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Environmental gaseous pollutants are related to increase of acute coronary syndrome in Valencia region

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ABSTRACT

Introduction and aims: Environmental pollution are one of the most relevant risk factors to atherosclerosis. To know awareness about the importance of urban air pollution as a trigger for hospital admission due to acute coronary syndrome (ACS), this study analyzed levels of different gaseous air pollutants in the air and its correlation with number of ACS.
Methods: Epidemiological data of patients admitted for ACS in five towns during the years 2006–2008 were recovered. Clinical data regarding admissions for ACS were obtained from the hospital admission services. Measures of seven air contaminants were recovered from the environmental stations. Mixed model including sex, age, location, and the average levels of air pollutants contaminants as fixed effects and its interaction were performed.
Results: The incidence rate of ACS is higher in man than woman, and higher in older people than young. The maximum ACS were in the last trimester of the year, was the most elevated levels of gaseous pollutants have been found. Levels of NO_2, NO, and CO are positively correlated between them, and negatively correlated with O_3 levels. All air pollutants analyzed increase the number of ACS hospital admission in the five locations evaluated.
Conclusions: Levels of gaseous pollutants are related between them, being the levels of NO_2, NO, and CO, positively correlated, and negatively correlated with levels of O_3. Number of ACS hospital admission increases with levels of five air gaseous pollutants studied.

Los contaminantes gaseosos ambientales están relacionados con el aumento del síndrome coronario agudo

Palabras clave:
Síndrome coronario agudo
Contaminantes atmosféricos
Ingresos hospitalarios
Factores de riesgo

RESUMEN

Introducción y objetivos: La contaminación ambiental es uno de los factores de riesgo más relevantes para la aterosclerosis. Para conocer la importancia de la contaminación del aire urbano como desencadenante del ingreso hospitalario por síndrome coronario agudo (SCA), este estudio analizó los niveles de diferentes contaminantes atmosféricos gaseosos en el aire y su correlación con el número de SCA.
Métodos: Se recuperaron datos epidemiológicos de pacientes ingresados por SCA en 5 municipios durante los años 2006 a 2008. Los datos clínicos relativos a los ingresos por SCA se obtuvieron de los servicios de ingreso hospitalario. Se recuperaron medidas de 7 contaminantes del aire de las estaciones ambientales. Se realizó un modelo mixto que incluye sexo, edad, ubicación y los niveles promedio de contaminantes atmosféricos como efectos fijos y su interacción

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Resultados: La tasa de incidencia de SCA es mayor en hombres que en mujeres, y mayor en personas mayores que en jóvenes. La mayoría de los SCA se dieron en el último trimestre del año, cuando se encontraron niveles más elevados de gases contaminantes. Los niveles de NO_2, NO y CO se correlacionan positivamente entre ellos y negativamente con los niveles de O_3. Todos los contaminantes atmosféricos analizados aumentan el número de ingresos hospitalarios por SCA en las 5 localidades evaluadas.
Conclusiones: Los niveles de contaminantes gaseosos se relacionan entre sí, estando los niveles de NO_2, NO y CO correlacionados positivamente entre sí y negativamente con los niveles de O_3. El número de ingresos hospitalarios por SCA aumenta con los niveles de 5 contaminantes gaseosos del aire estudiados.

Introduction

Urban air pollution derived from vehicles, industry, heating, and other natural causes, has widespread detrimental effects on health and it is one of the most relevant problems for the industrialized world.[1] Different studies related the air pollution with increase of mortality,[2,3] respiratory,[4,5] and cardiovascular diseases[6–8] in USA. In Spain, the data recovered are similar.[9] Air pollution could be responsible for up to 20% of cardiovascular deaths.[10] However, the awareness of the role of this relevant risk factor in cardiovascular health is low. In fact, a recent study from World Heart Federation, American College of Cardiology, American Heart Association, and the European Society of Cardiology classifies research and awareness on the role of pollution in cardiovascular diseases as a priority.[11]

The major air pollutants include air pollutants particles matter (PM) and gaseous pollutants as nitrogen dioxide (NO_2), carbon monoxide (CO), and sulfur dioxide (SO_2).[12] Air pollutants particles matter (PM) are classified by aerodynamic diameter in PM_{10} (diameter smaller than 10 μm) o thoracic particles, $PM_{2.5}$ (diameter smaller than 2.5 μm) or fine particles, and PM_1 (diameter smaller than 1 μm)[13] or ultrafine particles, the major component of $PM_{2.5}$.[14]

