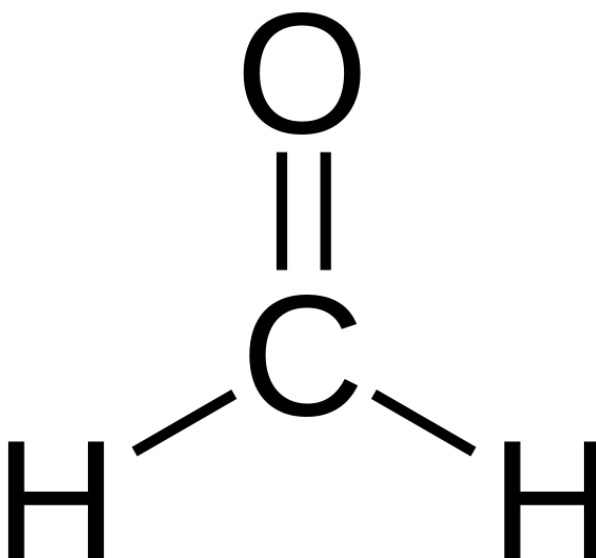

Draft Risk Evaluation for Formaldehyde

Systematic Review Supplemental File:

Data Quality Evaluation Information for
General Population, Consumer, and Environmental Exposure

CASRN: 50-00-0



March 2024

This supplemental file contains information regarding the data extraction results for data sources that met the PECO screening criteria for the *Draft Consumer Exposure Assessment for Formaldehyde* {U.S. EPA, 2024, 11347019}, *Draft Indoor Air Exposure Assessment for Formaldehyde* {U.S. EPA, 2024, 11347020}, *Draft General Population Exposure Assessment for Formaldehyde* {U.S. EPA, 2024, 11347021}, and *Environmental Exposure Assessment for Formaldehyde* {U.S. EPA, 2024, 11347119}. EPA performs data extraction as part of the TSCA systematic review process described in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* {U.S. EPA, 2021, 10415760}. The systematic review steps are further described in the Draft Risk Evaluation for Formaldehyde – Systematic Review Protocol U.S. EPA, 2023, 11151804.

Additionally, the overall quality determination (OQD) for each reference represents the data as a whole for each evidence stream, not for individual scenarios described within a study. For example, a reference that has both monitoring and experimental data would have OQDs using the data quality evaluation metrics for monitoring and experimental data, respectively. An OQD utilizing the data quality evaluation metrics for monitoring data, or any other single evidence stream, would consider all data pertinent to that evidence stream in the reference. Acronyms and abbreviations used within this supplemental file are defined in the table at the end of this file. This supplemental file may also be referred to as Formaldehyde Data Quality Evaluation Information for General Population, Consumer, and Environmental Exposure.

Table of Contents

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22183	Matthews, T. G., Fung, K. W., Tromberg, B. J., Hawthorne, A. R. (1986). Surface emission monitoring of pressed-wood products containing urea-formaldehyde resins. Environment International 12:301-309.	280

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4646215	Ng, L., Poppendieck, D., Dols, W. S., Emmerich, S. J. (2018). Evaluating indoor air quality and energy impacts of ventilation in a net-zero energy house using a coupled model. 24:124-134.	293
5645091	Davis, A. Y., Zhang, Q., Wong, J. P. S., Weber, R. J., Black, M. S. (2019). Characterization of volatile organic compound emissions from consumer level material extrusion 3D printers. <i>Building and Environment</i> 160.	294
5943658	Matthews, T. G., Reed, T. J., Tromberg, B. J., Daffron, C. R., Hawthorne, A. R. (1985). Formaldehyde emission from combustion sources and solid formaldehyde-resin-containing products - Potential impact on indoor formaldehyde concentrations. <i>Advances in Chemistry Series</i> 210:131-150.	295
5950617	Dong, H., Yue, G., Li, M. (2016). Characteristics of formaldehyde emission from indoor crib. 3:283-287.	296
11181057	U.S. EPA, (2016). Formaldehyde from composite wood products: Exposure assessment for TSCA Title VI Final Rule.	297
Glossary of Select Terms for Data Evaluation Tables		298

Study Citation:	Bracken, M. J., Leasa, D. J., Morgan, W. K. C. (1985). Exposure to formaldehyde: Relationship to respiratory symptoms and function. Canadian Journal of Public Health 76:312-316.			
HERO ID:	3481			
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Sampling Methodology	Medium	The study provides limited description of sampling methods.	
	Metric 2: Analytical Methodology	Low	There is a limited description of analytical methods. Information missing such as LOQ, LOD, detection limits, and/or reporting limits of the formaldehyde, and recoveries, is likely to have a substantial impact on results.	
	Metric 3: Biomarker Selection	N/A	The study is testing for the parent chemical in an environmental media (air).	
Domain 2: Representativeness	Metric 4: Geographic Area	High	Canada	
	Metric 5: Currency	Low	Timing of sample collection for monitoring data was not provided but the study was published in October 1985.	
	Metric 6: Spatial and Temporal Variability	Medium	The study used a large sample size (>100 samples in total), however, no replicate samples were mentioned in the study.	
	Metric 7: Exposure Scenario	High	Data closely represent relevant exposure scenarios; general population living in urea-formaldehyde foam insulation homes and hospital pathology technicians exposed to "high concentrations of formaldehyde while at work".	
Domain 3: Accessibility/Clarity	Metric 8: Reporting of Results	Medium	The study only provided summary statistics. Supplementary or raw data (i.e., individual data points) are not reported, and therefore summary statistics cannot be reproduced.	
	Metric 9: Quality Assurance	Low	QA/QC techniques and results are not directly discussed but can be implied by the use of NIOSH methods cited.	
Domain 4: Variability and Uncertainty				
	Metric 10: Variability and Uncertainty	Low	Key uncertainties and study limitations are not discussed.	

Overall Quality Determination**Medium**

Study Citation:		Seifert, B., Becker, K., Helm, D., Krause, C., Schulz, C., Seiwert, M. (2000). The German environmental survey 1990/1992 (GerES II): reference concentrations of selected environmental pollutants in blood, urine, hair, house dust, drinking water and indoor air. Journal of Exposure Analysis and Environmental Epidemiology 10:552-565.		
HERO ID:		13249		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods not reported such as sampler calibration
	Metric 2:	Analytical Methodology	High	LOQ reported
	Metric 3:	Biomarker Selection	N/A	Study tests for parent chemicals.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Germany
	Metric 5:	Currency	Low	Samples collected between 1985 and 1992.
	Metric 6:	Spatial and Temporal Variability	High	>10 samples; no replicates
	Metric 7:	Exposure Scenario	Medium	Exposure source not well characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data not reported
	Metric 9:	Quality Assurance	High	QA reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Few gaps and limitations reported
Overall Quality Determination			Medium	

Study Citation:		Gupta, K. C., Ulsamer, A. G., Preuss, P. W. (1982). Formaldehyde in indoor air: Sources and toxicity. Environment International 8:349-358.		
HERO ID:		21861		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Low	A single measurement was taken per home or mobile home by "a modified NIOSH chromotropic acid or equivalent method;" no further sampling information for Table 1 was reported.
	Metric 2:	Analytical Methodology	Low	For Table 1, analysis for HCHO was via "a modified NIOSH chromotropic acid or equivalent method" for which the LOD apparently was 0.01 mg/m3. For Table 2, "conditions closely resembling Japanese Desiccator Test" were used, and the results were reported as "preliminary." No additional information on analytic methods was reported. Emission studies were conducted by the Inhalation Toxicology Research Institute in Albuquerque, NM.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of exposure were evaluated.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Locations of the > 1,000 homes sampled based on complaints to the Consumer Product Safety Commission (CPSC) were not specified (assume all in the United States); HCHO emission rates were evaluated for specific materials in a laboratory in Albuquerque, NM.
	Metric 5:	Currency	Low	Sampling dates were not reported, but must have been before or up to the publication year of 1982.
	Metric 6:	Spatial and Temporal Variability	Low	Table 1 data on indoor home air HCHO are uninformative because only a single sample taken per home. For Table 2, the emission range for each material tested represents 2 or more tests on 3 to 5 samples per material category.
	Metric 7:	Exposure Scenario	Low	The "indoor air" exposure scenario is not described.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	The air concentrations were summarized by sample size, mean, and range (no SD) in Table 1, and emission rates were summarized by range only (with detection limit not reported).
	Metric 9:	Quality Assurance	Low	The authors did not directly mention QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Uncertainty and variability were not discussed beyond what could be inferred from the data tables (1 and 2).
Overall Quality Determination			Low	

Study Citation:		Kalinic, N., Fugas, M., Sega, K., Sisovic, A. (1986). Formaldehyde levels in selected indoor microenvironments. Environment International 12:297-299.		
HERO ID:		22182		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Some sampling methods not reported such as sample storage conditions and sampler calibration
	Metric 2:	Analytical Methodology	Medium	Recovery samples not reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Croatia
	Metric 5:	Currency	Low	Study published in 1986
	Metric 6:	Spatial and Temporal Variability	Medium	>10 samples; no replicates
	Metric 7:	Exposure Scenario	Medium	Exposure source not well characterized
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	High	Raw data reported
	Metric 9:	Quality Assurance	Low	QA not reported
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	Gaps and limitations not reported
Overall Quality Determination		Medium		

March 2024

Formaldehyde

Monitoring

HERO ID: 22183

Study Citation:		Matthews, T. G., Fung, K. W., Tromberg, B. J., Hawthorne, A. R. (1986). Surface emission monitoring of pressed-wood products containing urea-formaldehyde resins. Environment International 12:301-309.		
HERO ID:		22183		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
Metric 1:	Sampling Methodology	High	HCHO concentrations were measured in indoor air at two experimental houses for 16 different environmental conditions spanning 17 to 29 degrees C and 41% to 88% RH. Conditions were controlled for 2 to 4 days prior to measurements to allow quasi-steady-state conditions. Internal circulating fans operated continuously. Samples were taken at three locations (living room and two bedrooms).	
Metric 2:	Analytical Methodology	Low	The LOD was not reported for the air measurements, just for the board emission rate measures. Formaldehyde vapor concentrations were measured over 30 minutes (30 liters pumped air) using a 13X molecular sieve sorbent as described in Matthews et al. (1982) as developed at the Oak Ridge National Laboratory over several years.	
Metric 3:	Biomarker Selection	N/A	Biomarkers of exposure were not evaluated.	
Domain 2: Representativeness				
Metric 4:	Geographic Area	High	Air samples (and carpet/floor emission rates) were taken from experimental houses in Oak Ridge, TN, USA.	
Metric 5:	Currency	Low	The dates of experimental house sampling were not listed, but likely occurred in 1983 when board sampling also occurred.	
Metric 6:	Spatial and Temporal Variability	Medium	HCHO vapor samples were collected in three different rooms in each of the two experimental houses (total of six rooms) over a total of 16 different relative humidity and air temperature combinations.	
Metric 7:	Exposure Scenario	Medium	The experimental houses were built to simulate real home configuration, HCHO vapor sources, and ventilation, but were unfurnished and unoccupied.	
Domain 3: Accessibility/Clarity				
Metric 8:	Reporting of Results	Medium	Raw data for measured HCHO vapor can be read from Figure 2. Summary statistics were not compiled for air measurements (presented in Table 3); however, the coefficient of variation for HCHO was reported to average 7%.	
Metric 9:	Quality Assurance	Low	Quality assurance was not discussed; however, the comparison among methods and description of the continued refinement of formaldehyde measurement methods at Oak Ridge National Laboratory suggest high quality assurance.	
Domain 4: Variability and Uncertainty				
Metric 10:	Variability and Uncertainty	Medium	The authors discussed variation in factors (e.g., air flow, temperature, building materials) that could affect concentrations of HCHO vapors. The demonstrated agreement between measured air concentrations and modeled concentrations based on measured flooring HCHO emission rates (correlation coefficient 0.90) indicated reasonable precision.	
Overall Quality Determination			Medium	

Study Citation:		Dally, K. A., Hanrahan, L. P., Woodbury, M. A., Kanarek, M. S. (1981). Formaldehyde exposure in nonoccupational environments. Archives of Environmental and Occupational Health 36:277-284.		
HERO ID:		22217		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Structures investigated by the Wisconsin Division of Health after receiving complaints of health problems from occupants. Standard collection protocol provided on p.278 last paragraph. Air samples collected in rooms most frequented (primarily the kitchen, living room, bedrooms, and bathroom). Air was sampled with midge impingers. Samples were collected utilizing the NIOSH chromotropic acid procedure. Samples stored in bottles and refrigerated until analysis.
	Metric 2:	Analytical Methodology	Medium	Air samples were analyzed utilizing the NIOSH chromotropic acid procedure. Limit of detection was 0.1 ppm. Recovery samples not discussed.
	Metric 3:	Biomarker Selection	N/A	This study measured parent chemical in air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	This study was conducted in Wisconsin, USA.
	Metric 5:	Currency	Low	This study was conducted from January 1978 to November 1979.
	Metric 6:	Spatial and Temporal Variability	High	100 structures sampled over more than a year time period. 2 to 11 air samples were taken in different locations within the home. Table 3 provides types of homes sampled. Except for apartment and modular homes, all other type of homes sampled at least twice. Personal air collected for 30-60 minutes.
	Metric 7:	Exposure Scenario	High	Indoor air sampled to determine the concentration of formaldehyde in the home of people reporting health problems. Table 3 presents the concentration per the type of home and age of urea-formaldehyde containing material.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Formaldehyde concentration in ppm (median and range) provided in Table 3. The highest reported value in a home was 4.18 ppm. Raw data not provided. Only the overall detection frequency for all homes was provided (20%).
	Metric 9:	Quality Assurance	Low	QA/QC not directly discussed, but implied through the use of standard protocols.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability of the samples within each structure was examined by pairing sample locations to construct an 11 X 11 correlation matrix. The paper discussed how the concentrations can vary depending on the age of home. The paper briefly discussed how cigarette smoke can affect formaldehyde concentrations.
Overall Quality Determination			Medium	

Study Citation:		Georghiou, P. E., Snow, D., Williams, D. T. (1983). Formaldehyde monitoring in urea-formaldehyde foam-insulated houses in St. John’s, Newfoundland, Canada: Correlative field evaluation of a real-time infrared spectrophotometric method. Environment International 9:279-287.		
HERO ID:		22629		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The air sampling methodology was well described, citing NIOSH methods.
	Metric 2:	Analytical Methodology	Low	The analytical methods were not described in detail. The authors reported the LOD, but not the recoveries.
	Metric 3:	Biomarker Selection	N/A	The authors analyzed air samples.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Canada
	Metric 5:	Currency	Low	The air samples were taken in 1981.
	Metric 6:	Spatial and Temporal Variability	Low	n=50 households, <5 replicates per household.
	Metric 7:	Exposure Scenario	High	The data closely represent relevant exposure scenarios related to indoor airborne concentrations of formaldehyde in Canadian households with urea-formaldehyde foam-insulation.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Independent sample concentrations and limited summary statistics were reported (maximum concentrations).
	Metric 9:	Quality Assurance	Medium	QA/QC techniques were not described but control samples were analyzed.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Variability was not characterized. Uncertainties and study limitations were not discussed.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Monitoring

HERO ID: 22630

Study Citation:		Gesser, H. D. (1984). The reduction of indoor formaldehyde gas and that emanating from urea formaldehyde foam insulation (UFFI). Environment International 10:305-307.		
HERO ID:		22630		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Critically Deficient	UFFI FDH emissions in experimental setting: Sampling methodology in terms of equipment, sample storage not described, however procedures within experimental setting described briefly. House FDH sampling: sampling methodology not discussed.
	Metric 2:	Analytical Methodology	Critically Deficient	UFFI FDH emissions in experimental setting: Analytical methods (House FDH sampling): analytical methodology not discussed.
	Metric 3:	Biomarker Selection	N/A	Sampling for parent chemicals of interest in air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	Critically Deficient	Geographic location is not reported, discussed or referenced.
	Metric 5:	Currency	Low	No dates of sampling reported. Publication date noted as 1984.
	Metric 6:	Spatial and Temporal Variability	Medium	Replicate sampling within experimental setting on UFFI FDH emissions over four months. Housing FDH sampling conducted with replicate samples with different filters within four houses.
	Metric 7:	Exposure Scenario	Medium	This was a report on an experimental study of UFFI FDH emissions as well as FDH within homes using different air filters. Exposure source within both scenarios was the UFFI foam insulation.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Raw data reported in Figure 1, however the number of samples and sampling schedule is unclear. Summary statistics included levels reported in Tables 1 and 2.
	Metric 9:	Quality Assurance	Low	Quality assurance not discussed.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Characterization of variability over time for results reported within the experiment, study limitations not discussed.

