NIPPON PAINT

INDOOR AIR: THE SILENT KILLER

20th AUG 2013

DID YOU KNOW

- Indoor air quality can be **5 TIMES** worse than ourdoor air quality?
- Formaldehyde exposure is the leading cause of symptoms of sicknesses in buildings?

Research findings by Nippon Paint tell us how IAQ affects health and productivity in the workplace.

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Indoor air TVOCs & formaldehyde monitoring programme and its impact on respiratory health, allergies, and asthma among building occupants.

- Scope of presentation
  - Introduction of IAQ
  - Objective
  - Methodology
  - Result
  - Discussion
  - Recommendation & Conclusion

What are the side-effects of exposure to IAP?

Scientists have discovered sicknesses that are associated with the exposure to indoor air pollutants such:

1. Sick Building Syndrome (SBS)*

   Where more than 30 percent of occupants experience adverse effects while in the building, but no clinically diagnosed disease is found.

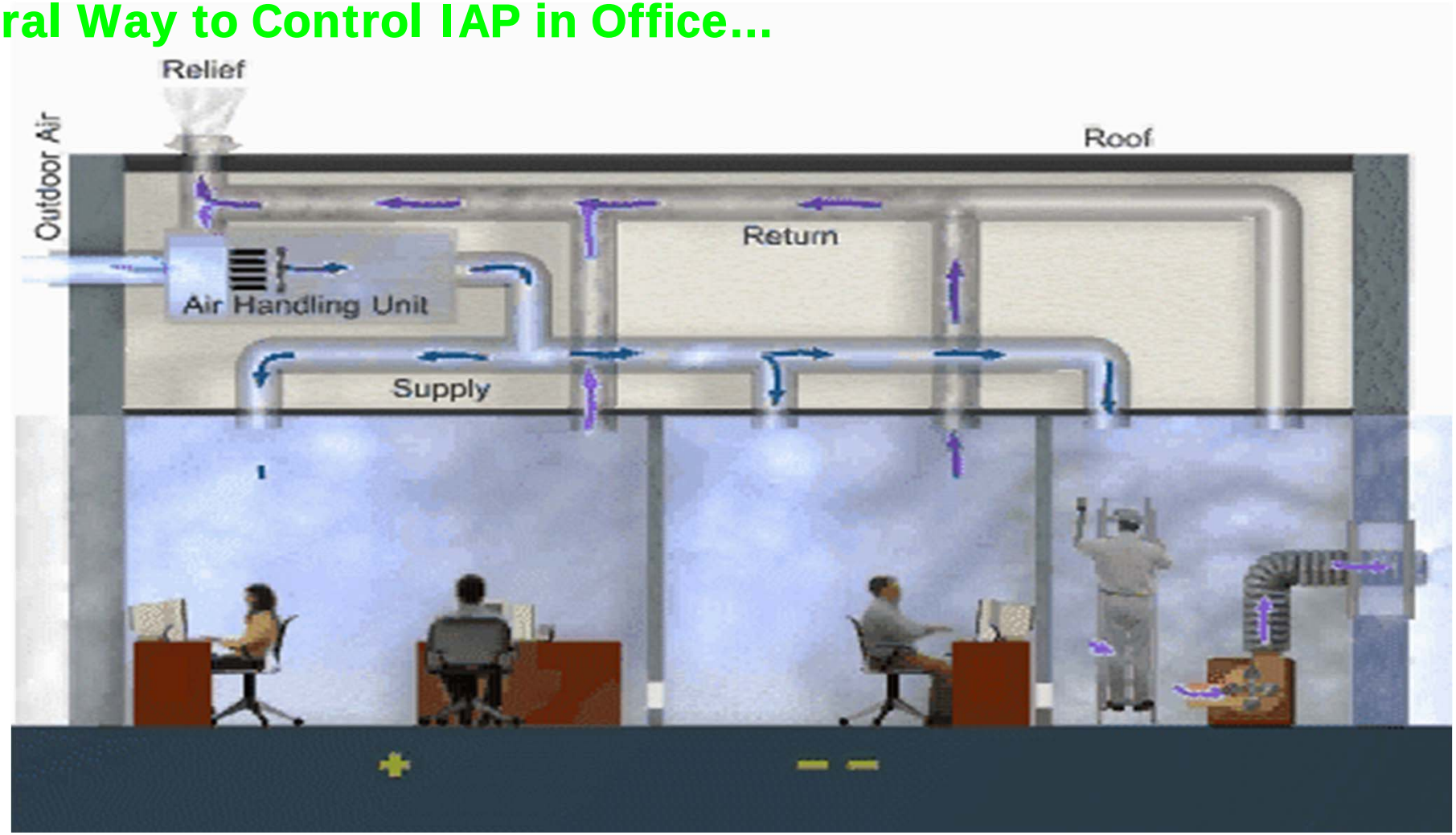
2. Building Related Illness (BRI)

   General term for a medically diagnosable illness caused by, or related to, building occupancy.

3. Multiple Chemical Sensitivity (MCS) or Environmental Illness (EI)

   A controversial condition where an individual has, or develops sensitivity to, even low levels of certain chemicals due to extended exposure.

General Way to Control IAP in Office...



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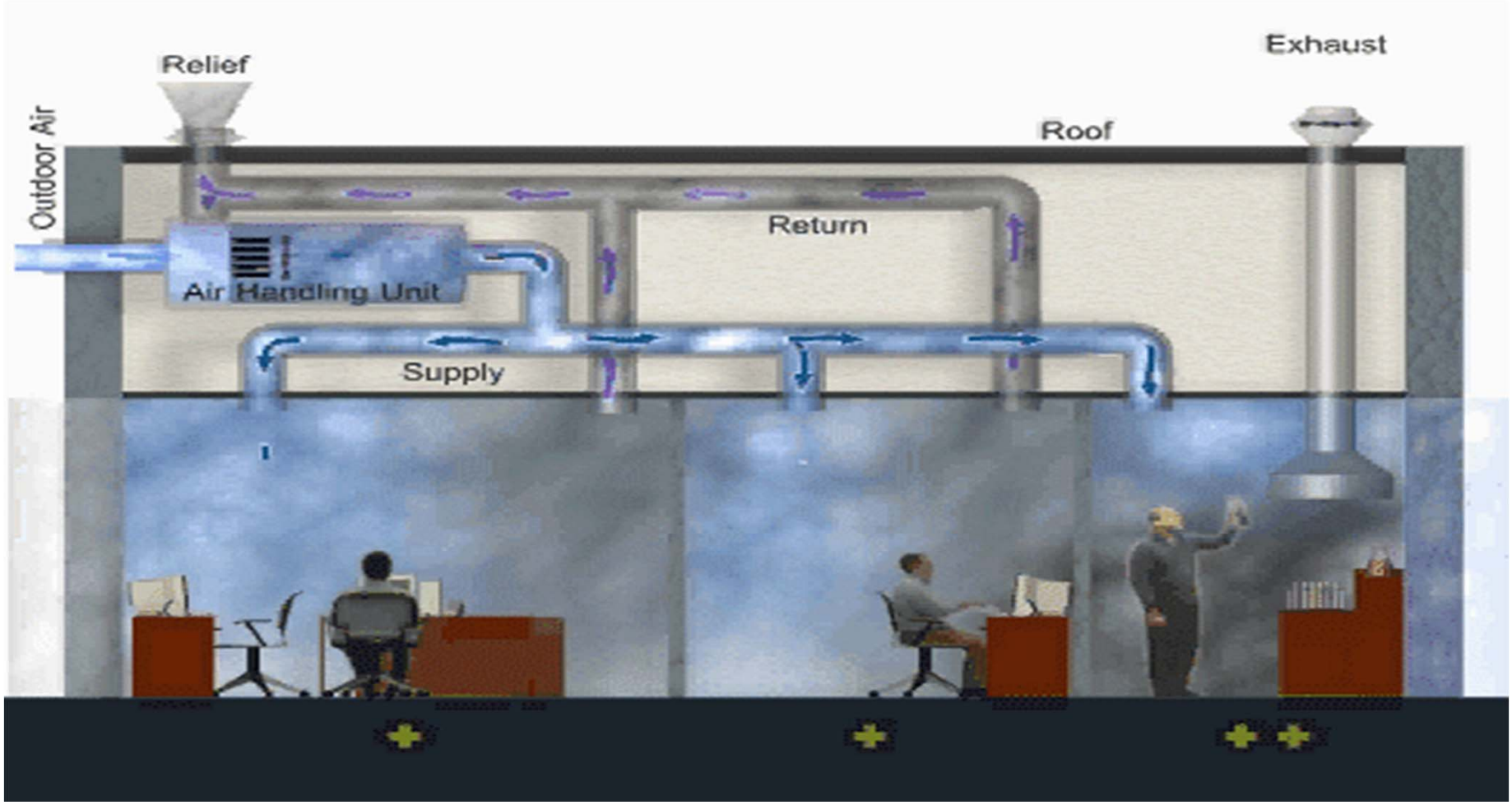
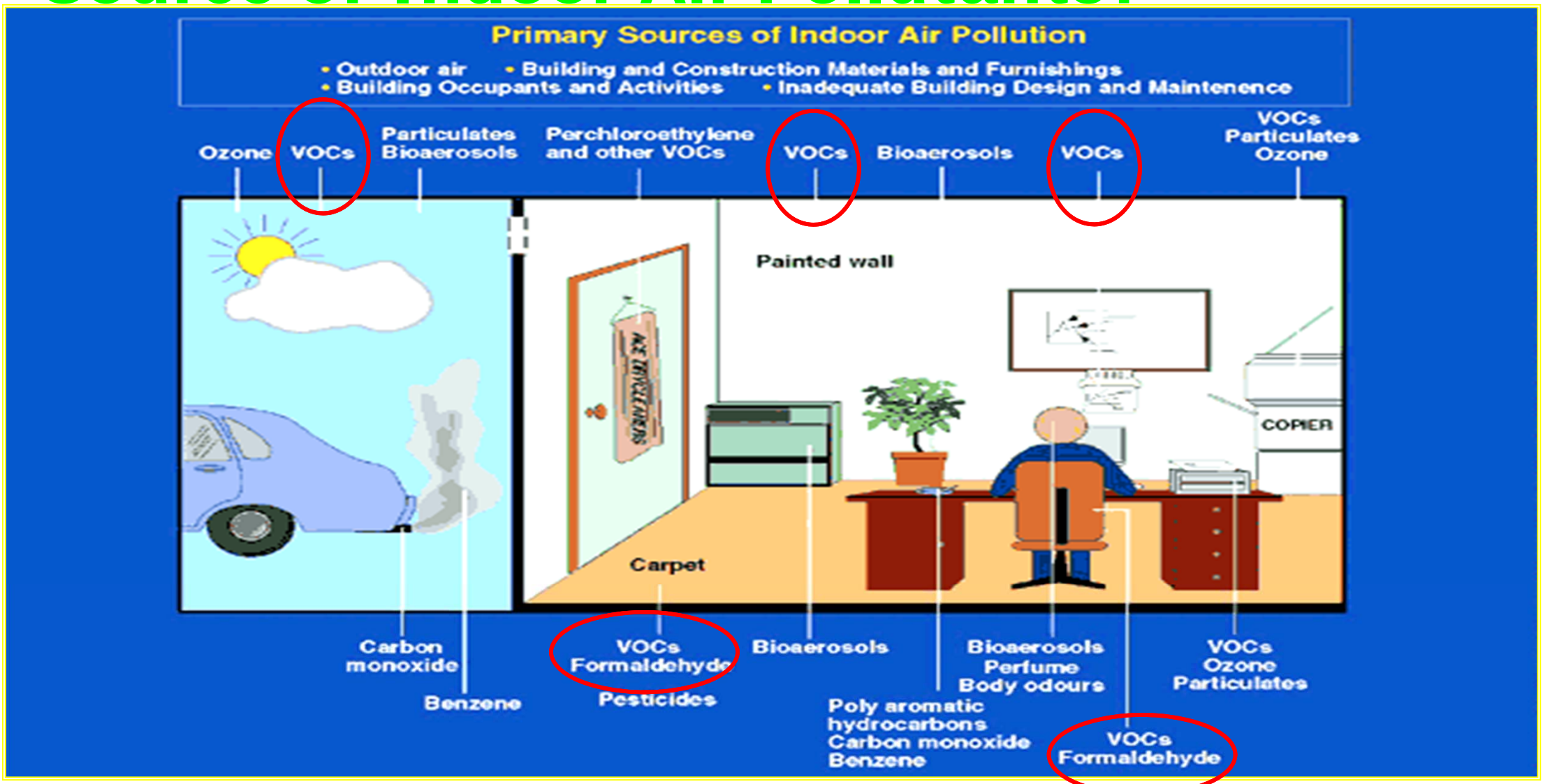


