Assessing hazardous risks of human exposure to temple airborne polycyclic aromatic hydrocarbons

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ABSTRACT

We proposed an integrated probabilistic risk assessment framework based on reported data to quantify human health risks of temple goers/workers to airborne polycyclic aromatic hydrocarbons (PAHs) from incense burning in typical Taiwanese temples. The framework probabilistically integrates exposure, human respiratory tract, and incremental lifetime cancer risk (ILCRs) models to quantitatively estimate size-dependent PAHs exposure in human lung regions and cancer risks for temple goers (moderate and high exposures) and temple workers (extreme exposure). Our results show that the ILCRs are greater than the acceptable level of $10^{-6}$ for extreme and high exposure groups through inhalation route. The result also indicates that the higher ILCRs ($10^{-6}$ to $10^{-4}$) are found in ingestion and dermal contact routes for temple goers/workers. For personal extreme exposure to carcinogenic PAH in the temple, 95% probability total ILCR (TILCR) ($9.87 \times 10^{-4}$ to $1.13 \times 10^{-3}$) is much greater than the range of $10^{-6}$ to $10^{-4}$, indicating high potential health risk to temple workers. For temple goers with high and moderate exposure groups, however, the 95% probability TILCRs were estimated from $6.44 \times 10^{-3}$ to $7.50 \times 10^{-2}$ and $5.75 \times 10^{-2}$ to $6.99 \times 10^{-2}$, respectively. This study successfully offers a scientific basis for risk analysis due to incense burning to enhance broad risk management strategies for temple indoor air quality.

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1. Introduction

Burning incense to worship deities is a daily religious ritual in most Buddhist and Taoist temples in Taiwan. It is also a part of the daily routine of about 50% of families in Taiwan [1]. Approximated 1.5 million frequent temple goers visit more than 14,500 temples across the Taiwan region and subject to burn incense inside the temples (http://www.moi.gov.tw/stat/). Incense burning is found across the Taiwan region and subject to burn incense inside the temples (http://www.moi.gov.tw/stat/). Incense burning is found across the Taiwan region and subject to burn incense inside the temples (http://www.moi.gov.tw/stat/). Incense burning is found across the Taiwan region and subject to burn incense inside the temples (http://www.moi.gov.tw/stat/).

To further understand and identify individuals who are “at risk” of carcinogenic effects by PAHs exposure during religious practices, we argue that, by understanding the linkage between human respiratory tract dynamics and probabilistic risk analysis, we can provide a cancer risk estimates and scientific based risk methodology to enhance broad risk management for temple indoor air quality issues. Here we intended to develop an integrated risk assessment framework, including probabilistic exposure model, human respiratory tract (HRT) model, and incremental lifetime cancer risk (ILCR) model, to quantify temple goers/workers exposed to airborne PAHs in temples. Specifically, the objectives of this study are 3-fold:

- To develop an integrated risk assessment framework, including probabilistic exposure model, human respiratory tract (HRT) model, and incremental lifetime cancer risk (ILCR) model, to quantify temple goers/workers exposed to airborne PAHs in temples.
- To provide a scientific basis for risk analysis due to incense burning to enhance broad risk management strategies for temple indoor air quality.

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The result indicates that the higher ILCRs ($10^{-6}$ to $10^{-4}$) are found in ingestion and dermal contact routes for temple goers/workers. For personal extreme exposure to carcinogenic PAH in the temple, 95% probability total ILCR (TILCR) ($9.87 \times 10^{-4}$ to $1.13 \times 10^{-3}$) is much greater than the range of $10^{-6}$ to $10^{-4}$, indicating high potential health risk to temple workers. For temple goers with high and moderate exposure groups, however, the 95% probability TILCRs were estimated from $6.44 \times 10^{-3}$ to $7.50 \times 10^{-2}$ and $5.75 \times 10^{-2}$ to $6.99 \times 10^{-2}$, respectively. This study successfully offers a scientific basis for risk analysis due to incense burning to enhance broad risk management strategies for temple indoor air quality.

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1. We delineated exposure estimation. Temple goers visiting the temple on the 1st and 15th days have high exposure levels and temple workers with extreme exposure.