Overall Quality Determination**Uninformative**

March 2024

Formaldehyde

Monitoring

HERO ID: 22861

Study Citation:		Dement, J. M., Smith, N. D., Hickey, J. L. S., Williams, T. M. (1984). An evaluation of formaldehyde sources, exposures and possible remedial actions in two office environments. 3:99-104.		
HERO ID:		22861		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methods for office indoor air were described, including equipment and site information, but not in great detail.
	Metric 2:	Analytical Methodology	Low	Paper cites NIOSH Manual for analytical methods (Method 127 and 125). Detection limits not reported.
	Metric 3:	Biomarker Selection	N/A	Study measured parent chemical in indoor air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	Critically Deficient	Geographic location not indicated.
	Metric 5:	Currency	Low	Table 2 indicates sampling for office building conducted from 1981-1983. Paper published in 1984.
	Metric 6:	Spatial and Temporal Variability	Medium	12 modular offices sampled (24 samples unoccupied without ventilation, 39 occupied before improvements, and 6 occupied after improvements). 1 new office building sampled (18 initial samples, 155 interim sampling, and 10 recent sampling). Replicate sampling for modular offices not provided. Periodic sampling performed over 3 years. No further information on timing provided.
	Metric 7:	Exposure Scenario	High	Sampling indoor air of two different office environments.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Table 1 provides the range of average values for modular offices. Table 2 provides the average concentration in the new office building. No other statistics provided. No raw data provided.
	Metric 9:	Quality Assurance	Low	QA/QC no discussed, but implied through the study's use of standard lab methods
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Paper briefly discusses variability with increased ventilation. Gaps and limits not reported.
Overall Quality Determination		Uninformative		

March 2024

Formaldehyde

Monitoring

HERO ID: 22912

Study Citation:		Andersen, I., Lundqvist, G. R., Molhave, L. (1975). Indoor air pollution due to chipboard used as a construction material. Atmospheric Environment 9:1121-1127.		
HERO ID:		22912		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling method for measuring indoor air of homes was described, including equipment, procedure, and sample information. Sample storage conditions and duration not addressed.
	Metric 2:	Analytical Methodology	Medium	Lab analysis carried out with the chromotrophic acid method. Reference citation provided. Detection limit provided. No further discussion on analytical methodology provided.
	Metric 3:	Biomarker Selection	N/A	Study measured parent chemical in indoor air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in Jutland, Denmark.
	Metric 5:	Currency	Low	Samples collected in 1973.
	Metric 6:	Spatial and Temporal Variability	Medium	25 rooms in 23 dwellings (houses or flats) were measured from February to September. No replicates indicated.
	Metric 7:	Exposure Scenario	High	Indoor air samples collected from dwellings where chipboard was used in walls, floors, and ceilings.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Table 1 provides the concentration (mean and number of samples) per dwelling. Figure 1 shows the distribution of formaldehyde concentrations in dwellings.
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not discussed. No deficiencies indicated.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	There was limited discussion about concentrations variability by age of the house and use of chipboard as building material versus fixtures only. There was not discussion of uncertainty, gaps in the study, or study limitations.
Overall Quality Determination			Medium	

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Formaldehyde

Monitoring

HERO ID: 23810

Study Citation:		van Netton, C., Shirtliffe, C., Svec, J. (1988). Formaldehyde release characteristics from a Swedish floor finish. Bulletin of Environmental Contamination and Toxicology 40:672-677.		
HERO ID:		23810		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Sampling methodology discussed, including sampling equipment, procedure (van Netten, 1983), duration, and calibration.
	Metric 2:	Analytical Methodology	Low	Analytical methods discussed. Reporting limits not provided, but paper stated that determinations were made using the NIOSH chromatographic acids method.
	Metric 3:	Biomarker Selection	N/A	Analyte measured is a parent chemical in indoor air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Monitoring performed in Vancouver, British Columbia
	Metric 5:	Currency	Low	Date of sampling not provided, but paper published in 1988.
	Metric 6:	Spatial and Temporal Variability	Medium	3 dwellings sampled. Three 15-minutes air samples collected at different temperatures. 4 rooms per dwelling sampled. No replicate samples.
	Metric 7:	Exposure Scenario	High	Indoor air measured in dwellings with floors finished with urea formaldehyde foam insulation (UFFI).
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Table 1 provides the individual sample concentrations by dwelling and temperature. No summary stats provided.
	Metric 9:	Quality Assurance	Low	Control samples collected. No recoveries reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability between the three dwellings and temperatures discussed. Limitations and uncertainties were not discussed.
Overall Quality Determination			Medium	

Study Citation:	Van der Wal, J. F. (1982). Formaldehyde measurements in Dutch houses, schools and offices in the years 1977-1980. Atmospheric Environment 16:2471-2478.			
HERO ID:	26999			
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Sampling Methodology	Medium	Some sampling methods not reported such as sample storage conditions and sampler calibration	
	Metric 2: Analytical Methodology	Medium	Recovery samples not reported	
	Metric 3: Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.	
Domain 2: Representativeness	Metric 4: Geographic Area	High	Netherlands	
	Metric 5: Currency	Low	Studies published in 1982	
	Metric 6: Spatial and Temporal Variability	Medium	>10 samples; no replicates	
	Metric 7: Exposure Scenario	Medium	Exposure source not well characterized	
Domain 3: Accessibility/Clarity	Metric 8: Reporting of Results	High	Raw data reported	
	Metric 9: Quality Assurance	Low	Limited QA reported	
Domain 4: Variability and Uncertainty	Metric 10: Variability and Uncertainty	Low	Few gaps and limitations reported	
Overall Quality Determination		Medium		

Study Citation:		Raiyani, C. V., Shah, S. H., Desai, N. M., Venkaiah, K., Patel, J. S., Parikh, D. J., Kashyap, S. K. (1993). Characterization and problems of indoor pollution due to cooking stove smoke. Atmospheric Environment 27A:1643-1655.		
HERO ID:		28657		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear, detailed, and appropriate. Details such as sampler calibration are provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear, detailed, and appropriate; however, no LOD is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in India.
	Metric 5:	Currency	Low	Air samples were collected in 1987.
	Metric 6:	Spatial and Temporal Variability	High	20 samples were collected as shown in Table 2.
	Metric 7:	Exposure Scenario	High	The study is testing for formaldehyde in indoor air during cooking in homes. This scenario is of interest for the chemical and is well characterized.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	The mean and coefficient of variation are provided in Table 2. Raw data is not given.
	Metric 9:	Quality Assurance	Medium	QA/QC measures are discussed, including the use of blanks and controls. QA/QC issues were not identified.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	The coefficient of variation is provided in Table 2. No other characterization of variability or uncertainty is provided.
Overall Quality Determination			Medium	

Study Citation:		Nitschke, I. A., Traynor, G. W., Wadach, J. B., Clarkin, M. E., Clarke, W. A. (1985). Indoor air quality, infiltration and ventilation in residential buildings.		
HERO ID:		34686		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sample storage conditions not reported
	Metric 2:	Analytical Methodology	Low	LOD nor LOQ reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	US
	Metric 5:	Currency	Low	Study published in 1985
	Metric 6:	Spatial and Temporal Variability	High	>10 samples; replicates
	Metric 7:	Exposure Scenario	Medium	Exposure source not well characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	raw data not reported
	Metric 9:	Quality Assurance	High	QA reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Some limitations reported
Overall Quality Determination			Medium	

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Formaldehyde

Monitoring

HERO ID: 34687

Study Citation:		Leaderer, B. P., Zagraniski, R. T., Berwick, M., Stolwijk, J. A. J. (1986). Assessment of exposure to indoor air contaminants from combustion sources: methodology and application. American Journal of Epidemiology 124:275-289.		
HERO ID:		34687		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	Sampling method of indoor air monitoring discussed in the third level. Diffusion tubes measured in the kitchen, living room, and bedroom. The paper also discussed the sampling procedures.
	Metric 2:	Analytical Methodology	Critically Deficient	Analytical methodology not described.
	Metric 3:	Biomarker Selection	N/A	Study measured parent chemical in indoor air.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Study performed in New Haven, Connecticut.
	Metric 5:	Currency	Low	Study performed from in 1983.
	Metric 6:	Spatial and Temporal Variability	High	10 homes measured over two-week period, for a total of 57 unit of observations for formaldehyde.
	Metric 7:	Exposure Scenario	High	Concentrations in indoor air of homes.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	p. 280 last paragraph presents the average level and std deviation. No other summary data or raw data provided.
	Metric 9:	Quality Assurance	Low	The use of controls were discussed, but no other key QA reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The paper discussed variability between residence categories (kerosene heaters vs non kerosene heaters) and how too few observations did not allow for further comparisons (smoking vs nonsmoking). Other uncertainties, limitations, or data gaps were not discussed.
Overall Quality Determination		Uninformative		

Study Citation:	Wieslander, G., Norbäck, D., Björnsson, E., Janson, C., Boman, G. (1996). Asthma and the indoor environment: The significance of emission of formaldehyde and volatile organic compounds from newly painted indoor surfaces. International Archives of Occupational and Environmental Health 69:115-124.			
HERO ID:	81160			
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Most necessary sampling methods were reported. The study did not report sampler calibration or sampler storage conditions.
	Metric 2:	Analytical Methodology	Low	The LOD nor LOQ were reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in Uppsala, Sweden.
	Metric 5:	Currency	Low	The study was published in 1997.
	Metric 6:	Spatial and Temporal Variability	Medium	There were 62 samples collected but no replicates (as reported in Table 6).
	Metric 7:	Exposure Scenario	High	The study used regression models to link formaldehyde levels with the type of house and house characteristics.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Low	Raw data were not reported. The study only reported the mean formaldehyde levels.
	Metric 9:	Quality Assurance	Low	The study reported limited QA.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination			Low	

Study Citation:		Williams, I. D., Revitt, D. M., Hamilton, R. S. (1996). A comparison of carbonyl compound concentrations at urban roadside and indoor sites. Science of the Total Environment 189/190:475-483.		
HERO ID:		81275		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Sampling method for ambient air sampling near roads were described in detail, including sampling procedures and use of EPA Method TO5.
	Metric 2:	Analytical Methodology	High	Analytical methodology was discussed in detail, including extraction method, calibration procedures, recoveries, and LOD (Table 1).
	Metric 3:	Biomarker Selection	N/A	Study measured parent chemical in ambient air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Study performed in London, United Kingdom.
	Metric 5:	Currency	Low	Study was performed in 1991 and 1992.
	Metric 6:	Spatial and Temporal Variability	High	Four sites in two locations were sampled. 26 and 47 samples at Ealing and Wood Green locations respectively during 1991 and 1992. Table 2 provides number of samples for each site (17, 9, 40, and 7).
	Metric 7:	Exposure Scenario	High	Ambient air samples collected at residential and commercial roadside sites.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Table 2 provides the mean, std dev, range, and DF at each site. Raw data not provided. Table 3 provides concentrations at the Wood Green site by morning and afternoon collection periods.
	Metric 9:	Quality Assurance	High	Key QA reported including use of blanks and recoveries.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Results are compared to previously reported measurements in the UK and with indoor air measurements. SD is provided. The advantages and limitations of the method employed are discussed.
Overall Quality Determination			High	

Study Citation:		Sakai, K., Norbäck, D., Mi, Y., Shibata, E., Kamijima, M., Yamada, T., Takeuchi, Y. (2004). A comparison of indoor air pollutants in Japan and Sweden: Formaldehyde, nitrogen dioxide, and chlorinated volatile organic compounds. Environmental Research 94:75-85.		
HERO ID:		89521		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling method discussed but missing details like storage time and sampling instrumentation calibration
	Metric 2:	Analytical Methodology	Medium	Analysis detailed but missing details on calibration and spike matrix
	Metric 3:	Biomarker Selection	N/A	Air concentration measurements
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Japan and Sweden
	Metric 5:	Currency	Low	Data collected in 1998
	Metric 6:	Spatial and Temporal Variability	Medium	No replicates collected
	Metric 7:	Exposure Scenario	High	Indoor and outdoor air concentrations in urban dwellings
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	No raw data reported.
	Metric 9:	Quality Assurance	Medium	Detailed detection limit, reproducibility and storage stability
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Didn't sample in various seasons. Relatively small sample size and overall sample duration (1 month in Japan and 4 months in Sweden)
Overall Quality Determination			Medium	

Study Citation:		Gilbert, N. L., Gauvin, D., Guay, M., Heroux, M. E., Dupuis, G., Legris, M., Chan, C. C., Dietz, R. N., Levesque, B. (2006). Housing characteristics and indoor concentrations of nitrogen dioxide and formaldehyde in Quebec City, Canada. Environmental Research 102:1-8.		
HERO ID:		95801		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Detailed methods
	Metric 2:	Analytical Methodology	Medium	Reported LOD, limited description of methods
	Metric 3:	Biomarker Selection	N/A	Did not test for biomarkers, analyzed air samples for parent chemical
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Canada
	Metric 5:	Currency	Medium	Sampling in 2005
	Metric 6:	Spatial and Temporal Variability	High	93 sampling sites, with replicates
	Metric 7:	Exposure Scenario	High	Data closely represent relevant exposure scenarios related to airborne formaldehyde in homes from Quebec City, Canada
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics
	Metric 9:	Quality Assurance	Medium	Analyzed control samples, limited QA/QC description
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Study characterized variability, discussed uncertainties and limitations
Overall Quality Determination			High	

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Formaldehyde

Monitoring

HERO ID: 106705

Study Citation:		Baez, A. P., Padilla, H. G., Garcia, R. M., Belmont, R. D., Torres Mdel, C. (2004). Measurements of carbonyls in a 13-story building. Environmental Science and Pollution Research 11:400-404.		
HERO ID:		106705		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methodology is discussed and is generally appropriate (i.e., scientifically sound); however, some information is missing such as sampling storage duration and the matrix characteristics (e.g., the phase of air) are not reported.
	Metric 2:	Analytical Methodology	High	The analytical method used was not a publicly available method from a trusted or authoritative source, but the methodology is clear and appropriate. Samples were analyzed by HPLC-UV/VIS and the analytical detection limit was reported.
	Metric 3:	Biomarker Selection	N/A	The study tested for the parent chemical in environmental media (air).
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Mexico City, Mexico.
	Metric 5:	Currency	Low	The samples were collected during two sampling periods. The first sampling period was between April 20 and 29, 1998. The second sampling period was between December 1 and 23, 1998.
	Metric 6:	Spatial and Temporal Variability	High	Replicate samples were collected and used to determine sampling precision. A total of 90 indoor air samples (at 5 sites) were collected and 44 outdoor air samples were collected during the two phases of the sampling campaigns.
	Metric 7:	Exposure Scenario	High	Data likely represent relevant exposure scenarios related to airborne formaldehyde in indoor and outdoor spaces.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported. Summary statistics (mean, standard deviation, minimum, and maximum) were reported in Tables 1a and 2.
	Metric 9:	Quality Assurance	High	QA/QC measures were discussed such as determining cartridge collection efficiency (>95%), analyzing cartridge laboratory blanks and cartridge field controls to determine background levels, and determining sampling precision.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability is characterized in the media studied. Standard deviation is reported, and seasonal and locational variability is investigated. The study has limited discussion of key uncertainties, limitations, and data gaps.
Overall Quality Determination			High	

Study Citation:	Lee, S. C., Li, W. M., Ao, C. H. (2002). Investigation of indoor air quality at residential homes in Hong Kong - case study. Atmospheric Environment 36:225-237.			
HERO ID:	180286			
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Sampling Methodology	High	The sampling methodology was detailed in section 3 of the article.	
	Metric 2: Analytical Methodology	Medium	The analytical methodology was detailed in section 3 of the article, including LOD but not recoveries.	
	Metric 3: Biomarker Selection	N/A	The authors analyzed air samples.	
Domain 2: Representativeness	Metric 4: Geographic Area	High	The study was conducted in Hong Kong.	
	Metric 5: Currency	Low	the samples were collected from July to October 1999	
	Metric 6: Spatial and Temporal Variability	Medium	<10 samples were collected, with less than 5 replicates per sampling site.	
	Metric 7: Exposure Scenario	High	Exposure scenarios are relevant to the risk evaluation of airborne formaldehyde in Hong Kong.	
Domain 3: Accessibility/Clarity	Metric 8: Reporting of Results	Medium	The authors reported summary statistics and raw data per house.	
	Metric 9: Quality Assurance	Low	QA/QC techniques were briefly described.	
Domain 4: Variability and Uncertainty	Metric 10: Variability and Uncertainty	Low	Variability was characterized (error bars, range, SD). Limitations were not reported.	
Overall Quality Determination		Medium		

Study Citation:		Guggisberg, M., Hessel, P. A., Michaelchuk, D., Atiemo, M. (2003). Particulate matter and gaseous contaminants in indoor environments in an isolated northern community. International Journal of Circumpolar Health 62:120-129.		
HERO ID:		193211		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some methods for an indoor air sampling study were reported. Some methods were not reported, including sample storage conditions, sampler calibration, etc.
	Metric 2:	Analytical Methodology	Medium	The LOD was reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	The metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Canada.
	Metric 5:	Currency	Low	Samples were collected in 1994.
	Metric 6:	Spatial and Temporal Variability	Medium	There were >10 samples collected but there were no replicates collected.
	Metric 7:	Exposure Scenario	High	The sources of exposure, smoking, PM, stoves, and smoke curing were characterized.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported.
	Metric 9:	Quality Assurance	Low	There was no QA reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations were reported.
Overall Quality Determination			Medium	

Study Citation:		Clarisse, B., Laurent, A. M., Seta, N., Le Moullec, Y., El Hasnaoui, A., Momas, I. (2003). Indoor aldehydes: measurement of contamination levels and identification of their determinants in Paris dwellings. Environmental Research 92:245-253.		
HERO ID:		195854		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some methods not reported such as sample storage conditions
	Metric 2:	Analytical Methodology	Medium	Recovery samples not reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Paris, France
	Metric 5:	Currency	Low	Study published in 2003
	Metric 6:	Spatial and Temporal Variability	Medium	>10 samples; replicates
	Metric 7:	Exposure Scenario	High	Exposure source characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data not reported
	Metric 9:	Quality Assurance	Low	Limited QA reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations reported
Overall Quality Determination			Medium	