Source of Indoor Air Pollutants?



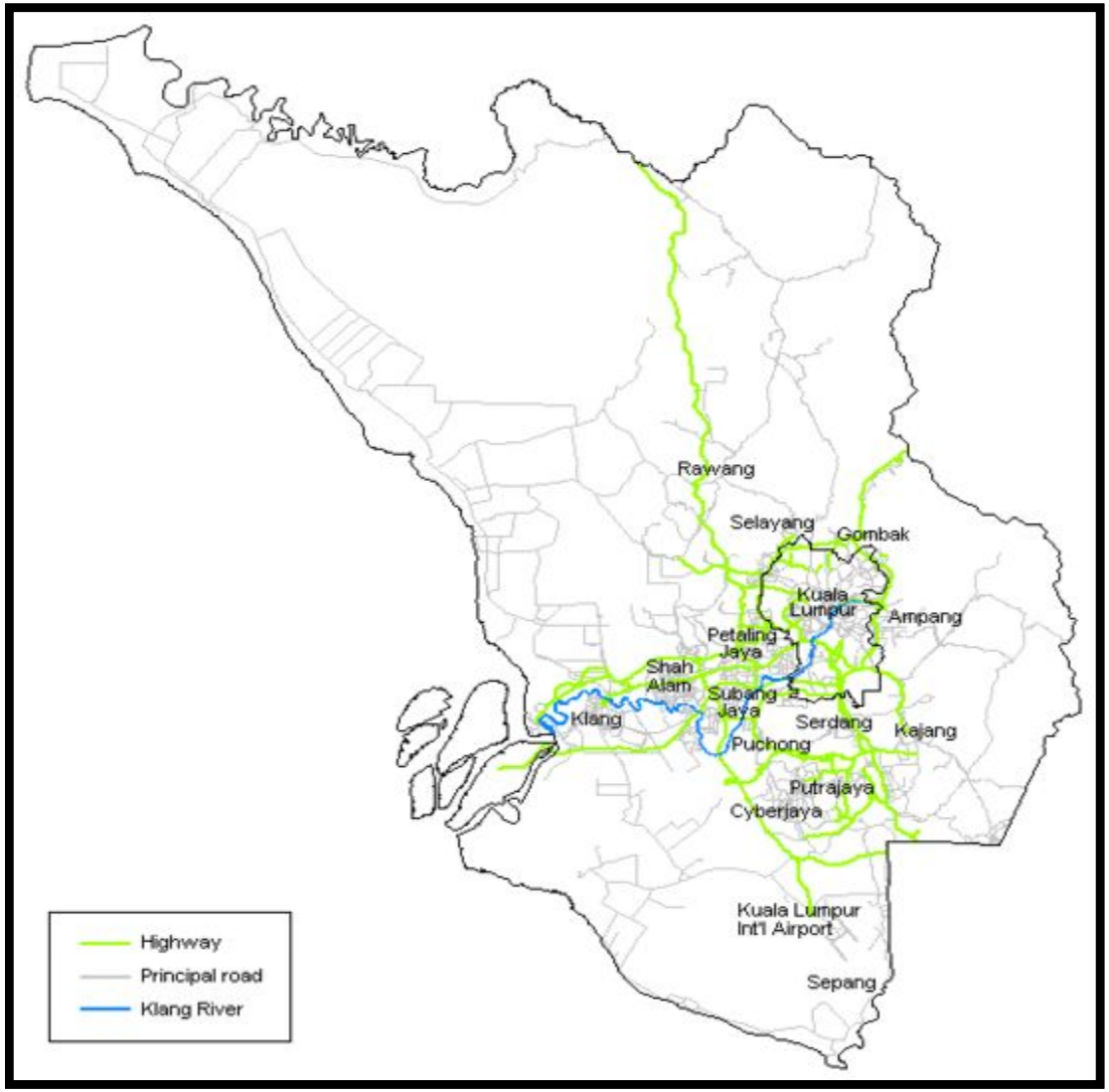
Objective of the Study

- To **classify and characterize** the general indoor air **TVOCs and formaldehyde** inside different types of buildings.
- To **compare** the indoor air TVOCs and formaldehyde level **between new and old buildings.**
- To **compare** the respiratory **symptoms** and sick building syndrome symptoms between the different types of buildings.
- To determine the **association** between the level of indoor air **TVOCs and formaldehyde** and reported **symptoms** among building occupants in differently designed buildings.
- To **characterise the risk** of indoor air TVOCs and formaldehyde existing in association with allergies and asthma among building occupants.

What is our Sample?

- This programme covered 43 postcodes in the Klang Valley. Basically the buildings monitored covered **offices, houses (landed and apartments) and public spaces in urban and village areas**.
- The ventilation systems - a mixture of air conditioning system (centralised and split unit), fan and open window.
- All the buildings monitored were a mixture of old and new buildings covering all types of buildings (offices, houses and public spaces).

Location


Rawang
Selayang
Gombak
Kuala Lumpur
Ampang
Petaling Jaya
Shah Alam
Subang Jaya
Klang
Serdang
Kajang
Puchong
Putrajaya
Cyberjaya
Kuala Lumpur Int'l Airport
Sepang
Highway
Principal road
Klang River

Design and Sampling

- Cross-sectional study (exposure and health effect investigated simultaneously)
- This study was a pilot research which focused on four major types of buildings, namely:
  - **private houses (landed property and apartments);**
  - **public places (library, shopping mall and others);**
  - **commercial buildings (offices and shop lots) and**
  - **offices (public / government or private).**
- Multi-stages systematic random sampling was deployed during the monitoring period. Buildings were selected based on determined postcodes (three examples of buildings randomly selected)

Design and Sampling

Selected Indoor Environment (Offices, Private Houses, Public Space, Public Areas) in Klang Valley

↓

Determined the Klang Valley Locations and Postcode

↓

Postcode randomly selected in each locations as shown in Klang Valley areas map

↓

Each selected locations will be determined its available indoor environment (etc houses)

↓

Monitoring will be randomly collected by convenient sampling parallel with the questionnaire

↓

Data will be gathered for indoor TVOCs and Formaldehyde parallel with CO2, Temp and RH

↓

Next postcode will be randomly sample and each step start until all locations in Klang Valley achived it representative areas.

Sampling Method and Sample Size

- Purposive sampling / universal samples
- 1163 samples in Klang Valley buildings were collected
- Over 400 building occupants were interviewed
- Following inclusive criteria such as:
  - Staying in the particular indoor environment for at least 1 year;
  - Staying / using the indoor environment for at least 8 hours per day;
  - Not suffering from any chronic related diseases such as heart disease, kidney disease and mental illness

FINDINGS

Readings / Levels of indoor pollutants

- Formaldehyde/ TVOCs
- TVOCs
- Temperature/ RH
- Air Movement

Sick Building Symptoms – indicator chronic illness

Symptoms	
General	
Fatigue	•Related to the neurological effect •Central nervous system •Neurobehavioral effect indicator •Persistent pattern and may prolong for 4-5 days
Feeling heavy headed	
Headache	
Nausea or dizziness	
Difficulty concentrating	
Mucosal	
Itching, burning, or irritation of the eyes	•Irritation effect to the upper respiratory system •Lower respiratory system/ systemic function from lung to blood vessels •Develop in 2-3 days before manifesting
Irritated, stuffy, or runny nose	
Hoarse, dry throat	
Cough	
Dermal	
Dry or flushed facial skin	•Skin irritation effect •Physical stressor indicator/ chemical sensitivity indicator •Immediate effect on the skin contact
Scaling or itching scalp or ears	
Hand dry, itching, red skin	

