Short-term Effects of PM_{10} to Increase Rate of Hospital Admission Cardiovascular and Respiratory of Sanandaj, Iran During 2015

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ABSTRACT
Sanandaj in the west of Iran is one of the main city that suffered from Arabic Dust Storm (ADS). As Sanandaj isn't industrial city and located in the mountainous region, one of the main sources of air pollution which has adverse effects on citizens and environment is PM_{10} which comes from Arabic Dust Storm. In this way, the goal of this study was to the assessment of these adverse health effects. So the hourly data of concentration of PM_{10} (measured by Beta attenuation method) were taken from Kurdistan Environmental Protection Agency in 2015.
the 24-hour average concentration of particulate matter has exceeded about 182 times (days) more than the National Standards and WHO guideline values and the average annual concentration of PM_{10} were about 1.5 times more than the National Standard and WHO guideline values during the period of the exam.
By means of Air Q2,2,3 software the data analyzed and baseline incidence(BI), relative risk(RR) and attributable proportion(AP) were calculated. The results of this study showed that short-term health effect of PM_{10} could increase of total mortality except accidents and poisoning(4.13%), hospital admission cardiovascular(4.98%), cardiovascular mortality(4.45%), hospital admission respiratory(4.45%) and respiratory mortality(0.2%).
This study demonstrated that a high percentage of cardiovascular and respiratory morbidity and mortality rate increased due to the raising of the concentration of PM_{10}. To reduce the emission of PM_{10} from main sources and relationship between the hospital and Kurdistan Environmental Protection Agency and whether organization and people to be alert are necessary.
Key words: Air Pollution, PM_{10}, Hospital Admission Cardiovascular and Respiratory

INTRODUCTION
Air pollution is a widespread public health problem associated with several adverse health outcomes ranging from premature mortality to respiratory symptoms and impaired lung function [1-3].
The respiratory system is considered as the first target of particle attacks, and respiratory inflammation has been proposed as a critical pathway in the biological mechanism of the particle-induced effect [4].
The potential of particles to cause adverse respiratory and systemic health effects is related to their ability to enter the lungs, potentially carrying a number of toxic compounds with them. At present, it is not known which particle size, morphology or chemical components are most strongly related to the negative effects on human health and further research in this field is required. In terms of particle size, attention has shifted between mass (PM_{10} or $PM_{2.5}$), surface are and particle number concentrations [5-7].
Previous studies have shown that the exposure to particulate matter (PM) is associated with increased morbidity and mortality, primarily from cardiovascular disease (CVD) [8-12].
Several investigators have hypothesized that oxidative stress directly induced in the lungs after PM inhalation might cause a systemic inflammatory cascade, increasing cardiovascular risk among susceptible individuals [13-16].
Epidemiological studies have provided substantial evidence that short-term exposure to particulate matter (PM) is associated with increased cardio-respiratory mortality and a series of adverse

respiratory effects such as decreased lung function and increased inflammation [17-18].

Previous studies examined health effects of different particle size fractions, such as PM_{10} (particles less than 10 mm in aerodynamic diameter), $PM_{2.5}$, PM_1 and $PM_{0.1}$; and increasing evidence suggested that smaller particles might be more harmful to human health [19-20].

PM is a concern because its inhalation is related with many adverse health effects (such as cardiovascular and pulmonary diseases), being estimated that this pollutant is responsible for around 2.1 million of premature deaths per year globally [21-22].

Worldwide, air pollution has become a main environmental cause of premature mortality [23].

The biological mechanisms behind these associations have not been fully elucidated yet, but many of the obesity-related diseases are thought to be linked to a state of chronic oxidative stress and inflammation. Obese subjects have indeed increased systemic oxidative stress and impaired oxidant defense [24-26].

Furthermore, the International Agency for Research on Cancer (IARC), which is the specialized cancer agency of the World Health Organization (WHO), classified outdoor air pollution as group-1 carcinogenic to humans. Outdoor air pollution has also been linked with non-carcinogenic effects, which range in terms of severity from subclinical physiological changes to mortality [28].