Study Citation:		Zhao, Z., Zhang, Z., Wang, Z., Ferm, M., Liang, Y., Norbäck, D. (2008). Asthmatic symptoms among pupils in relation to winter indoor and outdoor air pollution in schools in Taiyuan, China. Environmental Health Perspectives 116:90-97.		
HERO ID:		196712		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Comprehensive sampling methodology.
	Metric 2:	Analytical Methodology	Medium	Limited description of methods, LOD for formaldehyde not reported.
	Metric 3:	Biomarker Selection	N/A	Did not test for biomarkers, analyzed air samples for parent chemical.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Study completed in China.
	Metric 5:	Currency	Low	Sampling conducted in 2004.
	Metric 6:	Spatial and Temporal Variability	High	31 indoor continuous 7-day samples.
	Metric 7:	Exposure Scenario	High	Data closely represent relevant exposure scenarios related to airborne formaldehyde in schools from Taiyuan, China.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics.
	Metric 9:	Quality Assurance	Low	QA/QC not directly discussed.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Study characterized variability and discussed uncertainties and data gaps.
Overall Quality Determination			Medium	

Study Citation:		Lindgren, T. (2010). A case of indoor air pollution of ammonia emitted from concrete in a newly built office in Beijing. Building and Environment 45:596-600.		
HERO ID:		383423		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Limited description of sampling methods.
	Metric 2:	Analytical Methodology	Medium	No LOD reported, brief discussion of analytical methods.
	Metric 3:	Biomarker Selection	N/A	Did not test for biomarkers, analyzed air samples for parent chemical.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sweden and China.
	Metric 5:	Currency	Low	Sampling in 2004.
	Metric 6:	Spatial and Temporal Variability	Low	3 samples.
	Metric 7:	Exposure Scenario	Medium	Data likely represent relevant exposure scenarios related to indoor airborne formaldehyde in offices based in Beijing, China.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Individual sample concentrations reported, no summary statistics.
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not directly discussed.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Variability was not characterized, key uncertainties, limitations and data gaps were not discussed.
Overall Quality Determination			Low	

Study Citation:		Schieweck, A., Lohrengel, B., Siwinski, N., Genning, C., Salthammer, T. (2005). Organic and inorganic pollutants in storage rooms of the Lower Saxony State Museum Hanover, Germany. Atmospheric Environment 39:6098-6108.		
HERO ID:		518785		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods not reported, such as storage conditions and duration.
	Metric 2:	Analytical Methodology	Medium	Some analytical methods not reported, such as recovery samples.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	"The paper presents the results of measurements instorage rooms in the Lower Saxony State MuseumHanover, Germany."
	Metric 5:	Currency	Low	Publication date is 2005.
	Metric 6:	Spatial and Temporal Variability	Medium	No replicates sampled or reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario fits that of interest for the HCHO risk evaluation.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	No raw data presented.
	Metric 9:	Quality Assurance	Low	QA/QC not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	No limitations reported; variability not characterized.
Overall Quality Determination			Medium	

Study Citation:	Grosjean, D., Miguel, A. H., Tavares, T. M. (1990). Urban air pollution in Brazil: Acetaldehyde and other carbonyls. Atmospheric Environment 24:101-106.			
HERO ID:	597806			
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Sampling Methodology	Medium	Sample storage conditions not reported	
	Metric 2: Analytical Methodology	Low	LOD nor LOQ reported	
	Metric 3: Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.	
Domain 2: Representativeness	Metric 4: Geographic Area	High	Brazil	
	Metric 5: Currency	Low	Study published in 1990	
	Metric 6: Spatial and Temporal Variability	Medium	<10 samples; replicates	
	Metric 7: Exposure Scenario	High	Exposure source characterized	
Domain 3: Accessibility/Clarity	Metric 8: Reporting of Results	High	Raw data not reported	
	Metric 9: Quality Assurance	Low	QA not reported	
Domain 4: Variability and Uncertainty	Metric 10: Variability and Uncertainty	Low	Few gaps and limitations reported	
Overall Quality Determination		Medium		

Study Citation:		Marchand, C., Le Calve, S., Mirabel, P., Glasser, N., Casset, A., Schneider, N., de Blay, F. (2008). Concentrations and determinants of gaseous aldehydes in 162 homes in Strasbourg (France). Atmospheric Environment 42:505-516.		
HERO ID:		613222		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Well described sampling methods.
	Metric 2:	Analytical Methodology	High	Detailed analytical methods, included LODs.
	Metric 3:	Biomarker Selection	N/A	Did not test for biomarkers, sampled air and analyzed for parent chemical.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	France.
	Metric 5:	Currency	Medium	Sampling began in 2004 and ended in 2005.
	Metric 6:	Spatial and Temporal Variability	Medium	162 sampling sites, no replicates.
	Metric 7:	Exposure Scenario	High	Data closely represent relevant exposure scenarios related to airborne formaldehyde inside homes from France.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics.
	Metric 9:	Quality Assurance	Medium	Control samples were analyzed, limited description of QA/QC techniques.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Absent discussion of study limitations and uncertainties.
Overall Quality Determination			Medium	

Study Citation:		Wang, B., Lee, S. C., Ho, K. F. (2007). Characteristics of carbonyls: Concentrations and source strengths for indoor and outdoor residential microenvironments in China. Atmospheric Environment 41:2851-2861.		
HERO ID:		622212		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Limited description of sampling methods.
	Metric 2:	Analytical Methodology	High	Well described analytical methods, reported LODs.
	Metric 3:	Biomarker Selection	N/A	Did not test for biomarkers, analyzed air samples for parent chemical.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	China.
	Metric 5:	Currency	Low	2004.
	Metric 6:	Spatial and Temporal Variability	High	12 sampling sites, with replicates.
	Metric 7:	Exposure Scenario	Medium	Data likely represent a relevant exposure scenario related to airborne formaldehyde indoors and outdoors in urban residences in China.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics.
	Metric 9:	Quality Assurance	Medium	Analyzed control samples, limited description about QA/QC techniques.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Key uncertainties and study limitations were not discussed.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Monitoring

HERO ID: 626512

Study Citation:		Hayes, R. B., Klein, S., Suruda, A., Schulte, P., Boeniger, M., Stewart, P., Livingston, G. K., Oesch, F. (1997). O6-alkylguanine DNA alkyltransferase activity in student embalmers. American Journal of Industrial Medicine 31:361-365.		
HERO ID:		626512		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methodology for formaldehyde exposures described in terms of sampling equipment, brief procedures and study site characteristics according to referenced study (Suruda et al., 1993). Details in terms of sample storage with sample storage duration prior to analysis information lacking.
	Metric 2:	Analytical Methodology	Low	Limits of detection not reported. Analytical methodology detailed in terms of instrumentation method and referenced study (Katz, 1977) for personal monitoring and instrumentation, direct reading instrument, for short-term peak exposures.
	Metric 3:	Biomarker Selection	N/A	Sampling for chemical of interest within environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples described as collected in within participants within a college of mortuary science in Cincinnati, Ohio.
	Metric 5:	Currency	Low	Sampling dates not reported. Publication date 1997.
	Metric 6:	Spatial and Temporal Variability	Low	Number of samples not noted, however details of exposure assessment noted to be within Suruda, 1993 reference. Replicate samples not taken. Sampling appears to have been conducted only with single sample per participant.
	Metric 7:	Exposure Scenario	Medium	This was a peer-reviewed study of personal and short term peak formaldehyde exposures in mortuary science students while at a college laboratory and the association between formaldehyde exposures and DNA repair and serum AGT. Exposure sources discussed in text embalming activities and smoking.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Formaldehyde concentration results reported as mean, standard deviation and ranges. Number of samples not noted. Raw data not reported. Frequency of detection not noted.
	Metric 9:	Quality Assurance	Low	Quality assurance not discussed, however sampling methodology referenced (Saruda, 1993). Control sampling noted as conducted (pre-exposure sampling), but results not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability of results reported as range and standard deviation. Potential study limitations briefly discussed as small study group and potential previous exposures.
Overall Quality Determination			Low	

March 2024

Formaldehyde

Monitoring

HERO ID: 626642

Study Citation:		Yager, J. W., Cohn, K. L., Spear, R. C., Fisher, J. M., Morse, L. (1986). Sister-chromatid exchanges in lymphocytes of anatomy students exposed to formaldehyde-embalming solution. Mutation Research 174:135-139.		
HERO ID:		626642		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Sampling methodology for formaldehyde exposures described in terms of sampling equipment, brief procedures, study site characteristics, sample storage with sample storage duration prior to analysis. Sample collection method noted to be similar to NIOSH impinger method.
	Metric 2:	Analytical Methodology	Low	Limits of detection not reported. Analytical methodology noted to utilize NIOSH standard chromotropic acid method.
	Metric 3:	Biomarker Selection	N/A	Sampling for chemical of interest within environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples described as collected in within participants within an anatomy laboratory, inferred from author affiliations to be within California.
	Metric 5:	Currency	Low	Sampling dates not reported. Publication date 1986.
	Metric 6:	Spatial and Temporal Variability	Low	Average sampling duration noted as 18 minutes. Results in Table 2 note that area and breathing zone sampling was not conducted on all 30 students during each week, with n=13 area and n=35 breathing zone samples collected over the ten week period. Replicate samples not described.
	Metric 7:	Exposure Scenario	Medium	This was a peer-reviewed study which examined changes in peripheral lymphocyte sister-chromatid exchanges in anatomy class students before and after a ten- week anatomy class and conducted area and personal formaldehyde exposures during each week of class. Exposure sources discussed in text as anatomy specimen preservative and smoking.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Formaldehyde concentration results reported as mean and variance. Number of samples noted as n=13 area and n=35 breathing zone samples. Raw data not reported. Frequency of detection not noted.
	Metric 9:	Quality Assurance	Low	Quality assurance not discussed, however sampling methodology noted back-up filters analyzed separately to control for break-through. NIOSH methods utilized for sampling and analysis. Control sampling not conducted.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Variability of results reported “variance” in Table 2. Potential study limitations not detailed.
Overall Quality Determination			Low	

Study Citation:		Choi, D. W., Moon, K. W., Byeon, S. H., Lee, E. I., Sul, D. G., Lee, J. H., Oh, E. H., Kim, Y. H. (2009). Indoor volatile organic compounds in atopy patients’ houses in South Korea. Indoor and Built Environment 18:144-154.		
HERO ID:		632318		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Detailed sampling methodology
	Metric 2:	Analytical Methodology	Medium	Limited description of analytical methods, mentioned LOD but it is not reported
	Metric 3:	Biomarker Selection	N/A	Indoor air sampling
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	South Korea
	Metric 5:	Currency	Medium	Sampling in 2006
	Metric 6:	Spatial and Temporal Variability	Medium	114 sampling sites, no replicates
	Metric 7:	Exposure Scenario	High	Data closely represent relevant exposure scenarios
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not directly discussed
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Characterized variability, limited discussion of uncertainties and study limitations
Overall Quality Determination			Medium	

Study Citation:		Ohura, T., Amagai, T., Senga, Y., Fusaya, M. (2006). Organic air pollutants inside and outside residences in Shimizu, Japan: Levels, sources and risks. Science of the Total Environment 366:485-499.		
HERO ID:		632484		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	Sampling methodology detailed and included sampler preparation, sampling time, and sample transport and storage conditions.
	Metric 2:	Analytical Methodology	Medium	Key analytical methods reported. Recoveries supposedly measured but not identified for each chemical.
	Metric 3:	Biomarker Selection	N/A	Study measured parent chemical in indoor and outdoor air.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples collected in Shimizu, Japan.
	Metric 5:	Currency	Low	Samples collected in 2001.
	Metric 6:	Spatial and Temporal Variability	Medium	There were greater than 10 samples, but no replicates mentioned.
	Metric 7:	Exposure Scenario	High	The source of exposure well characterized. Samples measured pollutants inside and outside residences in Japan.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Raw data not reported. Summary statistics provided, including mean, standard deviation, and 10th and 90th percentile.
	Metric 9:	Quality Assurance	Medium	Key QA reported but no recoveries listed or applied.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Few gaps and limitations reported. Variation, such as SD, reported.
Overall Quality Determination		Medium		

Study Citation:		Norback, D., Wieslander, G., Nordstrom, K., Walinder, R. (2000). Asthma symptoms in relation to measured building dampness in upper concrete floor construction, and 2-ethyl-1-hexanol in indoor air. International Journal of Tuberculosis and Lung Disease 4:1016-1025.		
HERO ID:		683713		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The air sampling methodology is well described and scientifically sound
	Metric 2:	Analytical Methodology	Medium	The analytical methods are well described but don't mention LOD or recoveries
	Metric 3:	Biomarker Selection	N/A	Analyzed air samples for parent chemical of interest
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sweden
	Metric 5:	Currency	Low	Samples from 1997
	Metric 6:	Spatial and Temporal Variability	Low	n= 4 samples (7 days each, passive sampling)
	Metric 7:	Exposure Scenario	Medium	Data closely represent relevant exposure scenarios related to airborne formaldehyde in Sweden's geriatric hospitals
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	limited summary statistics reported (mean, range)
	Metric 9:	Quality Assurance	Low	QA/QC details were not provided
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Limited characterization of variability (range), study limitations and uncertainties were briefly discussed
Overall Quality Determination			Medium	

Study Citation:	Blondel, A., Plaisance, H. (2011). Screening of formaldehyde indoor sources and quantification of their emission using a passive sampler. Building and Environment 46:1284-1291.			
HERO ID:	814332			
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Scientifically sound sampling methods
	Metric 2:	Analytical Methodology	High	Well described analytical methods, reported LOD
	Metric 3:	Biomarker Selection	N/A	Did not test for biomarkers, analyzed environmental media (air) for parent chemical
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in France
	Metric 5:	Currency	Medium	Sampling in 2009-2010
	Metric 6:	Spatial and Temporal Variability	High	13-15 samples per room in 24 rooms
	Metric 7:	Exposure Scenario	Medium	Data likely represent relevant exposure scenarios related to airborne formaldehyde indoors in student rooms in France
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Individual sample concentrations and summary statistics reported
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not directly discussed except for sampler calibration
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Limited discussion of uncertainties, no discussion of study limitations
Overall Quality Determination			High	

Study Citation:		Herndon, S. C., Wood, E. C., Northway, M. J., Miake-Lye, R., Thornhill, L., Beyersdorf, A., Anderson, B. E., Dowlin, R., Dodds, W., Knighton, W. B. (2009). Aircraft Hydrocarbon Emissions at Oakland International Airport. Environmental Science and Technology 43:1730-1736.		
HERO ID:		953085		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	The sampling methodology is clear and appropriate, but missing details such as sampler calibration.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate, but no LOD or LOQ is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in Oakland, CA, USA.
	Metric 5:	Currency	Medium	Sampling was conducted August 2005.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	No sample size reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor and ambient air at airports. This scenario is of interest for the chemical and is well characterized.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Mean and standard deviation are in Table 1 of the supplemental file. No raw data are provided.
	Metric 9:	Quality Assurance	Low	QA/QC methods are not discussed, and issues are not identified. The use of blanks or controls is not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	There is significant discussion of variability and some discussion of uncertainty. Standard deviations are provided.
Overall Quality Determination		Uninformative		

Study Citation:		Trenbath, K., Hannigan, M. P., Milford, J. B. (2009). Evaluation of retrofit crankcase ventilation controls and diesel oxidation catalysts for reducing air pollution in school buses. Atmospheric Environment 43:5916-5922.		
HERO ID:		1006807		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate. Details such as sampler calibration and sample storage are provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD or LOQ for formaldehyde is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media (air in school buses).
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Pueblo, Colorado, US.
	Metric 5:	Currency	Medium	Samples were collected from 2007-2008.
	Metric 6:	Spatial and Temporal Variability	Medium	9 samples were collected pre and post retrofit, as reported in Table 3. Replicates were not reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in school bus air in Colorado. This scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	The raw data, as well as mean, median, and SD, are reported in Table 3.
	Metric 9:	Quality Assurance	Medium	The use of field blanks is reported. No other QA/QC measures are discussed and issues were not identified.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	SD is provided in Table 3. No other discussion on variability or uncertainty is provided.
Overall Quality Determination			Medium	

Study Citation:	Wu, X. M., Apte, M. G., Maddalena, R., Bennett, D. H. (2011). Volatile organic compounds in small- and medium-sized commercial buildings in California. Environmental Science and Technology 45:9075-9083.
HERO ID:	1062239

Domain	Metric	Rating	Comments
Domain 1: Reliability			
	Metric 1: Sampling Methodology	High	Authors provided detailed descriptions of the sampling methodology. No major flaws were identified.
	Metric 2: Analytical Methodology	High	Authors provided detailed descriptions of the analytical methodology. No major flaws were identified.
	Metric 3: Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representativeness			
	Metric 4: Geographic Area	High	Study location is California.
	Metric 5: Currency	Critically Deficient	Timing of sample collection for monitoring data is not reported, discussed, or referenced.
	Metric 6: Spatial and Temporal Variability	High	Over ten samples were studied.
	Metric 7: Exposure Scenario	High	Sampling scenarios are realistic and applicable to TSCA's HCHO risk evaluation.
Domain 3: Accessibility/Clarity			
	Metric 8: Reporting of Results	Medium	No raw data was provided.
	Metric 9: Quality Assurance	High	The quality assurance measures were detailed in this report.
Domain 4: Variability and Uncertainty			
	Metric 10: Variability and Uncertainty	Medium	Limited limitations were reported.

