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Review Article

The Effects of Heat Stress on Bakery Workers: A Systematic Review

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Abstract

Background: Working in hot environments can cause diseases and reduce performance by upsetting the balance of physiological parameters of workers' bodies. Bakers are among the people exposed to heat stress continuously and daily. This review study aimed to investigate the effect of heat stress on bakers.

Methods: In this review study, the related articles based on keywords were reviewed using "IranMedex", "Science Direct", "PubMed", "Scopus", "Web of Science", "SID", "Google Scholar", and "Magiran" databases from the years 2000 to 2021. The used search terms were "Heat stress", "Heat strain", "Heat exposure", "Heat waves", "Workplace", "Baker", and "health effects". In order to extract the required data, all parts of the articles have been reviewed.

Results: Out of the 16 studies reviewed in this study, 43.75% were cross-sectional, 25% were descriptive cross-sectional, and 31.25% were performed according to other study designs. In all of the studies, the WBGT index was used to assess ambient heat stress. In most studies, the mean exposure temperature was higher than the WBGT-ACGIH limit, especially among traditional bakery workers. The findings showed that exposure to thermal stress significantly affects some hematological parameters of blood, oxidative stress, heart rate, and body temperature.

Conclusion: The situation of heat stress in the bakery environment is worrying in terms of health and reduced productivity of employees. Therefore, it is essential to take the necessary preventive and control measures to reduce heat stress and the resulting strain.

Keywords: Baker; Exposure to heat; Heat stress; Heat index

Introduction

The improvement of economic conditions and the development of many industries depend on many components, including the health status and quality of life of the workers working in those industries. Unfortunately, the conditions of many work environments are such that workers'

health is overshadowed. The existence of various hazards in the workplace, including physical, chemical, biological, and psychological hazards, has caused workers to face many challenges in the workplace on an ongoing basis (1).

Each of these risks has different effects on workers depending on the working conditions and nature, and they have different degrees of importance. One of these hazards is heat stress, emerged as a crucial physical hazard in many industries and occupations, including foundries, mines, bakeries, and farmers. Heat stress is a specific heat load that workers may encounter in various environments (2). In summer and hot and dry weather conditions and hot and humid, the impact of this physical hazard doubles. In work environments, with the increasing effects of heat stress, people's health is more endangered, and consequently, the rate of occupational accidents increases (3).

Reports suggest that heat stress will be directly associated with adversely affecting productivity, poverty, and unequal socioeconomic conditions in workers (4, 5). It is predicted that by 2030, nearly 1,000,000 years of working life will be lost due to overheating in workers, and also 70,000,000 years of working life will be lost due to reduced labor productivity due to exposure to heat (4, 5). Bakers face many hazards in their work environments, such as heat, noise, flour dust, viruses, bacteria, stress, and anxiety (1). Among the mentioned hazards, frequent and daily exposure to heat stress poses challenges for bakers (6). Bakers working in traditional bakeries face more challenges as they become more exposed to heat stress. In traditional bakeries, the direct exposure of bakers to radiant heat from the flame and the short distance to the flame has caused more thermal stress to be applied to bakers than industrial bakeries (7).

Following the exposure of bakers to heat, the scope of action of this physical factor goes beyond an organ or a part of the body and affects a set of organs and physiological parameters of the body (8). In environments with high heat stress, such as bakeries, the effects of ambient heat and metabolic heat generated from a person's activity combine to cause heat to be stored in the body. Subsequently, deep body temperature rises and can cause physiological effects such as sweating, fever, and increased heart rate, resulting in heat strain. A cross-sectional study conducted to investigate the rate of heat stress and dehydration in workers of a sugar factory in Iran showed that many of the subjects exposed to heat stress had high levels of dehydration, which puts them at risk for kidney disease (8). Another cross-sectional study also showed that after exposure to heat stress, body water decreases, and the heart rate is also affected (9).

In general, common neurological and psychological symptoms in the individual, changes in the secretion of some hormones and hematological parameters, decreased physical and mental function of employees are among the common complications that occur after exposure to heat stress in bakers (10-13).

Due to the prevalence and increase in the number of people working in the bakery and exposure to heat stress and its destructive effects on health, it is essential to evaluate heat stress in bakers. In addition, according to the searches conducted by the authors of this study, no review study has been found so far that has collected information in this field. Therefore, this review study was conducted to investigate the effect of heat stress on bakers.