To try to improve our understanding of the role of PM_{10} as a number one air pollution factor in Sanandaj which has a main health effects on citizens in this part of Iran, we designed an epidemiological study where we investigated the short-term effects of PM_{10} total mortality except accidents and poisoning, hospital admission cardiovascular, cardiovascular mortality, hospital admission respiratory and respiratory mortality.

MATERIALS AND METHODS

Type of study

This study was a descriptive-analytic and Air Q software2.2.3 software was used to the evaluation of short-term hospital admission cardiovascular, cardiovascular mortality, hospital admission respiratory and respiratory mortality attributed to the concentration of PM_{10} in Sanandaj city. Location of Sanandaj is shown in Fig.1.

Study location and PM_{10} data

Sanandaj is one of the main city in the west of Iran which located in the border of Iraq, this city is the center of Kurdistan province (35°18′52″N, 46°59′32″E) at an altitude of approximately 1500meter above sea level The population of the city is 374,000people according to population statistics of 2015. Sanandaj located and surrounded by hills and mountains. As this city isn't industrial city the main source for make air pollution is dust particles which comes from Arabic Desert. this kind of particles is well known as Arabic Dust Particles or Arabic Dust Storm. dry-lands around North Africa and the Arabian peninsula are the main terrestrial sources of these airborne dust. As the only one station for air pollution analyses is in Sanandaj city, we have to gotten data from this station. Location of this station was chosen before by Kurdistan Environmental Protection Agency in the center of Sanandaj approximately. location of monitoring or sampling site, Sanandaj city, Kurdistan province and Iran are shown in Fig. one.

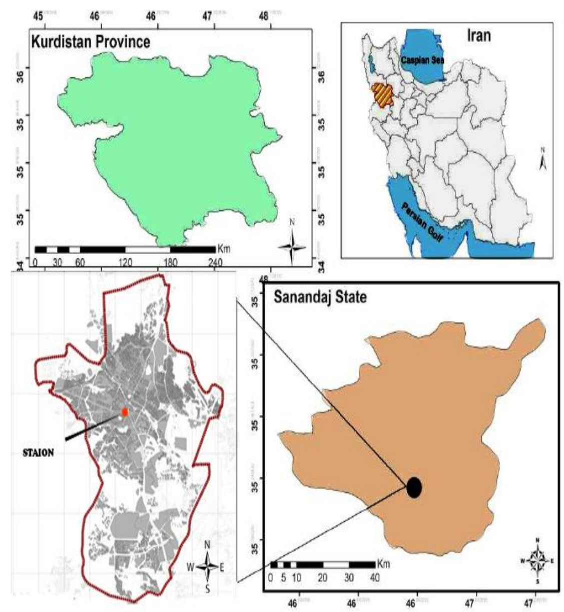

Fig.1: location of monitoring site, Sananadaj city, Kurdistan province, and Iran.

Time duration of sampling:

In this study data of PM_{10} concentration and cumulative days when the index of PM_{10} raised more than standard, collected during 2015 that showed in Table 1. It must be mention that the selection of duration of exam or data collection was based on Arabic dust storm as the main source of air pollution in Sanandaj. This phenomenon happen in Sanandaj during April to October each years. As we wanted to compared data to each other in each season, we chose one year(Iranian date) for a period of study.

The data of concentration of PM_{10} collected daily as mention in Table 1.