Overall Quality Determination**Uninformative**

Study Citation:		Lim, S., Lee, K., Seo, S., Jang, S. (2011). Impact of regulation on indoor volatile organic compounds in new unoccupied apartment in Korea. Atmospheric Environment 45:1994-2000.		
HERO ID:		1063163		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate. Information such as the sampler calibration and sample storage is reported.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD or LOQ is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in Korea.
	Metric 5:	Currency	Medium	Samples were collected from 2005 to 2007.
	Metric 6:	Spatial and Temporal Variability	Medium	228 samples were collected. No replicates are reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air of new apartments in Korea. This scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	The mean, SD, median, and other summary statistics are given in Tables 1 and 2. No raw data are provided.
	Metric 9:	Quality Assurance	Medium	QA/QC measures were described in section 2.3. "A mass spectrometer was used to quantify and identify 43 individual VOCs. It calibrated and quantified all samples according to their respective standards (52 Component Indoor Air Standards, Supelco, USA)."
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Standard deviations were provided in Tables 1 and 2.
Overall Quality Determination			Medium	

Study Citation:		Fenech, A., Strlič, M., Kralj cigić, I., Levart, A., Gibson, L. T., De Bruin, G., Ntanos, K., Kolar, J., Cassar, M. (2010). Volatile aldehydes in libraries and archives. Atmospheric Environment 44:2067-2073.		
HERO ID:		1063196		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	All the key sampling methods necessary for a study on indoor air quality were reported by the study authors.
	Metric 2:	Analytical Methodology	Low	The study did not report an LOD nor LOQ. Recovery samples were not reported either.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected from ten different locations across Europe.
	Metric 5:	Currency	Low	The date of sample collection was not reported. The study was published in 2010.
	Metric 6:	Spatial and Temporal Variability	Medium	There were ten sampling locations but no replicates collected (Table 1).
	Metric 7:	Exposure Scenario	Medium	The study attempted to examine the links between FDH and aldehydes in libraries, but there were no statistical associations conducted.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported. Some descriptive statistics were calculated in the figures.
	Metric 9:	Quality Assurance	Low	The study did not report any QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination			Medium	

Study Citation:		Gordon, S. M., Callahan, P. J., Nishioka, M. G., Brinkman, M. C., O'Rourke, M. K., Lebowitz, M. D., Moschandreas, D. J. (1999). Residential environmental measurements in the National Human Exposure Assessment Survey (NHEXAS) pilot study in Arizona: Preliminary results for pesticides and VOCs. Journal of Exposure Analysis and Environmental Epidemiology 9:456-470.		
HERO ID:		1065862		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
Metric 1:		Sampling Methodology	High	The air sampling methodology was well described and is scientifically sound.
Metric 2:		Analytical Methodology	Medium	The analytical methods were described in detail but did not include the LOD or recoveries.
Metric 3:		Biomarker Selection	N/A	The authors analyzed air samples.
Domain 2: Representativeness				
Metric 4:		Geographic Area	High	Arizona, USA.
Metric 5:		Currency	Low	The study was published in 1999
Metric 6:		Spatial and Temporal Variability	Low	n=257 (<5 replicates) for Formaldehyde, estimated from Table 10.
Metric 7:		Exposure Scenario	High	The data closely represent relevant exposure scenarios related to airborne 1,3 Butadiene inside and outside of households in Arizona.
Domain 3: Accessibility/Clarity				
Metric 8:		Reporting of Results	Medium	Only summary statistics were reported (median, 75 and 90 percentile)
Metric 9:		Quality Assurance	High	QA/QC techniques were described by the authors, including the use of control samples.
Domain 4: Variability and Uncertainty				
Metric 10:		Variability and Uncertainty	High	Variability was characterized (percentiles), and uncertainties were discussed by the authors.
Overall Quality Determination			Medium	

Study Citation:		Harada, K., Hara, K., Wei, C. N., Ohmori, S., Matsushita, O., Ueda, A. (2007). Case study of volatile organic compounds in indoor air of a house before and after repair where sick building syndrome occurred. International Journal of Immunopathology and Pharmacology 20:69-74.		
HERO ID:		1313640		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Not all sample methods reported, including sample storage conditions and calibration of the sampler
	Metric 2:	Analytical Methodology	Low	Analytical methods described- but LOD nor LOQ reported
	Metric 3:	Biomarker Selection	N/A	Parent chemical in environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in Japan.
	Metric 5:	Currency	Low	Data collected in 2001.
	Metric 6:	Spatial and Temporal Variability	Low	Two samples- before and after remodeling. No duplicates.
	Metric 7:	Exposure Scenario	High	Indoor air quality from renovation.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Concentrations given before and after remodeling. Little summary statistics given.
	Metric 9:	Quality Assurance	Low	No QA/QC reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	No limitations reported. The study measured different rooms and temperatures.
Overall Quality Determination			Medium	

Study Citation:	Hutter, H. P., Moshhammer, H., Wallner, P., Damberger, B., Tappler, P., Kundi, M. (2006). Health complaints and annoyances after moving into a new office building: a multidisciplinary approach including analysis of questionnaires, air and house dust samples. International Journal of Hygiene and Environmental Health 209:65-68.
HERO ID:	1313723

Domain	Metric	Rating	Comments
Domain 1: Reliability			
Metric 1:	Sampling Methodology	Low	Limited sampling methods reported. Only information provided is equipment, a vacuum cleaner with an inserted particle filter.
Metric 2:	Analytical Methodology	Low	LOD mentioned but not reported
Metric 3:	Biomarker Selection	N/A	Parent compound in environmental media.
Domain 2: Representativeness			
Metric 4:	Geographic Area	Critically Deficient	Not reported
Metric 5:	Currency	Medium	Study published in 2006
Metric 6:	Spatial and Temporal Variability	Low	<5 samples collected
Metric 7:	Exposure Scenario	High	Indoor office building relevant exposure scenario.
Domain 3: Accessibility/Clarity			
Metric 8:	Reporting of Results	Low	Individual points reported. No summary statistics given.
Metric 9:	Quality Assurance	Low	QA/QC information not provided
Domain 4: Variability and Uncertainty			
Metric 10:	Variability and Uncertainty	Low	Limited gaps and limitations reported.

Overall Quality Determination**Uninformative**

Study Citation:	Lévesqu, B., Allaire, S., Gauvin, D., Koutrakis, P., Gingras, S., Rhainds, M., Prud’Homme, H., Duchesne, J. F. (2001). Wood-burning appliances and indoor air quality. Science of the Total Environment 281:47-62.			
HERO ID:	1313943			
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Most sampling methods for a study on indoor air quality were reported. The study did not report sample stor- age conditions or sampler calibration.
	Metric 2:	Analytical Methodology	Medium	The study reported the LOD. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Quebec City region of Canada.
	Metric 5:	Currency	Low	The study was published in 2001 and the survey was conducted in 1995 and 1996.
	Metric 6:	Spatial and Temporal Variability	Medium	Sampling was conducted in 45 homes and there were no replicates.
	Metric 7:	Exposure Scenario	Medium	The study focused on the links between chemicals exposures and health outcomes.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported. The study reported the arithmetic mean, standard deviation, and the max value.
	Metric 9:	Quality Assurance	Low	There was limited QA reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps limitations or uncertainties.
Overall Quality Determination			Medium	

Study Citation:		Priha, E. (1996). Formaldehyde Release from Resin-Containing Wood Board Dusts: Evaluation of Methods to Determine Formaldehyde. Applied Occupational and Environmental Hygiene 11:465-470.		
HERO ID:		1316564		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Most necessary sampling methods were reported for a study on formaldehyde in wood. The study did not report sample storage conditions or sampler calibration.
	Metric 2:	Analytical Methodology	High	The study reported the LOD and recovery samples.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	Critically Deficient	The study location is not reported.
	Metric 5:	Currency	Low	The study was published in 1996.
	Metric 6:	Spatial and Temporal Variability	Medium	There were >10 samples collected but no replicates.
	Metric 7:	Exposure Scenario	Low	The study looked at formaldehyde in wood and not an exposure scenario in real world scenarios.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Low	Raw data were not reported. Limited descriptive statistics were reported.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination		Uninformative		

Study Citation:		Konopinski, V. J. (1983). Formaldehyde In Office And Commercial Environments. American Industrial Hygiene Association Journal 44:205-208.		
HERO ID:		1316673		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some methods not reported such as sampler calibration and sample storage conditions
	Metric 2:	Analytical Methodology	Low	LOD nor LOQ reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	USA
	Metric 5:	Currency	Low	Study published in 1983
	Metric 6:	Spatial and Temporal Variability	Medium	<10 samples; replicates
	Metric 7:	Exposure Scenario	Medium	Exposure source not well characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Raw data reported
	Metric 9:	Quality Assurance	Low	Limited QA reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations reported
Overall Quality Determination		Medium		

Study Citation:		Smedje, G., Norback, D. (2001). Irritants and allergens at school in relation to furnishings and cleaning. Indoor Air 11:127-133.		
HERO ID:		1319766		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Many methods appropriate for an indoor air study were reported. Some methods were not reported such as sampler calibration and sampling procedures.
	Metric 2:	Analytical Methodology	Medium	The LOD was reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	The metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Sweden.
	Metric 5:	Currency	Low	The samples were collected in 1992 and 1993.
	Metric 6:	Spatial and Temporal Variability	High	Samples were collected from several locations (>10 samples) and recoveries were reported.
	Metric 7:	Exposure Scenario	Medium	The exposure source was not well characterized as this study focused on school furnishings and cleaning and allergens.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported.
	Metric 9:	Quality Assurance	Low	Limited QA was reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations were reported.
Overall Quality Determination			Medium	

Study Citation:		Priha, E., Pennanen, S., Rantio, T., Uitti, J., Liesivuori, J. (2004). Exposure to and acute effects of medium-density fiber board dust. Journal of Occupational and Environmental Hygiene 1:738-744.		
HERO ID:		1319863		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	The sampling methodology is clear and appropriate; however, details such as sampler calibration and sample storage are not provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD or LOQ for formaldehyde is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Finland.
	Metric 5:	Currency	Low	Publication date is 2004. No sample collection date is provided.
	Metric 6:	Spatial and Temporal Variability	Medium	The number of samples is 7 for MDF Board and 9 for wood. No replicates were reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air at furniture factories in Finland. This scenario is of interest for the chemical and the exposure route is well characterized.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Mean, range, and standard deviations are provided in Table 1. Raw data is not provided.
	Metric 9:	Quality Assurance	Medium	One control is reported in Table 1. No other QA/QC measures are discussed and issues were not identified.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	SD and GSD are provided in Table 1. No other discussion on variability or uncertainty is provided.
Overall Quality Determination			Medium	

Study Citation:		Nordström, K., Norbäck, D., Wieslander, G. (1999). Subjective indoor air quality in geriatric hospitals. Indoor and Built Environment 8:49-57.		
HERO ID:		1513035		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods not reported such as sample storage conditions
	Metric 2:	Analytical Methodology	Medium	recovery samples not reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sweden
	Metric 5:	Currency	Low	Samples collected in 1997
	Metric 6:	Spatial and Temporal Variability	Low	<5 samples
	Metric 7:	Exposure Scenario	Medium	Exposure source not well characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data not reported
	Metric 9:	Quality Assurance	Medium	Limited QA reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Few gaps and limitations reported
Overall Quality Determination		Medium		

Study Citation:		Pang, S. K., Cho, H., Sohn, J. Y., Song, K. D. (2007). Assessment of the emission characteristics of VOCs from interior furniture materials during the construction process. Indoor and Built Environment 16:444-455.		
HERO ID:		1513097		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Based on the Korean Ministry of Environment 2004–80 Official Test Method.
	Metric 2:	Analytical Methodology	Low	Neither the LOD or LOQ were reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Korea.
	Metric 5:	Currency	Medium	Data was collected in 2005.
	Metric 6:	Spatial and Temporal Variability	Medium	8 samples per scenario
	Metric 7:	Exposure Scenario	Medium	The exposure scenario is relevant to the HCHO risk evaluations. However, the exposure scenario(s) studied in this location may be somewhat different to those found in the U.S.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	The data was reported with no major deficiencies, inconsistencies and errors.
	Metric 9:	Quality Assurance	Low	A limited QA/QC discussion was provided.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	A limited discussion of variability and uncertainty was provided.
Overall Quality Determination			Medium	

Study Citation:	Ohmichi, K., Komiyama, M., Matsuno, Y., Takanashi, Y., Miyamoto, H., Kadota, T., Maekawa, M., Toyama, Y., Tatsugi, Y., Kohno, T., Ohmichi, M., Mori, C. (2006). Formaldehyde exposure in a gross anatomy laboratory–personal exposure level is higher than indoor concentration. Environmental Science and Pollution Research 13:120-124.			
HERO ID:	1514215			
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Sampling Methodology	High	The air sampling methodology is scientifically sound, describing the procedure, equipment and the study site	
	Metric 2: Analytical Methodology	Medium	The manuscript includes well described analytical methods, but they are missing recovery details and LOD	
	Metric 3: Biomarker Selection	N/A	The study analyzed environmental media (air)	
Domain 2: Representativeness	Metric 4: Geographic Area	High	Japan	
	Metric 5: Currency	Low	The article was published in 2006.	
	Metric 6: Spatial and Temporal Variability	Low	n=15, estimated from 5 sampling sites, sampled three times.	
	Metric 7: Exposure Scenario	High	The data closely represent a relevant exposure scenario related to indoor airborne formaldehyde exposure in gross anatomy laboratories in Japan	
Domain 3: Accessibility/Clarity	Metric 8: Reporting of Results	Medium	The authors only provided summary statistics (average, range and SD)	
	Metric 9: Quality Assurance	Low	QA/QC techniques were briefly described and did not mention the use of blanks or controls.	
Domain 4: Variability and Uncertainty	Metric 10: Variability and Uncertainty	Medium	Variability was characterized (range, SD), but uncertainties and limitations were not discussed.	
Overall Quality Determination		Medium		

Study Citation:		Chiappini, L., Dagnelie, R., Sassine, M., Fuvel, F., Fable, S., Tran-Thi, T., George, C. (2011). Multi-tool formaldehyde measurement in simulated and real atmospheres for indoor air survey and concentration change monitoring. Air Quality, Atmosphere and Health 4:211-220.		
HERO ID:		1532421		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Detailed and scientifically sounds methods
	Metric 2:	Analytical Methodology	High	Well described analytical methods, included LODs
	Metric 3:	Biomarker Selection	N/A	Analyzed environmental media (air) for parent chemical
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	France
	Metric 5:	Currency	Low	Published in 2011
	Metric 6:	Spatial and Temporal Variability	Medium	7 sampling sites, continuous measurements taken for 1 h, 8 h, or48 h, no replicates
	Metric 7:	Exposure Scenario	Medium	Data likely represent relevant exposure scenarios related to indoor airborne formaldehyde, missing details on population of interest
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Reported individual sample concentrations and summary statistics
	Metric 9:	Quality Assurance	High	Analyzed control samples, described instrument calibration
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Limited discussion of study limitations and uncertainties
Overall Quality Determination			High	

Study Citation:		Dudzinska, M. R., Staszowska, A., Polednik, B. (2009). Preliminary study of effect of furniture and finishing materials on formaldehydhe concentration in office rooms. Environment Protection Engineering 35:225-233.		
HERO ID:		1537571		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Low	Sampling method is only briefly discussed, mostly focuses on study site description
	Metric 2:	Analytical Methodology	Low	Only briefly discussed, reported LOD
	Metric 3:	Biomarker Selection	N/A	Tested environmental media (air) for parent chemical
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Poland
	Metric 5:	Currency	Medium	Sampling in 2008
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	Sample size not reported
	Metric 7:	Exposure Scenario	Low	Data lack multiple pieces of information about the exposure scenarios related to indoor airborne formaldehyde in offices
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Only summary statistics provided
	Metric 9:	Quality Assurance	Low	QA/QC techniques not discussed, analyzed control samples
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	Key uncertainties, study limitations and data gaps are not discussed
Overall Quality Determination		Uninformative		

Study Citation:		Kolarik, B., Gunnarsen, L., Logadottir, A., Funch, L. (2012). Concentrations of Formaldehyde in new Danish Residential Buildings in Relation to WHO Recommendations and CEN Requirements. Indoor and Built Environment 21:552-561.		
HERO ID:		1551845		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Well described sampling methods
	Metric 2:	Analytical Methodology	High	Scientifically sound analytical methods, reported LOD
	Metric 3:	Biomarker Selection	N/A	Analyzed air samples for parent chemical
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Denmark
	Metric 5:	Currency	Medium	Sampling in 2007
	Metric 6:	Spatial and Temporal Variability	Low	20 sampling sites sampled once, no replicates
	Metric 7:	Exposure Scenario	Medium	Data likely represent relevant exposure scenarios related to indoor airborne formaldehyde in residential buildings from Denmark. Limited details about the population of interest.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics reported
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not directly discussed, cited DS/EN ISO 16000-3:2001 standard
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Study limitations and uncertainties were not discussed
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Monitoring

