

## Calculations used to predict geometric mean exposures and exceedance by trade

This supplementary file describes the computational steps involved in the prediction of geometric mean (GM) exposures by trade. Briefly, GMs were predicted for each of the 260 models of the model set, according to the exposure scenario. Multimodel averaged predictions were then computed across the model set. Finally, this procedure was repeated 20 times to account for the variation in individual exposure values imputed from results reported as summary statistics in the source of data. The mean predicted GM by trade across the 20 iterations was used as the final estimate, from which the group exceedance fractions of the ACGIH TLV ( $0.025 \text{ mg m}^{-3}$ ) and Québec OEL ( $0.1 \text{ mg m}^{-3}$ ) were estimated. The following provides a more detailed walkthrough of this process, using the bricklayer/stone mason trade category as an example.

### 1. Prediction for a single model of the model set

The first step involved computing a prediction for each of the 260 models of the model set, based on the variables present in each single model and the exposure scenario. Examples for two of these models are provided, with **Table S1** presenting the model containing all the variables and the three interactions (model weight of 0.019). **Table S2** presents the calculations with the model structure containing only the sampling duration, sample year, project type, sampling strategy and trade variables. For the latter, the parameter estimates of the variables absent from this model were taken as 0 for the calculations. This second model had a very low model weight ( $4.86 \times 10^{-12}$ ) and therefore had a negligible effect on the multimodel averaged prediction.

For both tables, the “multiplicative factor” represents the exposure scenario selected. The intercept is in itself a specific exposure scenario consisting of the reference levels identified in Table 3 of the main article, the earliest sample year of the dataset (1991) and a sampling duration of 1 minute. As we aimed to predict 8h exposures, the sampling duration of 480 minutes was selected. Our predictions were based on the median value of the sample year in the dataset (1999), with the multiplicative factor of 8 representing the difference between 1999 and 1991. For the trade variable, as this example deals with predicting a GM for the category of bricklayer/stone mason, only the corresponding coefficient was selected. Categories of the other variables were given averaged multiplicative factors. For the construction sector variable, the residential and industrial/commercial categories were given factors of 1/3, with a value of 0 given to the “unreported” category. The remaining 1/3 is attributed to the civil engineering category, which is included in the intercept; this therefore corresponds to making a prediction using an average influence of the three types of sectors. Similarly, a factor of 1/2 was given to the compliance strategy, with the remaining 1/2 associated with the category of surveillance included in the intercept. For the interaction between compliance and sampling duration, the multiplicative factor was  $1/2 * \text{LN}(480)$ , or 3.09. The model coefficients ( $\beta$ ) multiplied by their corresponding factors are then summed to obtain the natural logarithm of the predicted GM. The computation of the uncertainty associated with a predicted GM (as its natural logarithm) was based on the variance-covariance matrix of the parameters and is not shown here.

**Table S1** Prediction of a logged GM for the model containing all the variables and interactions (model weight of 0.019)

Variable	$\beta$	Multiplicative factor	$\beta^*$ Multiplicative factor
Intercept	-2.11	1	-2.11
Sampling duration (ln(min))	-0.219	6.17	-1.35
Sample year (-1991)	0.048	8	0.385
Sector - Unreported	0.638	0	0
Sector - Industrial and Commercial	0.601	1/3	0.200
Sector - Residential	0.379	1/3	0.126
Project - New construction	-0.695	1/3	-0.232
Project - Demolition	0.026	1/3	0.009
Project - Unreported	-1.06	0	0
Strategy - Compliance	2.81	1/2	1.40
Workspace - Enclosed/Indoors	0.401	1/2	0.200
Workspace - Unreported	1.52	0	0
Controls - Unreported	-0.472	0	0
Controls - Yes	-0.108	1/2	-0.054
Trade - Other	-1.02	0	0
Trade - Bricklayer/stone mason	0.544	1	0.544
Trade - Cement grinder/concrete finisher	0.812	0	0
Trade - Foreman	-0.154	0	0
Trade - Drilling rig operator	1.66	0	0
Trade - Roofer	1.68	0	0
Trade - Unskilled labor	0.005	0	0
Trade - Skilled labor 2	0.008	0	0
Trade - Heavy equipment operator	-0.330	0	0
Trade - Tunnel construction worker	1.15	0	0
ln(Duration) : Compliance	-0.082	3.09	-0.252
Year(-1991) : Compliance	-0.233	4	-0.932
Workspace : Controls - Interior : Unreported	0.965	0	0
Workspace : Controls - Both unreported	-0.502	0	0
Workspace : Controls - Interior : With controls	-0.152	1/2	-0.076
Workspace : Controls - Unreported : With controls	-1.58	0	0
<b>Sum [ln(mg m<sup>-3</sup>)]</b>			<b>-2.14</b>

