

Analysis of hospital interior air quality audits

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Abstract. In general, people spent more than 80~90% of living time in the indoor every day, human health and indoor environmental quality are closely related. The hospital has a complex and unique environmental characteristics, medical personnel and patients are prolonged exposed to risk factors in a variety of environments. Therefore, the merits of indoor air quality in the hospital, not only has a threat to the health of medical personnel and patients, but also will directly affect the quality and efficiency of health care work. A regular monitoring can, improve and maintain a well of indoor air quality, thus ensuring the safety maintenance of medical personnel and patients in hospital, it has become an important issue for hospital. This study has literatures review to collate and analyse that are related issues with indoor air quality. Then measures the indoor air quality test with direct-reading instruments. In selected hospital of this study were field-tested, then use the measured data in the field, discussion and analysis of the causes of air pollutants and the establishment of the sensing area of pollutants Concentration empirical mode.

1 Introduction

In recent years, as environmental awareness promotion, indoor air quality and harm to people's health issues more attention, Taiwan is the world's second country indoor air quality legislation. People per day on average, about 80~90% time in indoor environments, Indoor environmental quality and human health related, poor indoor air quality can lead to sick building syndrome, legionellosis and other various diseases of indoor environmental quality is at stake.

Hospitals have complex and special environmental characteristics, indoor air quality requirements are also relatively more stringent, health care workers are exposed to different risk factors for a long time in the environment of, so the quality of indoor air quality, Will threaten the health of medical staff and the quality of care and efficiency. In addition, the long stay patient in the hospital, Because of its body has been weak, poor immune system, More vulnerable to the effects of poor indoor air quality, Therefore, how to monitor, on a regular basis to improve and maintain good indoor air quality, And ensuring the safety of health care workers and hospital patients maintain hospital has become an important topic.

Implementation of this research purposes is to discussion on indoor air quality for hospitals, research purposes include the following:

- (1) On the actual hospital indoor air quality testing, understanding hospital indoor air (CO₂), (HCHO), (PM₁₀) levels.

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- (2) Collection and analysis of relevant literature, medical home indoor air quality may be affected by factors, and the effect type, characteristics, source ,through data analysis to analyze of causes of air pollution.
- (3) Through the characteristics of the highly correlated pollutants and environmental factors, Using data analysis, Establish concentrations of pollutants in the area experience formula , Assessing the degree of pollution, determine whether the three pollutants in hospitals out of indoor air quality standard.

2 Main contents

2.1 Indoor air quality and health

According to the Bulletin of the Republic of China Executive Yuan's Environmental Protection Department the purpose of "indoor air quality management Act," definition of article III of the "indoor" refers to the use of the public buildings of closed or semi-closed spaces, and the public means of transport to take the space. "Indoor air quality" refers to the presence in indoor air after long-term exposure is sufficient to directly or indirectly to prejudice the health or living conditions of substance, Include carbon dioxide, carbon monoxide, formaldehyde and total volatile organic compounds, bacteria, fungi, particle size less than or equal to ten Micron particulate matter (PM₁₀), particle size less than or equal to the second. Five microns particulate matter (PM_{2.5}) and ozone and other substances designated by the central competent authority notice concentrations, air humidity and temperature.

World in view of indoor air pollution for the public health impact or potential threats, according to their architectural characteristics and lifestyles of States, invested a lot of resources for research, laws are in place and management programmers, and so on. Overall, the poor air quality on human health hazard in severity can be divided into three different classes (Figure1), First for the sick building syndrome, the second for building-related illness, Third is through research and reasoning are aware of many air pollutants have carcinogenic properties, long time stimulation can affect the heart and blood vessels and chronic respiratory diseases.