Result – Exceeding acceptable limit of 0.1 ppm

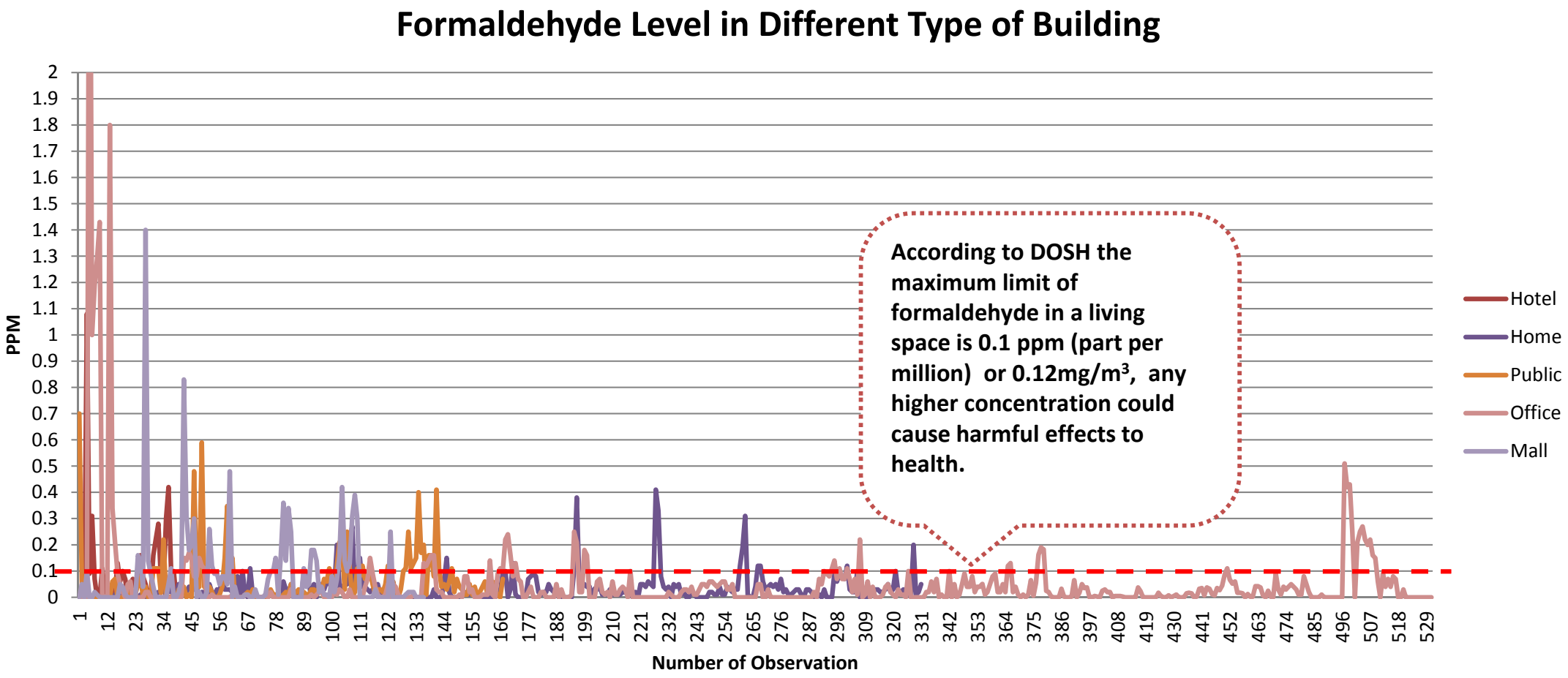


Figure 3.1.2 Distribution of Formaldehyde concentration over different types of buildings versus number of observations

Result – Explanation

- 8 hours exposure ICOP-DOSH suggest not exceed **0.1 ppm**.
- Current research suggests **20-30%** of office buildings have formaldehyde (screening) levels **above the standard (> 0.1)**. This is very critical as the indoor environment should not exceed occupational exposure based on the nature of the workstation

How bad is formaldehyde?

- Toxicological study – formaldehyde can cause **irritation to the eyes, respiratory irritant** effect and **neurological problems**
- Chronic exposure can lead to upper respiratory system cancers
- Irritation of the **eyes and nose, and throat dryness**

Toxic kinetics of formaldehyde

Inhalation (40-50%)

Irritation will occur to your
- eyes
- nose
- throat

Lung absorbs gases + chemicals
Formaldehyde will enter the blood and thus affect the neuron function

But!!!
-This is influenced by your:
-**Age** (younger/ older people have poor immune system/mechanism which had poor mechanism to remove pollutants), **genetics** and current **health status**

Headache, fatigue, sleeplessness, digestive symptoms such as diarrhea and unnatural thirst and menstrual irregularities (Dally et al., 1981)

Result

Table 3.2 Comparison of indoor air pollutant parameters between old and new buildings

Parameters	New		Old		Statistic	p-value
	Mean	SD	Mean	SD		
Formaldehyde (ppm)	0.071	0.16	0.051	0.16	1.061	0.289
TVOCs (ppm)	0.032	0.12	0.020	0.20	0.515	0.606
Temperature (^{0}C)	26.37	3.88	26.74	3.30	-0.801	0.425
Relative Humidity (%)	64.50	8.36	61.08	8.78	3.233*	0.001
Air Movement (m/s)	0.110	0.16	0.141	0.99	-0.233	0.816
Carbon Dioxide (ppm)	587.1	192.9	600.7	315.2	-0.383	0.702

Temperature recorded above suggested standard regulated by DOSH

Result – Explanation

- High formaldehyde in new buildings = new structure more hazardous compared to old buildings in most of Klang Valley areas (but, old buildings have inefficient MVAC systems = therefore formaldehyde was still captured during our investigation
- **Formaldehyde is influenced by the temperature**, RH and ventilation

Result – Explanation

- **High temperature** as shown in old and new buildings influence the **formaldehyde level indoors**
- Even when RH is within limit, high temperature increases the potential of chemical dispersion and accumulation effect of formaldehyde and Aldehydes compounds

How bad is this issue?

- Most of the buildings(**≈700 building**) have **poor temperature control**, leading to chemical dispersion especially Aldehydes containing material including formaldehyde

Result

3.2.1c Formaldehyde measurement between different types of buildings

Higher Formaldehyde in most of the hotel areas

No	Item	Vent System	Mean	Median	SD	Min	Max	Stat
1.	Home	Air-Condition	-	-	-	-	-	N/A
		No Air-Condition	0.03	0.02	0.05	0.0	0.41	
2.	Office	Air-Condition	0.05	0.01	0.20	0.00	3.32	0.849
		No Air-Condition	0.03	0.03	0.04	0.00	0.05	
3.	Public	Air-Condition	0.06	0.03	0.10	0.00	0.70	0.508
		No Air-Condition	0.08	0.03	0.16	0.00	0.48	
4.	Mall	Air-Condition	0.08	0.01	0.16	0	1.40	N/A
		No Air-Condition	-	-	-	-	-	
5.	Hotel	Air-Condition	**0.11**	0.05	0.19	0.00	1.08	0.841
		No Air-Condition	0.09	0.10	0.02	0.07	0.10	

Result – Explanation

- Home exposure can go up to **0.08,** but maximum exposure is **0.41ppm** = **not good** for **babies, children, and the elderly**
- Office exposure can go up to **0.05±0.20 = 0.25** which exceeds the limit and can cause irritation to the eyes, skin and throat. Prolonged exposure may lead to **neurological effects**
- Public areas (healthcare, museum, library) can go up to **0.06±0.10 = 0.16 ppm**. Effects similar to the office conditions can occur
- Shopping malls present unhealthy indoor air and prolonged exposure can go up to **0.08±0.16 = 0.24 ppm**. Most huge malls/exhibition areas present a threat to common people (baby, children, elderly) and especially among those more susceptible
- Hotels recorded levels above the standard set by DOSH. Staying in hotels with pure air-conditioning units only can accumulate a number of hazardous pollutants in your body

How bad is this issue?

Samples Number	Office	Home	Public	Mall	Hotel	Total
TOTAL	546	303	102	154	38	1163

- Number of affected areas more than **60%** of total categories (we are **in danger of exposing ourselves to possible carcinogen agents** – formaldehyde/ Aldehydes)

Result

3.2.1d TVOCs measurement between different types of buildings

No	Item	Vent System	Mean	Median	SD	Min	Max	Stat
1.	Home	Air-Condition	-	-	-	-	-	N/A
		No Air-Condition	0.009	0	0.43	0.43	0.03	
2.	Office	Air-Condition	0.035	0	0.30	0	5.91	0.870
		No Air-Condition	0	0	0	0	0	
3.	Public	Air-Condition	0.016	0	0.07	0	0.50	0.511
		No Air-Condition	0	0	0	0	0	
4.	Mall	Air-Condition	0.013	0	0.05	0	0.28	N/A
		No Air-Condition	-	-	-	-	-	
5.	Hotel	Air-Condition	0.044	0	0.15	0	0.83	0.610
		No Air-Condition	0	0	0	0	0	

Highest value recorded in offices are above the suggested guideline

Result – Explanation

- Homes, Public Areas, Malls and Hotels have shown levels of TVOCs within the standard suggested by DOSH
- However, several locations (**5%)** of the study population show maximum readings of TVOCs **more than 3 ppm**. This can **trigger asthmatic symptoms** for asthmatic people, irritation to the throat and eyes

How bad is this issue?

Samples Number	Office	Home	Public	Mall	Hotel	Total
TOTAL	546	303	102	154	38	1163

- TVOCs can cause neurobehavioral disorders
- Common symptoms like **“headache”** highly **associated with exposure to TVOCs**
- TVOCs may need up to **6 months to reach dilution effect** – therefore, introducing TVOC will damage the indoor air quality and may require measures to manage these prolonged issues

Result

3.2.1a Temperature measurement between different types of buildings (Result in Degrees Celsius)

No	Item	Vent System	Mean	Median	SD	Min	Max	Stat
1.	Home	Air-Condition	31.6	31.6	0	31.6	31.6	N/A
		No Air-Condition	30.7	31.1	2.02	22.5	34.70	
2.	Office	Air-Condition	24.5	24.6	2.12	17.35	32.30	**0.005**
		No Air-Condition	**28.8**	28.8	1.13	28.0	29.60	
3.	Public	Air-Condition	**26.2**	26.3	2.39	20.0	34.20	**0.029**
		No Air-Condition	**28.13**	28.05	2.24	24.30	30.70	
4.	Mall	Air-Condition	25.72	25.50	1.98	22.20	34.10	N/A
		No Air-Condition	-	-	-	-	-	
5.	Hotel	Air-Condition	**27.31**	27.2	2.17	23.30	32.3	0.650
		No Air-Condition	**27.9**	27.3	1.40	26.9	29.5	

Most of the hotels recorded higher temperatures compared to other types of buildings

Result – Explanation

- Temperature in most of the building categories are **above the DOSH standard (23°C - 26°C).**
- This might be due to poor maintenance of the MVAC system/ radiant heat from the outdoors/ heat generated from elsewhere. Poor management/design of outdoor radiant heat
- **Formaldehyde emissions and levels increase** with **increasing temperature**
- Any changes in RH and temperature (over the range) will cause chemical dispersion and poor air quality

How bad is this issue?

Samples Number	Office	Home	Public	Mall	Hotel	Total
TOTAL	546	303	102	154	38	1163

- High temperature related to the maintenance of **AHU/ MVAC** and **heat sources** (radiant, convection, conduction heat)
- Lower temperatures lead to air stagnant effect where pollutants in the air become **heavier and more difficult to be diluted** by outdoor air
- Split unit systems pose a threat especially when the system is not properly operated/ heat not estimated very well

Result

3.2.1g Air movement measurement between different types of buildings

Poor air-movement (stagnant air effect) found in most buildings

No	Item	Vent System	Mean	Median	SD	Min	Max	Stat
1.	Home	Air-Condition	**0.07**	0.07	0	0.07	0.07	N/A
		No Air-Condition	0.33	0.17	1.79	0	31.0	
2.	Office	Air-Condition	**0.06**	0	0.099	0	0.61	0.127
		No Air-Condition	0.17	0.17	0.24	0	0.34	
3.	Public	Air-Condition	**0.05**	0	0.0939	0	0.46	0.193
		No Air-Condition	0.10	0.025	0.126	0	0.28	
4.	Mall	Air-Condition	**0.08**	0.01	0.11	0	0.44	N/A
		No Air-Condition	-	-	-	-	-	
5.	Hotel	Air-Condition	**0.04**	0	0.11	0	0.56	0.090
		No Air-Condition	0.19	0.19	0.042	0.16	0.22	

Result – Explanation

- Low air movement suggests stagnant air occurs in most air-conditioned buildings
- CO_2 as the ventilation indicator shows the well mixing of outdoor air and return air. However, **poor dilution** happens indoors in most locations **due to low air movement** creating a **"dead space episode"**
- Ventilation conditions influence chemical indoor dispersion eg. Formaldehyde (lowest levels are experienced in cold conditions and the infiltration rates are high on warm days or when occupants open windows).
- **Sufficient air movement** is needed to "**drive**" the air from positive spaces to negative spaces, thus **diluting indoor pollutants**.
- Formaldehyde (HCHO) concentration depends on the potency of HCHO-emitting products present, the extent of their use, the loading factor (m^2/m^2) determined by **surface area** (m^2) of HCHO-emitting materials vs. volume (m^2) of interior space.
- Small spaces have **poor air-movement, poor dilution, high risk of sickness, localised symptoms**.