2.2. Reanalyze the published PAHs data

We quantitatively reanalyzed the particle size distribution, total-PAH, particle-bound PAH (p-PAH), and individual PAH (particulate and gas phase) concentrations, and size-dependent PAHs concentrations of temple incense burning from published data. Thanks to Fang et al. [13], Lin et al. [2], and Chuang [8] who have provided the remarkable dataset related to existed PAHs in Taiwanese temples. The PAHs data give us the opportunity to test all theoretical considerations of temple PAHs exposure effects and quantify its strength. Fang et al. [13] selected a famous Taiwanese temple Tzu Yun Yen located at Ching Shui town in central Taiwan as the study site. The sampling time was from 9:00 am to 7:00 pm daily and sampling periods were from August 2001 to January 2002. Lin et al. [2] selected a Taiwanese temple located at the suburban area of Tainan city in southern Taiwan. Sampling was conducted from 9:00 am to 5:00 pm and from 9:00 am to 9:00 am the next day, respectively, for 3 sequential days during March 1996. Moreover, the reported measurements also included the relationship between incense compositions and PAH emissions for three representative types of incense of aloe wood, Taiwan yellow, and Taiwan black.

(i) to conduct a probabilistic lifetime cancer risk assessment of personal multi-routes exposure to PAHs for temple goers/workers; (ii) to estimate the PAHs mass concentrations, size distribution, and daily dose for different HRT regions; and (iii) to recommend a visiting frequency advice to temple goers and a suggested incense burning amount of different types of commonly used incense.

2. Materials and methods

2.1. Study population

A Taiwanese temple that we employed to study is a typical famous Buddhist–Taoist combined temple. The average numbers of temple goers are nearly 3000–5000 d

Table 1

Potency equivalency factor (PEF) for PAHs relative to B[a]P used in this study.

<table>
<thead>
<tr>
<th>Name with abbreviation</th>
<th>PEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Benzo(a)pyrene (B[a]P)</td>
<td>1</td>
</tr>
<tr>
<td>PAHs</td>
<td></td>
</tr>
<tr>
<td>Aacenaphthene (Acp)</td>
<td>0.001 [18]</td>
</tr>
<tr>
<td>Aacenaphthylene (Acy)</td>
<td>0.001 [18]</td>
</tr>
<tr>
<td>Anthracene (Ant)</td>
<td>0.01 [18]</td>
</tr>
<tr>
<td>Benzol[a]anthracene (B[a]A)</td>
<td>0.1 [18]</td>
</tr>
<tr>
<td>Benzo[b]chrycene (B[b]C)</td>
<td>NA</td>
</tr>
<tr>
<td>Benzo[b]fluoranthene (B[b]FT)</td>
<td>0.1 [18]</td>
</tr>
<tr>
<td>Benzo[k]fluoranthene (B[k]FT)</td>
<td>0.1 [18]</td>
</tr>
<tr>
<td>Benzo[e]pyrene (B[e]P)</td>
<td>0.01 [19]</td>
</tr>
<tr>
<td>Benzo[g,h,i]perylene (B[g,h,i]P)</td>
<td>0.01 [18]</td>
</tr>
<tr>
<td>Chrysene (CHR)</td>
<td>0.01 [18]</td>
</tr>
<tr>
<td>Coronene (COR)</td>
<td>0.001 [19]</td>
</tr>
<tr>
<td>Cyclopenta[c,d]pyrene (C,c,d)P</td>
<td>0.1 [19]</td>
</tr>
<tr>
<td>Dibenzo[a,h]anthracene (DB[a,h]A)</td>
<td>1 [19]</td>
</tr>
<tr>
<td>Fluoranthene (FL)</td>
<td>0.001 [18]</td>
</tr>
<tr>
<td>Fluorene (Flu)</td>
<td>0.001 [18]</td>
</tr>
<tr>
<td>Indeno[1,2,3-c,d]pyrene (In,c,d)P</td>
<td>0.1 [18]</td>
</tr>
<tr>
<td>Naphthalene (Nap)</td>
<td>0.001 [18]</td>
</tr>
<tr>
<td>Perylene (PER)</td>
<td>0.001 [19]</td>
</tr>
<tr>
<td>Phenanthrene (PA)</td>
<td>0.001 [18]</td>
</tr>
<tr>
<td>Pyrene (Pyr)</td>
<td>0.001 [18]</td>
</tr>
</tbody>
</table>
Exposure is expressed in terms of lifetime daily average daily dose (LADD) and is calculated separately for each element and for each exposure pathway. Specifically, the doses contact through inhalation and ingestion of particles and absorbed through the skin have been documented by U.S. EPA [20]. LADD for incident inhalation, ingestion, and dermal contact pathways are listed in Table 2. We treated $C_a$, $IR_a$, $C_{p,a}$, $IR_p$, $AB$, $SA$, $AF_d$, $RT$, and $BW$ in Eqs. (1)–(3) probabilistically.