The logarithm of the predicted GM (log-GM) for this model was -2.14 ln(mg m<sup>-3</sup>), with a standard error of 0.231.

**Table S2** Prediction of a logged GM for the model containing the sampling duration, sample year, project type, sampling strategy and trade variables (model weight of  $4.86 \times 10^{-12}$ )

Variable	$\beta$	Multiplicative factor	$\beta^*$ Multiplicative factor
Intercept	-0.798	1	-0.798
Sampling duration (ln(min))	-0.372	6.17	-2.29
Sample year (-1991)	-0.028	8	-0.221
<i>Sector - Unreported</i>	0 <sup>a</sup>	0	0
<i>Sector - Industrial and Commercial</i>	0	1/3	0
<i>Sector - Residential</i>	0	1/3	0
Project - New construction	-0.080	1/3	-0.027
Project - Demolition	0.688	1/3	0.229
Project - Unreported	0.108	0	0
Strategy - Compliance	0.567	1/2	0.283
<i>Workspace - Enclosed/Indoors</i>	0	1/2	0
<i>Workspace - Unreported</i>	0	0	0
<i>Controls - Unreported</i>	0	0	0
<i>Controls - Yes</i>	0	1/2	0
Trade - Other	-0.748	0	0
Trade - Bricklayer/stone mason	0.644	1	0.644
Trade - Cement grinder/concrete finisher	0.831	0	0
Trade - Foreman	-0.009	0	0
Trade - Drilling rig operator	1.41	0	0
Trade - Roofer	1.45	0	0
Trade - Unskilled labor	-0.080	0	0
Trade - Skilled labor 2	0.103	0	0
Trade - Heavy equipment operator	-0.268	0	0
Trade - Tunnel construction worker	1.17	0	0
<i>ln(Duration) : Compliance</i>	0	3.09	0
<i>Year(-1991) : Compliance</i>	0	4	0
<i>Workspace : Controls - Interior : Unreported</i>	0	0	0
<i>Workspace : Controls - Both unreported</i>	0	0	0
<i>Workspace : Controls - Interior : With controls</i>	0	1/2	0
<i>Workspace : Controls - Unreported : With controls</i>	0	0	0
<b>Sum [ln(mg m<sup>-3</sup>)]</b>			-2.18

<sup>a</sup> Coefficients of a variable absent of the model are taken as 0

The logarithm of the predicted GM for this model was -2.18 ln(mg m<sup>-3</sup>), with a standard error of 0.173.

## 2. Computation of multimodel averaged predictions

**Table S3** presents a partial list of the 260 model weights and predicted log-GMs of the model set for a single iteration. The computation of a multimodel averaged prediction first involved multiplying the 260 predicted log-GMs by their corresponding model weights. The sum of these weighted GMs represents the log of geometric mean exposure for the bricklayer/stone mason trade category from the 260 models.