Table 1: The frequency distribution of average concentrations (24 hour) of PM_{10} and Cumulative days raised more than standard in Sanandaj during 2014 – 2015

Concentration of PM_{10} $(\mu g / m^3)$	**Total days**	**Cumulative days**	**Concentration of PM_{10} $(\mu g / m^3)$**	**Total days**	**Cumulative days**
١٠<	1	1	130 - 139	10	**285**
10 – 19	11	12	140 – 149	0	**285**
20 – 29	23	35	150 - 159	1	**286**
30 – 39	35	70	160 – 169	3	**289**
40 – 49	50	120	170 – 179	2	**291**
50 – 59	46	166	180 – 189	1	**292**
60 – 69	37	203	190 – 199	0	**292**
70 – 79	26	229	200 – 249	5	**297**
80 – 89	11	240	250 – 299	0	**297**
90 – 99	10	250	300 – 349	0	**297**
100 – 109	14	264	350 – 399	0	**297**
110 - 119	6	270	400>	2	**299**
120 – 129	5	275			

Air Q software 2.2.3

An assessment tool of air quality impact on health (Air Q) was developed by the WHO European Centre for Environmental Health, Bilthoven Division. Air Q software3.2.2 is one special software which enables users to estimate potential effects on human health caused by exposure to pollution in a particular city and in a specific time.This software has been used in several studies in recent years [28-30].

In this model, evaluation is carried out by Air Q software2.2.3 (WHO) the fraction of the health effect in a defined population attributable to exposure to the atmospheric pollutant, assuming a demonstrated causal relationship between exposure and health effect, and no major confounding effects in this association. Attributable Proportion (AP) can be obtained by the No.1 equation:

$$\mathbf{AP = \Sigma\ (RR(C) - 1\ ) \times P(c) / \Sigma\ RR(C) \times P(c)} \quad (1)$$

Where Relative Risk(RR) is the RR for a given health endpoint, in category "c" of exposure, obtained from the exposure response functions derived from epidemiological study and P(c) implies the proportion of the population in category "c "of exposure [31].

RR= probability of an event when exposed to air pollution/ probability of an event when non-exposed to air pollution .RR reflects the rate of a pollutant's impact on the health by a change in exposure to air pollutants. RR is obtained through time-series studies that evaluate the concentration changes of air pollutants and their effects on health during a long time period [28-31].

If the baseline frequency of the health effect in the population under investigation is ascertained, the rate attributable to the exposure can be calculated by the No.2 equation [31] .

$$\mathbf{IE = I \times AP} \quad (2)$$

Where, IE is the amount of health effect attributable to the exposure, and I is the baseline frequency of the health effect in the population under investigation. Finally, knowing the size of the population, the number of cases attributable to the exposure can be estimated as a No.3 equation [31].

$$\mathbf{NE = IE \times N} \quad (3)$$

Where NE implies the number of cases attributed to the exposure and N implies the size of the investigated population [29-32]

during the study, we collected the data concentration of that pollutant, in fact, all of them were as low as could be mentioned(under the Iranian Standard) based on reported by Kurdistan Environmental Protection Agency from Air Quality Index.

Collecting data

The hourly data were collected from Kurdistan Environmental Protection Agency. Only one station of air sampling which places in Main Building of

Medical Sciences exist. By means of Beta attenuation method detected of the concentration of PM_{10} from January of 2014 to December of 2015 performed. The data that needs for software are shown in Table 2.

Table 2: data that are necessary as input of the software

station	Main Building of Medical Sciences
Year	2015-2016
Annual Mean	71
Winter Mean	68
Summer Mean	73
98 percent	714
Annual Maximum	900
Winter Maximum	900
Summer Maximum	248

Remove the confounding data

As the zero data that recorded by pollution measuring devices, didn't mean there is not pollutants in that hour, so these parameters which called missing data, have been omitted and considered as confounding data.

Mortality and hospitalization information

Enter the data about total mortality, cardiovascular and respiratory mortality, hospital admission cardiovascular and respiratory diseases were taken from Kurdistan Center of Diseases Control (KCDC) from 2014 to 2015. It must be mention that KCDC is one of the most important branches of Kurdistan University of Medical Sciences.

RESULTS AND DISCUSSION

The annual concentrations of PM_{10}

The annual average maximum, summer average, winter average, and 98 percentiles of PM_{10} concentrations have been shown in Table 3.

