Original Article

To review this article online, scan this QR code with your Smartphone

Respiratory Abnormalities among Occupationally Exposed, Non-Smoking Brick Kiln Workers from Punjab, India

Supriya Tandon[1], Sharat Gupta[2], Sharanjeet Singh[1], Avnish Kumar[1]

[1]Physiology Department, Govt. Medical College, Patiala, India
[2]Physiology Department, Kalpana Chawla Govt. Medical College, Karnal, India

Abstract

Background: Brick manufacturing industry is one of the oldest and fast-growing industries in India that employs a large section of people. Brick kiln workers are occupationally exposed to air pollutants. Nonetheless, only a few studies have so far been conducted on their respiratory health.

Objective: To investigate the extent of respiratory impairment in brick kiln workers and to correlate it with the duration of exposure.

Methods: A cross-sectional study was conducted. Spirometric parameters of 110 non-smoking male brick kiln workers aged 18–35 years in Patiala district, Punjab, India, were compared with an age-matched comparison group of 90 unexposed individuals.

Results: Brick kiln workers showed a significant ($p<0.05$) decline in forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), forced mid-expiratory flow rate ($FEF_{25-75\%}$) and peak expiratory flow rate (PEFR) compared with those of the comparison group. The extent of deterioration in lung function of brick kiln workers was associated with the duration of exposure. In workers with >8 years of exposure, the mean values of FEV_1 (1.92 L), FVC (2.01 L), $FEF_{25-75\%}$ (2.19 L/s) and PEFR (4.81 L/s) were significantly ($p<0.05$) lower than those recorded in workers with <8 years of exposure in whom the values were 2.01 L, 2.68 L, 2.71 L/s, and 5.76 L/s, respectively.

Conclusion: There is a significant association between exposure to workplace pollutants and lung function deterioration among brick kiln workers.

Keywords: Air pollution; Spirometry; Vital capacity; Respiratory function tests; Peak expiratory flow rate

Introduction

The past few years have witnessed a growing awareness throughout the world regarding various occupational health problems.[1] The brick manufacturing industry is one of the oldest and the most rapidly growing industries in India so much so that India has been ranked just behind China as the second largest producer of bricks in the world.[2] This is attributed to the ever-rising demand for bricks in construction works for continued rural and urban expansions.[3] As per a recent re-

Correspondence to Sharat Gupta, MBBS, MD, SST Nagar, Rajpura Road, Patiala, 147001, India
Tel: +91-78-3727-3208
E-mail: sharatgupta29@yahoo.co.in
Received: Feb 20, 2017
Accepted: May 21, 2017

Cite this article as: Tandon S, Gupta S, Singh S, Kumar A. Respiratory abnormalities among occupationally exposed, non-smoking brick kiln workers from Punjab, India. *Int J Occup Environ Med* 2017;**8**:166-173. doi: 10.15171/ijoem.2017.1036

port by World Bank, more than 100 000 brick kilns are currently functional in Bangladesh, India, and Nepal; these brick kilns have emerged as the topmost sources of air pollution in these countries.[4]

The Indian brick industry is a labor intensive industry that employs more than 10 million migratory workers.[5] Nonetheless, this sector is not regulated by any specific statutory guidelines regarding the designing of kilns, type of fuels to be used, workplace safety measures, *etc*.[6] Consequently, a majority of the brick kilns are poorly designed and use a variety of combustible materials as fuels, *eg*, wood, coal, diesel, petrol, cow dung cakes, plastics, old tires, recyclable motor oils, *etc*.[7] This leads to the emission of a gamut of toxic gases in large amounts from the furnaces of the kilns, *eg*, oxides of sulfur (SO_x) and nitrogen (NO_x), fluoride compounds, hydrogen sulfide (H_2S), carbon monoxide (CO), carbon dioxide (CO_2), suspended particulate matters (SPM) and various amounts of carcinogenic dioxins.[8]

The brick kiln workers are engaged in mainly three types of tasks—carriage (transport of clay dust and bricks), molding (shaping of wet clay into bricks), and baking (burning of molded bricks in furnaces). Exposure to the aforementioned pollutants can occur during any of these activities.[9] It has been documented that chronic inhalation of these pollutants can induce inflammation and release of toxic oxide radicals, leading to local lung tissue injury and pulmonary distress.[10] Therefore, brick kiln workers are occupationally at a high risk of developing various respiratory disorders like bronchitis, emphysema, asthma, and decreased lung function.[11]

Hitherto, to the best of our knowledge, only a few research studies have been conducted to assess the respiratory health status of brick kiln workers in India and other developing countries. We therefore, conducted the present study to determine the extent of occupationally induced respiratory morbidity in workers engaged in brick manufacturing units of Punjab, India.