HERO ID: 1579130

Study Citation:		Fan, J., Tang, Y. J., Feng, S. L. (2002). Determination of formaldehyde traces in fabric and in indoor air by a kinetic fluorimetric method. International Journal of Environmental Analytical Chemistry 82:361-367.		
HERO ID:		1579130		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Low	The air sampling methodology was briefly discussed. The equipment, calibration and storage conditions are missing.
	Metric 2:	Analytical Methodology	Medium	The analytical methods were discussed and referenced, including the LOD but not recoveries.
	Metric 3:	Biomarker Selection	N/A	The authors analyzed air samples.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in China.
	Metric 5:	Currency	Low	The study was published in 2002.
	Metric 6:	Spatial and Temporal Variability	Low	Four samples taken with no replicates.
	Metric 7:	Exposure Scenario	Low	The data may represent a relevant exposure scenario related to airborne formaldehyde, but the small sample size and limited methodological details limit the study results' validity. There is no information on the location and setting of the indoor air sampled.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics were reported (mean, RSD). Individual points not reported.
	Metric 9:	Quality Assurance	Low	QA/QC techniques were briefly discussed and can be inferred from the study procedures. Recoveries not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Limited characterization of variability was conducted with RSD. Uncertainties and limitations were not discussed.
Overall Quality Determination			Low	

Study Citation:		Sohn, J., Yang, W., Kim, J., Son, B., Park, J. (2009). Indoor air quality investigation according to age of the school buildings in Korea. Journal of Environmental Management 90:348-354.		
HERO ID:		1642001		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Detailed sampling methods
	Metric 2:	Analytical Methodology	Low	Only briefly discussed, LOD not reported
	Metric 3:	Biomarker Selection	N/A	Tested air samples for parent chemical
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in South Korea
	Metric 5:	Currency	Low	Sampling in 2004
	Metric 6:	Spatial and Temporal Variability	Low	55 schools, 3 sampling sites per school during 3 seasons, no replicates
	Metric 7:	Exposure Scenario	Medium	Data likely represents relevant exposure scenarios related to airborne formaldehyde in Korean schools, missing details about microenvironment of interest and exposure characteristics
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics
	Metric 9:	Quality Assurance	Low	QA/QC details were not directly discussed
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Did not discuss uncertainties and study limitations
Overall Quality Determination			Low	

Study Citation:	Reddy, M. K., Suneela, M., Sumathi, M., Reddy, R. C. (2005). Indoor air quality at Salarjung Museum, Hyderabad, India. Environmental Monitoring and Assessment 105:359-367.			
HERO ID:	1643090			
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Sampling Methodology	Medium	Some sampling methods not reported such a sample storage conditions and sampler calibration	
	Metric 2: Analytical Methodology	Low	LOD nor LOQ reported	
	Metric 3: Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.	
Domain 2: Representativeness	Metric 4: Geographic Area	High	India	
	Metric 5: Currency	Low	Samples collected in 2001	
	Metric 6: Spatial and Temporal Variability	Medium	Replicates but from less than 10 sites	
	Metric 7: Exposure Scenario	Medium	Exposure source not well characterized	
Domain 3: Accessibility/Clarity	Metric 8: Reporting of Results	High	Raw data reported	
	Metric 9: Quality Assurance	Low	QA not reported	
Domain 4: Variability and Uncertainty	Metric 10: Variability and Uncertainty	Low	Few gaps and limitations	
Overall Quality Determination		Medium		

Study Citation:		Norback, D., Wieslander, G., Edling, C. (1995). Occupational exposure to volatile organic compounds (VOCs), and other air pollutants from the indoor application of water-based paints. Annals of Occupational Hygiene 39:783-794.		
HERO ID:		1763128		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Most sampling methods for an indoor air quality study were reported. Some methods were not reported such as sample storage conditions and sampler calibration.
	Metric 2:	Analytical Methodology	High	All key analytical methods were reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Sweden.
	Metric 5:	Currency	Low	The study was published in 1995. Samples were collected from 1989 to 1991.
	Metric 6:	Spatial and Temporal Variability	Medium	The study reported that more than 10 samples were collected. However, there were no replicate samples collected.
	Metric 7:	Exposure Scenario	High	The study explored the links between paints and VOC exposures in indoor settings.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported. The study reported the arithmetic mean, the geometric mean, and the range.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination			Medium	

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Formaldehyde

Monitoring

HERO ID: 1785600

Study Citation:		Kheirbek, I., Johnson, S., Ross, Z., Pezeshki, G., Ito, K., Eisl, H., Matte, T. (2012). Spatial variability in levels of benzene, formaldehyde, and total benzene, toluene, ethylbenzene and xylenes in New York City: a land-use regression study. Environmental Health: A Global Access Science Source		
HERO ID:		11:51. 1785600		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Monitoring conducted throughout NYC as part of the New York City Community Air Survey (NYCCAS). 70 sites selected for this study (Fig 1). Air measured for 1-week with radial passive sampling tubes in weather protected shelters at 10 feet above the ground. Air phase not specified in the paper.
	Metric 2:	Analytical Methodology	Low	Passive samplers contained 2,4-DNPH coated with silica to convert aldehydes to hydrazone derivatives. Hydrazones extracted with acetonitrile. The LOQ not provided.
	Metric 3:	Biomarker Selection	N/A	Study measuring formaldehyde in air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Monitoring sites located in New York City.
	Metric 5:	Currency	Medium	Samples collected from 3/22/2011 to 6/1/2011.
	Metric 6:	Spatial and Temporal Variability	High	Samples collected across 10 weeks from 69 sites. At two sites in each session, two sets of samplers were deployed side by side.
	Metric 7:	Exposure Scenario	High	Ambient air sampled along streets across New York City.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Table 3 provides the mean and range for concentrations within NYC and reference sites. Raw data not provided. The coefficient of variation (CV) was calculated across all temporally adjusted samples and provided in Results section on p. 5.
	Metric 9:	Quality Assurance	High	QA reported included use of field blanks. QC followed standard EPA (NELAP Quality Manual: 13.0 Passive sampling) and OSHA methodologies (Method 0011). One result was removed from analysis due to implausibly high concentrations.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Spatial and temporal variability discussed. Figure 2 provides one-week concentrations with session temperatures at monitoring sites. The uncertainties were briefly discussed as minimal and addressed.
Overall Quality Determination			Medium	

Study Citation:		Shin, S. H., Jo, W. K. (2012). Volatile organic compound concentrations, emission rates, and source apportionment in newly-built apartments at pre-occupancy stage. Chemosphere 89:569-578.		
HERO ID:		1787932		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods not reported, such as sample storage conditions
	Metric 2:	Analytical Methodology	High	GC/MS and GC/FID method described. Method detection limit reported.
	Metric 3:	Biomarker Selection	N/A	Indoor and outdoor air sampling
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Metropolitan and Rural areas in Korea
	Metric 5:	Currency	Low	Timing of sample collection for monitoring data is not directly reported but is inferred by discussion of 2003 building standards that sampling occurred after 2003. Publication date is 2012
	Metric 6:	Spatial and Temporal Variability	High	107 buildings sampled
	Metric 7:	Exposure Scenario	High	Sources of potential exposure in buildings such as building material and proximity to roadways identified.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	No raw data reported. Statistical summaries presented.
	Metric 9:	Quality Assurance	High	QA/QC conducted including blanks, spiked samples, and duplicate sample analysis.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	No gaps or limitations reported
Overall Quality Determination			High	

Study Citation:		Gibson, L. T., Ewlad-Ahmed, A., Knight, B., Horie, V., Mitchell, G., Robertson, C. J. (2012). Measurement of volatile organic compounds emitted in libraries and archives: an inferential indicator of paper decay?. Chemistry Central Journal 6:42.		
HERO ID:		1793021		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Confusing description of sampling methods, unconventional format
	Metric 2:	Analytical Methodology	Low	Only briefly discussed, did not report LOD
	Metric 3:	Biomarker Selection	N/A	Did not test for biomarkers, tested air samples for parent chemical
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in UK and Ireland
	Metric 5:	Currency	Low	Published in 2012
	Metric 6:	Spatial and Temporal Variability	Low	Eight sampling sites, no replicates
	Metric 7:	Exposure Scenario	Medium	Data likely represent relevant exposure scenarios related to airborne formaldehyde in libraries in the UK and Ireland. Missing details about the population or scenario of interest (e.g., exposure time).
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics
	Metric 9:	Quality Assurance	Medium	Limited description of QA/QC techniques, did not analyze control samples
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Uncertainties and study limitations were not discussed
Overall Quality Determination			Low	

Study Citation:		Abdel Hameed, A. A., Khoder, M. I., Farag, S. A. (2000). Organic dust and gaseous contaminants at wood working shops. Journal of Environmental Monitoring 2:73-76.		
HERO ID:		1942922		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Most key sampling methods were reported by the study authors. The study did not report sample storage.
	Metric 2:	Analytical Methodology	Low	The LOD nor the LOQ was reported. The study did not report recovery samples.
	Metric 3:	Biomarker Selection	N/A	This metric was not applicable to this data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Egypt.
	Metric 5:	Currency	Low	The study was published in 1999.
	Metric 6:	Spatial and Temporal Variability	Medium	28 samples were collected at two wood workshops.
	Metric 7:	Exposure Scenario	Medium	The study characterized formaldehyde in a woodworking shop but not make any specific statistical comparisons in concentration levels.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported in this study. The study reported the mean and range.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations or uncertainties.
Overall Quality Determination			Low	

Study Citation:		Koeck, M., Pichler-Semmelrock, F. P., Schlacher, R. (1997). Formaldehyde–study of indoor air pollution in Austria. Central European Journal of Public Health 5:127-130.		
HERO ID:		1943311		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	There were several methods that were not reported.
	Metric 2:	Analytical Methodology	Critically Deficient	The analytical methodology is not described, including the analytical instrumentation.
	Metric 3:	Biomarker Selection	N/A	The metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in Austria.
	Metric 5:	Currency	Low	The study was published in 1997.
	Metric 6:	Spatial and Temporal Variability	Medium	There were >10 samples collected but no replicate samples.
	Metric 7:	Exposure Scenario	Medium	The exposure source was not well characterized by the study authors.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Raw data were reported in Figure 2.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination		Uninformative		

Study Citation:		Tsakas, M. P., Siskos, P. A. (2011). Indoor Air Quality in the Control Tower of Athens International Airport, Greece. Indoor and Built Environment 20:284-289.		
HERO ID:		1948818		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Limited description, cited method TO-11 from EPA
	Metric 2:	Analytical Methodology	Medium	Limited description, cited method TO-11 from EPA, LOD not reported.
	Metric 3:	Biomarker Selection	N/A	Tested air samples for parent chemical
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples collected in Greece.
	Metric 5:	Currency	Low	Sampling in 2003
	Metric 6:	Spatial and Temporal Variability	Low	48 samples in total, with 3-5 replicates per site
	Metric 7:	Exposure Scenario	High	Data closely represent relevant exposure scenarios related to indoor airborne formaldehyde in airport control towers from Greece
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Only individual sample concentrations, no summary statistics
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not directly discussed, did not analyze control samples
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Variability was not characterized, uncertainties and limitations were not discussed
Overall Quality Determination		Medium		

Study Citation:		Brown, S. K. (2001). Air toxics in a new Australian dwelling over an 8-month period. Indoor and Built Environment 10:160-166.		
HERO ID:		1949370		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some methods not reported such as sample storage conditions and sampler calibration
	Metric 2:	Analytical Methodology	Low	LOD nor LOQ reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Australia
	Metric 5:	Currency	Low	Samples collected in 1998
	Metric 6:	Spatial and Temporal Variability	High	>10 samples; replicates
	Metric 7:	Exposure Scenario	Medium	Exposure source not well characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Raw data reported
	Metric 9:	Quality Assurance	Low	QA not reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations reported
Overall Quality Determination		Medium		

Study Citation:		Dannemiller, K. C., Murphy, J. S., Dixon, S. L., Pennell, K. G., Suuberg, E. M., Jacobs, D. E., Sandel, M. (2013). Formaldehyde concentrations in household air of asthma patients determined using colorimetric detector tubes. Indoor Air 23:285-294.		
HERO ID:		1949600		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methodology is discussed and is generally appropriate (i.e., scientifically sound); however, some information is missing such as sampling storage duration and the matrix characteristics (e.g., the phase of air) are not reported.
	Metric 2:	Analytical Methodology	High	The analytical method used was not a publicly available method from a trusted or authoritative source, but the methodology is clear and appropriate. Samples were analyzed by colorimetric detector tubes and the analytical detection limit was reported.
	Metric 3:	Biomarker Selection	N/A	The study tested for the parent chemical in environmental media (air).
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The samples were collected in Boston, MA.
	Metric 5:	Currency	Medium	The samples were collected between July 2008 and February 2010.
	Metric 6:	Spatial and Temporal Variability	Medium	The collection of replicate samples was not reported. Samples were collected in 70 homes.
	Metric 7:	Exposure Scenario	Medium	Data likely represents relevant exposure scenarios related to indoor airborne formaldehyde in houses from Boston, MA. Cross-sectional design without replicates limits the study's generalizability.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported. Summary statistics (geometric mean) were reported in Tables 1 and S1.
	Metric 9:	Quality Assurance	Medium	QA/QC measures were discussed such as validating formaldehyde readings and pump performance and checking for possible interferences from ammonia and NOx.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Variability is characterized in the media studied by investigating effects of temperature, humidity, seasonal and consumer product variability. A relative standard deviation for the tubes is provided and statistical significance is reported. The study has some discussion of key uncertainties and limitations such as potential interference and how the analysis would not detect the effect of short-term formaldehyde spikes.
Overall Quality Determination			Medium	

Study Citation:		Bartzis, J. G., Michaelidou, S., Missia, D., Tolis, E., Saraga, D., Demetriou-Georgiou, E., Kotzias, D., Barero-Moreno, J. M. (2008). Indoor concentrations of VOCs and ozone in two cities of Northern Europe during the summer period. WIT Transactions on Ecology and the Environment 116:459-466.		
HERO ID:		1951853		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Most methods for a study on indoor air were reported. Some methods were not reported such as sample conditions, sampler calibration.
	Metric 2:	Analytical Methodology	Low	The study did not report an LOD or LOQ. There were no recovery samples reported by the study authors.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in Dublin and Copenhagen.
	Metric 5:	Currency	Medium	The study was conducted in 2007.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	The number of samples collected was not reported.
	Metric 7:	Exposure Scenario	Medium	The specific sources of exposure were not well characterized by the study authors. This was a monitoring study.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Low	Raw data were not reported.
	Metric 9:	Quality Assurance	Low	Limited QA was reported.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations were reported.
Overall Quality Determination		Uninformative		

Study Citation: Sidheswaran, M., Chen, W., Chang, A., Miller, R., Cohn, S., Sullivan, D., Fisk, W. J., Kumagai, K., Destailats, H. (2013). Formaldehyde emissions from ventilation filters under different relative humidity conditions. Environmental Science and Technology 47:5336-5343.

HERO ID: 1953616

Domain	Metric	Rating	Comments
Domain 1: Reliability	Metric 1: Sampling Methodology	High	The sampling methodology is clear and appropriate. Details such as sampler calibration and sampling procedure are provided.
	Metric 2: Analytical Methodology	High	The analytical methodology is clear, detailed, and appropriate. The LOD is provided.
	Metric 3: Biomarker Selection	N/A	Study is testing environmental media.
Domain 2: Representativeness	Metric 4: Geographic Area	High	Samples were collected in the US.
	Metric 5: Currency	Medium	Study was published in 2013. No sample collection date is provided.
	Metric 6: Spatial and Temporal Variability	Critically Deficient	Sample size is not provided.
	Metric 7: Exposure Scenario	High	The exposure scenario is formaldehyde in indoor and outdoor air at an unoccupied office based on filters in HVAC units. This scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity			
	Metric 8: Reporting of Results	Medium	The mean and standard deviation are provided in Figure 4 and the text of page 5340. Raw data is not provided.
	Metric 9: Quality Assurance	Low	QA/QC measures were briefly discussed and the use of blanks is reported. QA/QC issues were not identified.
Domain 4: Variability and Uncertainty			
	Metric 10: Variability and Uncertainty	Medium	Standard deviations are reported in Figure 4.