Materials and Methods

Search strategy

In this systematic review study, the authors used eight databases: "IranMedex", "Science Direct", "PubMed", "Scopus", "Web of Science", "Google", "SID Scholar", and "Magiran" to search for related articles. Research articles published in English and Persian in these databases were extracted from 2000 to 2021. Keywords used for the search included "Heat stress", "Heat strain", "Heat exposure", "Heat waves", "Workplace", "Baker", "health effects", and "Baking bread workers about heat stress".

Study selection and Data extraction

Two authors independently reviewed search results and screened eligible articles for full-text review based on title and abstract. Inclusion and exclusion criteria were examined according to the opinion of the third author. Inclusion criteria in this study were:

- A reputable journal has published the article.
- The article that has been published from 2000 to 2021.
- The article has been published in English and Persian.

Exclusion criteria in this study were:

- The article has been published as a conference abstract, letter to the editor, editorial, and review.
- The article examined the health effects other than exposure to heat in the bakery work environment.
- The article has been published to investigate the heat generated by cooking.
- Mannequin simulation laboratory papers

In order to extract data, the authors used a form containing information such as authors' names, year of publication, article title, a brief description of the study, place, and country of study, number of samples, type of bakery (for example, traditional or industrial), thermal indicators measured and study results.

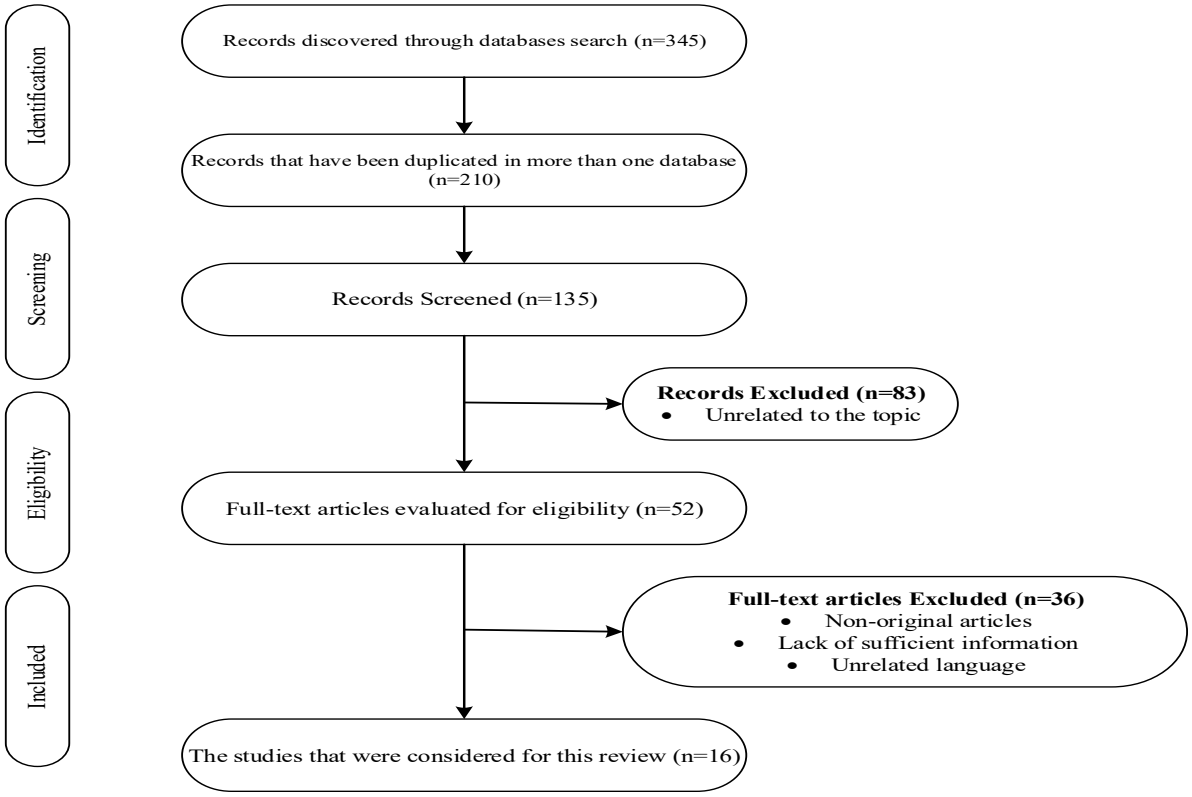

Fig. 1: The process of identifying and selecting the articles

Evaluation of the quality of articles

In addition, in order to evaluation of the quality of articles, The Joanna Briggs Institute (JBI) checklist was used. This checklist consists of 9 items. Authors should evaluate the quality of articles by answering these items as "yes", "no", "unspecified", and "not applicable". This checklist is an evaluation criterion in systematic studies designed in 2014 by a group of methodologists and researchers to evaluate the methodological

quality of studies and methods of obtaining and diagnosing errors in studies, design, and data analysis (14). The Meta-analyses Of Observational Studies in Epidemiology (MOOSE) checklist was also used to write the article itself. This 35-item checklist contains features for specifying systematic review articles and observational meta-analyses such as search strategy, background, method selection and results writing, discussion, and conclusion (15).