Materials and Methods

The present cross-sectional study was conducted from 2010 to 2012 in various brick manufacturing units in Patiala district, Punjab, India. Informed consent was taken from all participants after thoroughly explaining the purpose of the study for them. The procedures followed the ethical standards of the institutional committee on human experimentation.

Study Population

The present study comprised of non-smoking males, aged 18–35 years, who were sourced from 12 randomly selected brick manufacturing units in Patiala district. The participants were selected using convenience sampling method for lack of data on the exact number of registered brick kilns and their employees. Out of the initial 140 volunteers, 30 were subsequently excluded as per the exclusion criteria; the remaining 110 workers underwent lung function tests. The results of spirometry of this group were compared with an age-matched comparison group of 90 males, who were selected at random from the lower support staff of the institute and its attached hospital. The workers were examined at the worksite itself while the comparison group members were examined in the physiology laboratory of the institute. Both the brick kiln workers and controls were examined in small batches from 11:00 to 13:00 on all days, except weekends and holidays.

Inclusion and Exclusion criteria

In both groups, all the available non-smoking and apparently healthy volunteers aged 18–35 years were included. Due care was also taken to include only those par-

For more information on lung function among Greek cotton industry workers see http://www.theijoem.com/ijoem/index.php/ijoem/article/view/888

Table 1: Assessment of different components of ambient air of brick kilns

Component	Measured range at brick kilns (μg/m^3)	Mean (SD) (μg/m^3)	Maximal permissible annual limit as per CPCB (μg/m^3)
Oxides of sulfur (SO_x)	78–110	91.76 (12.32)	50
Oxides of nitrogen (NO_x)	80–100	96.00 (9.05)	40
Suspended particulate matter (SPM)	130–160	133.00 (18.76)	60
Carbon monoxide (CO)	0.96–3.23	2.02 (0.82)	2
Carbon dioxide (CO_2)	0.11–1.22	0.89 (0.32)	—

ticipants who had completed a minimum schooling of upto primary level, to ensure better understanding of study procedure and questionnaire. However, we excluded those who were absolutely illiterate; gave a history of wheezing, smoking, tobacco chewing, alcohol abuse, cardiac and/or respiratory illness, and any systemic illness (*eg*, diabetes mellitus, hypertension, thyroid disorders, *etc*); those with any visible musculoskeletal deformity/injury of chest wall; or any evidence of use of medications that could affect the outcome of the study, *eg*, anti-asthmatics, anti-depressants, *etc*.

Workplace Environment of the Study Participants

Brick kiln workers worked around eight hours a day. An assessment of the ambient air quality of the brick kilns was carried out using a portable air monitoring apparatus (Lamotte, USA). The data was compared with the maximum annual permissible limit of various air pollutants in industrial areas, proposed by Central Pollution Control Board (CPCB), Government of India (Table 1).[12]

The comparison group worked from 9:00 to 15:00 in relatively pollution-free environment, unlike the brick workers. It was also ensured that there was no visible source of indoor air pollution in the workplace of the comparison group.

Table 2: Anthropometric data of brick kiln workers and the comparison group. The figures are mean (SD)

Parameter	Brick kiln workers (n=110)	Comparison group (n=90)
Age (yrs)	31.6 (4.9)	30.6 (4.4)
Height (cm)	160.5 (7.8)	159.0 (7.9)
Weight (kg)	60.63 (8.89)	60.00 (9.38)
Duration of exposure (yrs)		
<8	58%	—
≥8	42%	

None of the between-group differences was significant.

Preliminary Health Assessment of Participants

The data on the health status of all participants were collected using a slightly modified Respiratory Medical Evaluation Questionnaire.[13] It was translated to local language, for easy communication, and then back-translated upon completion to validate the outcomes. This was followed by a thorough general physical examination of the participants, with special focus on thoracic region, as per the guidelines of the American Thoracic Society.[14] Age to the nearest completed year, standing height without shoes (in cm), and body weight with minimal clothing (in kg) were measured for all participants.