How bad is this issue?

Samples Number	Office	Home	Public	Mall	Hotel	Total
TOTAL	546	303	102	154	38	1163

- HCHO is easily diluted by sufficient ventilation and air movement. Poor air "drive" causes air travel to be inconsistent (back-draft episode) – pollutants coming back

Result

3.2.2 Exposure of indoor air pollutants between types of buildings either private or public buildings

No	Parameter	Space Type	Mean	Median	SD	Min	Max	Stat
1.	Formaldehyde	Private	0.04	0.01	0.16	0	3.32	**0.004**
		Public	0.07	0.02	0.14	0	1.40	
2.	TVOC	Private	0.021	0	0.23	0	5.91	0.783
		Public	0.017	0	0.07	0	0.83	
3.	Temperature	Private	26.9	26.2	3.64	17.35	34.7	**0.001**
		Public	26.1	26.1	2.264	20.0	34.20	
4.	Relative humidity	Private	65.2	61.9	46.64	30	788.7	**0.016**
		Public	58.9	58.9	8.27	41	84.9	
5.	Carbon dioxide	Private	551.4	505.5	257.6	348	5599	**p<0.001**
		Public	721.7	626.5	383.9	350	5550	
9.	Air movement	Private	0.16	0.05	1.09	0	31	0.223
		Public	0.07	0	0.11	0	0.56	

Public areas show significant higher levels of formaldehyde compared to private buildings

Result – Explanation

- Private = Houses, Private office; Public = Mall, Library, Museum, Clinic and Government Office
- **Public areas** (such as government offices) recorded **higher levels of formaldehyde compared to private offices** 0.07 vs 0.04 ppm ≈ Public areas recorded levels twice as high as private offices (complaints among staff of government offices higher compared to those in private sector)
- **High temperature in Private areas compared to Public** (potential of chemical dispersion will be greater in both types due to existing high level of air temperature readings)
- Low air movement in Public buildings explain the higher level of formaldehyde accumulated indoors
- **Formaldehyde = temperature + RH + ventilation (air-movement) + space**

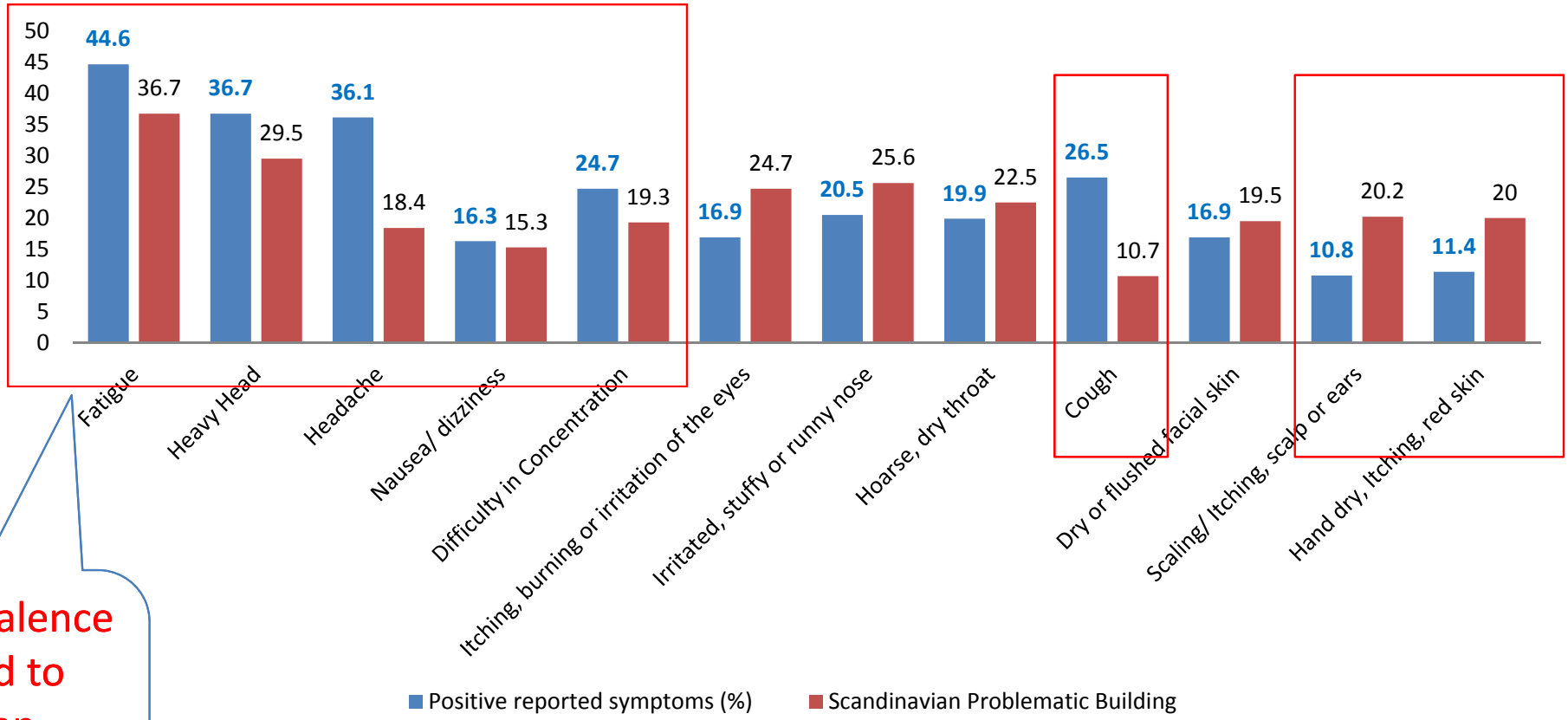
Result

Table 3.3 Classification of the High and Low pollutants according to levels

Parameter	Mean/ Median	Classification
Temperature	26.72^{0}C	Higher than Mean = High Lower than Mean = Low
Relative Humidity	61.28 %	Higher than Mean = High Lower than Mean = Low
Carbon Dioxide	≈ 600 ppm	Higher than Mean = High Lower than Mean = Low
Formaldehyde	≈ 0.02 ppm	Higher than Median = High Lower than Median = Low
Ozone	0.01 ppm	Higher than Median = High Lower than Median = Low
TVOCs	0.02 ppm	Higher than Median = High Lower than Median = Low
Carbon Monoxide	1.2 ppm	Higher than Median = High Lower than Median = Low
Respirable Particulate	0.05 mg/m^3	Higher than Median = High Lower than Median = Low
Air Movement	0.03 m/s	Higher than Median = High Lower than Median = Low

Result

Association between high formaldehyde levels and positive reported symptoms (Malaysia vs. Scandinavia)



Higher prevalence compared to European problematic buildings

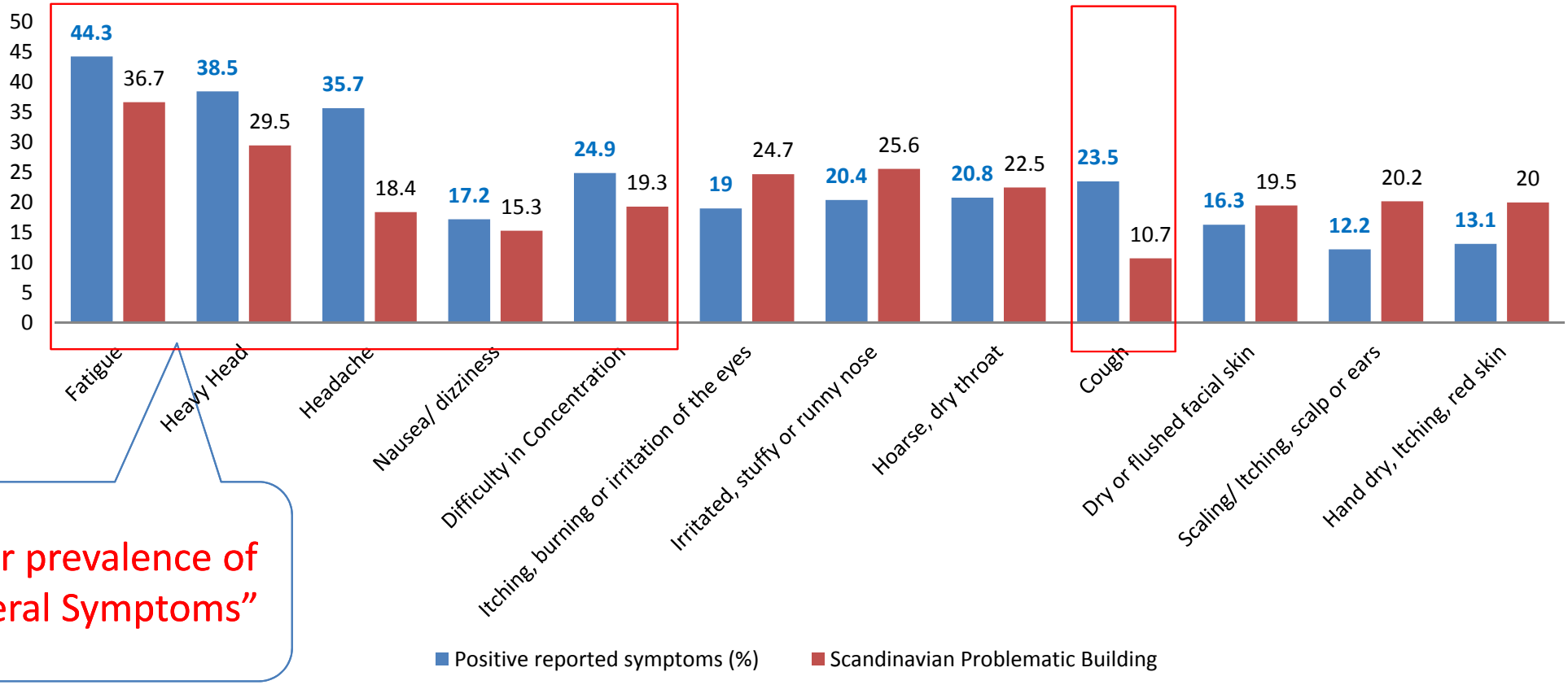
3.3.2 Association between formaldehyde levels (0.02ppm as cut of point) and positive reported symptoms (YES) compared to external references (Swedish Problematic Buildings)

Result – Explanation

- Formaldehyde causes higher prevalence of General Symptoms such as “Headaches”, Neurological symptoms (Dizziness/ Nausea) and respiratory irritants (cough).
- High formaldehyde exposure results in dermal and general symptoms complaints.
- Klang Valley current indoor air status is **worse than the most problematic** buildings overseas.
- This exposure is possibly causing high reported non-communicable diseases such as migraine, severe headache, brain cancer and lung cancer.
- Exposure to formaldehyde suggests that even levels set at 0.02 ppm can trigger minor health complaints among building occupants.
- Therefore, exposure of up to 0.1 ppm (DOSH standard) are a threat to our long term health especially on the neurological system.