Results

The process of article selection is presented in Fig. 1. Out of 52 selected articles, finally, 16 articles were used in this study, among which seven articles (43.75%) were cross-sectional, one article (6.25%) was descriptive, one article (6.25%) was case-based, four articles (25%) were cross-sectional-descriptive, and three articles (18.75%) were cross-sectional descriptive-analytical. Table 1 shows the studies performed to investigate heat stress in bakery workers.

According to Table 1, out of 16 studies, one article (6.25%) related to the environment of industrial bakeries, four articles (25%) related to the environment of traditional bakeries, and seven studies (43.75%) were conducted in both industrial and traditional environments. Four other articles were done without mentioning the type of bakery. Most of the studies, 13 articles (81.25%), were conducted in Asian regions, of which 12 articles (75%) were related to Iran, and one article (6.25%) was related to Saudi Arabia. Among the indices used in all studies, in 16 studies (100%), the WBGT index was used alone or combined with other indices.

According to Table 1, most workers in bakeries are exposed to excessive heat stress (6, 11, 22, 24, 28). However, heat stress has a more significant effect on bakers in traditional bakeries due to the environmental conditions and equipment used, so research findings show that thermal stress in traditional bakeries is much higher than in industrial bakeries (6, 7, 20, 24). Excessive exposure to heat stress also affects the performance of bakers (18).

Thermal stress affects some hematological parameters of blood such as Mean Cell Volume (MCV), White Blood Cell (WBC), Lymphocytes (LYM), and Red Blood Cells (RBC) (21) and can harm bakers by affecting oxidative stress (19). In addition, heat stress affects the fertility status of bakers and can have adverse effects on the bakers' reproductive system (27). Other adverse effects of exposure to heat stress on bakers include musculoskeletal disorders, skin rashes, heat cramps, and heat stroke (18, 27). Exposure to heat stress sets the stage for Ischemic Heart Disease (IHD) and hyperlipidemia (21). These destructive effects have led to more attention in recent years to the effect of heat stress on bakers.