We divided human respiratory tract (HRT) into five major compartments from the suggestion of ICRP66 [21]: (i) the nasal passage (ET1), comprising the anterior nose and the posterior nasal passages; (ii) the pharynx (ET2), comprising the larynx and mouth; (iii) the bronchial region (BB), comprising the airway from the trachea, main bronchi, and intrapulmonary bronchi; (iv) the bronchiolar region (bb), comprising the bronchicles and terminal bronchiolies; and (v) the alveolar-interstitial region (Al), comprising the airway from the respiratory bronchioles through the alveolar sacs. Followed by the principle of mass balance, the dynamic equations of inspiratory and expiratory cavity varying with particle size range $k$ and time $t$ to each regional compartment are given by a state-space realization form of a linear dynamic representation (Table 2, Eq. (4)) [22,23].

The reference values for anatomical and physiological parameters, including volumes, breathing rates, transfer coefficients, and clearance rate, are taken from the ICRP66 [21]. More details for HRT model developments and constructions have been described in elsewhere [22,23].

The incremental lifetime cancer risk (ILCR) is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. We used the linear low-dose carcinogenic risk equation to reflect each of exposure routes of inhalation, ingestion, and dermal contact (Table 2, Eq. (5)). The cancer slope factor (CSF), which is used to estimate the risk potential (Table 2, Eq. (5)) in the present study, for each exposure route are normalized to account for extrapolation to a different body weight from standard of 70 kg. The CSFs for B[a]P inhalation and ingestion exposure were 12 and 3.9 (mg kg$^{-1}$ d$^{-1}$)$^{-1}$, respectively. Those values were adopted from OEHHA [24] and Neal and Rigdon [25]. For exposure to B[a]P by dermal contact pathway, the potencies were estimated to be 37.47 and 23.5 (mg kg$^{-1}$ d$^{-1}$)$^{-1}$, based on incidence of skin tumors in mice [26] and a gastroin-
testinal absorption ($AB_{50}$) factor of 0.31, respectively [27,28]. We averaged those two CSF values and resulted in the arithmetic mean 30.5 (mg kg$^{-1}$ d$^{-1}$)$^{-1}$.

Cancer risks from various exposure routes are assumed to be additive, as long as the risks are for the same individuals and time period. The total ILCR (TILCR) is the sum of risks associated with each exposure route (Table 2, Eq. (6)). The lower end of the range of acceptable risk distribution (TILCR) is defined by a single constraint on the 95th percentile of risk distribution that must be equal or lower than $10^{-6}$ for carcinogens.

A Monte Carlo simulation is performed using Crystal Ball software (Version 2000.2, Decisioneering, Inc., Denver, CO, USA) to quantify the uncertainty and its impact on the estimation of expected risk. A sensitivity analysis by using Spearman rank correlations is performed to determine which probability density functions have the greatest effect on the risk estimates.

Current literature was reviewed to develop probability distributions for the random variables appearing in the risk models adopted (Table 3). Having no site-specific data on population body weight, a second-order distribution was chosen for this parameter with the population age distribution in the Taiwan region to estimate the population body weight followed a lognormal distribution as a function of age [29]. Probability distributions chosen for the inhalation, ingestion, and dermal adherence rates and for the skin surface area are based on the body weight distribution probability. The PAHs inhalation rates are estimated from USEPA [30] suggested inhalation rates for various activities combined with the specific activity patterns (rest, sedentary, light, and moderate activities) of the average household. The exposed skin surface areas of PAHs are given by the specific exposed skin surface area for different exposures (summer and winter) [31]. In our probabilistic exposure assessment, not only the point estimate values (e.g., $VF$, $ED$, $EF$, and $AT_{d}$) but also the proposed random variables (e.g., $RT$, $IR_{inh}$, $IR_{ing}$, $SA$, $AF_{d}$, $AB$, and $BW$) are considered (Table 3).