Result

Association between high temperature levels and reported symptoms (Malaysia vs. Scandinavia)



Higher prevalence of "General Symptoms"

3.3.1 Association between temperature and positive reported symptoms (YES) compared to external references (Swedish Problematic Buildings)

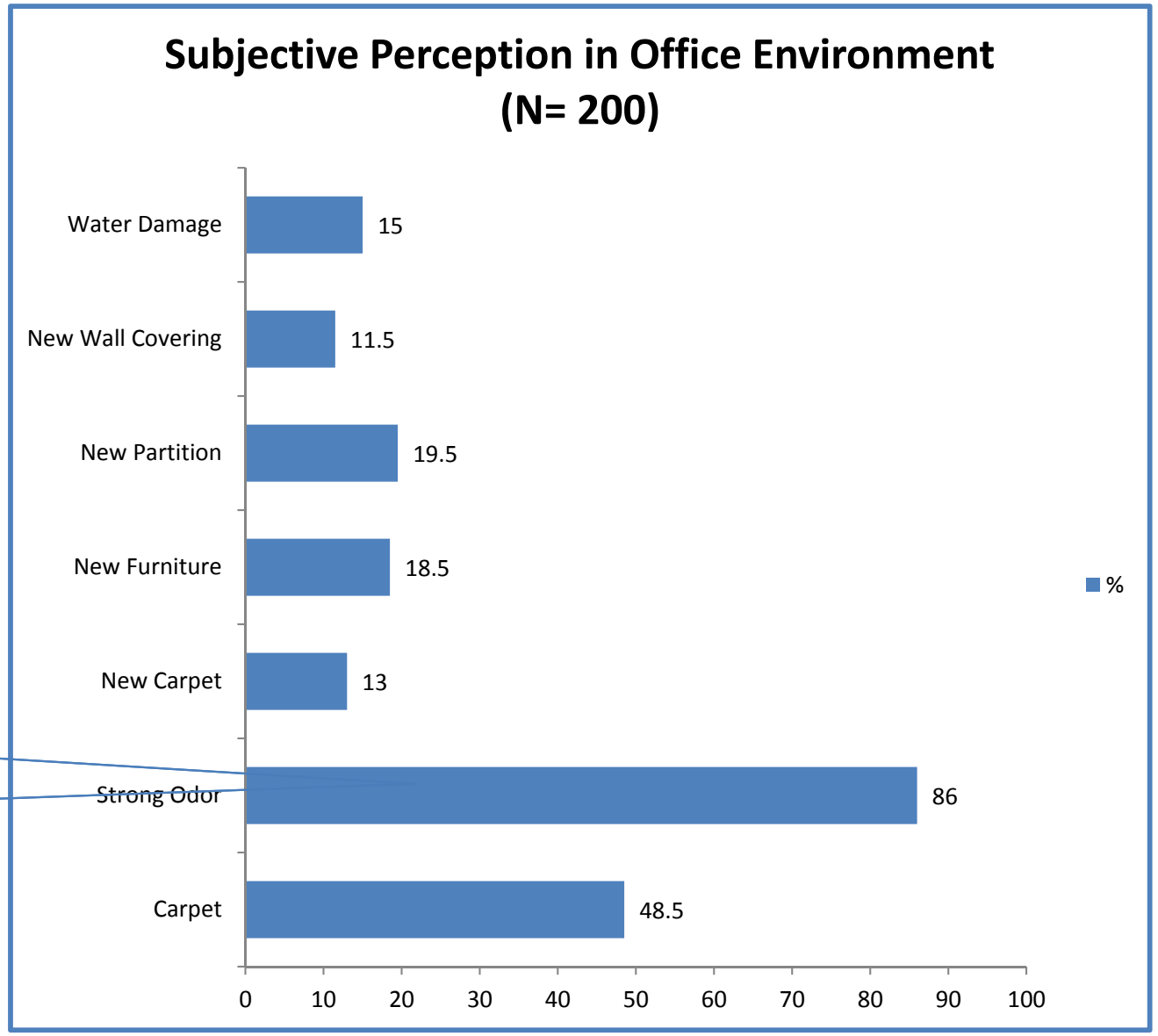
Result – Explanation

- Data shows temperature in most of the areas are above the range suggested by DOSH
- Dry air was a common complaint among most workers (result not shown), this reflects efficiency issues of the MVAC system
- High temperature (more than 26.7°C) being hypothetical testing for high and low level of temperature
- **More complaints about Mucosal symptoms (Cough)** among Malaysians **compared to Problematic Buildings (elsewhere)**
- "General Site/Symptoms" higher among Malaysians in non-industrial workplace (office workers)
- Even in **temperatures of 26.7°C**, more than **6 symptoms (50% of SBS symptoms)** have the possibility of affecting workers in indoor environments
- High temperatures associated with high prevalence of headache, heavy head, nausea, dizziness that leads to absenteeism among Malaysians. This probably leads to high medical bills and thus reduces motivation to work.

R E S U L T S

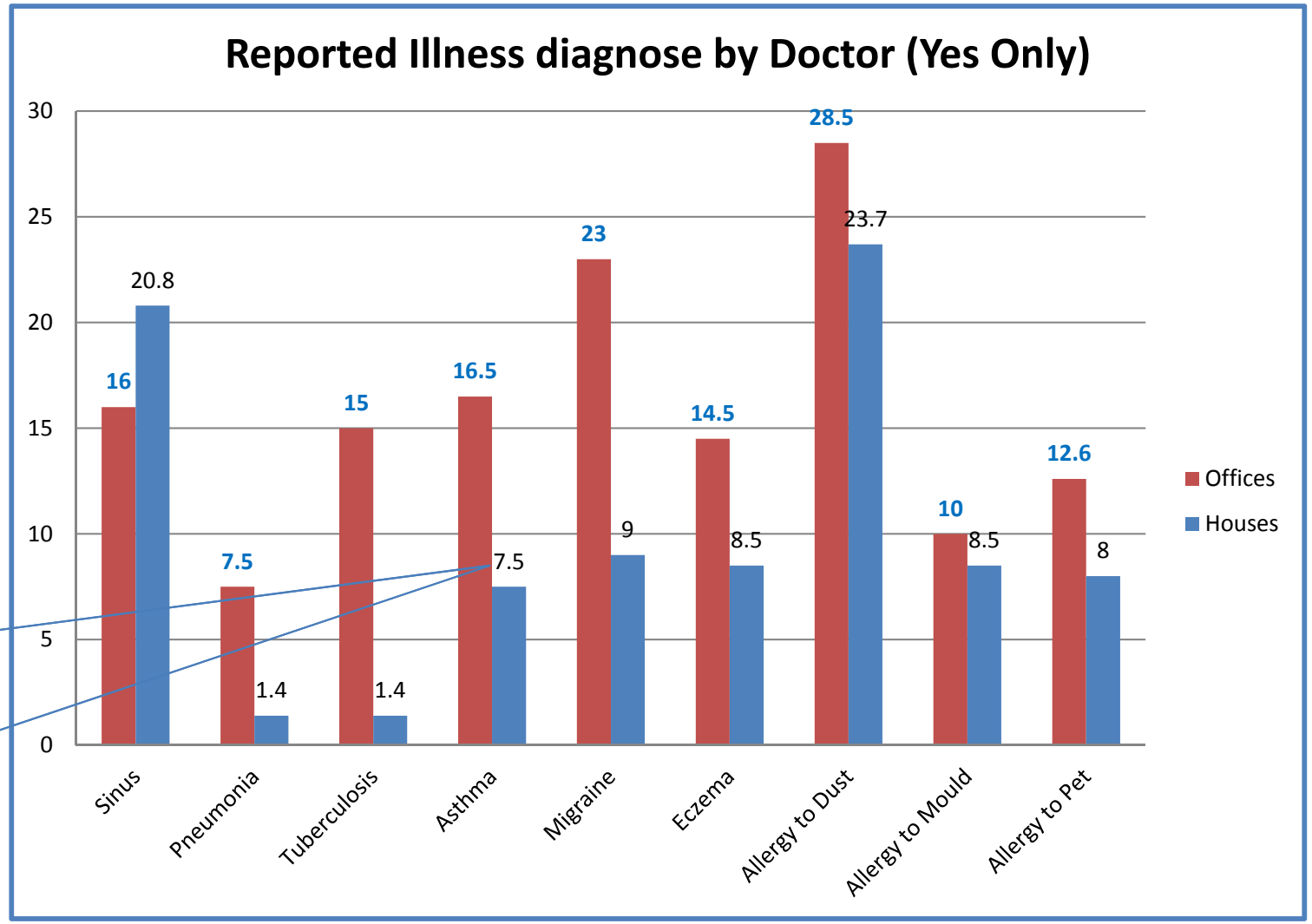
Complaints of Illness/ Disorder (Office)

Result



Most occupants complained about strong odours

Result



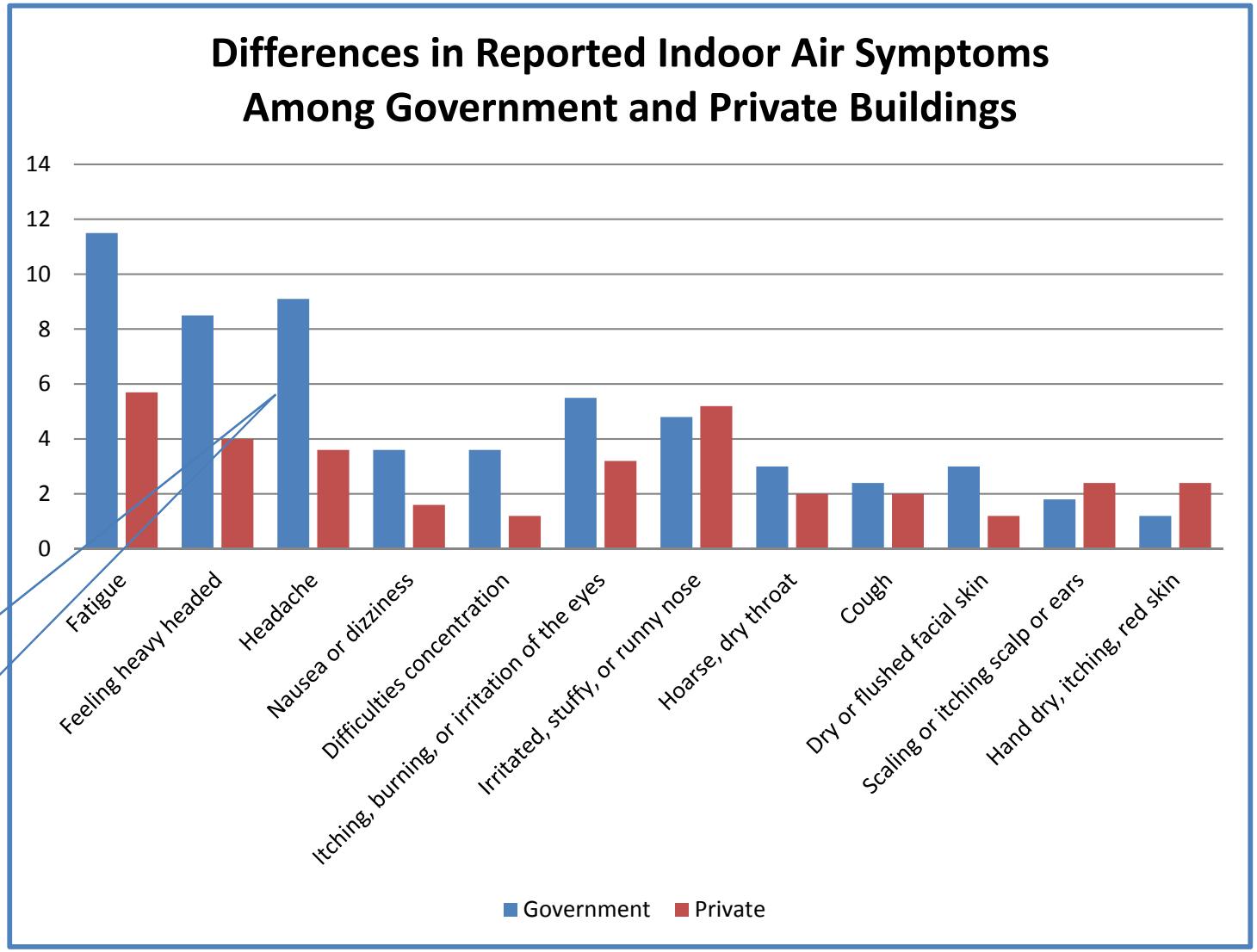
Differences in prevalence of disease/ illness:
- higher in offices compared to homes (offices showed health related risk that could influence workers condition)