Table 1: Studies conducted to investigate heat stress in bakery workers

Type of study (Country)	Sample size	Index(s) range used (ºC)	Type of bakery (number)		Results
Cross-sectional study (Iran) (16)	103 Male, Mean Age: 37.2 ± 8.14 Years, BMI: 24.27 ± 3.41 Kg/m2	WBGT: 28.69 ± 1.41, HSSI: 15.02 ± 2.6	Traditional	-	• A large percentage of workers are exposed to heat stress above the allowable level. • The body temperature of people working near the oven is higher than other workers. • There is a significant relationship between temperature index and distance to storage.
Descriptive-analytical and Cross-sectional study (Iran) (17)	88 Male, Traditional Bakers: Mean Age: 41.57 Years, Industrial Bakers: Mean Age: 39.62 Years	WBGT in traditional bakeries: 44.49 ± 6.69, WBGT in industrial bakeries: 43.38 ± 39.88	Traditional (n=21)	Industrial (n=67)	• Heat stress is higher in traditional bakeries than in industrial bakeries. • There is a significant difference in wet ambient temperature, ambient dry temperature, humidity, and WBGT between traditional and industrial bakeries.
Cross-sectional study (Nigeria) (18)	40 Male, Range age: 21-50 Years, Average work experience: 6 Years	-	Traditional	Industrial	• Thermal stress reduces the efficiency and performance of workers. • Heat stress can cause injury to workers, including muscle cramps, heat rashes, and in very severe cases, heatstroke. • Due to the lack of awareness of workers about heat stress and control measures, not much attention is paid to it, and also employers do not do anything to prevent heat stress disorder.
Cross-sectional study (Iran) (19)	163 Bakers and 135 office workers, Exposed group: Range age = 30-40, Work Experience = 14 Years, Unexposed group: Range age = 30-40, Work Experience =14 Years	WBGT in the exposed group: 2.3 ±27.7 WBGT in the unexposed group: 1.3±22.8	Not mentioned	Not mentioned	• MCV and WBC count were abnormal in more than 50% of bakery workers. • More than 10% of bakery workers had an average concentration of abnormal MCHC. • MDA and NO levels in bakery workers were higher than allowed. • Exposure to heat stress can be an abnormal risk factor for WBC, RBC, LYM, and MCV.

Table 1: (Continued) Studies conducted to investigate heat stress in bakery workers

Sample size	Index(s) range used (°C)	Type of bakery (number)		Results	Authors' names
116 Male	WBGT in industrial bakeries: 25.63±2.79 WBGT in traditional bakeries: 28.55±2.82	Traditional (20)	Industrial (43)	• Workers are more exposed to heat stress in winter. • Heat stress affects the prevalence of musculoskeletal disorders.	Bolghanabadi S, et al.
58 Male, Age: exposed Group = 28-57 Years and control group = 30-55 Years. Work Experience for the exposed group: 18±7.54 Years	WBGT in Exposed group: 51.7±14.38 WBGT in Unexposed group: 26.88±6.42	Not mentioned	Not mentioned	• Workers working in hot environments are prone to IHD and adverse hyperlipidemia. • Older workers exposed to heat are more likely to develop IHD, which is why they are advised to avoid working in hot conditions.	Haghshenas Darona Z, et al.
30 Male, Mean Age: 33 ± 9.5 Years, Mean Height: 174 ± 4.8 cm, Mean Weight: 71 ± 10.1 Kg, Work experience: 13 ± 7.7 Years	WBGT Tanoori: 35.8 WBGT Sangak: 32.9 WBGT Taftoon: 34.1	Traditional, (Tanoori (n=10), Sangak (n=10), Taftoon (n=10))	-	• The mean WBGT index for all cooking stations was higher than the allowable limit, but there is no significant relationship between the WBGT index and physiological parameters. • The use of WBGT as a standard indicator for measuring thermal stress in hot dry climates is inappropriate.	Owhor SC, et al
163 Male	WBGT: 29.35± 2.10	Not mentioned	Not mentioned	• The PHS index does not show the actual amount of heat stress in open environments. • The PHS index is a good indicator for indoor environments	Gharibi V, et al.

Table 1: (Continued) Studies conducted to investigate heat stress in bakery workers

Index(s) range used (°C)	Type of bakery (number)		Results	Authors' names	Type of study (Country)
-	Traditional	-	• WBGT index measurements showed that heat stress in bakeries is much higher than the allowable limit.	Barzegar A, et al.	Descriptive-analytical and Cross-sectional study (Iran) (20)
Mean WBGT: 28.16 ±1.89 in 15 min, Mean WBGT: 28.54 ± 1.98 in 30 min	Traditional (19)	Industrial (n=2)	• The heat stress in traditional bakeries is much higher than in industrial bakeries. • More than 80% of traditional bakery workers are exposed to abnormal heat stress.	Farahat S, et al.	Cross-sectional study (Egypt) (21)
WBGT: 28.81±3.42	Traditional (n=15)	Traditional (n=49)	• Most of the bakers who worked in front of and near the oven had poor working conditions, and their exposure to heat stress was higher than the allowable values.	Afshari D, et al.	A case study (Iran) (22)
WBGT: 28.81±3.42 Max WBGT in industrial bakeries: 37.3, Max WBGT in Traditional bakeries: 40.8	Industrial (n=65)	Industrial (n=51)	• Heat stress in bakeries is inappropriate and critical. • Heat stress in a traditional bakery is much higher than in an industrial bakery.	Gharibi V, et al.	Cross-sectional study (Iran) (23)

