related excess hospital admissions. Worker studies in Thailand related occupational heat stress, kidney disease and psychological distress (Tawatsupa et al., 2010, Tawatsupa et al., 2012b)..."

3. Reviewer: Patrizia Schifano

1) The study is a cross-sectional study, based on a self administered questionnaire. The questionnaire contains questions on "perception of the effect of heat on daily activities" and on health outcomes. I would suggest to reformulate the objective of the paper, specifying they are measuring the association between the perceived interference of heat stress on daily activities and health outcomes. No direct measure of the exposure is taken.

Here, we added the word "self-reported" for heat stress interference in the objective of the Abstract (Page 2).

"...Objectives: This study aims to examine the association between self-reported heat stress interference with daily activities (sleeping, work, travel, housework, exercise) and three graded holistic health and wellbeing outcomes (energy, emotions, life satisfaction)..."

And in the Article summary (Page 3)

"...To examine the association between self-reported heat stress interference with daily activities (sleeping, work, travel, housework, exercise) during hot season and three graded holistic health outcomes (energy, emotions, life satisfaction) in Thailand.."

2) Furthermore the question on the interference between heat stress and daily activity is referred to the whole year. Why didn't they restrict the reference period to the hot season? Alternatively they could have repeated the question referring it separately to the hot season and the cold season. Also questions revealing the health status are referred to a different period (one is referred to the all-life time period, and the other two to the last month, and we don't know if this "last month" was in the hot season or not. Assuming that heat stress can influence the perception of their status, this might be important.

As we mentioned in the Methods (page 5) and Discussion section (page 11) that the heat stress and health outcomes questions were in different parts of questionnaire, the respondents could not easily link in their mind so answers on these issues were independent.

For heat stress question, we do not have detailed information on the date or season when respondents answered the questions as our cohort data were collected by mailing continuously during the year of study (in 2009). Although, the heat stress question did refer specifically to the hot period within that year, tropical Thailand in general has hot and humid weather almost all year round and not much variation within a year. We believe that the self-reported heat stress can give information on frequency of heat interference during the study period (times per month or week). For the health outcome measurements, the reason to use the period of past four weeks is to prevent the recall-bias of self-reported health outcomes. In this study, the period of the past four weeks was used according to the standard Medical Outcomes Short Form Instrument (SF8). Thus, it would be complex to classify in more detail of hot and cold season and our baseline questionnaire was very broad and was 20 pages long. We have done our best to utilise and classify the heat stress related information gathered.

3) It is well known that some subjects are more susceptible than others to heat. In many studies the elderly represents the part of the population more susceptible to the negative effect of heat on health. The studied cohort is composed mainly by very young. This should be stressed more in the paper.

This is a very helpful point. Our results showed heat stress and health impacts in a national group of young and middle-aged Thai adults. We are aware that age effects heat stress and health outcomes relationships so age was considered as a confounder in our analysis. Here we added a sentence in the Abstract (page 2) and Discussion section (last paragraph in page 13) showing our concern about heat stress effects in the elderly in the future;

“...We conclude that Thai populations are at high risk of heat stress during daily activities. Also, in Thailand an anticipated increase in temperature from climate change plus the ageing and urbanisation of the population could significantly increase heat impacts on health and wellbeing. There is a need for improvements in public health surveillance and public awareness regarding the risks of heat stress which hitherto have been considered unremarkable in such a tropical environment.”

Reference

- Guo, Y., Punnasiri, K. & Tong, S. 2012. Effects of temperature on mortality in Chiang Mai city, Thailand: A time series study. *Environmental Health*, 11, 36.
- Langkulsen, U., Vichit-Vadakan, N. & Taptagaporn, S. 2010. Health impact of climate change on occupational health and productivity in Thailand. *Global Health Action*, 3.
DOI:10.3402/gha.v3i0.5607.