Overall Quality Determination

Uninformative

March 2024

Formaldehyde

Monitoring

HERO ID: 1986334

Study Citation:		Shendell, D. G., Winer, A. M., Stock, T. H., Zhang, L., Zhang, J. J., Maberti, S., Colome, S. D. (2004). Air concentrations of VOCs in portable and traditional classrooms: results of a pilot study in Los Angeles County. Journal of Exposure Analysis and Environmental Epidemiology 14:44-59.		
HERO ID:		1986334		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	Sampling methodology provided in detailHCHO and acetaldehyde (CH3CHO) were sampled with a passive clip-on cartridge (Environmental and Occupational Health Sciences Institute ((EOHSI), UMDNJ/Rutgers University) designated as the DNSH Passive Aldehydes and Ketones Sampler (PAKS; Zhang et al., 2000). Dansylhydrazine (DNSH) was reagent grade 5-(dimethylamino)naphthalene-1-sulfohydrazide. The DNSH PAKS physical attributes, materials, chemistry, and empirically determined sampling rates have been described, including graphics (Zhang et al., 1999; Zhang and Zhang, 2000). During transport, capped samples were wrapped in aluminum foil and placed in plastic bags in cooler packs with blue ice to maintain temperature at or below 41C. Shipment for analysis was by overnight express carriers.
	Metric 2:	Analytical Methodology	High	Lab analyses for aldehydes and VOCs were detailed.For analysis, DNSH PAKS samples were removed from arefrigerator and allowed to equilibrate to room T, then elutedwith acetonitrile. Target compounds were identified andquantified using HPLC with fluorescence detection. Procedures for calibration of the HPLC for analysis and forconcentration calculations have been described (Zhang et al.,1999).Formaldehyde LOD was 0.1 ug/m3
	Metric 3:	Biomarker Selection	N/A	No biomarkers
Domain 2: Representativeness	Metric 4:	Geographic Area	High	US, Los Angeles County
	Metric 5:	Currency	Low	Data collected in 2000 and 2001
	Metric 6:	Spatial and Temporal Variability	Medium	Observations ranged from n = 5 to n = 46 for aldehydes; and n = 5 for VOCs
	Metric 7:	Exposure Scenario	High	Indoor air concentrations exposure scenario in classrooms
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	No raw data provided
	Metric 9:	Quality Assurance	High	QA/QC were discussed in detail and study was compared to other comparable studies
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	QA/QC were discussed in detail and study was compared to other comparable studies
Overall Quality Determination			High	

Study Citation:		Salthammer, T., Schripp, T., Wientzek, S., Wensing, M. (2014). Impact of operating wood-burning fireplace ovens on indoor air quality. Chemosphere 103:205-211.		
HERO ID:		2231397		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate; details on the sampling protocol and sampler calibration are provided.
	Metric 2:	Analytical Methodology	High	The analytical methodology is clear and appropriate, the LOD is provided in the supplemental material.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Germany.
	Metric 5:	Currency	Medium	Samples were collected from 2012 to 2013.
	Metric 6:	Spatial and Temporal Variability	Medium	7 samples were collected. No replicates are reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air of homes with wood burning fireplaces. This scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Table 3 has the maximum concentration and background concentration.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not discussed and issues are not identified. The use of blanks or controls is not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent. No standard deviations are provided.
Overall Quality Determination			Medium	

Study Citation:		Shinohara, N., Tokumura, M., Kazama, M., Yonemoto, Y., Yoshioka, M., Kagi, N., Hasegawa, K., Yoshino, H., Yanagi, U. (2014). Indoor air quality and thermal comfort in temporary houses occupied after the Great East Japan Earthquake. Indoor Air 24:425-437.		
HERO ID:		2231518		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Not all sampling methodology criteria, e.g., storage conditions, were reported.
	Metric 2:	Analytical Methodology	Medium	Not all analytical methods, e.g., recovery samples and LOD, were reported.
	Metric 3:	Biomarker Selection	N/A	The authors analyzed air samples.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Japan
	Metric 5:	Currency	Medium	The data was collected in 2012.
	Metric 6:	Spatial and Temporal Variability	High	n>10 samples, with replicates.
	Metric 7:	Exposure Scenario	High	The data closely represent relevant exposure scenarios related to indoor airborne pollutants in Japan.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Only summary statistics were reported.
	Metric 9:	Quality Assurance	High	QA/QC techniques were reported on page 427.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability was characterized (box plots). Limited information was reported on gaps and limitations.
Overall Quality Determination			High	

March 2024

Formaldehyde

Monitoring

HERO ID: 2282790

Study Citation:		Noris, F., Adamkiewicz, G., Delp, W. W., Hotchi, T., Russell, M., Singer, B. C., Spears, M., Vermeer, K., Fisk, W. J. (2013). Indoor environmental quality benefits of apartment energy retrofits. Building and Environment 68:170-178.		
HERO ID:		2282790		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate, and details such as sampler calibration are provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate. The LOD is not provided, but is referenced in the methods section and may be in the supplemental material.Supplemental doc: https://ars.els-cdn.com/content/image/1-s2.0-S0360132313001947-mmcl.docx
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in the US.
	Metric 5:	Currency	Medium	Samples were collected from 2011-2012.
	Metric 6:	Spatial and Temporal Variability	High	16 apartments were sampled. Duplicates were taken.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor and outdoor air in retrofitted apartments in the US. The scenario is well characterized with information about the microclimate and other details.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data is not provided. Data is shown in Figure 5.
	Metric 9:	Quality Assurance	Medium	The use of lab and field blanks is reported. QA/QC issues were not identified.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability is absent. No measures of variance were provided.
Overall Quality Determination			Medium	

Study Citation:		Poulhet, G., Dusanter, S., Crunaire, S., Locoge, N., Gaudion, V., Merlen, C., Kaluzny, P., Coddeville, P. (2014). Investigation of formaldehyde sources in French schools using a passive flux sampler. Building and Environment 71:111-120.		
HERO ID:		2331688		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate. Information such as the sampler calibration and sample storage is provided.
	Metric 2:	Analytical Methodology	High	The analytical methodology is clear and appropriate. The LOD is reported in Tables 3 and 4.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in France.
	Metric 5:	Currency	Medium	Samples were collected in 2011.
	Metric 6:	Spatial and Temporal Variability	High	The number of samples was greater than 10 per scenario, as reported in Table 3. Replicates were reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air at French schools. This is a scenario of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Table 3 and 4 provide the formaldehyde emission rate and total emissions. Not all raw data is reported.
	Metric 9:	Quality Assurance	Medium	The use of blanks in reported. QA/QC issues are not identified.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability is absent. No standard deviations or coefficients of variance are provided.
Overall Quality Determination			High	

Study Citation:		LISS, (2013). Pollution level and seasonal variations of carbonyl compounds, aromatic hydrocarbons and TVOC in a furniture mall in Beijing, China. Building and Environment 69:227-232.		
HERO ID:		2331779		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate. Information such as the sampler calibration and sampling procedure is provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, the LOD/LOQ is not provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in China.
	Metric 5:	Currency	Medium	Samples were collected in 2010.
	Metric 6:	Spatial and Temporal Variability	Medium	36 samples were collected. No replicates were reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air at a furniture mall. This is a scenario of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Figure 1 provides the mean and standard deviation. No raw data is reported.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not discussed and issues were not identified. The use of blanks or controls are not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	The geometric standard deviation is provided in Figure 1.
Overall Quality Determination			Medium	

Study Citation:		Liu, Q., Liu, Y., Zhang, M. (2014). Source Apportionment of Personal Exposure to Carbonyl Compounds and BTEX at Homes in Beijing, China. Aerosol and Air Quality Research 14:330-337.		
HERO ID:		2394125		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	The sampling methodology is clear and appropriate. Details such as sampler calibration and sampling protocol are provided.
	Metric 2:	Analytical Methodology	High	The analytical methodology is clear and appropriate, and the LOD is provided in the methods section.
	Metric 3:	Biomarker Selection	N/A	Study is testing for parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in Beijing, China.
	Metric 5:	Currency	Medium	Samples were collected in 2009.
	Metric 6:	Spatial and Temporal Variability	High	255 samples were collected (130 for living rooms, 125 for cooking rooms).
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air in living rooms and cooking rooms in residences. The scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Range, mean, and standard deviation are provided in Table 1. Raw data is not provided.
	Metric 9:	Quality Assurance	Medium	QA/QC measures are discussed and the use of standards is reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Standard deviations are provided in Table 1.
Overall Quality Determination		High		

Study Citation:		Lu, H., Wen, S., Feng, Y., Wang, X., Bi, X., Sheng, G., Fu, J. (2006). Indoor and outdoor carbonyl compounds and BTEX in the hospitals of Guangzhou, China. Science of the Total Environment 368:574-584.		
HERO ID:		2443638		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate, and details such as sampler calibration are provided.
	Metric 2:	Analytical Methodology	High	The analytical methodology is clear and appropriate. The LOD for all chemicals is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in China.
	Metric 5:	Currency	Low	Samples were collected from 2004.
	Metric 6:	Spatial and Temporal Variability	Low	4 hospitals were sampled. Replicate measurements were taken.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air in hospitals in China. The scenario is well characterized with information about the microclimate and other details.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Raw data is not provided. The mean and standard deviation are shown in Table 1.
	Metric 9:	Quality Assurance	Medium	The use of lab and field blanks is reported. QA/QC issues were not identified.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Standard deviations are provided in Table 1. No other measures or discussion of variance is provided.
Overall Quality Determination		Medium		

Study Citation:		Matthews, T. G., Hawthorne, A. R., Daffron, C. R., Corey, M. D., Reed, T. J., Schrimsher, J. M. (1984). Formaldehyde surface emission monitor. Analytical Chemistry 56:448-454.		
HERO ID:		2444112		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Most necessary sampling methods were reported. The study did not report sample storage conditions or sampler calibration.
	Metric 2:	Analytical Methodology	Medium	The study reports the LOD. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	Critically Deficient	The location of data collection was not reported.
	Metric 5:	Currency	Low	The study was published in 1984.
	Metric 6:	Spatial and Temporal Variability	Medium	Seven samples were collected.
	Metric 7:	Exposure Scenario	Low	This was more of an experimental study and did not explore a real world exposure scenario.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	High	Raw data were reported.
	Metric 9:	Quality Assurance	Low	Limited QA was reported.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination		Uninformative		

Study Citation:		Scheepers, P. T., de Hartog, J. J., Reijnaerts, J., Beckmann, G., Anzion, R., Poels, K., Godderis, L. (2014). Influence of combined dust reducing carpet and compact air filtration unit on the indoor air quality of a classroom. Environmental Science: Processes & Impacts 17:316-325.		
HERO ID:		2533901		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The air sampling methodology is detailed and scientifically sound, providing equipment, procedures, storage conditions and study site characteristics.
	Metric 2:	Analytical Methodology	Medium	Analytical methods were well-described but the authors did not report LOD.
	Metric 3:	Biomarker Selection	N/A	The study analyzed air samples.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in the Netherlands
	Metric 5:	Currency	Medium	Sampling happened in 2011
	Metric 6:	Spatial and Temporal Variability	Medium	Two sampling locations with 5 replicate samples.
	Metric 7:	Exposure Scenario	Medium	The data may represent relevant exposure scenarios related to indoor airborne formaldehyde in schools from the Netherlands, but the limited number of locations sampled
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Low	The authors only provided summary statistics (average concentrations).
	Metric 9:	Quality Assurance	High	QA/QC techniques were described, including the use of control samples.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability was not characterized for formaldehyde concentrations, but limitations and uncertainties were discussed.
Overall Quality Determination		Medium		

Study Citation:		Lee, J. H., Lee, H. S., Park, M. R., Lee, S. W., Kim, E. H., Cho, J. B., Kim, J., Han, Y., Jung, K., Cheong, H. K., Lee, S. I., Ahn, K. (2014). Relationship between indoor air pollutant levels and residential environment in children with atopic dermatitis. Allergy, Asthma & Immunology Research 6:517-524.		
HERO ID:		2533947		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	The sampling methodology is clear and appropriate; however, some details such as sampler calibration and sample storage are not provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD or LOQ is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Seoul, Korea.
	Metric 5:	Currency	Medium	Samples were collected from 2008 to 2010.
	Metric 6:	Spatial and Temporal Variability	Medium	149 samples were collected, replicates were not reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air of homes in Seoul, Korea. The exposure scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	The mean, standard deviation, and percentiles (5th through 99th) are provided in Table 2. No raw data is reported.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not discussed and issues were not identified. The use of blanks, controls, or standards is not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variance is characterized in Table 2, with the standard deviation and percentiles provided.
Overall Quality Determination			Medium	

Study Citation:		Chan, W. R., Cohn, S., Sidheswaran, M., Sullivan, D. P., Fisk, W. J. (2014). Contaminant levels, source strengths, and ventilation rates in California retail stores. Indoor Air 25:381-392.		
HERO ID:		2535652		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology	Medium	Some sampling method criteria not reported, such as storage conditions/duration
		Metric 2: Analytical Methodology	Medium	Some analytical method criteria not reported, such as recoveries
		Metric 3: Biomarker Selection	N/A	No biomarkers
Domain 2: Representativeness		Metric 4: Geographic Area	High	USA, California
		Metric 5: Currency	Medium	Data collected between 2011 and 2013
		Metric 6: Spatial and Temporal Variability	Medium	No sample replicates.
		Metric 7: Exposure Scenario	High	Measure indoor air concentrations at retail stores
Domain 3: Accessibility/Clarity		Metric 8: Reporting of Results	Medium	No raw data reported.
		Metric 9: Quality Assurance	Low	Limited QA/QC reported
Domain 4: Variability and Uncertainty		Metric 10: Variability and Uncertainty	Medium	Limited information provided on gaps and limitations
Overall Quality Determination			Medium	

Study Citation:		Ochs, S., Grotz, L., Factorine, L. S., Rodrigues, M. R., Pereira Netto, A. D. (2011). Occupational exposure to formaldehyde in an institute of morphology in Brazil: a comparison of area and personal sampling. Environmental Science and Pollution Research 19:2813-2819.		
HERO ID:		2566605		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	The sampling methodology is clear and appropriate; however, details such as the sampler calibration and sample storage are not provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD or LOQ is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Brazil.
	Metric 5:	Currency	Medium	Samples were collected from 2010 to 2011.
	Metric 6:	Spatial and Temporal Variability	Low	There were 4 sampling days, with both personal and area samplings. Two of the sampling days had two personal samplings.
	Metric 7:	Exposure Scenario	High	Exposure scenario is formaldehyde in indoor air of institute laboratories. This scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Concentrations were reported in Table 2 as raw data.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not reported and issues were not identified. The use of blanks, controls, or standards is not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability is absent. No standard deviations are reported.
Overall Quality Determination			Medium	

Study Citation:		Zhang, C., Hu, S., Wang, G. (2009). Experimental research on the formaldehyde diffusion performance in an air-conditioning office. 3:48-51.		
HERO ID:		2571257		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	Low	The authors provided a limited description of the sampling methodology, missing details about the sampling procedure or sampler calibration.
	Metric 2:	Analytical Methodology	Low	The analytical methods are only briefly described, missing details about the LOD, recovery samples and instrument calibration.
	Metric 3:	Biomarker Selection	N/A	The authors analyzed environmental media (air).
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Quindao, China
	Metric 5:	Currency	Low	The manuscript was published in 2009
	Metric 6:	Spatial and Temporal Variability	Low	n=6 sampling locations, no replicates
	Metric 7:	Exposure Scenario	Low	The formaldehyde concentration data may represent a relevant indoor exposure scenario, but the small sample size limits the results generalizability.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Critically Deficient	Figure 2 provides concentration measurements during the period of sampling, without providing units. Summary statistics were not provided.
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not described.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	Variability was not characterized. Uncertainties and limitations were not discussed.
Overall Quality Determination		Uninformative		

Study Citation:		Maruo, Y. Y., Yamada, T., Nakamura, J., Izumi, K., Uchiyama, M. (2010). Formaldehyde measurements in residential indoor air using a developed sensor element in the Kanto area of Japan. Indoor Air 20:486-493.		
HERO ID:		2583507		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Key sampling methods reported
	Metric 2:	Analytical Methodology	Medium	Recovery samples not reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Japan
	Metric 5:	Currency	Medium	Samples collected in 2007
	Metric 6:	Spatial and Temporal Variability	Medium	>10 samples; no replicates
	Metric 7:	Exposure Scenario	High	Exposure source characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data is reported in Table 2.
	Metric 9:	Quality Assurance	Low	Limited QA reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Few gaps and limitations reported
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Monitoring

HERO ID: 2591662

Study Citation:		Maddalena, R., Russell, M., Sullivan, D. P., Apte, M. G. (2009). Formaldehyde and other volatile organic chemical emissions in four FEMA temporary housing units. Environmental Science and Technology 43:5626-5632.		
HERO ID:		2591662		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Air in each unoccupied temporary housing unit (THU) was sampled with four 6-mm diameter tubes inserted through the trailer door, extending 1 m into the trailer positioned 1 m above the floor. Fans ensured whole-trailer air circulation. Formaldehyde concentrations were determined using ASTM Test Method D5197-92. Air samples of approximately 6 L were drawn through silica gel cartridges coated with 2,4-DNPH. Ventilation was determined using a tracer gas decay method. Temperature, %RH, and CO2 concentrations were measured in each trailer and outdoors. Each sample pump was checked against a calibrated flow meter before and after each sampling event. Samples were transported on ice and frozen until analysis. Characteristics of each THU are reported in the SI.
	Metric 2:	Analytical Methodology	High	Sampling cartridges were extracted with acetonitrile and analyzed by HPLC with UV detection at 360 nm. Amounts were quantified by multipoint calibration for the formaldehyde DNPH-derivative product (page S-4). Samples analyzed with EPA Method TO-17. The LOQ was reported (page S-5).
	Metric 3:	Biomarker Selection	N/A	No biomarker of HCHO exposure was evaluated.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Air was sampled from four closed trailer homes selected from stock available to FEMA as temporary housing units (THUs) in Purvis, Mississippi, USA.
	Metric 5:	Currency	Medium	All samples were collected on November 14, 2007, five days after the units were moved to the area.
	Metric 6:	Spatial and Temporal Variability	Low	Only four temporary housing units were sampled, with only two samples per unit, once in the morning, and once in the afternoon, on a single day in November. No replicates reported.
	Metric 7:	Exposure Scenario	Medium	The trailers were less than two years old, and had never been occupied. Doors and windows were closed for approximately one week prior to air sampling. Ventilation rates, therefore, were likely to be substantially lower than during normal occupancy, and HCHO concentrations correspondingly higher. The study focused on HCHO emission rates from different build materials and was not intended to simulate occupied trailers.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Table S-10 includes the raw data for measured HCHO trailer indoor air concentrations (n = 2 measures, am and pm, and 4 trailers, for total of 8 hour-long samples). Also included are two outdoor samples. Summary statistics not reported.
	Metric 9:	Quality Assurance	High	The Supplemental Information (SI) includes a Quality Assurance section. Sampling included two trip blanks for each (morning sample and afternoon sample, four trailers). Sample storage stability and recovery from spiked samples were determined. A laboratory reference material was analyzed to estimate precision. Analytical blanks were included in all analyses. Recovery from the spiked/stored samples were 100% ± 3% for all analytes.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	The sample size of four trailers was too small to reveal spatial or temporal variability, although afternoon air measurements of HCHO inside the trailers were consistently higher than the morning measurements. The study does report some limitations on page 6.
Overall Quality Determination			Medium	