Gaseous pollutants are related with an increase of mortality and different human diseases,[15,16] and the PM are related to different human diseases, including cardiovascular and respiratory diseases[17] and other, as alterations of trophoblast cell functions and regulation of epigenetic mechanisms,[18] and cancer.[19] Although the acute coronary syndrome is one of the most common cardiovascular diseases, only Chen et al. (2022) has been studied the relationship between the increase of air pollutants and acute coronary syndrome cases.[20]

The agricultural process, fossil fuels combustion, and industries human sewage are the main causes of the increase in air pollution,[12] which has been increased in the last years progressively around the world, including Spain,[21] and the relationship between this increase and short-term health effects has been studied.[22] In the Mediterranean region, several studies have been carried out to determine the air pollution levels and their relationship with hospital admission due to different pathologies, including asthma and acute respiratory disease in Murcia,[23] SARS-CoV2 infection in Catalonia,[24] asthma in Barcelona[25] and occupational accidents in Madrid.[26] However, the air contaminants pollution and their relationship between acute coronary syndrome has not been evaluated in the Valencia region.

The main objective of this work is to analyze the relationship between air gaseous pollutants levels and acute coronary syndrome in Valencia region.

Methods

Study population and outcome data

A total of 1998 patients with hospital admission due to ACS were included in this longitudinal study. The data were recovered in five hospitals distributed in Valencia region, including urban area of Valencia (from January 2006 to December 2008). As ACS hospital admission were included patients with myocardial infarction (CIE-410) and unstable angina (CIE-411). Death from ACS prior to hospital admission were not considered, but only patients admitted to hospital and discharged with the diagnoses, so the incidence data could be slightly underestimated. Epidemiological data as sex (man and woman), age (less or more than 70 years old), data of admission, reason for admission (CIE-410 or CIE-411), admission to the intensive care unit, location (H1, H2, H3, H4, and H5), and cause of discharge (myocardial infarction and unstable angina) were recovered from the patients. The study was approval of the Ethics Committee of the Arnau de Vilanova hospital in Valencia.

Environmental data

The five environmental gaseous pollutants analyzed are nitrogen dioxide (NO_2), nitrogen oxide (NO), sulfur dioxide (SO_2), carbon monoxide (CO), and ozone (O_3). The daily measures obtained come from the five environmental stations (station located around influence of the included hospital). The methods to analyze the air pollutants data were the chemiluminescence for NO_2 and NO, ultraviolet fluorescence for SO_2, non-dispersive infrared spectrometry for CO, and ultraviolet photometry for O_3.

Statistical analysis

The mean and standard deviation for each pollutant in the five hospitals evaluated have been calculated per week, month, and quarter. General linear model procedure (PROC GLM) was performed using SAS software package (North Carolina State University, USA) after the normality and homoscedasticity were tested by Shapiro–Wilks and Levene test, respectively. The model was carried out with ACS hospital admission as independent variable and sex, age, location, gaseous air pollutant concentration and time (week, month, and trimester) as fixed effects. The interactions between them have been evaluated. Pearson correlation between air pollutant levels were performed. The statistical significance was set at p-values < 0.05.

Results

Epidemiological data recovered to patients included in this study indicate higher prevalence of ACS in man than woman (p-value < 0.05), with a 2:1 ratio, and higher prevalence of ACS in patients older than younger (p-value < 0.05), with a 1.25:1 ratio (Table 1). Demographical and clinical of population studied show in Table 2. Briefly, the mean of habitants per location was between 60,000 and 80,000 people in small locations (H1, H2, H4, H5), and around 500,000 people in H3, the mean of age to patients included was around 70 years old in the five locations included. Related to clinical data, the incidence of ACS per 1000 habitants was 1.31, being the higher value in H1 (1.96) and lower value in location

Table 1
Epidemiological data of patients included in the study.

