



## ORIGINAL ARTICLE

**Evaluation of Suspended Matter less than 10  $\mu\text{m}$  and Cardiovascular and Respiratory Diseases: in Urmia City, 2015**Rasoul Entezarmahdi<sup>1</sup>, Mousa Ghelichi Ghoghjogh<sup>2\*</sup>, Hojjat Kargar<sup>3</sup>, Saeed Minaee Mehr<sup>4</sup><sup>1</sup>Department of Statistics and Epidemiology, Department of Health, Urmia University of Medical Sciences, Urmia, Iran<sup>2</sup>Urmia City Health Center, Urmia University of Medical Sciences, Urmia, Iran<sup>3</sup>Department of Health, Urmia University of Medical Sciences, Urmia, Iran<sup>4</sup>Department of Occupational Health and Occupational Health, Urmia University of Medical Sciences, Urmia, Iran**Corresponding Author:** Mousa Ghelichi Ghoghjogh, E-mail: [mghelichi2000@yahoo.com](mailto:mghelichi2000@yahoo.com)**ARTICLE INFO***Article history*

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*Key words**Heart Diseases,**Respiratory Diseases,**Particulate Matter***ABSTRACT**

**Introduction:** Air pollution induced by human activities is one of major challenges faced by Iran, as well as the world. The AirQ model was used to evaluate the cardiovascular and respiratory diseases attributable to the exposure to suspended particles of less than 10  $\mu\text{m}$  in Urmia city of West Azerbaijan Province, Iran, in 2015. **Materials and Methods:** This descriptive-analytic study was conducted in Urmia in 2015. The hourly data of the PM<sub>10</sub> (particle matter up to 10  $\mu\text{m}$ ) pollutant were extracted as the raw material from the Environmental Health Center. The health effects of suspended particles of less than 10  $\mu\text{m}$  were estimated by statistical analysis using the World Health Organization's AirQ model. **Results:** According to the results concentration of PM<sub>10</sub> was higher in the cold seasons compared with the warm seasons. The annual average of PM<sub>10</sub> concentration was 3.9 times higher than that prescribed as per the standards of clean air in Iran. In addition, the cumulative numbers of cardiovascular and respiratory diseases in the city of Urmia in the median estimate were 287 and 744 cases, respectively. **Conclusion:** As a consequently, air pollution in the Urmia city has contributed significantly to the rate of hospitalizations and deaths of people in 2015. Therefore, authorities should make appropriate, sustainable, and applicable strategies based on comprehensive research to control the Urmia air pollution crisis.

**INTRODUCTION**

Today, man-made air pollution has undoubtedly become one of the biggest challenges in Iran as well as worldwide (1-3). Due to its harmful consequences, it is one of the most pressing environmental problems across the globe. According to the World Health Organization (WHO), in 2012, about 3.7 million people died because of the ambient air pollution, and about 88% of the deaths occurred in low- and middle-income countries (4). In recent years, pollution from fuel combustion has reduced dramatically. However, newfound pollutants such as ozone and NO<sub>2</sub>, as well as changes in the distribution and the size of suspended particles are contributing significantly to urban health concerns (3, 5).

In recent years, many epidemiologic studies have been conducted in different parts of the world to determine the relationship between the effects of air pollution and human health. Results of these studies have indicated that increasing air pollution is responsible for causing acute respiratory infections, decreasing vision, chronic respiratory diseases, lung cancer, and heart diseases, in turn leading to an increase in the mortality rate (2,

6, 7). Suspended particles are considered to be the major pollutants responsible for causing health hazards. The various epidemiological evidence is based on research that uses suspended particles of less than 10  $\mu\text{m}$ , which is used as one of the indicators of contact with suspended particles which are related to a high mortality rate in the long- and short-term exposures (8-10).