Table 3: Annual and seasonal average concentrations of PM_{10}(µg/m^3)

Parameter	Sanandaj station
Average annual	71.25
Summer average	73.45
Winter average	68.50
98 percentiles annual	214.2
Annual maximum average	900
Summer maximum average	248
Winter maximum average	900

According to air quality standard, the concentration of PM_{10} is 50µg/m^3 for the annual average and 150µg/m^3 for the daily average. The annual average of PM_{10} in this study was1.5 time more than the standard and average daily concentration of it was 182 time was exceeded than standard from 2014 – 2015.

Estimated of some necessary information about RR, BI, AP and number of excess cases are shown in Table 4.

Table 4: health index, Relative Risk(RR), Baseline Incidence(BI), estimated Attributable Portion(AP) percentage and estimated of excess cases

Health Index		BI per 100000person	RR	estimated AP percentage	estimated of excess cases
Total Mortality	Low	375	1.0062	3.2198	49.3
	Average		1.0074	3.9017	58.5
	High		1.0086	4.5058	67.6
Cardiovascular Mortality	Low	134	1.005	2.6700	14.3
	Average		1.008	4.2047	22.5
	High		1.018	8.9882	48.2
Respiratory Mortality	Low	21	1.008	22.6306	0.1
	Average		1.012	30.9392	0.1
	High		1.037	55.7130	0.2
Hospital Admission Cardiovascular	Low	208	1.0048	2.5660	5.9
	Average		1.008	4.2047	9.6
	High		1.0112	5.7892	13.2
Hospital Admission Respiratory	Low	57	1.006	3.1870	26.5
	Average		1.009	4.7056	39.2
	High		1.0113	6.6577	55.4

The relative risks applied in this study in the concentrations of 50 and 400 mg/m3 were 1.005 and 1.037 respectively. Australia had the BI of 6e7 per 1000 people and 67 percent of population aging between 15 and 65 surveyed the influence of the Asian Dust Storm on asthma and Chronic Obstructive Pulmonary Disease (COPD) related to hospital visits [33].

In this study, the Relative Risks for the respiratory and cardiovascular disease at the concentration of 50 were 1.0513, 1.027 and for the concentration of 150 mg/m3 were 1.1653 and 1.087 [19].

The daily average of PM_{10} in ADS was about 150 mg/ m3. The total numbers of Non-accidental mortality per 100,000 during the nine-year period were 3123 deaths. The chemical composition of PM_{10} and its impacts on lung cells during MED was studied in Ahvaz, Iran [34].

Short-term exposure to PM_{10} and health effects:

Results of this study illustrated in figures. and four categories.

CONCENTRATION OF PM_{10} AND MORTALITY RATE

As it showed in the Fig. 2 (the relationship between a cumulative number of total mortality and PM10 concentration) by an increase of concentration of PM_{10} the rate of mortality increase too. Total mortality (without accidents and poisoning) that happened in Sanandaj from 2014 to 2015 according to KCDC reports were 375 case per 100000 death. The result of data analyses be AirQ2.2.3 software for estimate the number of death cases related to PM_{10} were 58.5 cases (3.9017%) as average level. These number for low and high level of total death are 49.3 (3.2198%) and 67.6(4.5058%).

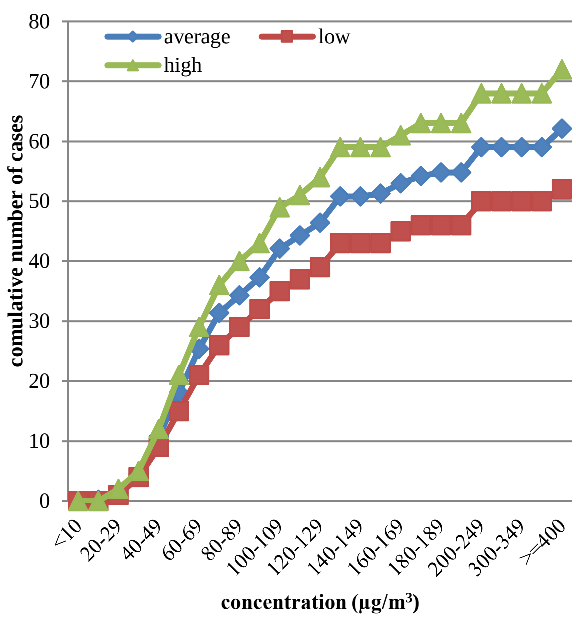

Fig.2: Relationship between cumulative number of total mortality and PM_{10} concentration