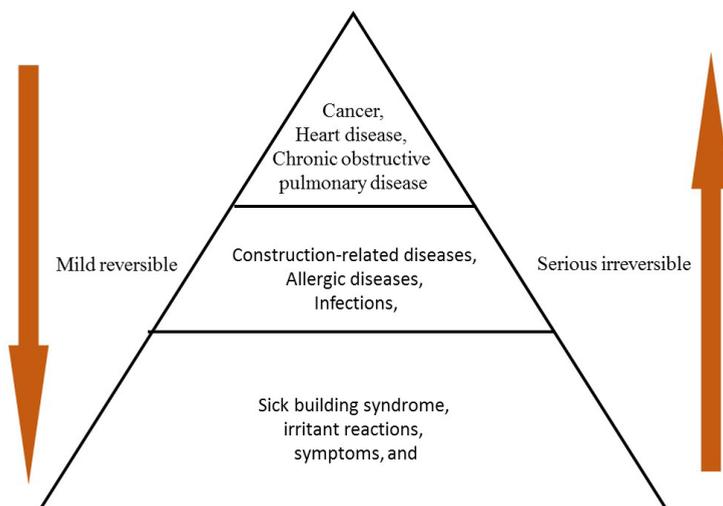


Figure 1. Indoor air quality and health hazards.

2.2 Indoor air pollutants

The national institute for occupational safe and health, investigation and analysis of indoor air quality, sources of indoor air pollutants include outdoor and indoor human activities, indoor air conditioning systems, building materials, equipment and supplies, and indoor sources of organic matter, such as the six, pollutants and sources is shown in table1.

Table 1. Indoor environmental pollution source and pollutant

Pollution Source		Pollutant
Outdoor air	Stationary sources	SO ₂ , O ₃ ,Dust,CO,Hydrocarbon,Other toxic substances
	Mobile sources	CO,Dust,Nitrogen oxides, Oxysulfide, Lead
	Soil	Radon, Microorganism (Bacteriumgerm, Fungifungus.)
Indoor human activities	Human activities	CO ₂ , Vapor, Bad smell,Microorganism
	Smoke	Dust,CO,CO ₂ , Ammonia,Nitrogen oxides, Hydrocarbon, Volatile organic contaminants,Carcinogenic compounds
	Spray	Fluorocarbon, Bad smell,Volatile organic contaminants
Air conditioning system	Air handling unit	Fungifungus,Allergen ,Bacteriumgerm , Bad smell
	Air conditioner line	Dust,Fiber,Fungifungus,Allergen, Bacteriumgerm
Building materials	Concrete, stone	Radon
	Inorganic mineral board, Plywood, Carpetrug, Furniture	HCHO,Volatile organic contaminants
	Insulating materials, Insulation or fireproofing materials	HCHO, Glass fiber,Asbestos,Volatile organic contaminants
Equipment and supplies	Burning appliances	CO ₂ ,CO, Nitrogen oxide, Hydrocarbons,Dust
	Service machines (Copier,Clean machine)	O ₃ , Dust,Bacteriumgerm, Fungifungus
	Other	Stationery solvent, Fungicide,Pesticides,Volatile organic contaminant
Indoor organic material	Perishable foods	Fungifungus, Bad smell
	Plants and flowers	Pollen, Fungifungus
	Waste	Ammonia,Allergen, Bacteriumgerm

This study only CO₂, HCHO and PM₁₀, three projects, Learn about indoor air pollutants will help to judge the sources of pollutants and control, improve indoor air quality and human health, the following will be described in detail for three pollutants.

(1) CO₂

CO₂ is a colorless, odorless and nonirritating gas, not toxic, Low concentrations are harmless to the human body, and High concentration has an impact on human health. Sources of CO₂ produced by human breathing as the main source. Concentration is usually with density and ventilation efficiency has great relevance. CO₂ concentration on human physiological effects as shown in table2.