Epidemiological evidence suggests that there is a close correlation between daily changes in suspended particle concentrations, cardiovascular mortality hospital admissions, the exacerbation of symptoms of cardiac patients, and early physiological responses (11,12). According to Goodarzi et al, about 4% of all cardiovascular and respiratory deaths in Tehran were attributed to air pollutants with concentrations of PM<sub>10</sub> (particle matter up to 10  $\mu\text{m}$ ) being greater than 20  $\mu\text{g}/\text{m}^3$  (13). Nadafi et al also attributed the highest share of the health hazards in Tehran to air pollutants with the annual mean concentration of PM<sub>10</sub> being 4.5 times higher than that set by the WHO guidelines (14). According to a study of Tomiz et al, in northeastern Italy, 1.8% of the deaths associated with respiratory diseases were attributed to concentrations of PM<sub>10</sub> that were more than 20  $\mu\text{g}/\text{m}^3$  (15). These

statistical figures suggested that the suspended particles in the atmosphere were the major cause of health issues in Urmia city, Tehran. The amount of air pollution in Iran's metropolitan cities, including the Urmia city, is increasing day by day. This requires the immediate attention of authorities and experts in Tehran. Controlling air pollution in metropolises is the most important solution for this growing concern; however, this would not be possible without relying on an authentic source that would provide correct and accurate information about the environmental situation and its impact on human health (16, 17).

The purpose of this study was to estimate cardiovascular and respiratory diseases attributable to suspended particles of less than 10  $\mu\text{m}$  in Urmia city, in 2015, by using the AirQ model.

## MATERIALS AND METHODS

According to the population growth rate, the population of Urmia city was estimated about 750,000 in 2015. It is the 10<sup>th</sup> most populated city in Iran and the second most populated city in the northwest region of Iran. It is located at a height of 1332 m to the west of Lake Urmia, on the slopes of Mount Sari, and along the Urmia Plain.

Urmia is relatively warm in summer and cold in winter (17). It is located in the northern hemisphere at 37 degrees and 32 minutes from the Equator and the Meridian, and 45 degrees and 2 minutes east along the Greenwich Meridian. In 2015, the average temperature in Urmia was 12.7°C, with a temperature of 39°C in the summer and a temperature of -11°C in the winter. The rainy season in the city normally begins in late October and the beginning of November and lasts until May. The average rainfall in Urmia is about 362 mm and the annual freezing days are 124 days. The humidity is 57% and the average wind speed is 5.2 m/s. In 2015, the dust collection number was 3.5 times higher than the one prescribed in the set standard (17).

### How to Process Data and Run the Model

In 2015, Urmia city had 4 air quality monitoring stations; only one of these is active at present. Parameters of sulfur dioxide and nitrogen, carbon monoxide, ozone, and suspended particles were measured at these stations. The hourly data of the PM<sub>10</sub> pollutant were extracted in the raw form from the environmental office, and the effects of the air pollutant PM<sub>10</sub> on Urmia city were analyzed from Shahid Bahonar, the first monitoring station where the data were recorded and which is located in Hijab Park at the latitude of 37° 32.4' 33" and longitude 45° 03' 07.2".

To determine the amounts of credit of data to statistical analysis, the recorded data at the stations were processed on

the basis of the WHO criteria, according to which the ratio between the numbers of valid data for 2 seasons (hot and cold) should not be more than 2 times. In addition, to achieve the 24-hour mean values of data with a shorter average time, at least 50% of the data were needed to be contained after validation (5, 14). Primary and secondary raw data were collected using the Microsoft Excel software. The required statistical parameters, including the annual average, the average of hot and cold seasons, and the percentile of 98 annual, maximum annual, and maximum of hot and cold seasons of the pollutants, were calculated using the formulas of the Excel software.

Then, to estimate and quantify the effects of health and the rate of mortality attributed to PM<sub>10</sub> due to the concentration of contaminants and the exposure of individuals, the information was entered into the Air Quality Health Impact Assessment software version 2.2.3 (AirQ2.2.3), and then the relative risk (RR), base incidence (BI), attributable fraction, and attributable excess cases were calculated with the help of AirQ2.2.3. The input section of the model consisted of 4 supplier screenshots, location, air quality data, and parameters that were complemented by entering the processed information from Excel. Eventually, the model results presented the cases of death in the form of Tables and Figures.

## RESULTS

The results of this study showed that the average annual concentration, mean cold season, average warm season, and percentile of 98 annuals were 115, 119, 111, and 285  $\mu\text{g}/\text{m}^3$ , respectively. The standards of Iran's clean air for annual average concentrations and for maximum 24-hour PM<sub>10</sub> concentration are 20 and 50  $\mu\text{g}/\text{m}^3$ , respectively. The results showed that the average annual concentration of PM<sub>10</sub> was 78  $\mu\text{g}/\text{m}^3$ , which was 3.9 times more than the standards of Iran's clean air (Table-1).