3. Results

3.1. Quantitative temple PAHs concentrations

The size distributions of $B[a]P$ and $B[a]P_{eq}$ are similarly followed a bimodal in the northern Taiwan temple (data reanalyzed from [8]) (Fig. 1A and B). Two peaks of the average mass distributions were found at 0.18–0.32 and 1.8–3.2 µm for $B[a]P$ and $B[a]P_{eq}$, respec-
tively. The concentrations of B[a]P and B[a]P$_{eq}$ in fine particles (aerodynamic diameter <1 μm) are nearly 1 order of magnitude higher than that in coarse particles (aerodynamic diameter <10 μm), indicating that fine particles are the major contribution of B[a]P and B[a]P$_{eq}$ concentrations in temple. In the southern Taiwan temple (data reanalyzed from [2]), the median B[a]P and B[a]P$_{eq}$-based concentrations are 142.45 and 182.88; and 36.28 and 68.95 ng m$^{-3}$ in indoor and outdoor, respectively (Fig. 1C), whereas the median particle-bound B[a]P- and B[a]P$_{eq}$-based concentrations are estimated to be 102.61 and 153.40; and 10.14 and 14.36 ng m$^{-3}$ for indoor and outdoor, respectively (Fig. 1D). The median B[a]P- and B[a]P$_{eq}$-based concentrations for three types incense are estimated to be 9.36 and 22.44; 160.92 and 420.04; and 15.64 and 29.19 ng g$^{-1}$, respectively, for Taiwan yellow, Taiwan black, and aloe wood (Fig. 1E), implicating that Taiwan black incense may be a significant contribution factor to PAH sources.

3.2. Estimates of lifetime average daily dose (LADD)

LADD estimates of PAHs for temple goers/workers and three exposure routes are shown in Table 4. For temple workers, the median and 95th percentile of LADDs of B[a]P and B[a]P$_{eq}$ for overall routes have orders of 10$^{-5}$ to 10$^{-4}$ d$^{-1}$, indicating high potential exposure risk; whereas for temple goers, the median and 95th percentiles of LADDs of B[a]P and B[a]P$_{eq}$ for overall routes have orders of 10$^{-6}$ and 10$^{-7}$ mg kg$^{-1}$ d$^{-1}$, respectively. Our results also show that ingestion exposure has higher LADD estimates of PAHs than those of inhalation and dermal for all three exposure groups (Table 4).

3.3. PAHs in human respiratory tract

The steady-state B[a]P mass concentrations are estimated to be 0.57–32.23, 0.35–23.84, 0.15–15.50, and 0.01–7.69 ng m$^{-3}$ in ET, BB, bb, and AI regions, respectively (Fig. 2A, C, E, G). The mass median diameters (MMDs) are calculated to be 0.293, 0.289, 0.283, and 0.269 μm in ET, BB, bb, and AI regions, respectively (Fig. 2B, D, F, H). Temple goers with 35 min of daily exposure (high exposure group), the average daily doses of B[a]P and B[a]P$_{eq}$ are estimated to be 0.002–0.020 and 0.008–0.32 μg d$^{-1}$; 0.016–0.227 and 0.077–0.360 μg d$^{-1}$; and 0.033–2.479 and 0.135–3.927 μg d$^{-1}$, respectively, in the BB, bb, and AI regions (Fig. 3A). Temple workers with 10 h of daily exposure (extreme exposure group), the estimated average daily doses of B[a]P and B[a]P$_{eq}$ are 0.03–0.35 and 0.14–0.55 μg d$^{-1}$; 0.27–3.98 and 1.34–6.30 μg d$^{-1}$; and 0.57–43.38, and 2.36–68.72 μg d$^{-1}$, respectively, in the BB, bb, and AI regions (Fig. 3B). The similar results indicate that the average daily doses of B[a]P and B[a]P$_{eq}$ obtained from fine fraction depositing to the AI region are significantly higher than those to the BB and bb regions.

3.4. Risk estimates

The 95% probability lung cancer risks (10$^{-6}$ to 10$^{-5}$) are greater than the USEPA acceptable level of 10$^{-6}$ for temple workers and temple goers with high exposure level through inhalation route (Fig. 4A and B). Our result indicates that the higher ILCRs (10$^{-6}$ to 10$^{-4}$) are found in ingestion and dermal contact routes for temple goers/workers (Fig. 4). Notably, a large proportion of the risk comes from above two exposure routes for which they are assumed to occur in the temples.