As has been shown in Fig. 2, by an increase of PM_{10} concentration the number of mortality rate increase. When it is more than 400 µg/m3 64 cases of total mortality are related to air pollution on average. These number for the low and high rate of mortality are 50 and 70 cases. Several epidemiological studies have identified the adverse health effects of air pollution on humans. These findings have confirmed that exposure to air pollutants increases mortality [35].

It was reported by Martuzzi, 8220 mean deaths in a year caused by exposure to PM_{10} with concentration more than 20µg/m^3. In this study, it was also estimated that 516 additional deaths occur annually for exposure to O_3 and that for short-term exposure to PM_{10} 1372extramortality was occurred [36].

CONCENTRATION OF PM_{10} AND CARDIOVASCULAR MORTALITY

One of the results of this study finds the relationship between PM_{10} concentration and Cardiovascular Mortality as illustrated in Fig. 3.

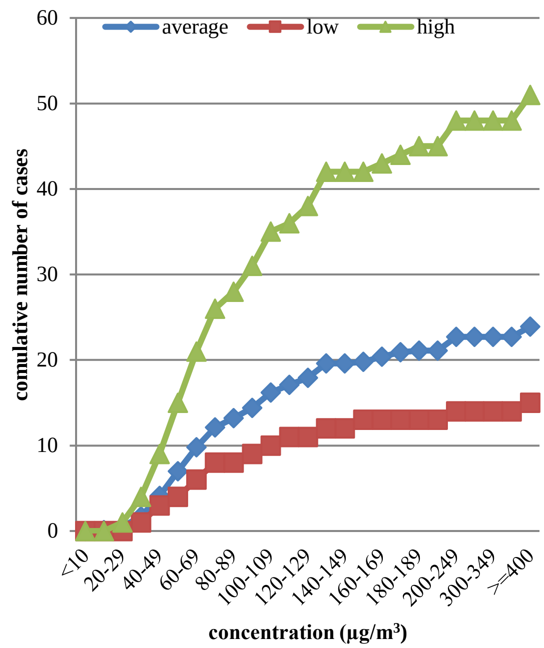

Fig.3: Relationship between PM_{10} concentration and Cardiovascular Mortality

It is clear to raising the PM_{10} concentration the number of Cardiovascular Mortality increase. It must be mention to this note, there is significant differences between high concentration and average than low concentration and average. Ischemic heart disease is recognized as the main cause of mortality due to PM air pollution. Both short-term and long-term exposures have been consistently associated with acute coronary syndrome and MI, in particular with fatal events [37].

Overall, heart failure has been consistently connected with air pollution, particularly in terms of the association between the increase of both PM_{10} and

$PM_{2.5}$ and hospital admissions for this condition[38-39].

Nevertheless, the majority of data and expert-consensus opinions consistently support the association between air pollution and cardiovascular disease [3].

CONCENTRATION OF PM_{10} RESPIRATORY MORTALITY

The respiratory system is the main part of the body that effected by PM_{10}. In Fig. 3 this effect showed.