Spirometry

Spirometry was done according to the standardized procedure mentioned else-

where,[15,16] using a portable digital spirometer (Medspiror, Recorders and Medicare Systems Pvt Ltd, Chandigarh, India). The procedure was thoroughly explained and demonstrated to all participants, beforehand. The test was done in standing position. The subjects were required to perform a maximal inspiration and then blow as rapidly and forcefully as possible into the mouthpiece. The test was repeated thrice for every subject and the best of the three efforts was considered for final analysis. The mouthpieces were sterilized before each use. Various lung function parameters analyzed were forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), forced mid-expiratory flow rate ($FEF_{25-75\%}$), and peak expiratory flow rate (PEFR).

Statistical Analysis

The data was analyzed using SPSS ver 20 (SPSS Inc, Chicago, IL, USA). All the values were expressed in mean and SD. *Student's t* test for independent samples was used to assess the difference in the means of brick kiln workers and the comparison group. A p value <0.05 was considered statistically significant. Odds ratio (OR) analysis was performed to determine whether the outcomes of respiratory disturbances of brick kiln workers differed significantly from those of the comparison group. Common respiratory symptoms, *ie*, frequent coughing, shortness of breath, irritation in respiratory tract, chronic phlegm, and chest tightness were considered for OR analysis.

Results

The present study was conducted on a total of 200 male participants (110 brick kiln workers and 90 unexposed workers), aged 18–35 years. The mean working hours of brick kiln workers were 8.2 (SD 2.0) hours per day. They were not using any personal protective equipment during work hours to shield themselves from ambient air pollution.

Table 3: Comparison of spirometric parameters among brick kiln workers (exposed) and controls (unexposed).

Pulmonary function parameter	Brick kiln workers (n=110)	Comparison group (n=90)
FEV_1 (L)	1.65 (0.56)	2.72 (0.45)
FEV_1 (%Pred)	86.45 (12.01)	93.01 (8.49)
FVC (L)	2.01 (0.60)	3.12 (0.40)
FVC (%Pred)	88.87 (9.28)	94.36 (8.91)
FEV_1/FVC (%)	83.69 (16.02)	86.78 (10.20)
FEV_1/FVC (%Pred)	80.71 (4.76)	85.21 (5.01)
$FEF_{25-75\%}$ (L/s)	1.91 (0.89)	3.49 (0.94)
$FEF_{25-75\%}$ (%Pred)	82.5 (11.41)	85.5 (5.01)
PEFR (L/s)	3.57 (1.93)	6.67 (1.94)
PEFR (%Pred)	88 (9.21)	102 (8.61)

The means of studied parameters are significantly (p<0.01) different between the two groups.

The internal consistency of the questionnaire was assessed (Cronbach's α 0.81–0.88). To ensure reliability of the data, the test-retest agreement of the responses to the questionnaire was assessed in 10% of the subjects (κ 0.85).

The measured levels of various air pollutants were much higher in the ambient air of brick kilns compared to their corresponding maximal permissible limits proposed by CPCB (Table 1).[12]

The studied groups were comparable in terms of their anthropometric characteristics (Table 2). A majority of the brick kiln workers had <8 years of exposure to workplace pollutants. FEV_1, FVC, $FEF_{25-75\%}$, and PEFR were significantly (p<0.01) lower in brick kiln workers as compared to the comparison group (Table 3). All the studied respiratory symptoms were significantly (p<0.05) more prevalent among brick kiln workers than the comparison group (Table 4).

Table 4: Comparison of risk of respiratory symptoms among the brick kiln workers (exposed) and the comparison (unexposed) groups

Symptoms	Brick kiln workers (n=110)	Comparison group (n=90)	Crude OR* (95% CI)
Frequent coughing	74	22	6.35 (3.40 to 11.86)
Shortness of breath	66	29	3.15 (1.76 to 5.65)
Irritation in respiratory tract	92	39	6.68 (3.47 to 12.86)
Chronic phlegm	77	31	4.49 (1.64 to 5.03)
Chest tightness	60	20	4.2 (2.25 to 7.82)

*Chi square test

An increase in the duration of exposure was associated with a concurrent decline in the respiratory parameters in brick kiln workers (Fig 1). The respiratory health of brick kiln workers with <8 years of exposure was significantly better ($p<0.05$) than their counterparts with >8 years of exposure.