Table 1: (Continued) Studies conducted to investigate heat stress in bakery workers

Type of bakery (number)		Results	Authors' names	Type of study (Country)	Sample size
-	Industrial (n=88)	• The WBGT index has more advantages than the HSI index and is generally more appropriate.	Rabeiy R	Cross-sectional study (Egypt) (11)	100 Male, Mean age: 31 ± 8.9 Years, Mean height: 171 ± 5.8 cm, Mean weight: 73.5 ± 13.3 kg, Mean BMI: 250 ± 40 $kg.m^{-2}$
Traditional (n=21)	Industrial (n=42)	• Bakers working in traditional bakeries had higher rates of heat exposure. • There was a high correlation between the WBGT index and the physiological index of sublingual temperature.	CharkhandazYeganeh R, et al.	Descriptive and Cross-sectional Study (Iran) (24)	82 Male: Mean Age: 32.64 ± 4.91 Years, Mean height: 1.74 ± 0.54 cm, Mean weight: 72.29 ± 9.72 kg, Mean BMI: 23.84 ± 2.64 $kg.m^{-2}$
Traditional (n=95)	-	• Industrial bakeries have the least heat stress and are the best place to make bread, while traditional bakeries are the worst place to make bread.	Rajabali Hakmabadi, et al.	Descriptive and Cross-sectional Study (Iran) (25)	-
Not mentioned	Not mentioned	• Exposure to heat stress affects fertility. • Infertility is high among bakery workers due to exposure to high ambient temperatures, as shown by the WBGT index.	Hannani M, et al.	Descriptive Study (Iran) (6)	175 Male

Abbreviations:
WBGT: Wet Bulb Glob Temperature; **HSSI**: Heat Strain Score Index; **BMI**: Body Mass Index; **HR**: Heart Rate; **MCV**: Mean Cell Volume; **WBC**: White Blood Cells; **MCHC**: Mean Cell Hemoglobin Concentration; **MDA**: Malondialdehyde; **RBC**: Red Blood Cell; **LYM**: Lymphadenopathy; **ECG**: Electrocardiography; **IHD**: Ischemic Heart Disease; **PHS**: predicted heat strain; **PSI**: physiological strain index; **HIS**: Heat Stress Index.

Authors' names	Type of study (Country)	Sample size	Index(s) range used (ºC)
Golmohammad R, et al.	Descriptive and Cross-sectional Study (Iran) (22)	-	WBGT: 28.57±1.97, HIS: 214.2%±43.7
Aliabadi M, et al.	Descriptive and Cross-sectional Study (Iran) (7)	126 Male	Mean WBGT in industrial bakeries: 42.5, Mean WBGT in Traditional bakeries: 44.5
Malakouti J, et al.	Descriptive-analytical and cross-sectional Study (Iran) (26)	-	WBGT (Baking furnace): 27.96 to 33.68, WBGT (kneaders): 26 to 30.68
Al-Otaibi ST	Cross-sectional study (Iran) (27)	244 Male: 137 bakery workers (Mean age: 32.3 ± 7.0 Years) and 107 individuals (Mean age: 30.5 ± 7.5 Years)	Mean WBGT in bakeries: 37.4

Discussion

This study aimed to investigate the effect of heat stress on the health of bakers. Regarding thermal stress in bakers, the investigation of the indicators used in these studies and the results show the place and importance of this harmful factor.

In many industrial environments, temperature as an environmental parameter affects employee performance, and if the temperature rises, the workers' health can be affected (22). The results of a descriptive cross-sectional study with the participation of employees working in domestic work environments with hot temperatures in Iran showed that excessive heat in the workplace affects employees' performance and productivity and threatens their health (13). Moreover, heat as a physical risk factor in many occupations such as bakers can affect the reproductive system of people (27, 29). The rate of infertility in bakers exposed to high temperatures in the bakery environments was high (27). On the other hand, workplace temperature conditions are essential to many workers, including bakeries. There are many occupational risk factors in bakers' work environments, but heat stress is more important due to the high temperature caused by the furnaces (30). Due to their occupational nature, bakers are exposed to excessive heat daily (19).