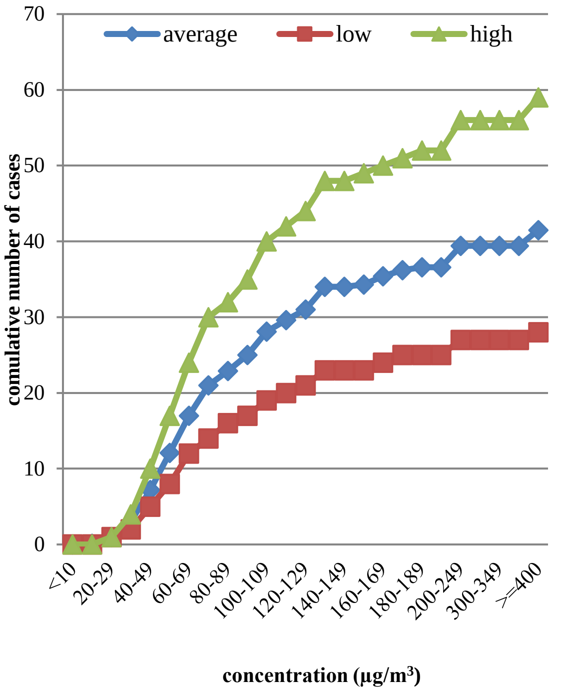

Fig.4: Relationship between PM_{10} concentration and Respiratory Mortality

The AP percentages for respiratory mortality and respiratory hospital admission were more than the cardiovascular mortality and cardiovascular hospital admission. It may be due to the relative risk for each health outcome. The number of excess cases for cardiovascular mortality was more than the respiratory mortality and this referred to the baseline incidence which showed the susceptibility of the people to the special health outcome [23].

Concentration of PM10 hospital admission cardiovascular

One of the acute health effects of PM_{10} is Hospital Admission Cardiovascular which This relationship is shown in Fig. 4. The pattern of Hospital Admission Cardiovascular is like to Cardiovascular Mortality Rate approximately.

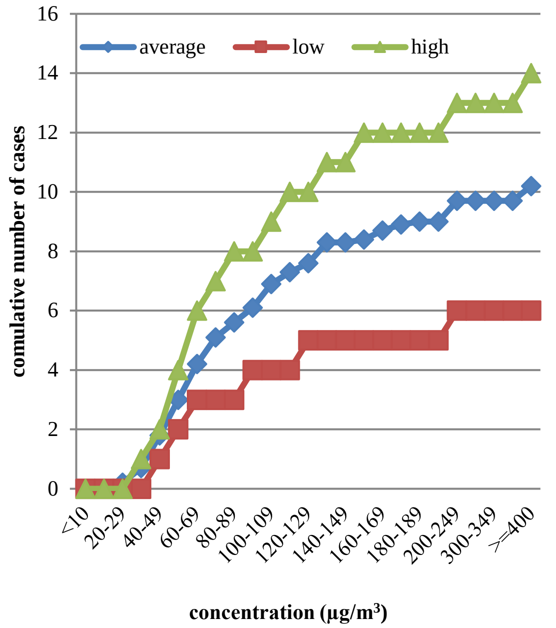

Fig.5: Relationship between PM_{10} and Hospital Admission Cardiovascular

Goudarzi *et al.* used Air Q software model to estimate the health effects of NO_2 in Tehran. Based on their results3.4%of total cardiovascular deaths, myocardial infarction and hospital admissions for the chronic obstructive pulmonary disease were attributed to concentrations greater than 60 µg/m³[40].

Concentration of PM_{10} hospital respiratory disease y

The final Fig. 5 is about the effect of PM_{10} and Hospital Admission Respiratory. Such as other Figs., increasing of PM_{10} increases the Hospital Admission Respiratory.