Location[a]	Data admission (year)	Sex		Age		Total
		Man (%)	Woman (%)	<70 years (%)	≥70 years (%)	
H1	2006	94 (64.83)	51 (35.17)	67 (46.21)	78 (53.79)	145
	2007	85 (72.03)	33 (27.97)	52 (44.07)	66 (55.93)	118
	2008	73 (65.18)	39 (34.82)	38 (33.93)	74 (66.07)	112
	Total H1	252 (67.20)	123 (32.80)	157 (41.87)	218 (58.13)	375
H2	2006	41 (56.16)	32 (43.84)	38 (52.05)	35 (47.95)	73
	2007	40 (65.57)	21 (34.43)	25 (40.98)	36 (59.02)	61
	2008	64 (79.01)	17 (20.99)	43 (53.09)	38 (46.91)	81
	Total H2	145 (67.44)	70 (32.56)	106 (49.30)	109 (50.70)	215
H3	2006	159 (62.35)	96 (37.65)	116 (45.49)	139 (54.51)	255
	2007	185 (63.14)	108 (36.86)	126 (43.00)	167 (57.00)	293
	2008	195 (67.94)	92 (32.06)	123 (42.86)	164 (57.14)	287
	Total H3	539 (64.55)	274 (35.45)	365 (43.71)	470 (56.29)	835
H4	2006	66 (70.97)	27 (29.03)	45 (48.39)	48 (51.61)	93
	2007	62 (73.81)	22 (26.19)	47 (55.95)	37 (44.05)	84
	2008	64 (73.56)	23 (26.44)	37 (42.53)	50 (57.47)	87
	Total H4	192 (72.73)	72 (27.27)	129 (48.86)	135 (51.14)	264
H5	2006	73 (67.59)	35 (32.41)	41 (37.96)	67 (62.04)	108
	2007	67 (62.04)	41 (37.96)	67 (62.04)	41 (37.96)	108
	2008	64 (68.82)	29 (31.18)	35(37.63)	58 (62.37)	93
	Total H5	204 (66.02)	105 (33.98)	143 (46.28)	166 (53.72)	309
	Total	1332 (66.67)	666 (33.33)	884 (44.24)	1114 (55.76)	1998

[a] H1: Sagunto; H2: Paterna; H3: Valencia city; H4: Gandía; H5: Alcoi.

Table 2
Demographical data of locations and patients included in the study.

Location[a]	Year	Population	Mean of age	Incidence of SCA per 1000 habitants	Hospital stay (number of days)	Admissions to intensive care (%)	Mortality (%)
H1	2006	62702	65	2.31	8.05	43.45	6.90
	2007	63359	72	1.86	9.73	59.32	8.47
	2008	65821	65	1.70	6.63	49.11	8.04
Mean of H1		63961	67.33	1.96	8.14	50.63	7.80
H2	2006	57343	69	1.26	6.47	28.01	12.50
	2007	59043	71	1.03	7.05	31.23	14.75
	2008	61,941	67	1.31	7.46	33.16	7.41
Mean of H2		59,442	69.00	1.20	6.99	30.80	11.55
H3	2006	519,822	62	0.49	8.85	62.75	9.41
	2007	507,587	63	0.58	8.35	61.56	12.92
	2008	519,567	69	0.56	8.41	61.38	10.34
Mean of H3		515,658	64.67	0.54	8.54	61.90	10.89
H4	2006	74,827	71	1.24	6.34	59.14	13.98
	2007	77,421	74	1.08	7.56	66.67	16.64
	2008	79,958	74	1.09	4.21	55.17	8.05
Mean of H4		77,402	73.00	1.14	6.04	60.33	12.89
H5	2006	60,590	73	1.78	6.74	44.44	11.11
	2007	60,700	70	1.78	6.48	52.78	9.26
	2008	61,698	72	1.51	7.15	53.76	9.68
Mean of H5		60,996	71.67	1.69	6.79	50.33	10.02
Overall mean		**155,491**	**69.13**	**1.31**	**7.30**	**50.80**	**10.63**

[a] H1: Sagunto; H2: Paterna; H3: Valencia city; H4: Gandía; H5: Alcoi.