Because of the work equipment in their work environment, bakers are among the occupations that are exposed to diseases and disorders caused by heat (31). The working conditions of the bakers in the workstations are such that they provide the ground for suffering from heat disorders (22).

The results of a cross-sectional study involving 504 bakers in Lebanon showed that almost half of the bakers had experienced symptoms of heat stress and were in poor working conditions (31). This is more evident in workers working in traditional bakeries than in bakers working in industrial bakeries (16). Bakers working in industrial bakeries face lower levels of heat stress due to their fully mechanized systems (32). Bakers working in traditional bakeries endure more hard work and heat stress due to their heavier and longer work and lack of modern technologies (32, 33). In such environments, factors such as temperature and humidity, people's level of activity, and their work clothes can cause heat stress (34).

The geographical location and temperature conditions around the bakeries are influential factors in increasing or decreasing the temperature inside the bakeries. If the ambient temperature of the bakeries is high, some heat is transmitted from the outside environment to the inside of the bakeries, and as a result, the temperature inside the bakeries increases (13). Due to the increase of the internal temperature of the bakeries to more than 35 °C, the health of the bakers is endangered, and the production of the bakers is reduced (18). A cross-sectional study was conducted to estimate the temperature emitted by six bakery ovens in Nigeria. The temperature emitted from the ovens exceeded the comfort limit (20-29 °C) provided by the WHO, which could affect the health of bakers (35).

Following the occurrence of heat stress (body temperature above 38 °C), adverse symptoms such as heat stroke, dry skin, tremors and dizziness, fainting, fatigue and weakness, nausea, and muscle cramps appear in the person (12, 31). In this case, the person's body responds to various physiological responses to the heat pressure from the environment, including increased heart rate and increased body temperature. Physiological responses (such as changes in hematological and hormonal parameters) by the body following exposure to heat stress are called thermal strain (35). These thermal strains vary in amplitude depending on the intensity of the received thermal stresses and occur in different ways (19).

Metabolism, heart rate, blood pressure, and body temperature are among the physiological parameters that can be affected by ambient temperature (17). The results of a cross-sectional study aimed at investigating the effect of heat stress on hematological parameters and oxidative stress on bakers in Shahroud showed that heat stress affects some hematological parameters and can stimulate oxidative stress (19). Many physiological parameters have a significant impact on the work process of bakers, and in case of disturbances in them, many negative consequences will be observed (28). Psychological disorders such as irritability, depression, anxiety, and mood swings can also occur due to exposure to these thermal stresses (13).

Among thermal analysis indicators, the WBGT index is the most widely used and essential indicator for assessing heat stress in work environments, especially bakeries (28). Due to its ease of use and high applicability, this index has been used in many studies in heat stress estimation in bakeries. In Iran, the average of this index in various studies was reported from 28.09 to 33.3 °C. Moreover, in the studies performed, thermal stress exceeding the recommended limit was reported in at least 50% of the surveyed stations. On the other hand, the results of studies showed that the amount of stress and thermal strain in traditional bakeries or baking ovens is significantly more than in machine bakeries. The mean wet-bulb globe temperature indices in traditional bakeries (31.5-33.3 °C) was higher than the mean of this index in industrial bakeries (28.09-30.7°) (24). Hence, measuring and evaluating thermal stresses in bakeries is essential, and in order to prevent heat disturbances and improve the working conditions of bakeries, it is necessary to make an accurate estimate of the thermal condition of bakeries.

Conclusion

Today, many bakeries have difficulty providing desirable and safe working conditions for bakers for various reasons, including poor economic

conditions. This has caused bakers to constantly face many problems, including the high temperature caused by bread ovens, which reduces their performance. In addition to this reduction in performance, exposure to heat stress has several other adverse effects, including an increase in accident rates. Therefore, exposure to excessive heat is a severe problem for bakers. This complication, which affects workers' health, is vital for many countries, especially developed countries. In general, this issue should be addressed in all countries, and by taking management measures and financial support from both the private sector and government organizations and institutions, the working conditions for this working-class should be more favorable.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflicts of interest

The authors have no competing interests to declare.

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