Mcmichael, A. J., Wilkinson, P., Kovats, R. S., Pattenden, S., Hajat, S., Armstrong, B., Vajanapoom, N., Niciu, E. M., Mahomed, H., Kingkeow, C., Kosnik, M., O'Neill, M. S., Romieu, I., Ramirez-Aguilar, M., Barreto, M. L., Gouveia, N. & Nikiforov, B. 2008. International study of temperature, heat and urban mortality: The 'isotherm' project. *International Journal of Epidemiology*, 37, 1121-31. 10.1093/ije/dyn086.

Pudpong, N. & Hajat, S. 2011. High temperature effects on out-patient visits and hospital admissions in Chiang Mai, Thailand. *Science of the Total Environment*, 409, 5260–5267. 10.1016/j.scitotenv.2011.09.005.

Tawatsupa, B., Dear, K., Kjellstrom, T. & Sleight, A. 2012a. The association between temperature and mortality in tropical middle income Thailand from 1999 to 2008. Canberra: National Centre for Epidemiology and Population Health.

Tawatsupa, B., Lim, L. L.-Y., Kjellstrom, T., Seubsman, S., Sleight, A. & The Thai Cohort Study Team 2010. The association between overall health, psychological distress, and occupational heat stress among a large national cohort of 40,913 Thai workers. *Global Health Action*, 3. 10.3402/gha.v3i0.534.

Tawatsupa, B., Lim, L. L.-Y., Kjellstrom, T., Seubsman, S., Sleight, A. & The Thai Cohort Study Team 2012b. Association between occupational heat stress and kidney disease among 37,816 workers in the Thai Cohort Study (TCS). *Journal of Epidemiology*, 22. 10.2188/jea.JE20110082.

VERSION 2 – REVIEW

REVIEWER	Patrizia Schifano Department of Epidemiology Lazio Regional Health Service - Rome - Italy
REVIEW RETURNED	25-Sep-2012

RESULTS & CONCLUSIONS	<p>Authors have answered in a satisfying way at the observations made in the first review.</p> <p>However, it is not clear both in the “objective” of the study, and even more in the way results are commented in the discussion, that authors can’t establish any causal relationship between the “outcome” and the “dependent variable” chosen i.e. “self reported heat stress interference with daily activities”</p> <p>They say in the discussion that “Our study shows that climate-related heat stress in tropical Thailand adversely affects self-reported health and wellbeing if the heat interferes with daily activities such as sleep, housework, travel, work, and exercise.” This is not something they can infer using a cross sectional design. They can only observe and comment that those who report higher levels of heat stress are also those who have the worse emotional reported status, or life satisfaction levels. Actually, a worse health status might be the cause of a higher level of interference of heat with all the activities they describe. Furthermore they can’t infer “We found negative health and wellbeing outcomes (low life satisfaction, low</p>
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	<p>energy level, and emotional problems) increased with higher frequency of heat stress while performing daily activities” This sentence seems to suggest a dose-response relationship between the two studied variables. In my opinion authors should revise the discussion taking into account these considerations for the paper to be considered for publication.</p> <p>Furthermore as a minor revision, authors should be clearer about the time period of reference. They say that the study is referred to the whole season, but in the “Measure of Heat stress” paragraph (page 6) it is reported ““How often did the hot period this year interfere with the following activities?” Furthermore they say that the questions from the SF36 are instead referred to the 4 weeks before the day of administration, and that the questionnaire was administered in different periods of the year to the participants. This is a further limit of the analysis that should be addressed</p>
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VERSION 2 – AUTHOR RESPONSE

Response to Reviewer comments

Reviewer: Patrizia Schifano

Department of Epidemiology Lazio Regional Health Service - Rome - Italy

Authors have answered in a satisfying way at the observations made in the first review.