The probability density functions (pdfs) of TILCRs for temple goers/workers (geometric standard deviations of lognormal distribution range from 1.95 to 2.42) are tended to be skewed (Fig. 5A, C, E). Percentile predictions of TILCRs personal exposure of temple goers/workers could be determined from cumulative density functions (cdfs) corresponding to pdfs. Under most regulatory program, an ILCR between 10$^{-6}$ and 10$^{-4}$ indicates potential risk; moreover, larger than 10$^{-4}$ indicates high potential health risk. All 95% probabilities of B[a]P- and B[a]P$_{eq}$-based TILCRs are larger than 10$^{-6}$, indicating unacceptable probability distributions for temple goers/workers (Fig. 5). For personal extreme exposure to carcinogenic PAH in the temple, 95% probability TILCR (9.87 × 10$^{-4}$ to
1.13 × 10⁻³) is much greater than the range of 10⁻⁶ to 10⁻⁴, indicating high potential health risk to temple workers; whereas for high and moderate exposed groups, 95% probability TILCRs range from 6.44 × 10⁻⁵ to 7.50 × 10⁻⁵ and 5.75 × 10⁻⁶ to 6.99 × 10⁻⁶, respectively (Fig. 5B, D, F), indicating that health risk is alarming to temple goers.

3.5. Sensitivity analysis

For temple goers/workers, the most contributions to variance in risk are 47.2 and 78.0% in air inhalation rate (IRₐ); 54.7 and 78.1% in particle ingestion rate (IRₚ); and 72.6 and 86.1% in particle-to-skin adherence factor (AFₜₚₐₖₚₜ), respectively, for inhalation, ingestion, and dermal contact routes (Fig. 6). Moreover, residence time (RT) (16.9–42.1%) and B[a]P concentration (C_B[a]P) (6–13%) play a more sensitive variable for temple goers, and C_B[a]P (6.7–17.6%) also does for temple workers, in three exposure routes.

The present result indicates that for all exposure routes, the exposures of 365 yr⁻¹ for temple goers yield ILCRs higher than 10⁻⁶. The yielded risk values would be approximately 12-fold times of risk estimates for 33 yr⁻¹. We also calculated a risk-based visiting frequency advice (VFadv) (yr⁻¹) and a suggested amount of incense burning associated with unit occupied volume of temple based on a maximum acceptable individual lifetime risk level of 10⁻⁶. Our results indicate that the B[a]Peq- and B[a]P-based median VFadv for temple goers are estimated to be 312.84 and 462.59 yr⁻¹; 48.15 and 60.01 yr⁻¹; 43.75 and 59.94 yr⁻¹; and 18.08 and 22.67 yr⁻¹, respectively, for inhalation, ingestion, dermal contact, and overall routes. The suggested median incense burning amount for three representative incense types of Taiwan yellow, Taiwan black, and aloes wood range from 0.31 to 0.74, 0.02 to 0.04, and 0.24 to 0.44 g m⁻³; 5.84 to 13.73, 0.31 to 0.81, and 4.49 to 8.16 g m⁻³; and 64.58 to 150.39, 3.49 to 8.95, and 48.87 to 92.33 g m⁻³, respectively, for temple workers and temple goers with high and moderate exposure levels, based on B[a]Peq- and B[a]P-based calculation (Fig. 7).

4. Discussion

We have developed an integrated probabilistic risk assessment framework based on limited reported data to quantify exposure risk of temple goers/workers to airborne polycyclic aromatic hydrocarbons (PAHs) in typical Taiwanese temples. For temple workers, the median and 95th percentile of LADDs of B[a]P and B[a]Peq for overall routes have orders of 10⁻⁵ mg kg⁻¹ d⁻¹, indicating high potential exposure risk. The MMDs of B[a]P are calculated to be 0.293, 0.289, 0.283, and 0.269 μm, respectively, in ET, BB, bb, and AI, indicating that fine particles are apt to exist in the AI region. The average daily doses of B[a]P and B[a]Peq obtained from fine fraction depositing...
Fig. 4. Box and whisker plots of \(\text{BaP}\) and \(\text{BaPeq}\)-based inhalation, ingestion, and dermal contact incremental lifetime cancer risks for (A) temple workers and temple goers with (B) high, and (C) moderate exposure in the temples.