H3 (0.54), the most inhabited location. The mean of hospitalization was 7.30 days and around of 50% of patients were admitted in intensive care. The associated mortality was 10.63%, being the higher value in H4 (12.89%), location with the older patients were hospitalized. The number of ACS is elevated in H3, due to the high habitants of this location than others. Analysis per trimester reveals that the high number of ACS occurred in the fourth trimester of the years, respectively (p-value < 0.05). Similar results have been found in different year and location. Air pollutants present high levels in five locations, being Valencia city the most elevated levels (Table 3). These levels increased over time in the five locations analyzed, and the correlations between some of them have been observed (Fig. 1). Concretely, high levels of NO_2 are correlated to high levels of NO ($r^2 = 0.68$), and CO ($r^2 = 0.22$), whereas levels of O_3 are negatively correlated to levels of NO_2 ($r^2 = 0.42$), NO ($r^2 = 0.36$) and CO ($r^2 = 0.25$). Levels of SO_2 are not related to other air pollutant levels.

The number of weekly hospital admission to ACS are correlated to levels of several air pollutants analyzed. Concretely, elevated levels of NO_2, NO, SO_2, CO, and O_3 (p-value < 0.05) are correlated to high number of ACS (Fig. 2). Year and location have not significative effect. These results are similar on a weekly, monthly, or quarterly.

Table 3
Levels of air pollutants in five location per year. Data shows as mean ± SD ((μg/m³).

Location[a]	Year	NO_2 (μg/m³)	NO (μg/m³)	SO_2 (μg/m³)	CO (μg/m³)	O_3 (μg/m³)
H1	2006	20.33 ± 7.71	13.49 ± 8.25	3.64 ± 0.85	297.69 ± 84.54	42.54 ± 12.52
	2007	17.98 ± 6.38	13.12 ± 7.15	4.29 ± 0.90	525.37 ± 226.52	39.79 ± 12.09
	2008	12.93 ± 9.00	10.56 ± 7.53	3.58 ± 0.91	198.89 ± 86.84	59.72 ± 17.77
H2	2006	19.34 ± 11.24	10.54 ± 6.16	3.65 ± 0.71	210.40 ± 92.47	51.79 ± 18.05
	2007	8.91 ± 6.11	10.42 ± 20.91	5.54 ± 1.68	277.32 ± 183.51	50.60 ± 21.23
	2008	16.36 ± 6.99	6.96 ± 3.67	4.04 ± 0.79	221.76 ± 80.06	52.97 ± 14.41
H3	2006	55.71 ± 16.25	52.61 ± 28.97	4.32 ± 1.13	493.27 ± 147.83	26.90 ± 11.09
	2007	55.35 ± 16.22	42.37 ± 31.43	4.56 ± 1.62	429.29 ± 146.65	24.94 ± 9.33
	2008	41.39 ± 16.72	32.19 ± 22.22	3.68 ± 0.89	336.27 ± 94.95	38.41 ± 19.85
H4	2006	22.93 ± 6.76	10.86 ± 4.96	3.17 ± 0.29	367.50 ± 292.99	50.23 ± 17.33
	2007	22.81 ± 5.77	10.50 ± 4.78	3.42 ± 0.69	273.19 ± 146.06	52.75 ± 18.21
	2008	9.85 ± 4.53	4.68 ± 2.09	3.31 ± 0.44	257.63 ± 111.04	54.45 ± 17.52
H5	2006	15.84 ± 6.07	5.06 ± 2.38	3.14 ± 0.20	202.40 ± 62.58	68.43 ± 18.24
	2007	20.28 ± 8.97	5.14 ± 2.44	3.38 ± 0.45	269.57 ± 43.89	62.46 ± 13.89
	2008	21.17 ± 7.72	6.43 ± 2.49	3.27 ± 0.43	237.84 ± 50.88	60.96 ± 13.73
Total		24.88 ± 17.76	16.25 ± 20.71	3.78 ± 1.08	303.54 ± 158.26	49.22 ± 19.91

[a] H1: Sagunto; H2: Paterna; H3: Valencia city; H4: Gandía; H5: Alcoi.