Comparing the average of 24-hour concentrations of PM<sub>10</sub> in the Urmia city with the values of standard guidelines (50  $\mu\text{g}/\text{m}^3$ ) showed that the average of the 24-hour concentration of 300 days was more than that of the standard level. According to Table 2, in 2015, the aggregate number of total mortality cases in Urmia city as per the estimation of an RR of 1.006 was 241, and the rate of BI was 543.5 per 10<sup>5</sup> people.

According to Table 3, the cumulative number of cases of mortality resulting from cardiovascular disease in estimating the mediocrity of an RR of 1.009 and the BI rate of 231 in 10<sup>5</sup> individuals were 147 cases, and the cumulative number of hospitalized cases resulting from cardiovascular disease in estimating the mediocrity of an RR of 1.009 and the BI rate of 436 in 10<sup>5</sup> individual were 286.8.

**Table 1.** Comparison of average annual concentration of PM<sub>10</sub> in urmia city in 2015 with values of guidelines and standards

Guidelines and standards	Annual average ( $\mu\text{g}/\text{m}^3$ )	Ratio annual average concentration of PM <sub>10</sub> in urmia to each of the standards
References of the world health organization (2005)	20	3.9
Iran's standard (approved in 2009)	20	3.9
European union standard (2012)	40	1.95

PM<sub>10</sub>, particle matter up to 10  $\mu\text{m}$

**Table 2.** Estimation of relative risk indicators, attributable fraction, and attributable cases of  $\text{PM}_{10}$  for total deaths (Base incidence=574.5 per  $10^5$  people per year)

Indicator estimate	RR (per 10 $\mu\text{g}/\text{m}^3$ $\text{PM}_{10}$ )	Attributable fraction	Attributable excess cases (Persons)
Low	1.004	6.02	164
Average	1.006	4.09	241
High	1.008	7.87	315

RR, relative risk;  $\text{PM}_{10}$ , particle matter up to 10  $\mu\text{m}$

**Table 3.** Estimation of relative risk indicators, attributable fraction, and attributable cases of  $\text{PM}_{10}$  for cases of deaths (Base incidence (BI)<sup>o</sup>=231) and hospitalization (BI<sup>o</sup>=436) resulting from cardiovascular diseases

Indicator estimate	RR (per 10 $\mu\text{g}/\text{m}^3$ $\text{PM}_{10}$ )	Attributable fraction	Attributable excess cases (Persons)
Case mortality			
Low	1.005	5.09	85
Average	1.009	8.8	147
High	1.013	12.25	204
Case hospitalization			
Low	1.006	6.02	196.9
Average	1.009	8.7	286.8
High	1.013	12.19	398.7

RR, relative risk;  $\text{PM}_{10}$ , particle matter up to 10  $\mu\text{m}$

Due to cardiovascular diseases resulting from the exposure of  $\text{PM}_{10}$  contaminants than their concentration, Figures 1 and 2 showed the cumulative number of cases of deaths and hospitalizations, respectively.

Due to respiratory diseases resulting from the exposure of  $\text{PM}_{10}$  contaminants than their concentration, Figures 3 and 4 showed the cumulative number of cases of deaths and hospitalization, respectively. There are 3 curves in each Figure. The central curve is the corresponding relative central risk, the inferior curve is the corresponding RR of 5%, and the upper curve is the corresponding RR of 95%.

Figure 1 showed that the effect of the concentration on the population of Urmia city leading to death from cardiovascular disease is considerable when the range of minimum and maximum changes based on the vertical axis of cumulative incremental amounts to death resulting from cardiovascular disease is more than the concentration average of 150  $\mu\text{g}/\text{m}^3$   $\text{PM}_{10}$ .

Figure 2 showed that the effect of the concentration on the population of Urmia city leading to death from cardiovascular diseases is considerable when the range of minimum and maximum changes based on the vertical axis of cumulative incremental amounts to cases of hospitalization resulting from cardiovascular diseases is more than the concentration average of 170  $\mu\text{g}/\text{m}^3$   $\text{PM}_{10}$ .