Study Citation:		Shinohara, N., Kai, Y., Mizukoshi, A., Fujii, M., Kumagai, K., Okuizumi, Y., Jona, M., Yanagisawa, Y. (2009). On-site passive flux sampler measurement of emission rates of carbonyls and VOCs from multiple indoor sources. Building and Environment 44:859-863.		
HERO ID:		2608028		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods not reported, such as
	Metric 2:	Analytical Methodology	Low	LOD nor LOQ reported
	Metric 3:	Biomarker Selection	N/A	Parent chemical is focus.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in Tokyo, Japan.
	Metric 5:	Currency	Low	Samples collected in 2003.
	Metric 6:	Spatial and Temporal Variability	Medium	No replicates.
	Metric 7:	Exposure Scenario	High	Exposure scenarios are relevant to HCHO RE.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Results are well reported. Raw data can be found in Table 2: Emission flux of carbonyl compounds from indoor sources.
	Metric 9:	Quality Assurance	Low	Limited QA/QC information reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	No limitations reported
Overall Quality Determination			Medium	

Study Citation:		Yamashita, S., Kume, K., Horiike, T., Honma, N., Fusaya, M., Amagai, T. (2012). Emission Sources and their Contribution to Indoor Air Pollution by Carbonyl Compounds in a School and a Residential Building in Shizuoka, Japan. Indoor and Built Environment 21:392-402.		
HERO ID:		2649942		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate. Details such as sampler calibration are provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear, appropriate, and detailed, but the LOD is not reported. The text says the LOD has already been provided in another reference.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Shizuoka, Japan.
	Metric 5:	Currency	Medium	Samples were collected in 2006.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	The number of samples is unclear and is not reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor and outdoor air in schools in Japan. This scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Mean concentrations are provided in Tables 2 and 3. Table 1 provides a range of concentrations of the passive sampler. No raw data is provided.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not discussed and issues are not identified. The use of blanks or controls is not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability is absent. No standard deviations are reported.
Overall Quality Determination			Uninformative	

Study Citation:		Weng, M. L. (2012). Levels and possible sources of formaldehyde in campus. Advanced Materials Research Volumes 479-481 479-481:546-549.		
HERO ID:		2657991		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods not reported such as sampler calibration
	Metric 2:	Analytical Methodology	Low	LOD nor LOQ reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	China
	Metric 5:	Currency	Medium	Study published in 2012
	Metric 6:	Spatial and Temporal Variability	Medium	>10 samples; no replicates
	Metric 7:	Exposure Scenario	Medium	Exposure sources not well characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Raw data reported
	Metric 9:	Quality Assurance	Low	QA not reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations reported
Overall Quality Determination			Medium	

Study Citation:		Peteffi, G. P., Basso da Silva, L., Antunes, M. V., Wilhelm, C., Valandro, E. T., Glaeser, J., Kaefer, D., Linden, R. (2015). Evaluation of genotoxicity in workers exposed to low levels of formaldehyde in a furniture manufacturing facility. Toxicology and Industrial Health 32:1763-1773.		
HERO ID:		2849798		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Air was sampled continuously for 8 hours in breathing zone of workers at a furniture factory and at a nearby university. Urine, 2 mL, was collected one time at end of the 8-hr day, but handling of samples was not described. The sample for workers was taken at the end of the fifth day of consecutive exposure. Air and urine samples for each individual were taken on the same day. Control subjects were selected from the nearby university provided they had no history of exposure to genotoxic substances. An air monitor was set at seven different locations/sectors in factory and at five different locations at university. The sex ratio of the control and exposed groups differed.
	Metric 2:	Analytical Methodology	Low	Air concentrations were measured using passive sampler according to EU ISO 16000-4-2004. Urinary formic acid concentrations were analyzed using GC flame ionization. LOD/LOQ were not reported, but for formic acid in urine, the LOD can be inferred from Table 3.
	Metric 3:	Biomarker Selection	N/A	Formic acid is not a relevant metabolite unique to formaldehyde.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The furniture factory and the local university were located in the Sinos River Valley region in the state of Rio Grande do Sul, southern Brazil.
	Metric 5:	Currency	Low	The sampling year was not reported. The report was published in 2015.
	Metric 6:	Spatial and Temporal Variability	Medium	HCHO concentrations were measured in 5 areas at the university and 7 different sector areas at the factory. An air sampler ran for 8 hours in each fixed location, and no replicates were taken. A single 2 mL urine sample was collected at the end of the day of air sampling for 46 workers at the factory (distributed across 7 work areas) 45 individuals at the university (relationship to air sampling locations not specified). No replicate samples were taken.
	Metric 7:	Exposure Scenario	Low	For the furniture factory workers, measured air concentrations were below the OSHA 8-hr limit, yet urinary formic acid concentrations among workers were correlated with air concentrations where they worked (n = 7 work sectors/areas). The different working areas were not described. Questionnaires surveyed habits of workers and control subjects (i.e., students and employees at local university); however, sources of HCHO were not reported.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	For air concentrations, the raw data are reported for the seven 8-hr measurements from the factory, but only the mean and SD were reported for the samples from the university. For urinary formic acid, raw data were not reported, and Table 3 reported the 25th, 50th, and 75th percentile values.
	Metric 9:	Quality Assurance	Low	Discussion of QA for urinary analysis of formic acid was limited to range of linearity and intra-day and inter-day precision of the analytic method, although when and how samples for analysis of precision were obtained were not described. The report did not discuss QA for air samples.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	For urinary formic acid samples, at least 75% of the control urine samples were below the range of the linear response of the analytic method, yet the report did not mention that limitation. The report did not discuss variation and uncertainty in air sample formaldehyde concentrations. The authors focused discussion of uncertainty and variability on biomarkers of genetic damage.
Overall Quality Determination			Low	

March 2024

Formaldehyde

Monitoring

HERO ID: 2993545

Study Citation:		Amiri, A., Pryor, E., Rice, M., Downs, C. A., Turner-Henson, A., Fanucchi, M. V. (2015). Formaldehyde exposure during pregnancy. MCN, The American Journal of Maternal Child Nursing 40:180-185.		
HERO ID:		2993545		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Low	Sampling equipment and methods were described in sufficient detail, but duration of storage was not clearly reported. Sampling frequency From referring to the citation provided, it was determined that duration of storage beyond two weeks can affect results as the manufacturer specifications for the sampler note that it is required to be returned for laboratory analysis within two weeks.
	Metric 2:	Analytical Methodology	Low	Analytical instrumentation and methods were not directly discussed, but can be implied through the use of a commercially available sampler for which the manufacturer reports use of standard laboratory protocols.
	Metric 3:	Biomarker Selection	N/A	This study was testing for the parent chemical of interest in environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	This study was conducted in Huntsville, Alabama, USA.
	Metric 5:	Currency	Medium	Participants were recruited during March-June 2013, and data collection is inferred to take place within the following nine months.
	Metric 6:	Spatial and Temporal Variability	Medium	24-hour samples were collected from 88 participants. No use of replicates was reported.
	Metric 7:	Exposure Scenario	High	Characteristics and behaviors of study participants were well documented and allow for this information to be confidently generalized. Exposure to residential sources of formaldehyde during pregnancy is relevant.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Raw data were not reported. Summary statistics included mean, standard deviation, and range of concentrations for the entire sample.
	Metric 9:	Quality Assurance	Low	Quality assurance/quality control techniques and results were not discussed.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Variability is quantitatively characterized through reporting of standard deviation of exposure levels. Analysis in the discussion further characterized variability by environmental conditions and participant behaviors and included discussion of limitations, which were minimal.
Overall Quality Determination			Medium	

Study Citation:		Hodgson, A. T., Rudd, A. F., Beal, D., Chandra, S. (2000). Volatile organic compound concentrations and emission rates in new manufactured and site-built houses. Indoor Air 10:178-192.		
HERO ID:		2994962		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Most sampling methods for a study on indoor air were reported. The study did not report sampler calibration.
	Metric 2:	Analytical Methodology	Low	The study did not report an LOD nor LOQ.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in the United States.
	Metric 5:	Currency	Low	The studies were collected in 1997 and 1998.
	Metric 6:	Spatial and Temporal Variability	Medium	Three projects were sampled. Two of the projects had replicate samples collected.
	Metric 7:	Exposure Scenario	Medium	There were not enough samples and too many chemicals collected to differentiate the specific sources of chemical concentrations.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	The study did not report raw data. The study reported the geometric mean, GSD, and range.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps and limitations.
Overall Quality Determination		Low		

Study Citation:		Wang, Y., Tsai, C. H., Lin, C. H., Chen, S. H. (2014). Measurement of Air Quality during a Decorating Engineering. Aerosol and Air Quality Research		
HERO ID:		14:2029-2039. 3001485		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	The sampling methodology is clear and appropriate; however, some details such as sample storage and sampler calibration are not provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in Taiwan.
	Metric 5:	Currency	Low	Publication date is 2014. No sample collection date is provided.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	The number of samples is not reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde during decorating engineering in Taiwan. The route of exposure is well characterized and details to inform the exposure scenario are provided.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Averages and standard deviations are provided in Table 1. No raw data is provided.
	Metric 9:	Quality Assurance	Medium	QA/QC measures are briefly discussed and the use of blanks is reported.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Medium	Standard deviations are provided in Table 1. There is no discussion on uncertainty.
Overall Quality Determination		Uninformative		

Study Citation:		Saowakon, N., Ngernsoungnern, P., Watcharavitoon, P., Ngernsoungnern, A., Kosanlavit, R. (2015). Formaldehyde exposure in gross anatomy laboratory of Suranaree University of Technology: a comparison of area and personal sampling. Environmental Science and Pollution Research 22:19002-19012.		
HERO ID:		3001567		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The indoor air and breathing zone air samples were collected based on NIOSH-2016 method. Sampling site characteristics are provided. Sampling equipment, sampling procedure and duration are reported.
	Metric 2:	Analytical Methodology	Low	LOD or LOQ is not reported.
	Metric 3:	Biomarker Selection	N/A	Biomarker not evaluated in this study.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Study located in Suranaree University of Technology, Thailand
	Metric 5:	Currency	Medium	Samples collected in January, August, and October of 2014.
	Metric 6:	Spatial and Temporal Variability	Medium	Replicate samples were collected for each observation. Sample numbers for indoor air and instructor’s breathing zone air is less 5 and 4, respectively.
	Metric 7:	Exposure Scenario	High	Exposure scenario was described. The source of exposure is from cadavers during anatomy dissection classes. The average room temperature also reported.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data not provided. The summary statistics are reported with central tendency and variance.
	Metric 9:	Quality Assurance	Low	The study applied quality control measures but limited information is provided. The reported QC method is analyses of blank cartridge with six levels of known formaldehyde concentrations.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The discussion of uncertainty and limitations is absent.
Overall Quality Determination			Medium	

Study Citation:		O’Connell, G., Colard, S., Cahours, X., Pritchard, J. D. (2015). An Assessment of Indoor Air Quality before, during and after Unrestricted Use of E-Cigarettes in a Small Room. International Journal of Environmental Research and Public Health 12:4889-4907.		
HERO ID:		3011067		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	The sampling equipment used in this study was reported as were the procedures. Some methods were not reported such as sampler calibration and sample storage conditions.
	Metric 2:	Analytical Methodology	Medium	The limit of detection was reported (9 mg/m ³). Recovery samples were not reported in this study.
	Metric 3:	Biomarker Selection	N/A	This metric was not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in the United Kingdom.
	Metric 5:	Currency	Low	The study was published in 2015 but there was no date of data collection that was reported.
	Metric 6:	Spatial and Temporal Variability	Low	Less than five samples were collected (4 total) and there were no replicates that were collected.
	Metric 7:	Exposure Scenario	High	The exposure scenario was characterized because this was a controlled study. The type of product used was characterized (E-cigarettes) meaning the source of exposure was known and the method of application.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	High	Raw data were reported in this study in Table 1.
	Metric 9:	Quality Assurance	Medium	Limited QA was reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Limitations were reported.
Overall Quality Determination		Medium		

March 2024

Formaldehyde

Monitoring

HERO ID: 3019371

Study Citation:		Derbez, M., Berthineau, B., Cochet, V., Pignon, C., Riberon, J., Wyart, G., Mandin, C., Kirchner, S. (2014). A 3-year follow-up of indoor air quality and comfort in two energy-efficient houses. Building and Environment 82:288-299.		
HERO ID:		3019371		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Temperature was measured continuously; exhaust air flow rate was measured at intervals. Characteristics of each house are reported in Table 1. Aldehydes were sampled by passive diffusive samplers over a period of 7 days (Radiello (R)). However, a single sampler was placed in the main bedroom of each house, and its location relative to the floor or walls was not described.
	Metric 2:	Analytical Methodology	Medium	The LOD not reported in this reference; however, the authors state that the LOD is reported in an earlier publication (Ramalho et al. 2006). Samples were analyzed by HPLQ with detection by UV absorption. The limit of identification was less than 1 ug/m3. None of the measurements were below the LOD. This metric likely could be upgraded to high with retrieval of the listed reference.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of HCHO exposure were evaluated.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The two energy-efficient single-family homes evaluated were in western France (Pays-de-la-Loire).
	Metric 5:	Currency	Medium	The two houses were sampled at intervals from June 2009 through January 2012.
	Metric 6:	Spatial and Temporal Variability	Medium	Spatial variability had limited representation (n = 2 houses), whereas each house was followed for three years. Seven weeks of measurements were spaced over three years: 1 week pre-occupancy; 1 week in the summers of 2009, 2010, and 2011; and 1 week in the corresponding winters in each house.
	Metric 7:	Exposure Scenario	High	Exposure to HCHO emitted inside energy-efficient newly built houses is a primary exposure route for families, particularly homemakers and young children.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Raw data are reported in Table 5 (seven week-long measurements for each house). The frequency of detection was 100%. Mean and standard deviations for each house are reported in Table 8.
	Metric 9:	Quality Assurance	Medium	Quality assurance for HCHO measurements are not discussed in this report per se, but likely reported in Ramalho et al. (2006). Many other chemicals and physical parameters were measured, and precision for each was reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Analytic uncertainty was estimated to be 10% for aldehydes. The authors described possible reasons for relatively steady HCHO concentrations over time (total of 7 measurements over 3 years). Mean and SD of measured HCHO concentrations for each house's main bedroom are reported in Table 8. Spatial variability was not evaluated.
Overall Quality Determination			Medium	

Study Citation:		Brown, S. K. (2002). Volatile organic pollutants in new and established buildings in Melbourne, Australia. Indoor Air 12:55-63.		
HERO ID:		3449470		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methodology details were not reported, e.g., storage conditions.
	Metric 2:	Analytical Methodology	Low	The analytical methods were briefly discussed and did not include LOD or recoveries.
	Metric 3:	Biomarker Selection	N/A	The authors measured chemicals in the air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Melbourne, Australia.
	Metric 5:	Currency	Low	Timing of sample collection for monitoring data is not reported, discussed, or referenced. The study was published in 2002.
	Metric 6:	Spatial and Temporal Variability	Medium	n<5 for formaldehyde and replicate samples were not collected.
	Metric 7:	Exposure Scenario	High	The data may represent relevant exposure scenarios related to airborne formaldehyde, but the small sample size and limited methodological details limit the results generalizability.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Limited summary statistics were reported.
	Metric 9:	Quality Assurance	Low	Limited QA/QC details were reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Variability was not characterized. Limited information provided on gaps and limitations.
Overall Quality Determination			Low	