Discussion

The results of the present study clearly established a decline in the respiratory function of brick kiln workers. Similar observations have been reported in brick kiln workers by several other authors from around the world.[17-19] In conformity with our study, Sheta, *et al*, observed a significant decline in FEV_1, FVC, and $FEF_{25-75\%}$ of Egyptian brick kiln workers.[20] It was also observed that brick kiln workers reported a significantly higher frequency of chronic respiratory problems such as chronic cough, dyspnoea, chest wheeze, *etc*, than controls.

In a 6-year follow-up study conducted in Iran, a significant yearly gradual decline was reported in FEV_1, FVC, $FEF_{75\%}$, and $FEF_{25-75\%}$ among firebrick workers.[21] Das also reported a significant reduction in FEV_1, FVC, FEV_1/FVC, and PEFR among the brick kiln workers from West Bengal, India, as compared with their age- and sex-matched healthy counterparts.[22]

Shaikh, *et al*, reported that the Pakistani brick kiln workers had a higher incidence of respiratory symptoms *vis-a-vis* the normal population.[23] They noted that 22.4% of workers had chronic cough, 21.2% had chronic phlegm, 13.8% had two or more attacks of dyspnea with wheezing, 17.1% were suffering from chronic bronchitis while 8.2% were asthmatics. Our study was in complete agreement with the observations made by all the above-said authors.

There is ample evidence in literature that corroborates the harmful effect of air pollutants on the health in general, and on lungs in particular.[24,25] Our assessment of

TAKE-HOME MESSAGE

- Brick manufacturing workers constitute a significant section of population who are continuously exposed occupationally to high levels of dust and toxic fumes at their workplace.
- These workers were found to have both obstructive as well as restrictive patterns of pulmonary dysfunction. Therefore, there is an urgent need of taking a slew of corrective measures to ensure optimum workplace environment for these workers.
- Interventions should mainly focus on proper workplace ventilation and use of personal protective equipment by this workforce.

the ambient air quality of brick kilns indicated that the measured levels of NO_x, SO_x, SPM, *etc*, were much higher than the CPCB set standard limits. Because these gases are highly hygroscopic, they produce mists in workplace that are notorious for inducing intense inflammation of airways resulting in excessive mucus production, bronchoconstriction, and lung function deterioration, if inhaled for long periods.[26]

The decline in the spirometric parameters, as well as the high incidence of respiratory symptoms reported by our brick kiln workers may thus be attributed to these pollutants. Because both the brick kiln workers and the unexposed participants were comparable in terms of their anthropometric parameters, we assumed that the observed alterations of respiratory parameters were neither attributed to malnutrition, nor due to the age of the workers. We could not identify any significant secondary risk factors that could seriously affect the respiratory system of the studied workers. In fact, apart from the work stress, no other factor was noted that could influence their lung function in any ways.

In the present study, both obstructive and restrictive patterns of respiratory impairments were diagnosed in brick kiln workers. These findings indicated the warning symptoms of impending asthma and other respiratory illnesses like interstitial lung disease, pulmonary fibrosis, *etc*, in these workers. Urgent intervention of concerned officials is therefore required to safeguard the pulmonary health of these workers.

Our study had certain limitations. One of the main limitations was the lack of a credible information source regarding the workplace environment and the exact number of kilns in Punjab and their employees. Therefore, an accurate estimation of the sample size was not possible and thus a convenience sampling method was adopted. Secondly, the ambient air quality varies among different brick kilns, mainly owing to the differences in the fuels being used by them. This could have caused variation in the study results. Thirdly, chest roentgenography of the brick kiln workers could not be taken due to financial constraints. Had chest x-rays been taken, they would have further substantiated the spirometric findings.