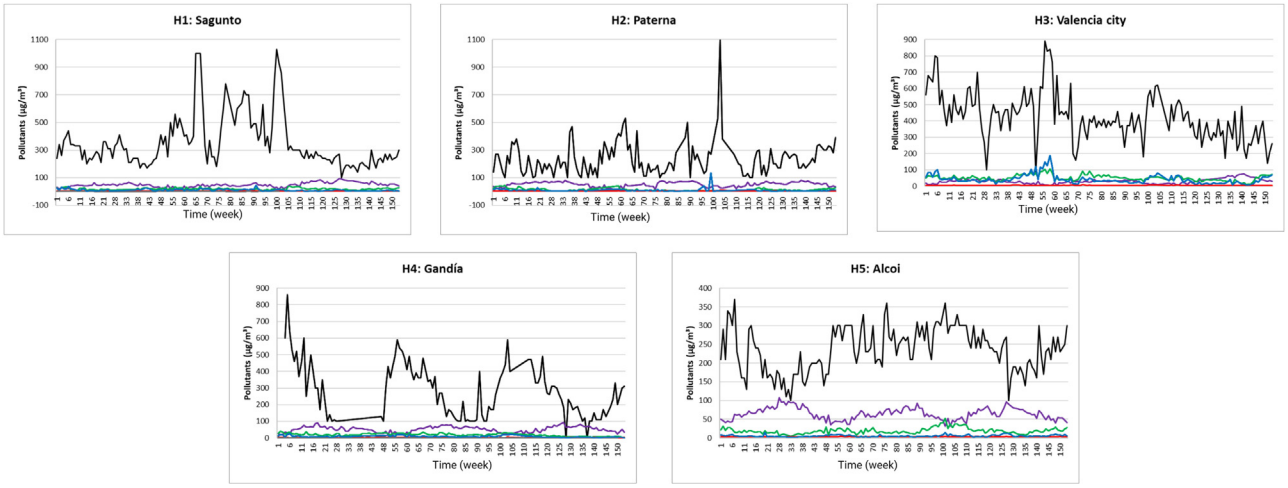

Fig. 1. Levels of five air pollutants studied over time in different locations (H1; H2; H3; H4; H5). Concentration of pollutants (NO_2-green, NO-blue, SO_2-red, CO-black, O_3-purple) (μg/m³).

Discussion

This work summarizes the levels of five air gaseous pollutants and their relationship between ACS hospital admission in five locations of Valencia region. The results obtained show that man and older people (more than 70 years old) have high risk of ACS. The ACS hospital admissions are higher in the last trimester of the year than others and are related to air gaseous pollutant levels. Levels of NO_2, NO, and CO are positively correlated between them, and negatively correlated to O_3 levels.

High levels of ACS in man and older people had already been published,[27] whereas the risk of death is elevated in young women.[28] However, the age of women suffering from ACS is 67–70 years, up to 10 years older than men, which could explain the high mortality in women.[29] Related to air pollutant levels found, there are more elevated, being above the recommendations of the WHO in some locations analyzed, who recommend maximum levels of annual exposure of 10 μg/m³ for NO_2, and short exposure of 7 mg/m³ for CO, 125 μg/m³ for SO_2, and 160 μg/m³ for O_3 (no maximum recommended for NO).[30] According to these recommendations, all the locations analyzed presented much higher values in all the years included in the study for both NO_2 and CO. These results indicate that effective measures are necessary in the Valencia region to reduce environmental pollution and improve the heart health of its population.

Several papers indicate the relationship between levels of pollutants and season, temperature, and climatology. Concretely, in Mediterranean western, the high levels of air pollutants have been related to winter season.[31] According with them, our results reveal high number of ACS hospital admissions are in the winter (the last trimester of the year), and there are correlated to high levels of air gaseous pollutants. Recently, Rus and Mornos (2022) reviewer the impact of air pollution and meteorological factors increase the risk of ACS.[32] In fact, high levels of air pollution as PM and atmospheric pressure are correlated to ACS.[33] According with our results, nitrogen dioxide, nitric oxide, carbon monoxide and ozone atmosphere levels are correlated to increase of ACS risk,[34] whereas other authors does not shown relationship between ozone levels.[20] These authors indicated that high levels of these gaseous pollutants are related to high ACS three days after. Our study analyzes the ACS hospital admission during the week with levels of gaseous pollutants are recovered, so are in agree with this time. To the best of our knowledge, no studies had related SO_2 levels with an increase of ACS. Finally, correlations found between gaseous pollutants have already been shown by Karanasious et al. (2014) in the Mediterranean Basin,[35] although this is the first time that