Result – Explanation

- **More complaints**/ reported **illness from offices** compared to houses suggests that the indoor workplace has **greater risks**
- However, **houses** also **posed the same risk** of exposure due to the fact that we spend at least 8 hours in our houses. 5% of complaints = 10 – 11 occurrences of illnesses in houses.

Result

Table 3.1.1g. Differences in Reported Indoor Air Symptoms Among Government and Private Buildings (male and female respondents)



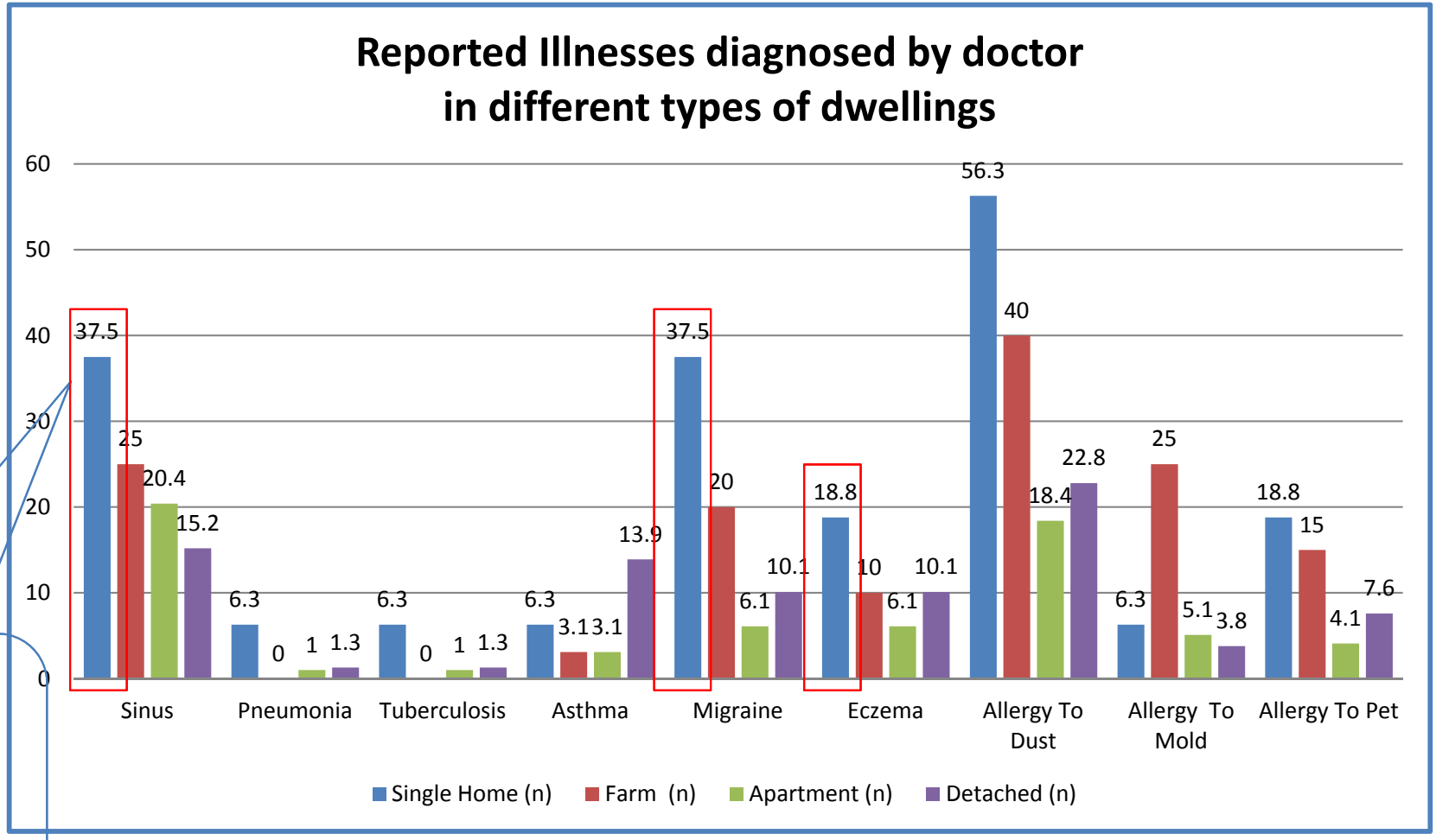
Government staff had more complaints than private sector staff (risk level = 4-6 times higher)

Result – Explanation

- **Public servants have a higher potential of falling ill** compared to private workers
- However, the risk of developing illnesses is similar
- Gender is also a factor with illnesses caused by the indoor environment (twice as high between female and male)

R E S U L T S
Complaints / Symptoms (Dwellings)

Result



Sinus, Migraine and Eczema prominent among single home occupants.

Table 3.1.3d. Reported Illness diagnosed by doctor in different types of dwellings

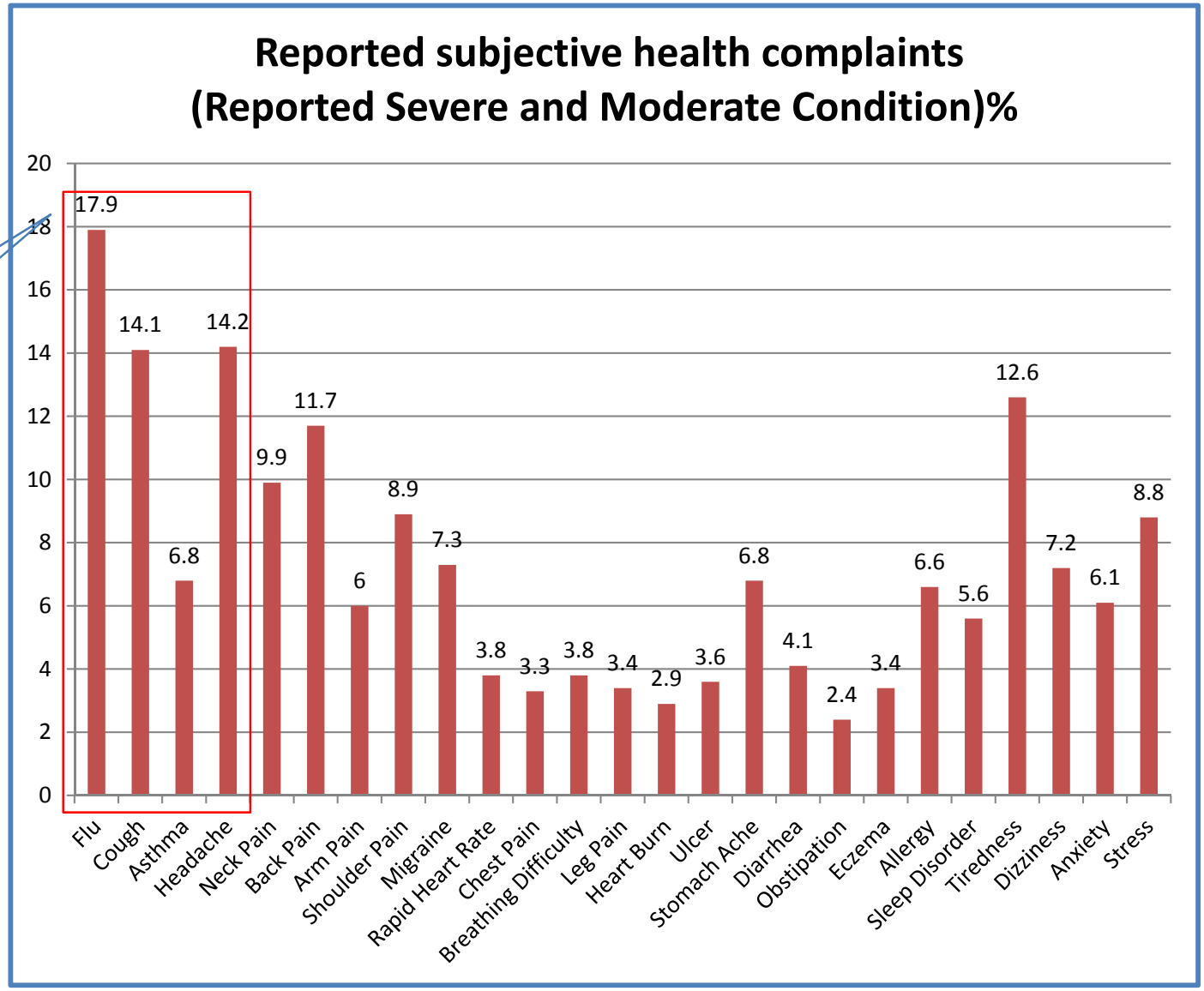
Result – Explanation

- Single home owners **(bungalows) reported higher prevalence of reported illnesses** compared to other types of houses
- Single houses are usually equipped with air-conditioning units and most houses investigated contained a number of chemical dispersion agents (formaldehyde, TVOCs/ Aldehydes) possibly emitted during high temperature conditions (when A/C not running)
- This condition becomes worse when most of the **single houses over decorate** with various **“indoor culprits”** such as **wall paper, furnishings and fragrances**.
- When these houses do not have sufficient air-movement/natural ventilation, chemicals be will stagnant inside the house

Result

Table 3.1.3c. Reported subjective health complaints (Reported Severe and Moderate Condition)

Most occupants complained about respiratory illness/ condition and neurological disturbance (due to chemicals)



Result – Explanation

- This study also adopted subjective health complaint questions
- Based on the findings, most occupants complained about **upper respiratory conditions, neurological disturbances and psychological issues (tiredness).**
- This suggests the **correlation** between **indoor chemistry and the reported complaints** which significantly correlates exposure and health effects.