Table 2. Effects of CO₂ concentration on the body

Concentration (ppm)	Physiological responses
≤600	No
600~1000	Occasional headaches, Lethargy, Sultry
1000~10000	Respiratory and circulatory organs and brain function is affected
10000~30000	Breathing speeds up, face the warm feeling
30000~40000	Ringin g in the ears, Headache, Increased blood pressure
40000~60000	Vascular dilatation of the skin, Nausea, Vomiting
70000~80000	Mental confusion, Difficulty in breathing
80000~100000	Mental confusion, Convulsions, Respiratory arrest
100000~200000	Central nervous system disorders, Life-threatening

(2) HCHO

HCHO is a transparent and pungent gas, its extensive use in man-made sheet metal, plastic flooring, synthetic materials, coatings and adhesive. Table3 is Effects of HCHO concentration on the body past animal and human epidemiological and toxicological data confirmed HCHO exposure, In addition to causing stimulation of the eyes, skin, throat, and is one of the chemicals that cause human cancer, International Agency for Research of Cancer was HCHO in 2006 as a definite human carcinogen. Indoor HCHO main source is dominated by furniture or use of a product, such as furniture or wood products on the surface of the adhesive, wallpapers, cleaning agents, or electronic devices is one of the sources. In addition, indoor decoration materials such as Styrofoam, insulation, adhesive materials, fabrics, carpets and floor layout with HCHO, And thus, HCHO levels to determine the health of the test building materials building materials one of the most important projects.

Table 3. Effects of HCHO concentration on the body

Concentration (ppm)	Effect
0.1~0.3	Minimum trigger amount
0.8	Bad smell
1.0~2.0	Micro stimulation
2.0~3.0	Eye, nose and throat stimulation
4.0~5.0	Mucous membrane irritation involuntary tears
10.0~20.0	Severe burning sensation, cough can only be tolerated for a few minutes
50.0~100.0	Seriously hurt in 5-10 minutes

(3) PM₁₀

Suspended particulates are tiny particles floating in the air, and the severity of harm to human health depends on the particle size, When the particle size is smaller, easier to enter the body of tracheal or Broncho alveolar region. Particles smaller than 2.5 μm particles, known as PM_{2.5}, Deposition in the lungs of the efficiency is the highest, and deposit resistance will harm human respiratory function, Allergic rhinitis, asthma, chronic obstructive pulmonary disease and other diseases, Effects of Suspended particles concentration on the body as shown in table4.

Table 4. Effects of Suspended particles concentration on the body

Concentration (mg/m ³)	Effect	Notes
0.15	Increase the frequency of asthma	Increased mortality when is above 0.1mg/m ³
0.23	To reduce the FEV1.0	
0.35	Influence of pulmonary function of chronic disease patients	
0.35	Increase in respiratory tract of patients with chronic bronchitis symptoms	

2.3 Data analysis and discussion

Detection in all test points in 8 hours, Living factors of temperature and relative humidity, Chemical factors on CO₂ and HCHO and physical factors in aerosols of size less than or equal to 10 microns (PM₁₀), choose the average regression analyses.

Table 5. Correlation between chemical pollution pointer-CO₂

CO ₂ Pointer	High positive correlation	Moderate positive correlation	High negative correlation	Moderate negative correlation
Indoor temperature	0.846			
Outdoor temperature	0.828			
Indoor PM ₁₀		0.590		
Outdoor PM ₁₀		0.429		

(1) CO₂ concentrations influence factor analysis

CO₂ concentrations affect indoor pollutant concentrations of important factors and correlation of factors, to detect the average data using statistical methods to further some factor of its relevance, as shown in table5. CO₂ show in the pointer in the statistical results to the indoor temperature, outdoor temperature Max.

(2) HCHO concentrations influence factor analysis

Establishment of HCHO concentrations affect indoor pollutant concentrations of important factors and correlation of factors, to detect the average data using statistical methods to further some factor of its relevance, as shown in table6. HCHO statistical outcome, the pointer appears to be indoor humidity maximum.