However, it is not clear both in the “objective” of the study, and even more in the way results are commented in the discussion, that authors can’t establish any causal relationship between the “outcome” and the “dependent variable” chosen i.e. “self reported heat stress interference with daily activities”

They say in the discussion that “Our study shows that climate-related heat stress in tropical Thailand adversely affects self-reported health and wellbeing if the heat interferes with daily activities such as sleep, housework, travel, work, and exercise.” This is not something they can infer using a cross sectional design. They can only observe and comment that those who report higher levels of heat stress are also those who have the worse emotional reported status, or life satisfaction levels. Actually, a worse health status might be the cause of a higher level of interference of heat with all the activities they describe. Furthermore they can’t infer “We found negative health and wellbeing outcomes (low life satisfaction, low energy level, and emotional problems) increased with higher frequency of heat stress while performing daily activities” This sentence seems to suggest a dose-response relationship between the two studied variables. In my opinion authors should revise the discussion taking into account these considerations for the paper to be considered for publication.

Furthermore as a minor revision, authors should be clearer about the time period of reference. They say that the study is referred to the whole season, but in the “Measure of Heat stress” paragraph (page 6) it is reported “How often did the hot period this year interfere with the following activities?” Furthermore they say that the questions from the SF36 are instead referred to the 4 weeks before the

day of administration, and that the questionnaire was administered in different periods of the year to the participants. This is a further limit of the analysis that should be addressed

- 1) We agree that this paper cannot prove a direct causal relationship between heat stress and health outcomes.

We revised our Abstract (Page 2)

“Results: Negative health and wellbeing outcomes (low energy level, emotional problems, and low life satisfaction) ~~increased~~ associated with increasing frequency of heat stress interfering with daily activities”

We revised the Article summary (Page 3):

“Negative health and wellbeing outcomes (low energy level, emotional problems, and low life satisfaction) ~~increased~~ associated with increasing frequency of heat stress interfering with daily activities”

We also revised the last paragraph of the Introduction section (Page 5):

“Here we report an investigation of association between heat stress interference with ~~effects on~~ daily activities and ~~on~~ health and wellbeing in a large national cohort of young and middle aged Thai adults”

For the Discussion, we revised the 1st, 2nd, and 3rd paragraph of Discussion (Page 10-11):

“Our study shows that climate-related heat stress in tropical Thailand associated with ~~adversely affects~~ self-reported health and wellbeing if the heat interfered with daily activities such as sleep, housework, travel, work, and exercise. The large study group included young and middle-age Thai adults, mostly doing paid work, with a little over half residing in urban areas. These cohort members ~~people~~ are active and over 20% report often experiencing heat interference for daily activities during the hot season.”

“We found those who report higher levels of heat stress interference with daily activities tend to also be the ones who have adverse ~~negative~~ health and wellbeing outcomes (low life satisfaction, low energy level, and worse emotional problems) ~~increased with higher frequency of heat stress while performing daily activities~~. Odds Ratios of heat stress effects across all daily activities for emotional problems are between 1.55 and 4.81 and in general are worse than energy level effects (between 1.31 and 2.91) and life satisfaction effects (between 1.10 and 2.49). The worst health outcomes were for heat stress while sleeping followed by heat stress for daily travel, work, housework and exercise.”

“Our data are based on self-report by educated Thais and we note that questions on heat stress and health outcomes were in different parts of the questionnaire. Findings show strong and highly consistent trends especially for adverse health effects of frequent heat interference during sleep, daily travel, and work. Elsewhere we have completed detailed analyses of associations between heat stress and self-reported health outcomes in the cohort using the questions from SF8 (10).”

- 2) We note the comment regarding the causal relationship and time period of reference, and now have added the following text to limitation section of the Discussion (Page 13);

“One limitation of this study is that it could not directly establish that health and wellbeing outcomes arose as a result of heat stress. Interpreting causality between heat stress exposure and health and wellbeing outcomes is complex in a cross-sectional study as we cannot be completely sure that heat stress preceded their health condition and wellbeing. Also, the source of the heat stress was not reported and we could not make direct measurements of heat stress exposure and health and wellbeing outcomes. Another limitation of this study arose because people answered the questionnaire at different times of the year (but most in March to July - the hot period). The questions on physical and emotional health assessed the previous four weeks so most (almost all) were answering for the hot period.”