R E S U L T S

Complaints of Illness/ Disorder (Overall)

Result – Explanation

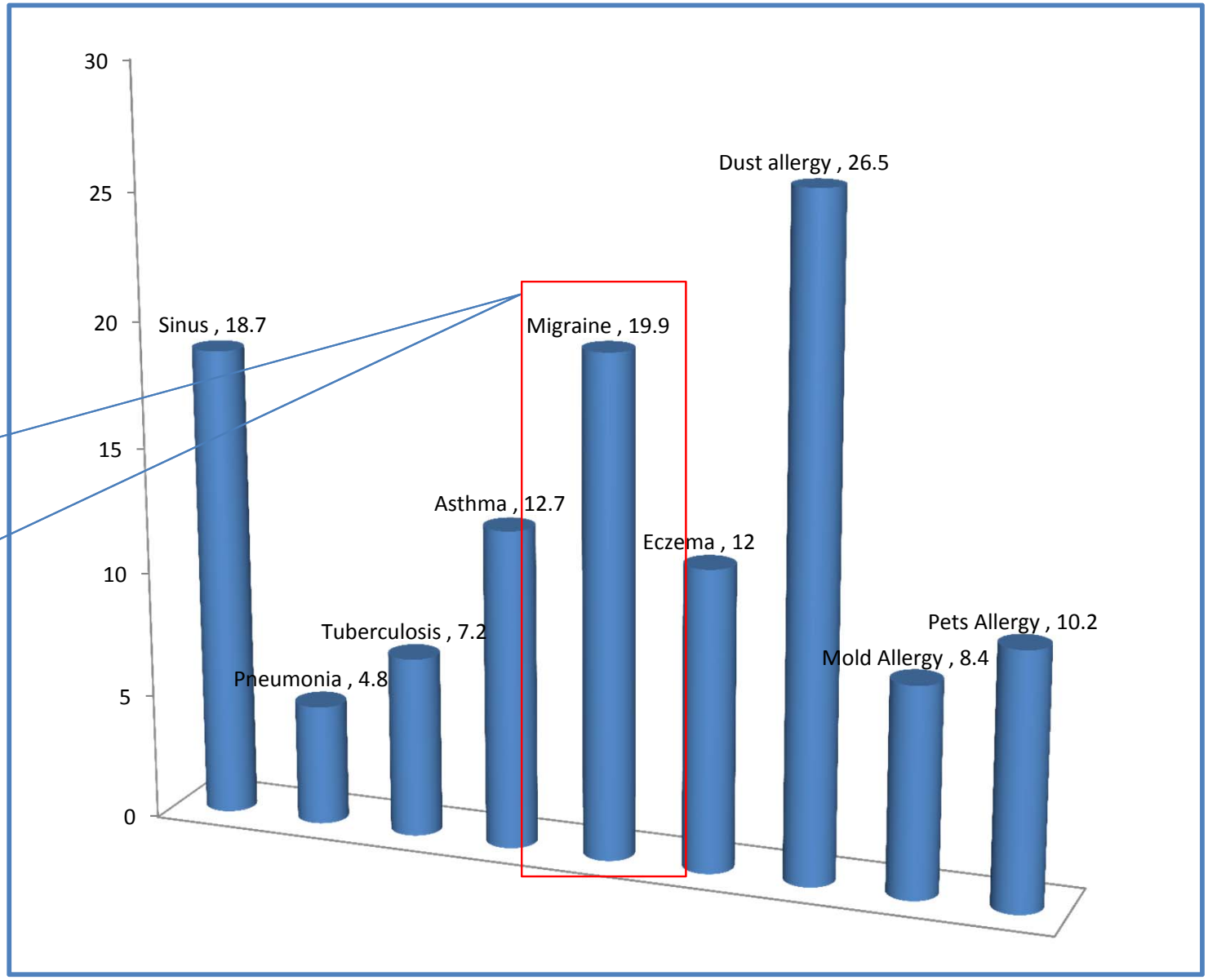
- **Temperature** plays an important role in **influencing reported illnesses**
- This episode occurs due to the fact that most of the pollutants are influenced by temperature changes and relative humidity

Illness	Level of Pollutants	Frequency	%	Stats
Sinus	High	40	18.1	0.514
	Low	31	17.7	
Pneumonia	**High**	**4**	**1.8**	**0.003**
	Low	**14**	**8.0**	
Tuberculosis	**High**	**8**	**3.6**	**p<0.001**
	Low	**24**	**13.7**	
Asthma	**High**	**16**	**7.2**	**0.001**
	Low	**31**	**17.7**	
Migraine	**High**	**26**	**11.8**	**0.017**
	Low	**35**	**20.0**	
Eczema	High	20	9.0	0.071
	Low	25	14.3	
Dust allergy	**High**	**47**	**21.3**	**0.035**
	Low	**52**	**29.7**	
Mold Allergy	High	17	7.7	0.137
	Low	20	11.4	
Pets Allergy	**High**	**15**	**6.8**	**0.006**
	Low	**26**	**15.0**	

Result

3.4.3 Association between exposure to formaldehyde and the reported illnesses

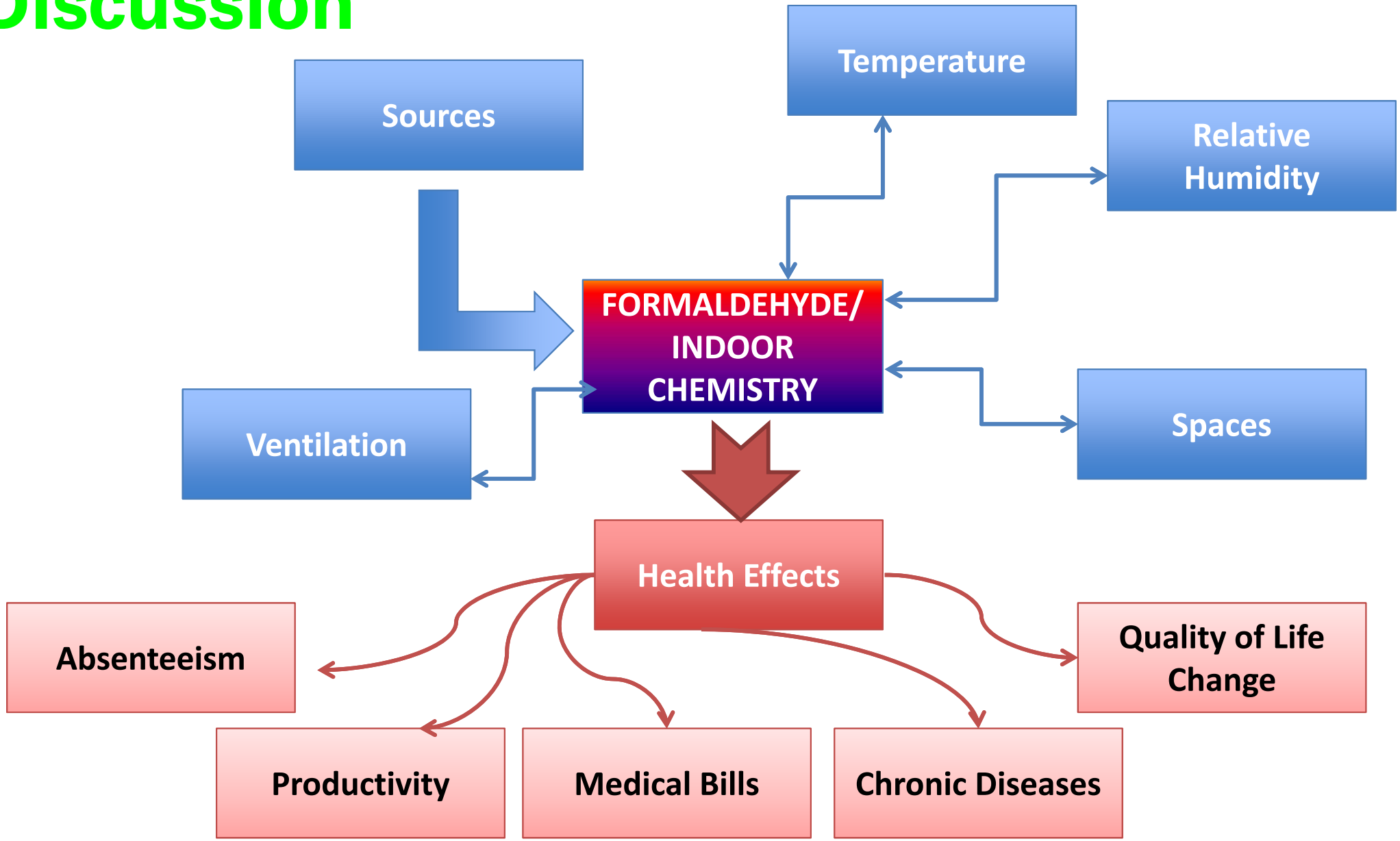
At level 0.02ppm, there was significant association between level of formaldehyde dispersion and reported diagnosed migraine among respondents (≈20%).