According to Table 4, the cumulative number of cases of death resulting from respiratory diseases in estimating the mediocrity of an RR of 1.013 and the BI rate of 48.4 per  $10^5$  individuals was 44.3, and the cumulative number of hospitalized cases resulting from respiratory diseases in estimating the mediocrity of an RR of 1.008 and the BI rate of 1260 per  $10^5$  individuals was 743.9.

Figure 3 showed that the effect of the concentration on the population of Urmia city leading to death from cardiovascular diseases is considerable when the range of minimum and

maximum changes based on the vertical axis of cumulative incremental amounts to death resulting from respiratory diseases is more than the concentration average of 100  $\mu\text{g}/\text{m}^3$   $\text{PM}_{10}$ .

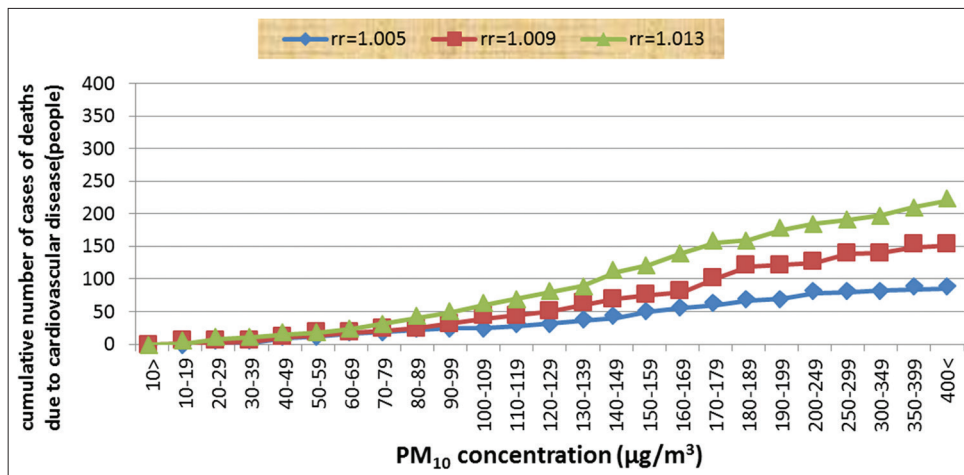
Figure 4 showed that the effect of the concentration on the population of Urmia city leading to death from cardiovascular diseases is considerable when the range of minimum and maximum changes based on the vertical axis of cumulative incremental amounts to cases of hospitalization resulting from respiratory disease is more than the concentration average of 100  $\mu\text{g}/\text{m}^3$   $\text{PM}_{10}$ .

## DISCUSSION

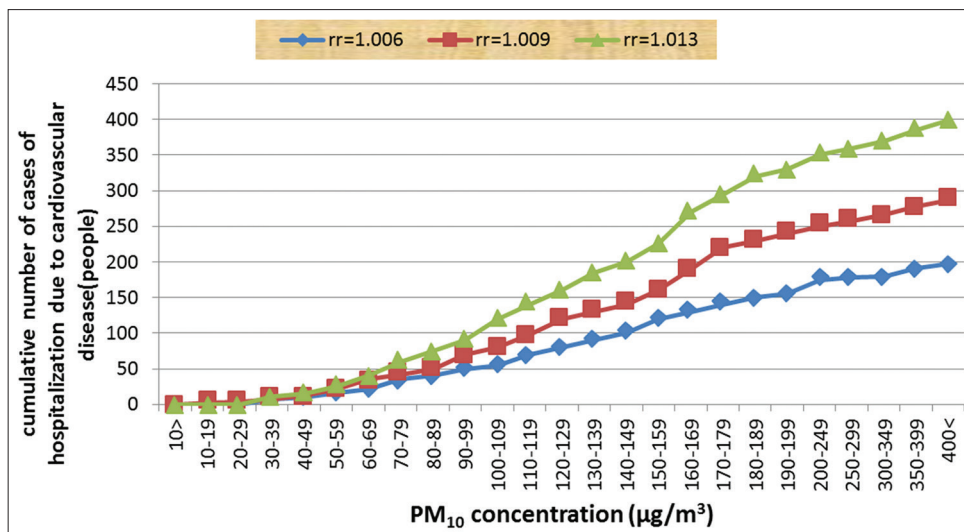
Urmia city is one of the major cities in Iran that, according to the results of this study, faces the problem of air pollution. On the basis of the quantifying and attributable effects of air pollution, the community members can consider the level of impressionability of air pollutants and thus can have a better show of the air quality of critical conditions. The results of this study showed that the cumulative cases of cardiovascular diseases increased with an increase in the concentration of  $\text{PM}_{10}$ . In this study, 65% of the cumulative cases of cardiovascular diseases in 2015 were related to the concentration of less than 160  $\mu\text{g}/\text{m}^3$ .