**Table S3** Partial list of model weights, predicted log-GMs and weighted predicted GMs for a single iteration

Model rank	Model weight	Predicted log GM ln(mg m <sup>-3</sup> )	Weighted log GM ln(mg m <sup>-3</sup> )
1	2.29E-01	-2.40	-5.49E-01
2	1.71E-01	-2.33	-3.99E-01
3	9.63E-02	-2.26	-2.18E-01
4	8.42E-02	-2.40	-2.02E-01
5	7.42E-02	-2.33	-1.73E-01
...	...	...	...
260	1.11E-28	-1.97	-2.19E-28
Sum [ln(mg m <sup>-3</sup> )]			-2.31E+00

The multimodel averaged predicted GM for this iteration is therefore  $e^{-2.31}$  or 0.099 mg m<sup>-3</sup>. The standard error of the predicted GM, computed over the 260 models, was  $e^{0.219}$  or 1.24. The details of how uncertainty is estimated in a multimodel averaging framework can be found in Burnham and Anderson (2002)<sup>1</sup>, with the specific equation given in page 162.

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<sup>1</sup> K. P. Burnham and D. R. Anderson, *Model selection and multimodel inference: a practical information-theoretic approach*, 2<sup>nd</sup> ed., Springer, New York, NY, 2002

### 3. Computation of a mean predicted GM across the 20 iterations of the Monte-Carlo simulation.

The computation of multimodel averaged predictions in steps 1 and 2 were repeated for the 20 iterations of the Monte-Carlo simulation procedure. **Table S4** presents the predicted GMs and standard errors for the bricklayer/stone mason trade category for each of the 20 iterations, with the value for the first iteration being the one illustrated previously. The values found in Table 6 of the main article were obtained by taking the arithmetic mean of the 20 values for the two estimates. In order to assess the variability of predicted GM across the 20 iterations, we calculated relative standard deviations (RSD) by dividing the standard deviations of the 20 predictions with its average value, for an RSD of approximately 2% for the bricklayer/stone mason trade.

**Table S4** Multimodel averaged predicted GM exposure and unconditional standard errors for the bricklayer/stone mason trade for by iteration

Iteration	Multimodel averaged predicted GM (mg m <sup>-3</sup> )	Standard error
1	0.099	1.24
2	0.100	1.25
3	0.103	1.25
4	0.098	1.25
5	0.101	1.24
6	0.100	1.24
7	0.102	1.24
8	0.097	1.24
9	0.100	1.24
10	0.100	1.24
11	0.102	1.25
12	0.099	1.24
13	0.101	1.24
14	0.097	1.24
15	0.101	1.24
16	0.103	1.25
17	0.102	1.25
18	0.103	1.24
19	0.099	1.24
20	0.100	1.24
Mean <sup>a</sup>	0.100	1.24
SD <sup>b</sup>	1.82E-03	
RSD <sup>c</sup> (%)	1.82	

<sup>a</sup> Arithmetic mean of the 20 iterations. <sup>b</sup> Standard deviation of the 20 iterations. <sup>c</sup> Relative standard deviation across the 20 iterations.

The 95% approximate confidence interval on the prediction was calculated from the natural logarithm of the mean predicted GM of 0.100 mg m<sup>-3</sup> and mean unconditional standard error of 1.24, for an interval of 0.065–0.154 mg m<sup>-3</sup> following exponentiation. These values were used in Figure 1 of the main article.

#### 4. Computation of the group exceedance fractions

Table 6 of the main article presents the estimated fractions of exposure expected to exceed a given occupational exposure limit (OEL) by trade category. These group exceedance fractions ( $\Theta$ ) were computed using equation 1 with the mean predicted GMs, the ACGIH TLV or the Quebec OEL, and for the geometric standard deviation (GSD), the exponent of the mean value of the scale parameter averaged over the 260 models and 20 iterations (GSD of 5.2).  $\Phi$  in equation 1 refers to the cumulative  $N(0,1)$  distribution function, given by the functions pnorm in R and NORMSDIST in Excel.

$$\Theta = 1 - \Phi \left[ \frac{\ln(OEL) - \ln(\text{mean predicted GM})}{\ln(GSD)} \right] \quad (1)$$

The predicted exceedance fraction of the Québec OEL (0.1 mg m<sup>-3</sup>) for the bricklayer/stone mason category is then given by:

$$\Theta = 1 - \Phi \left[ \frac{\ln(0.1 \text{ mg m}^{-3}) - \ln(0.100 \text{ mg m}^{-3})}{\ln(5.2)} \right] = 0.50 \text{ or } 50\%$$