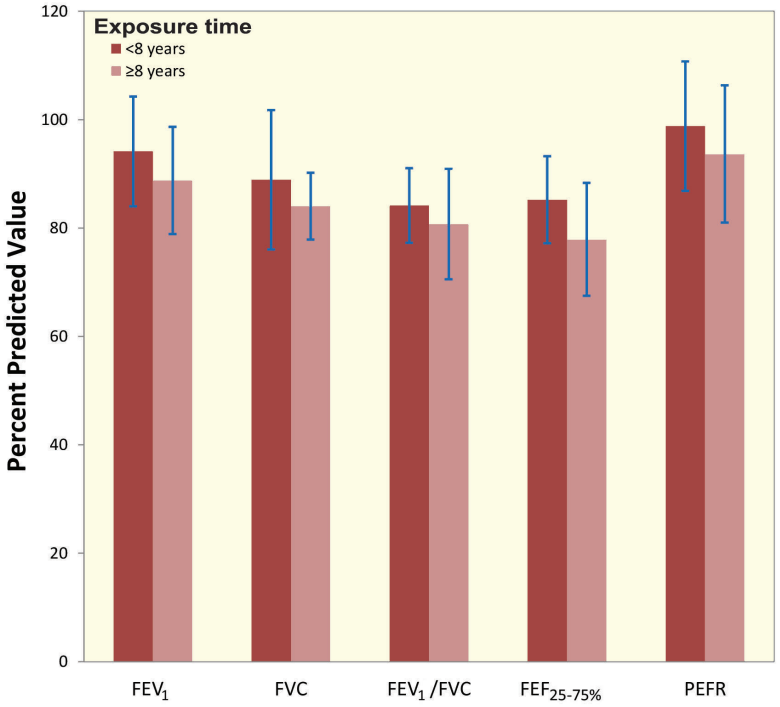

Figure 1: Spirometric parameters among brick kiln workers according to duration of exposure. Error bars represent SD. The means are significantly ($p<0.05$) different when compared between the two groups.

The evidence generated by this study needs to be further strengthened by conducting similar studies on a larger scale. Besides respiratory problems, other health hazards, such as work-related injuries, effect of heat stress, and musculoskeletal problems faced by brick kiln workers, should also be meticulously explored.

Acknowledgements

We are highly grateful for the cooperation

and support provided by all the brick kiln owners the participants for this study.

Conflicts of Interest: None declared.

References

1. Fingerhut M, Nelson DI, Driscoll T, *et al*. The contribution of occupational risks to global burden of diseases: summary and next steps. *Med Lav* 2006;**97**:313-21.
2. Thirupathi T, Anthoniswamy M. Health problems faced by brick kiln workers in Salem district. *International Journal of Applied Research* 2015;**1**:266-9.
3. Joshi SK, Dudani I. Environmental health effects of brick kilns in Kathmandu valley. *Kathmandu Univ Med J (KUMJ)* 2008;**6**:3-11.
4. Baum E. Present Status of Brick Production in Asia. INE Proceedings of the Workshop on public policies to mitigate environmental impact of artesanal brick production. Guanajuato, Mexico. 2012, Available from *www.ine.gob.mx/cenica-memorias/1111-taller-ladrilleras-2012-eng* (Accessed September 8, 2016).
5. Pariyar SK, Das T, Ferdous T. Environment and health impact for brick kilns in Kathmandu valley. *International Journal of Scientifics & Technology Research* 2013;**2**:184-7.
6. Prasad MA, Nayak S, Mudey AB, *et al*. Assessment of health status of brick industry workers in Wardha district. *Journal of Academia and Industrial Research (JAIR)* 2016;**5**:1-4.
7. Joshi SK, Dahal P, Poudel A, Sherpa H. Work related injuries and musculoskeletal disorders among child workers in the brick kilns of Nepal. *International Journal of Occupational Safety and Health* 2013;**3**:2-7.
8. Khan AR, Iqbal J, Parveen N, *et al*. Brick kiln and sugar mill: Severe environmental health hazards cause respiratory diseases in Tehsil Darya Khan, District Bhakkar, Punjab, Pakistan. *J Appl Environ Biol Sci* 2015;**5**:31-8.
9. Monga V, Singh L, Bhardwaj A, Singh H. Respiratory health in brick kiln workers. *Int J Phys Soc Sci* 2012;**2**:226-44.
10. Kaushik R, Khaliq F, Subramaneyaan M, Ahmed RS. Pulmonary dysfunctions, oxidative stress and DNA damage in brick kiln workers. *Hum Exp Toxicol* 2012;**31**:1083-91.
11. Raut AK. Brick kilns in Kathmandu valley: Current status, environmental impacts and future options. *Himalayan Journal of Sciences* 2003;**1**:59-61.
12. Central Pollution Control Board, Govt. of India. National ambient air quality standards. 2008, Available from *http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php* (Accessed August 29, 2016).
13. US Department of Labour, USA. Occupational Safety and Health Administration OSHA Respiratory Medical Evaluation questionnaire. Available from *www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9783* (Accessed August 29, 2016).
14. Miller MR, Hankinson J, Brusasco V, *et al*. Standardisation of spirometry. *Eur Respir J* 2005;**26**:319-38.
15. Gupta S, Mittal S, Kumar A, Singh KD. Respiratory effects of air pollutants among non smoking traffic policemen of Patiala, India. *Lung India* 2011;**28**:253-7.
16. Anyfantis ID, Rachiotis G, Hadjichristodoulou C, Gourgoulianis KI. Respiratory symptoms and lung function among Greek cotton industry workers: A cross sectional study. *Int J Occup Environ Med* 2017;**8**:32-8.
17. Das B. Assessment of respiratory symptoms and lung function values among the brick field workers of West Bengal, India. *Arch Environ Occup Health* 2016;**71**:222-30.
18. Chen YH, Wu TN, Liou SH. Obstructive pulmonary function defects among Taiwanese firebrick workers in a 2 year follow up study. *J Occup Environ Med* 2001;**43**:969-75.
19. Goel V, Singh S, Sood S, *et al*. Comparison of ventilatory function test among, non smoker, smoker and smoker brick kiln workers. *International Journal of Health Sciences and Research* 2015;**5**:242-6.
20. Sheta S, El Laithy N. Brick kiln industry and workers' chronic respiratory health problems in Mit Ghamr District, Dakahlia Governorate. *Egyptian Journal of Occupational Medicine* 2015;**39**:37-51.
21. Golshan M, Amra B, Faghini M. Effects of long term occupational silica exposure on pulmonary function tests in fire brick workers. *Tanaffos* 2003;**2**:23-8.
22. Das B. Assessment of occupational health problems and physiological stress among the brick field workers of West Bengal, India. *Int J Occup Med Environ Health* 2014;**27**:413-25.
23. Shaikh S, Nafees AA, Khetpal V, *et al*. Respiratory