In the study by Gravundy et al (2), more than 50% of the cumulative cases of cardiovascular diseases were related to the concentration of less than 150  $\mu\text{g}/\text{m}^3$ , and in the study by Gravundy et al (18), more than 62% of the cumulative cases of cardiovascular diseases were related to the concentration of less than 160  $\mu\text{g}/\text{m}^3$ . The results of this study in comparison with other studies indicated that Urmia faces the serious problem of pollution.

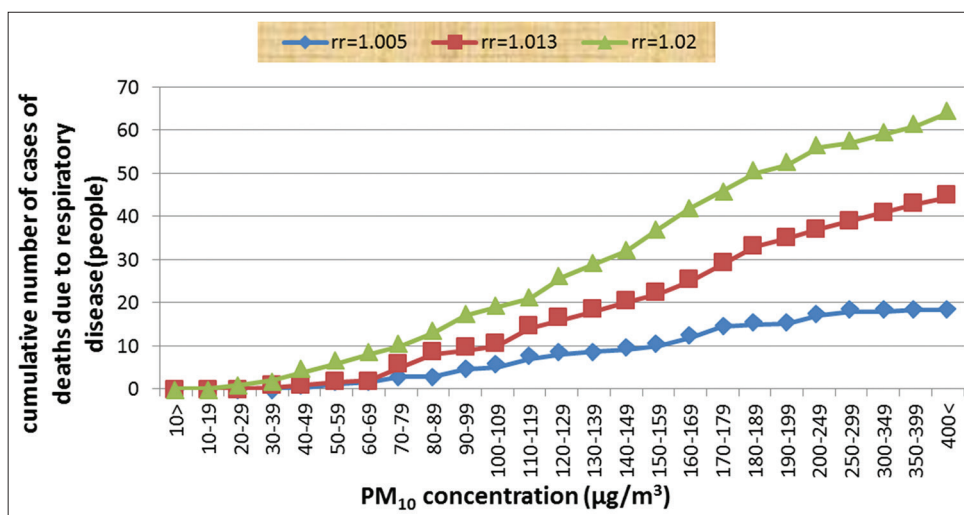
Reviews conducted in 29 European cities, 20 American cities, and some of the Asian countries showed that even a brief contact with  $\text{PM}_{10}$  affects health in an adverse manner, with similar effects ob-



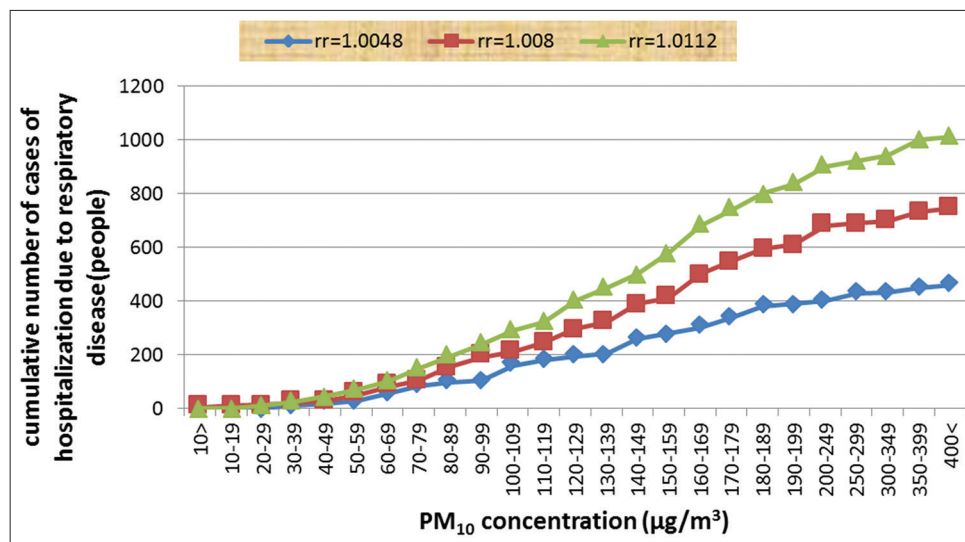
**Figure 1.** The Estimated Number of Cases of Death Resulting From Cardiovascular Diseases Attributable to PM10 in 2015 in Urmia City; RR indicates relative risk