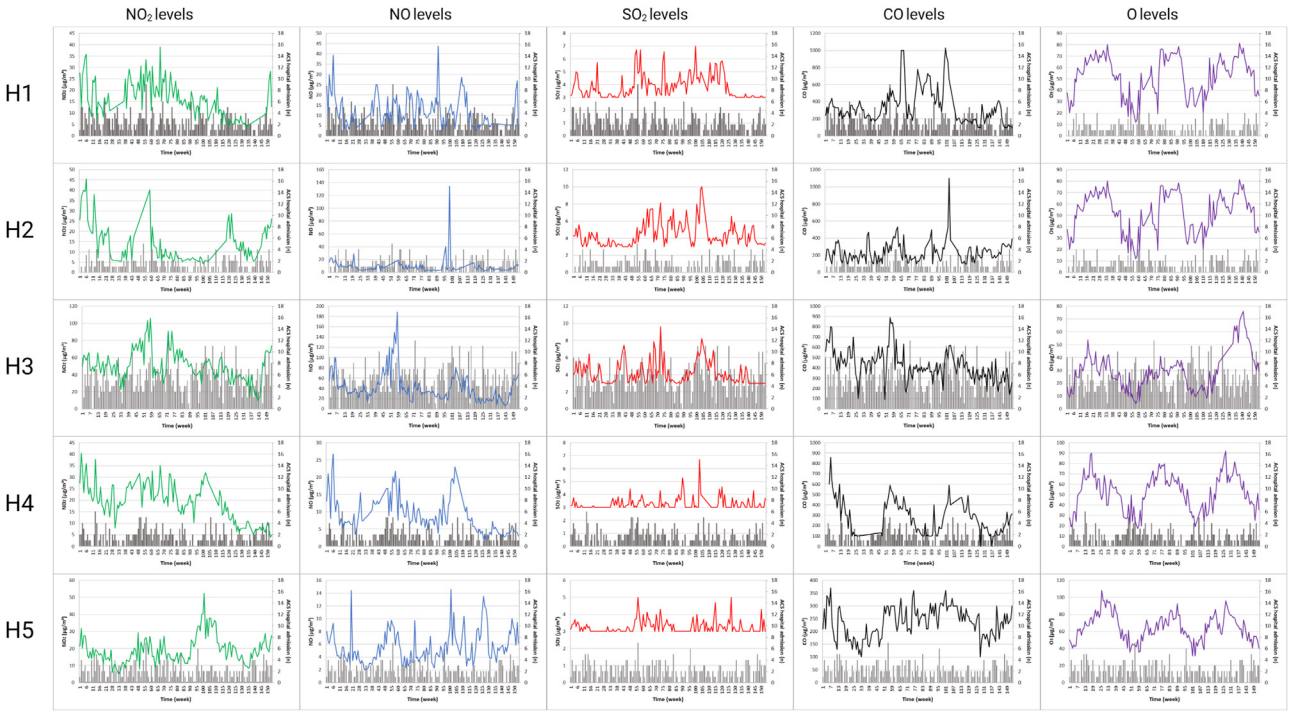

Fig. 2. ACS hospital admissions (grey bars) related to concentration of air pollutants analyzed (NO_2-green, NO-blue, SO_2-red, CO-black, O_3-purple) weekly in different locations (H1; H2; H3; H4; H5).

negative correlation between O_3 and other gaseous pollutants are demonstrated.

Conclusions

In summary, ACS risk is higher in men and older people (>70 years old), and it is related to gaseous pollutant levels in the air. Correlation between gaseous contaminants have been found, with NO_2, NO, and CO positively correlated, and all of them negatively correlated to O_3 levels. Levels of NO_2 and CO are well above the recommendations of the WHO, so effective measures to reduce gaseous pollution should be carried out in the Valencia region to improve the cardiac health of population.

Authors' contributions

G.R.: Conceptualization, writing original draft; J.R.-D.: Writing-review and editing; J.C.-S.: Writing-review and editing; P.J.M.-G.: Writing-review and editing, statistical analysis; L.L.: Conceptualization, methodology, data curation, writing-review and editing, supervision, funding acquisition.

Ethical considerations

This retrospective study was approval of the Ethics Committee of the Arnau de Vilanova hospital in Valencia.

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Conflict of interest

All authors declare that they have no conflict of interest.

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