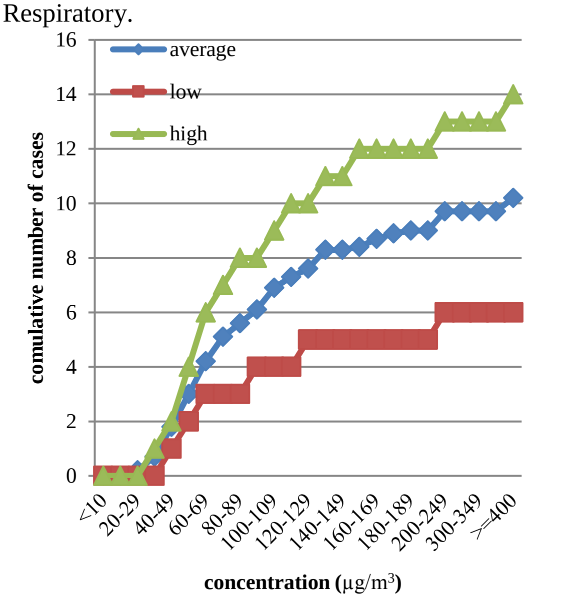

Fig.6: Relationship between Concentration of PM_{10} Hospital Admission Respiratory

Respiratory hospital admissions and emergency room visits in the general population increased by approximately .08% and 1.0% per 10 mg/m^3 of PM in the less than 10-mm size fraction (PM_{10}), respectively. The increase in emergency room visits and hospital admissions for asthmatics was higher at a 3.4% and 1.9% increase per 0 mg/m3 PM_{10}, respectively. Lung function tests showed a decrease of about .15% for forced expiratory volume and a .08%
decrease for peak flow, per 10 mg/m3 increase in PM_{10} [41].

Except for PM_{10} there are some pollutants such as SO_2, O_3 and NO_2 were exceeded on standard level or high average concentration in the air (for example in Tehran during 2005-2014) could effects on Chronic Obstructive Pulmonary Disease [42].

Recently Daryanoosh and *et al*. in their article showed that in two main city in the west of Iran which are a neighbourhood of Iraq (Ahvaz and Ilam) the relationship between PM_{10} and Cardiovascular Diseases Hospitalization During 2014 is statistically significant [43].

CONCLUSION

As mentioned above, PM_{10} concentration has harmful effects on human health, such as effects on cardiovascular and respiratory systems. short-term health effect of PM_{10} could increase of hospital admission cardiovascular and respiratory in Sanandaj.

It must be mention that the results of this study are much like with results of other researchers around the world and in Iran. In order to reduce the adverse health effects of PM_{10}, training by Ministry of health and branches (university of medical sciences), should be considered especially for lung and heart d illness, such as stay at home in abnormal air condition.

As the control of pollutants is omit or reduce pollution from its sources, it is clear that the control of PM_{10} from the desert by means of engineering manipulation, political knowledge, and financial supports must be conducted by governments.

LIMITATION

A limitation of Air Q software model is that are not taken into consideration the health effects caused by exposure to mixtures of several pollutants or their synergistic effects, but only the effect of a single pollutant is investigated. However, in quantitative assessments of health impacts by air pollution, the interaction between different pollutants cannot be investigated, because such investigations require knowledge about the mechanism of the toxicity of different compounds toxicity, which is today rarely available. The presence of only one sampling station in Sananadaj was another limitation case in our study.

FOR FUTURE RESEARCHER

In most of the researches that have been done on dust particle or Arabic Dust Storm, physical effects of particles have mentioned. As may be transfer pathogenic microorganisms (Bacillus spp, Pseudomonas aeruginosa spp and Mycobacterium spp) as air-borne bio-aerosols with Arabic Dust Storm and radioactive particles ß particles emitter) with it, we suggested to researchers done their study in those way too especially in Sanandaj according to Persian Gulf War which happened in Iraq in 1991 [43].

ETHICAL ISSUES

It is clear all parts of ethical issues (plagiarism, Informed Consent, misconduct, data fabrication, falsification, double publication submission, redundancy) have been completely observed by all of the authors. On the other hand, corresponding author's of this article has ethical issues as the header of this group for the whole of the article as a member of Kurdistan University of Medical Sciences.

CONFLICT OF INTEREST

The Authors of this article have no potential competing financial interest.

AUTHORS' CONTRIBUTION

Final of the manuscript with edited parts of them, read again by all members of the group.

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