**Figure 2.** Estimated Hospitalization Cases due to Cardiovascular Diseases Attributable to PM10 in Urmia City in 2015; RR indicates relative risk



**Figure 3.** The Estimated Number of Cases of Death Resulting From Respiratory Diseases Attributable to PM10 in Urmia City in 2015; RR indicates relative risk



**Figure 4.** Estimated Cases of Hospitalization due to Respiratory Diseases Attributable to PM<sub>10</sub> in Urmia City in 2015; RR indicates relative risk

**Table 4.** Estimation of relative risk indicators, attributable fraction, and attributable cases of PM<sub>10</sub> for cases of deaths (Base incidence (BI)<sup>0</sup>=<sup>0</sup>48.4) and hospitalization (BI<sup>0</sup>=<sup>0</sup>1260) resulting from respiratory diseases

Indicator estimate	RR (per 10 µg/m <sup>3</sup> PM <sub>10</sub> )	Attributable fraction	Attributable excess cases (Persons)
Case mortality			
Low	1.005	5.06	18.4
Average	1.013	12.19	44.3
High	1.02	17.6	63.9
Case hospitalization			
Low	1.048	4.8	460.9
Average	1.008	7.8	743.9
High	1.012	10.68	1009.7

RR, relative risk; PM<sub>10</sub>, particle matter up to 10 µm

served in various cities of developed and developing countries, and for each increase of 10 µg/m<sup>3</sup> PM<sub>10</sub>, the rate of risk of death increases by 0.5%. Therefore, the 150 µg/m<sup>3</sup> of PM<sub>10</sub> concentration can be a cause for an increase in 5% risk of death (19, 20-22). In this study, 8.8% of all cardiovascular deaths and 12.19% of all respiratory deaths were attributed to PM<sub>10</sub> concentrations of more than 20 µg/m<sup>3</sup>. In a study conducted in Trieste, Italy, the AirQ model was used to estimate the effects of suspended particles of less than 10 µm on human health, which showed that 1.8% of all cardiovascular deaths and 2.5% of respiratory deaths were related to more than 20 µg/m<sup>3</sup> concentrations of PM<sub>10</sub> (2), which is much lower than the results of this study. In addition, in the study by Gravundy et al (18), the attributed cases of PM<sub>10</sub> for total cardiovascular deaths were 8.4%, which is consistent with the results of the present study. The results obtained by Tabriz showed that about 6% of all cardiovascular and respiratory diseases were related to more than 10 µg/m<sup>3</sup> concentrations of PM<sub>10</sub> (23), which was lower than the results of the present study. A study in Ahvaz, Khuzestan Province, Iran, also showed that about 13% of all cardiovascular and respiratory deaths were related to more than 20 µg/m<sup>3</sup> concentrations of PM<sub>10</sub>, which is higher than the results of this study (18).

Major cases of cardiovascular deaths and the cases of referral to hospitals due to respiratory diseases can be due to the higher average of PM<sub>10</sub> or the persistent high concentration days in Urmia city. Also, there are various ways to con-

trol the emission of gaseous pollutants in the atmosphere and to deal with air pollution, such as the construction of weather stations for air pollution inside the city; the installation of monitoring devices and control of gases from the chimney industry; the use of alternative fuels; improved combustion conditions in equipment, industries, and households; proper management of energy consumption; the development of public transport fleet; and the development of green space, especially in urban regions.

### CONCLUSION

The results of this study indicate the fact that air pollution in Urmia city had a significant share in the rate of hospitalizations and deaths in 2015. The authorities should use appropriate, sustainable, and applicable strategies based on comprehensive research to control the Urmia air pollution crisis. The limitation of this study was the availability of one active station of total 4 air quality monitoring stations.

### AUTHOR CONTRIBUTIONS

All authors contributed equally to this study.

**CONFLICT OF INTEREST**

None

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