Table 6. Correlation between chemical pollution pointer-HCHO

HCHO Pointer	High positive correlation	Moderate positive correlation	High negative correlation	Moderate negative correlation
Indoor humidity	0.729			
Outdoor humidity		0.628		

(3) PM₁₀ concentrations influence factor analysis

PM₁₀ concentrations affect indoor pollutant concentrations of important factors and correlation of factors, to detect the average data using statistical methods to further some factor of its relevance, as shown in table7. For PM₁₀ statistical outcome, the pointer displays indoor temperature, outdoor PM_{2,5} PM₁₀, affected the most. For PM₁₀ statistical outcome, the pointer displays indoor temperature, outdoor PM_{2,5} PM₁₀, affected the most.

Table 7. Correlation between physical pollution pointer-PM₁₀

PM ₁₀ Pointer	High positive correlation	Moderate positive correlation	High negative correlation	Moderate negative correlation
Indoor temperature	0.760			
Outdoor temperature		0.634		
Indoor humidity				-0.504
Outdoor humidity				-0.594
CO ₂		0.590		
Outdoor PM ₁₀	0.887			
Outdoor PM _{2,5}	0.841			

(4) Regression model analysis

Regression analysis on optimization of inspection data, the detection zone can be obtained CO₂, HCHO, PM₁₀ the respective regression model are as follows:

(i) Pharmacies:

$$\text{CO}_2 = 364.671 + 2.304 \times (\text{Number of people}) - 0.004 \times (\text{Number of people})^2 + 2.4 \times 10^{-6} \times (\text{Number of people})^3$$

$$\text{HCHO} = 0.189 - 7.417 / (\text{Indoor humidity})$$

$$\text{PM}_{10} = 7.039 \times (\text{Number of people})^{0.348}$$

(ii) Draw blood:

$$\text{CO}_2 = 656.771 + 1.650 \times (\text{Number of people}) + 0.003 \times (\text{Number of people})^2$$

$$\text{HCHO} = 1.3 \times 10^{-7} \times (\text{Indoor humidity})^{3.321}$$

$$\text{PM}_{10} = 48.782 - 0.059 \times (\text{Number of people}) + 0.002 \times (\text{Number of people})^2$$

(iii) Registration area:

$$\text{CO}_2 = -294.806 + 13.280 \times (\text{Number of people}) - 0.046 \times (\text{Number of people})^2 + 5.4 \times 10^{-5} \times (\text{Number of people})^3$$

$$\text{HCHO} = 0.322 - 13.331 / (\text{Indoor humidity})$$

$$\text{PM}_{10} = -55.823 + 1.030 \times (\text{Number of people})$$

3 Conclusions and suggestions

Environmental awareness promotion, has attracted more attention to the health hazards and indoor air quality, Indoor air quality testing equipment in specific medical institutes carry out onsite inspection, to understand indoor air quality changes and features, Conclusions are as follows:

- (1) Determine whether the pollutants in hospitals out of indoor air quality standard, Pharmacies are in compliance with the standard, Blood area are HCHO of five days does not meet standards and PM₁₀ of one day does not meet standards, And the rest are in compliance with, Registered Area are CO₂ of two days does not meet standards and HCHO of one day does not meet standards and PM₁₀ of five day does not meet standards, And the rest are in compliance with.
- (2) Through the collection and analysis of data to know, CO₂ concentrations, and number, temperature, opening and closing with a high degree of correlation, HCHO concentrations, climate, and construction, opening and closing a high degree of association, PM₁₀ concentrations, and construction, cleaning, temperature, opening, closing, outdoor PM_{2.5}, PM₁₀ high outdoor Association

Indoor air quality testing and inspection data analysis, There are still inadequacies can be used as research recommendations:

- (1) Recommends that the follow-up could be explored in addition to medical institutions place, the change of indoor air quality and characteristics, and hospitals to compare indoor air quality analysis.
- (2) Can continue to discuss the improvement of indoor air quality benefits.

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