Generally, variables in the numerator of the exposure models (Eqs. (1)–(3)) \((\text{IR}_a, \text{IR}_p, \text{AF}_d, \text{RT}, \text{etc.})\) will tend to be positively correlated with risk, whereas variables in the denominator \((\text{BW})\) will tend to be negatively correlated with risk. Because temple workers spend much longer time in the temples, the variables with the greatest effect on risk are \(\text{IR}_a, \text{IR}_p, \text{and AF}_d\), followed by \(\text{CBaP}\). For temple goers/workers, there are several risk management options, for example (i) to reduce the residence time; (ii) to visit temples with a better ventilation conditions, fewer censers, and a lower required number of joss sticks; (iii) to avoid worshipping on the 1st and 15th days and major religious festivals in each lunar month; (iv) to wear masks; and (v) to maintain the cleanliness of the censers.

In fact, the population groups have different susceptibility for disease. Therefore, the potential risk induced from incense burning for specific subgroups (child, adolescent, and adult) should be taken into account in the future work, especially for child. In light of this aspect, different contact rates \((CR, \text{e.g., } CR=\text{IR}_\text{inh} \text{ through inhalation pathway})\), exposure durations \((ED)\), and subgroup body weights \((BW)\) should be taken into account in the estimates of lifetime average daily dose \((\text{LADD})\). A paradigm for consequent exposure group.
Fig. 6. Sensitivity analysis of inhalation, ingestion, and dermal contact cancer risk models for (A) temple goers and (B) temple workers.

in residential home, the LADD_{inh} should be revised as,
\[
LADD_{inh} = C_a \cdot RT \cdot VF \cdot cf \cdot AT_c \left( \frac{C_{\text{child}} \cdot ED_{\text{child}}}{BW_{\text{child}}} + \frac{C_{\text{adolescent}} \cdot ED_{\text{adolescent}}}{BW_{\text{adolescent}}} + \frac{C_{\text{adult}} \cdot ED_{\text{adult}}}{BW_{\text{adult}}} \right),
\]
where the parameters of \( C_a, RT, VF, cf, \) and \( AT_c \) have been defined in Table 3.

The differences in \( CSF_i \) for different routes of exposure are due in part to the different treatment procedures and to assumptions adopted on animal physiological parameters (e.g., surface area scaling and route-to-route extrapolation factors). The one of the used dermal \( CSF_i \) is based on a gastrointestinal absorption (ABS_{GI}) factor of 0.31 [28]. It is consistent with the following conditions: (i) the critical study upon which the toxicity is based on employing an administered dose (e.g., delivery in diet or by gavages) in its study design and (ii) adjustment of the oral toxicity value is significant only when the ABS_{GI} is <50% [31].

Kameda et al. [32] and Liao and Chiang [14] have evaluated the actual human exposure by HRT model and ILCRs exposed to carcinogenic PAHs, the former estimated the B[a]Peq-based ILCR from ambient using WHO unit risk, whereas the latter used an integrate framework which combine U.S. EPA protocol and probabilistic risk assessment model to assess the B[a]Peq-based ILCR. Recently, the resident home and church were investigated for human exposed to airborne pollutants from indoor activities [33–36], showing that the PAHs and/or PMs in smaller size fraction have significant potential toxicities, especially for ultrafine particles (UFPs). Ott and Siemann [37] monitored the p-PAH emitted from different activity indoors by concentration and active surface methods simultaneously. In the future, the mass concentration of exposure PAHs maybe replaced
dent that our model can be used to assess the cumulative cancer risk easily for any temple exposure scenario. At the same time, the framework also encourages risk managers to establish the appropriate safe airborne PAHs guideline or to quantify rigorous health risk estimates for temple goers/workers.

by number concentration and surface area of UFPs, those can be as ideal dosimetry for toxic exposure. Based on our results and literature evidence, Taiwan regulatory agencies should pay more attention to study UFP number concentrations and carcinogenic compositions in indoor environments and to establish the related criteria of indoor air quality.

We recognize limitations in each of our data sources, particularly the inherent problem of uncertainty and variability of the data. The strength of these results rests on the consistent agreement of mathematical models and public and regulatory authority’s guideline values. Our analysis may provide a wider context for the interpretation of regional PAHs-induced cancer risk estimates that produced diverging and controversial outcomes, which has economic and policy implications. Although more complex models may be necessary to answer specific questions regarding risk or particular management strategies, our simple model captures the particular management strategies, our simple model captures the

In conclusion, our proposed probabilistic risk assessment framework provides a template for integrating the temple PAHs data, human respiratory tract model, and risk modeling techniques to accurately estimate the safe temple visiting frequency guideline associated with the safe incense burning amounts. We are不是很了解...