symptoms and illnesses among brick kiln workers: A cross sectional study from rural districts of Pakistan. BMC Public Health. 2012, Available from *http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-12-999* (Accessed September 1, 2016).

24. Gotschi T, Heinrich J, Sunyer J, Kunzli N. Long-term effects of ambient air pollution on lung function: a review. *Epidemology* 2008;**19**:690-701.

25. Brunekreef B, Beelen R, Hoek G, *et al*. Effects of long-term exposure to traffic-related air pollution on respiratory and cardiovascular mortality in the Netherlands: the NLCS-AIR study. *Res Rep Health Eff Inst* 2009;**139**: 5-71.

26. Sahu S, Roy B, Moitra S. Assessment of the lung function status of goldsmiths working in an unorganised sector of India. *Lung India* 2013;**30**:33-7.

Guidelines for Filing a Competing Interest Statement

Definition: Conflict of interest (COI) exists when there is a divergence between an individual's private interests (competing interests) and his or her responsibilities to scientific and publishing activities such that a reasonable observer might wonder if the individual's behavior or judgment was motivated by considerations of his or her competing interests. COI in medical publishing affects everyone with a stake in research integrity including journals, research/academic institutions, funding agencies, the popular media, and the public.

COI may exist in numerous forms including financial ties, academic commitments, personal relationships, political or religious beliefs, and institutional affiliations. In managing COI, *The IJOEM* abides to the policy statement of the *World Association of Medical Editors (WAME)*. All authors should declare their COI, if any, during the manuscript submission. Reviewers are asked to declare their COI after they accept to review a manuscript. Editors should also declare their COI during handling of a manuscript.

Managing COI depends on disclosure because it is not possible to routinely monitor or investigate whether competing interests are present. COI disclosed by authors will be presented in the Editorial Board and an appropriate action will be taken. Those reviewers and Editors with COI will be excluded from the manuscript process. If competing interests surface from other sources after a manuscript is submitted or published, *The IJOEM* investigates allegations of COI and depending on their nature, appropriate actions will be taken if the allegations were found to be true. If a manuscript has been published and COI surfaces later, the journal will publish the results of the investigation as a correction to the article and ask the author to explain, in a published letter, why the COI was not revealed earlier.