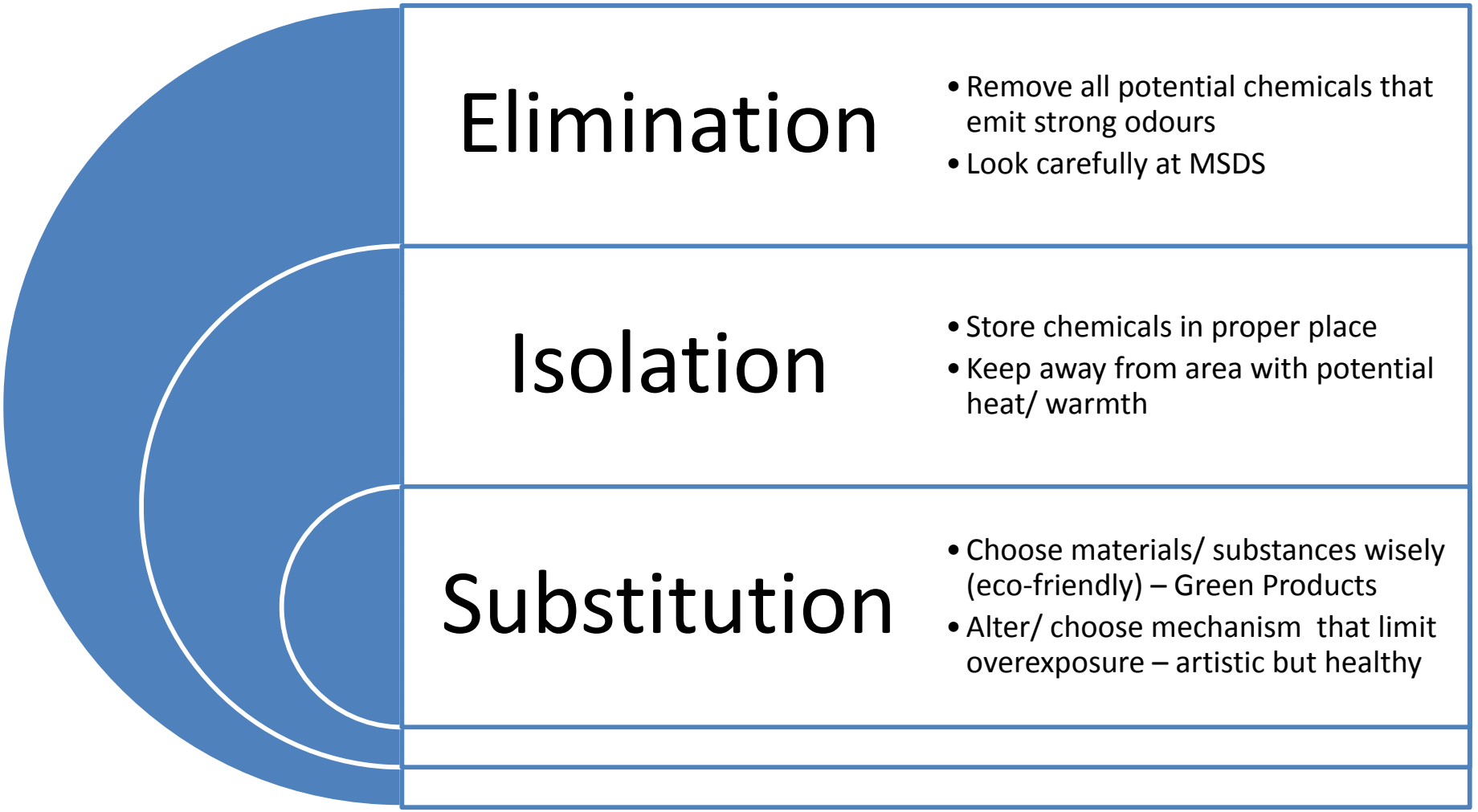
Result – Explanation

- Emission of formaldehyde shows a median of **0.02 ppm**, thus this level was tested for hypothesis linkage in association with the reported illness.
- Results indicate 20% of respondents complained about **having migraine with exposure as low as 0.02 ppm (current state).**
- This indicates that even low levels of emission (>0.02 ppm) can influence the development of neurological disorders explainable by statistical analysis and epidemiological evidence
- Based on predicted values, **exposure of more than 0.06 ppm can potentially** give occupants preliminary **irritant symptoms** first then if the exposure continues, the chronic exposure will lead to neurological changes
- Chemical management indoors should be emphasized to reduce this potential disease/ disorders and ensure public health and safety

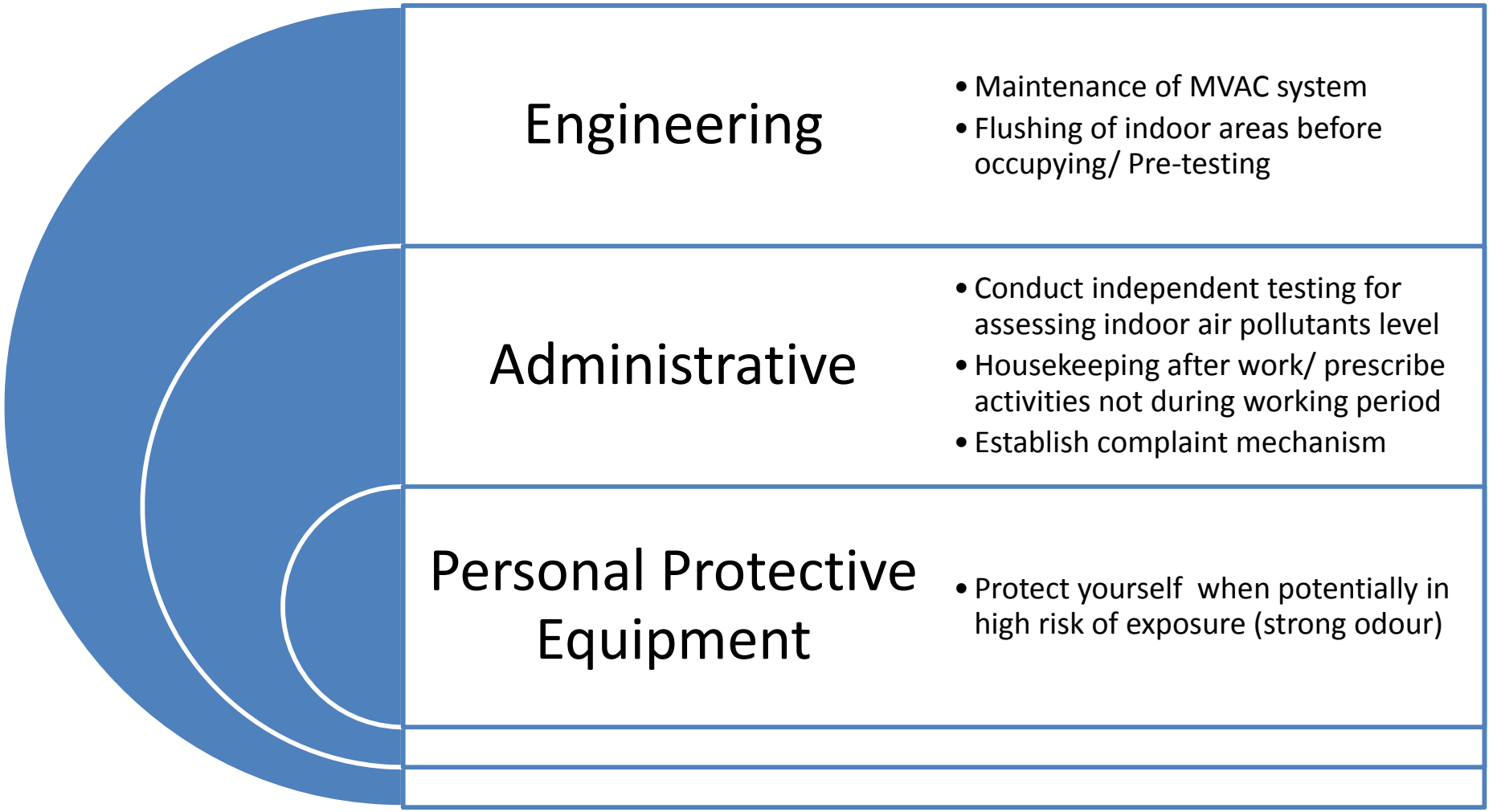
Discussion


Temperature
Sources
Relative Humidity
FORMALDEHYDE/ INDOOR CHEMISTRY
Ventilation
Spaces
Health Effects
Absenteeism
Quality of Life Change
Productivity
Medical Bills
Chronic Diseases

Conclusion – Controlling Exposure - 1



Conclusion – Controlling Exposure - 2



Additional Information – Published Material

- Published online (free) - **Gender, airborne chemical monitoring, and physical work environment are related to indoor air symptoms among nonindustrial workers in the Klang Valley, Malaysia**.
- This paper describe:

Table 4 Percentage (%) of reported illness by doctor

Variables	Men (n = 81)	Women (n = 119)	Total (n = 200)	*P*
Sinus	16.0	16.0	16.0	0.568
Pneumonia	8.6	6.7	7.5	0.403
Tuberculosis	13.6	16.0	15.0	0.400
Asthma	9.9	21.0	16.5	0.027*
Migraine	14.8	28.6	23.0	0.017*
Eczema	8.6	18.5	14.5	0.039*
Allergy to dust	23.5	31.9	28.5	0.289
Allergy to mould	12.3	8.5	10.1	0.484
Allergy to food	13.6	20.2	17.5	0.333
Allergy to pets	9.9	15.3	13.1	0.293

Note: *Significant at $P < 0.05$ (chi-squared test).

Additional Information – Published Material

- This paper describe continue:

Table 12 Results stratified for gender: regression analyses of total, general symptoms, mucosal, dermal, and perceived physical complaint

Factor	All	Men	Women
Indoor air symptoms			
Carbon dioxide (ppm)	T*G*M*D*	T*G*M^D^	T*G*M*D^
Carbon monoxide (ppm)	T**G**M**D*	T*G**M*D*	T*G*M*D^
Formaldehyde (log ppm)	T*G*M^D^	T*G*M*D*	T*G*M^D^
TVOCs (log ppm)	T*G*M*D^	T**G**M**D**	T*G**M^D^
Dust (log mg/m³)	T^G*M*D^	T*G*M*D*	T*G***M*D^
Subjective environment			
Air temperature (°C)	T*G*M^D^P^	T*G*M**D*P*	T^G^M^D^P**
RH (%)	T^G*M^D^P**	T^G^M^D^P*	T^G^M*D^P*
Air movement (m/second)	T^G^M*D^P*	T*G*M**D*P*	T*G*M**D^P**
Environmental complaints			
Draft			
Temperature	*	*	*
RH	*	*	*
Air movement	*	^	*
Varying temperature			
Temperature	***	*	**
RH	**	*	*
Air movement	^	*	*
Passive smoking			
Temperature	*	*	^
RH	^	^	^
Air movement	*	*	^
Dust (log mg/m³)	^	^	^

Notes: *$P < 0.5$; **$P < 0.05$; ***$P < 0.01$; ^no association.
Abbreviations: D, dermal; G, general symptoms; M, mucosal; P, perceived physical complaint; RH, relative humidity; T, total; TVOC, total volatile organic compound.

Additional Information – Published Material

- This paper describe continue:

Table 13 Result stratified for gender: regression analyses of individual complaints (12 symptoms)*

Factor	All	Women	Men
Parameters/indoor air symptoms			
Carbon dioxide (ppm)	C	^	HD
Carbon monoxide (ppm)	F, FHH, H, SN, DT, C	^	IE, SN
Formaldehyde (log ppm)	^	^	^
TVOCs (log ppm)	C	F	F
Dust (log mg/m³)	^	FHH, H	^
Temperature (°C)	^	^	^
Relative humidity (%)	^	^	^
Air movement (m/second)	^	^	^

Notes: The symptoms included general symptoms (F, FHH, H, ND, and DC), four questions on mucosal symptoms (IE, SN, DT, and C), and three on skin symptoms (FS, SE, and HD); adjusted for age, gender, job category, new furniture, new partition, and workstation; *$P < 0.05$; ^no association.

Abbreviations: C, cough; DC, difficulty concentrating; DT, hoarse, dry throat; F, fatigue; FHH, feeling heavy-handed; FS, dry or flushed facial skin; H, headache; HD, red skin; IE, itching, burning, or irritation of the eyes; ND, nausea or dizziness; SE, scaling, itching scalp, or ears; SN, irritated, stuffy, or runny nose; TVOC, total volatile organic compound.

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Thank You

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What We Measured?

- Measure the temperature & humidity (THI Index)
- Air Movement
- Chemical (Formaldehyde, TVOCs)
- Gases (CO,CO_2, O_3)
- Particulate (PM_{10})
- Health effect questionnaire (Syazwan et al., 2009)

How We Measured?