Study Citation:		Kauneliene, V., Prasauskas, T., Krugly, E., Stasiulaitiene, I., Ciuzas, D., Seduikyte, L., Martuzevicius, D. (2016). Indoor air quality in low energy residential buildings in Lithuania. Building and Environment 108:63-72.		
HERO ID:		3458632		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Samples were collected with passive sampler tubes. Procedures were listed. Some sampling methods were not reported such as sample storage conditions and sampler calibration
	Metric 2:	Analytical Methodology	High	Key analytical methods were reported, including the LOD.
	Metric 3:	Biomarker Selection	N/A	Metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Lithuania.
	Metric 5:	Currency	Medium	Study was conducted in 2014
	Metric 6:	Spatial and Temporal Variability	High	>10 scenarios and replicates were collected for this study
	Metric 7:	Exposure Scenario	Medium	The exposure source was not well characterized. The amount of chemical used was not reported.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported
	Metric 9:	Quality Assurance	High	QA was reported in the study, including duplicate samples, blanks, etc.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Few gaps and limitations were reported
Overall Quality Determination			High	

March 2024

Formaldehyde

Monitoring

HERO ID: 3464476

Study Citation:		Abbass, O. A., Sailor, D. J., Gall, E. T. (2017). Effect of fiber material on ozone removal and carbonyl production from carpets. Atmospheric Environment 148:42-48.		
HERO ID:		3464476		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methods for formaldehyde at experimental chamber exit described in terms of equipment, referenced (Coleman, 2008) procedures and experimental chamber set-up. Duration between sampling and sample analysis not detailed.
	Metric 2:	Analytical Methodology	Low	Limits of detection not reported, sampling analytical methodology described in terms of instrumentation and instrument calibration.
	Metric 3:	Biomarker Selection	N/A	Study measured chemical of interest within air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sampling area not mentioned within text, but assumed to be Oregon as noted within Acknowledgements for testing chamber site and analyses.
	Metric 5:	Currency	Low	Dates of sampling not noted. Publication date 2017.
	Metric 6:	Spatial and Temporal Variability	Low	A total of n=12 one hour formaldehyde air samples (assumed from description of procedures) collected for each 20 centimeter square sample of n=6 types of unused carpet stock samples from local carpet stores within ozonated and non-ozonated chamber sessions. No repeated sampling conducted.
	Metric 7:	Exposure Scenario	Medium	Sources of exposure described in terms of details of utilization of 20 centimeter squares of carpet samples as taken from unused carpet stock samples from local carpet stores for six types of commercial or residential carpets tested within experimental chamber. Exposure sources discussed within discussion of carpet type emission differences noted within previous studies.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Reported results presented only for samples taken after experimental chamber ozonation as calculated molar yields per mole of ozone with no statistical summary measure of variation in Figure 7, and for primary and secondary emissions results within text page 6 with no measure of variation. Frequency of detection not reported. Raw data not reported.
	Metric 9:	Quality Assurance	Medium	Description of QA/QC techniques lacking, however measures made before (control) and after introduction of ozone to the chamber.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Characterization of variability within statistical (SD) summary measures lacking, and discussion of potential study limitations lacking.
Overall Quality Determination			Low	

Study Citation:		Shang, Y., Li, B., Baldwin, A. N., Ding, Y., Yu, W.,ei, Cheng, L.,i (2016). Investigation of indoor air quality in shopping malls during summer in Western China using subjective survey and field measurement. Building and Environment 108:1-11.		
HERO ID:		3468878		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods were not reported such as sample storage conditions and sampler calibration
	Metric 2:	Analytical Methodology	Medium	Recovery samples were not reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in China.
	Metric 5:	Currency	High	Samples were conducted in 2014 and 2015
	Metric 6:	Spatial and Temporal Variability	Medium	<10 samples but there were replicates
	Metric 7:	Exposure Scenario	High	The exposure source was characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Raw data were reported
	Metric 9:	Quality Assurance	Low	Limited QA was reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Some limitations were reported
Overall Quality Determination			Medium	

Study Citation:		Pei, J., Yin, Y., Liu, J. (2016). Long-term indoor gas pollutant monitor of new dormitories with natural ventilation. Energy and Buildings 129:514-523.		
HERO ID:		3474643		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some sampling methods were not reported such as sample storage conditions and sampler calibration
	Metric 2:	Analytical Methodology	Medium	Recovery samples were not reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Study was conducted in China
	Metric 5:	Currency	High	Samples were collected in 2015
	Metric 6:	Spatial and Temporal Variability	Medium	<10 scenarios with replicates were collected
	Metric 7:	Exposure Scenario	High	The exposure source was characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported
	Metric 9:	Quality Assurance	Low	Limited QA was reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations were reported
Overall Quality Determination			Medium	

Study Citation:		Kang, J., Liu, J., Pei, J. (2017). The indoor volatile organic compounds (VOCs) characteristics and source identification in a new university campus in Tianjin, China. Journal of the Air and Waste Management Association 67:725-737.		
HERO ID:		3603736		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some methods were not reported such as sample storage conditions and sampler calibration. Samples were collected in accordance with the Chinese indoor air quality standardGB/T 18883-2002. The LOD nor LOQ were reported in this study. The metric is not applicable to the data source.
	Metric 2:	Analytical Methodology	Low	
	Metric 3:	Biomarker Selection	N/A	
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted at a university in Tianjin, China.
	Metric 5:	Currency	High	The study was conducted in June to September 2015 in two stages.
	Metric 6:	Spatial and Temporal Variability	High	518 samples were collected which includes replicates.
	Metric 7:	Exposure Scenario	Medium	The amount and type of chemical used is not explicit; the sources of exposure are somewhat clear (new construction products), and the use of exposure controls is not reported.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	The raw data for this study are not reported. The average concentration of formaldehyde is reported but several other summary statistics are missing.
	Metric 9:	Quality Assurance	Low	QA/QC was not reported in the study
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Gaps and limitations were not reported and there was no characterization of variability in the study.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Monitoring

HERO ID: 3864192

Study Citation:		Plaisance, H., Vignau-Laulhere, J., Mocho, P., Sauvat, N., Raulin, K., Desauziers, V. (2017). Volatile organic compounds concentrations during the construction process in newly-built timber-frame houses: source identification and emission kinetics. Environmental Science: Processes & Impacts 19:696-710.		
HERO ID:		3864192		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methodology described in terms of sampling equipment, procedures and study site characteristics. Some details, such as duration of time between sampling and analysis, lacking.
	Metric 2:	Analytical Methodology	Medium	Limits of detection reported (LODs, Table 1). Analytical methodology reported in terms of instrumentation, instrument calibration, LODs, however some details regarding recovery lacking. Analytics performed according to procedures within referenced (Bourdin et al., 2014).
	Metric 3:	Biomarker Selection	N/A	Study measured chemical of interest within air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sampling conducted within three houses in Egleteons, France.
	Metric 5:	Currency	Low	Sampling dates not described. Publication date 2017.
	Metric 6:	Spatial and Temporal Variability	Medium	Text (page 3) notes between 2 to 5 replicate VOC measurements obtained at each of six construction site stage with sampling conducted at a rate of 1 to 2 samples every half hour. Non-continuous, vacuum air sampling.
	Metric 7:	Exposure Scenario	Medium	Potential sources of VOC exposures, with a focus on polyurethane adhesive mastic, described throughout text for each stage of construction of three houses over 25-26 months of construction in France. VOC monitoring conducted within single room (main bedroom). Emission rates of 20 construction materials examined within experimental chamber.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Results reported within Table 3 for mean and range of concentrations. Raw data not reported.
	Metric 9:	Quality Assurance	Low	Quality assurance in sampling not directly described, however procedures for assuring the comparativeness of test houses detailed within text (page 2) and study use of standard sampling and analytic procedures.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability of concentration results presented within statistical summary materials (Table 3). Study limitations discussed in terms of sampling design within Conclusions (page 14).
Overall Quality Determination			Medium	

Study Citation:		Rahman, M. A., Rossner, A., Hopke, P. K. (2017). Occupational exposure of aldehydes resulting from the storage of wood pellets. Journal of Occupational and Environmental Hygiene 14:417-426.		
HERO ID:		3870738		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methodology described in terms of sampling equipment, procedures and study site characteristics. Some details, such as equipment calibration and duration of time between sampling and analysis, lacking.
	Metric 2:	Analytical Methodology	Low	Limits of detection not detailed. Analytical methodology described in terms of extraction, analytical instrumentation, and NIOSH standard methodology.
	Metric 3:	Biomarker Selection	N/A	Study measured chemical of interest within air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sampling conducted within warehouse and areas in the state of New York.
	Metric 5:	Currency	High	April–June 2016. The Sampling dates are not specified in the method but it say April–June 2016 in the abstract.
	Metric 6:	Spatial and Temporal Variability	Low	Two residential homes with bulk wood pellet storage bins
	Metric 7:	Exposure Scenario	Medium	Basement of a residential home and outside the residential home.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Results reported within Figures 4-8 and text for mean and range statistical summary measures. Raw data, frequency of detection, not reported.
	Metric 9:	Quality Assurance	Low	Quality assurance not discussed in detail but implied through the use of standard NIOSH analytic methodologies.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Characterization of concentration variability within reported ranges, robust discussion of potential study limitations lacking.
Overall Quality Determination			Medium	

Study Citation:		Diodiu, R., Galaon, T. (2017). Comparing carbonyls levels in indoor air in two offices - green and old building. Revista de Chimie 68:1708-1710.		
HERO ID:		4082578		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	This study contains most sampling methods for indoor air. Some methods were not reported such as sample storage conditions.
	Metric 2:	Analytical Methodology	Low	The LOD nor LOQ were reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Romania.
	Metric 5:	Currency	Low	The date of sample collection was not reported.
	Metric 6:	Spatial and Temporal Variability	Low	The data were collected from two scenarios.
	Metric 7:	Exposure Scenario	Medium	Exposure sources were not well characterized in this study.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported in this study.
	Metric 9:	Quality Assurance	Low	Limited QA was reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Gaps and limitations were not reported
Overall Quality Determination			Low	

Study Citation:		Mentese, S., Gullu, G. (2006). Variations and sources of formaldehyde levels in residential indoor air in Ankara, Turkey. Indoor and Built Environment 15:273-281.		
HERO ID:		4085781		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology	High	Key sampling methods reported
		Metric 2: Analytical Methodology	Medium	Recovery samples not reported
		Metric 3: Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness		Metric 4: Geographic Area	High	Ankara, Turkey
		Metric 5: Currency	Low	Samples collected in 2004
		Metric 6: Spatial and Temporal Variability	Medium	>10 samples; no replicates
		Metric 7: Exposure Scenario	Medium	Exposure scenario not well characterized
Domain 3: Accessibility/Clarity		Metric 8: Reporting of Results	Medium	Raw data not reported
		Metric 9: Quality Assurance	High	Key QA reported
Domain 4: Variability and Uncertainty		Metric 10: Variability and Uncertainty	Low	Few gaps and limitations reported
Overall Quality Determination			Medium	

Study Citation:		Derbez, M., Wyart, G., Le Ponner, E., Ramalho, O., Ribéron, J., Mandin, C. (2017). Indoor air quality in energy-efficient dwellings: Levels and sources of pollutants. Indoor Air 28:318-338.		
HERO ID:		4166147		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The dwelling selection criteria are described in the report. Aldehydes were sampled using radial diffusive samples with 2,4-DNPH-coated Florisil (ISO method 16000-4) placed in the master bedroom. Samples were frozen for storage and transport to the lab. Each dwelling was sampled twice for 7 days, one week during heating season and one week during non-heating season. Technical inspectors filled out questionnaires on building location, type, materials, ventilation, family occupancy, and recent activities.
	Metric 2:	Analytical Methodology	High	Aldehyde samples were quantified by HPLC and UV absorption (ISO method 16000-4).
	Metric 3:	Biomarker Selection	N/A	No biomarkers of exposure were evaluated.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Dwellings in France were selected from a program with voluntary participation in new and retrofitting high-energy-performance buildings in three different climatic regions.
	Metric 5:	Currency	Medium	Air samples were collected between January 2013 and July 2014.
	Metric 6:	Spatial and Temporal Variability	High	Dwellings (n=65) included at least 15 single-family houses and 50 multi-family apartments in three climatic zones (slightly different for heating and non-heating seasons). Characteristics of the buildings are listed in Table S3 of SI. Some replicate samples were taken.
	Metric 7:	Exposure Scenario	High	Air concentrations representative of master bedroom, estimated daily exposure duration of >9 hours/day. Air exchange rates were estimated in two ways using carbon dioxide measurements and data on persons present.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Raw data not reported; mean (SD), 25th, 50th, and 75th percentiles reported for all dwellings and single-family houses for the non-heating and heating seasons separately.
	Metric 9:	Quality Assurance	Medium	In "a limited number of dwellings", field blank samples and duplicates were collected; results are reported in Table S2.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Medium	Variation in HCHO concentrations were examined considering air exchange rates and many building/room characteristics covered in the questionnaire. Investigators discussed uncertainties from self-selection of dwellings sampled (voluntary program), unknown variation in daytime ventilation rates, and unknown range of possible HCHO sources in dwellings. Variation and uncertainties were discussed in detail for only three chemicals, none of which were HCHO.
Overall Quality Determination			High	

Study Citation:		Chang, T., Ren, D., Shen, Z., Huang, Y.,u, Sun, J., Cao, J., Zhou, J., Liu, H., Xu, H., Zheng, C., Pan, H.,ua, He, C.,hi (2017). Indoor Air Pollution Levels in Decorated Residences and Public Places over Xi'an, China. Aerosol and Air Quality Research 17:2197-2205.		
HERO ID:		4178623		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Most necessary sampling methods for a study on indoor air pollution levels were reported by the study authors. Sample storage conditions were not reported.
	Metric 2:	Analytical Methodology	Low	The LOD nor the LOQ were reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Xi'an, China.
	Metric 5:	Currency	High	Samples were collected in 2014 and 2015.
	Metric 6:	Spatial and Temporal Variability	Medium	Samples were collected in 471 residential rooms and 58 public rooms.
	Metric 7:	Exposure Scenario	Medium	The specific sources of pollution were not well characterized by this study.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported by the study authors. Summary statistics reported included the min, max, mean, and SD.
	Metric 9:	Quality Assurance	Medium	Limited QA was reported by study authors.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	There were few gaps and limitations reported by this study.
Overall Quality Determination			Medium	

Study Citation:		Diodiu, R., Galaon, T., Bucur, E., Pascu, L. F. (2016). Aldehydes and acetone in indoor air of 19 houses from Bucharest (Romania). Revista de Chimie 67:1466-1468.		
HERO ID:		4259532		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	Samples were collected according to US EPA methods.
	Metric 2:	Analytical Methodology	Low	The LOD nor LOQ were reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in homes in Bucharest, Romania.
	Metric 5:	Currency	High	The samples were collected in 2015.
	Metric 6:	Spatial and Temporal Variability	Medium	19 samples were collected but there were no replicates collected
	Metric 7:	Exposure Scenario	Medium	The exposure source was not well characterized because the source of exposure and the amount and type of chemical used was not reported in the study.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported. The mean was reported but other summary statistics are missing.
	Metric 9:	Quality Assurance	Low	Limited QA was reported in the study.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations were reported. Measures of variability were not reported.
Overall Quality Determination		Medium		

March 2024

Formaldehyde

Monitoring

HERO ID: 4263995

Study Citation:		Kurose, T., Kodera, H., Aoyama, H., Kawamata, S. (2004). Formaldehyde concentration in the air and in cadavers at the gross anatomy laboratory in Hiroshima University. Hiroshima Journal of Medical Sciences 53:33-37.		
HERO ID:		4263995		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Critically Deficient	The sampling methods are briefly described and are not scientifically sound. The authors did not describe, e.g., sample storage conditions or calibration of instruments.
	Metric 2:	Analytical Methodology	Low	Analytical methods were briefly described and did not include LOD, instrumental calibration details or recoveries
	Metric 3:	Biomarker Selection	N/A	The authors analyzed formaldehyde in cadavers' tissue and in the air
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Japan
	Metric 5:	Currency	Low	Samples collected in 2003
	Metric 6:	Spatial and Temporal Variability	Low	Sample size was not described and it is challenging to estimate based on the data provided; n=32 for formaldehyde concentrations in cadavers.
	Metric 7:	Exposure Scenario	Low	Data may represent relevant exposure scenarios related to formaldehyde released from cadavers at the gross anatomy laboratory from Hiroshima University, Japan. However, the lack of methodological details limits the study's validity.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	A range of formaldehyde concentrations in the air is provided in the text (p.35). Individual data points and summary statistics were provided for formaldehyde concentrations in the cadavers.
	Metric 9:	Quality Assurance	Low	QA/QC techniques were not discussed
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The authors provided a limited characterization of variability (SD, range), and did not discuss uncertainties or limitations.

Overall Quality Determination**Uninformative**

March 2024

Formaldehyde

Monitoring

HERO ID: 4455765

Study Citation:		Sugata, Y., Miyaso, H., Odaka, Y., Komiyama, M., Sakamoto, N., Mori, C., Matsuno, Y. (2016). Levels of formaldehyde vapor released from embalmed cadavers in each dissection stage. Environmental Science and Pollution Research 23:16176-16182.		
HERO ID:		4455765		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Active air samplers impregnated with DNPH collected HCHO vapor above the thoracoabdominal region of each dissected cadaver for 30 minutes. The authors described the sampling room, procedure, and durations; however, handling of cadavers between stages of dissection is not described (e.g., during the 60 minutes of ventilation between 30-min sampling sessions, where was the cadaver and was it covered). Calibration not reported.
	Metric 2:	Analytical Methodology	Low	HFHO was eluted from each sampler using acetonitrile and analyzed by HPLC. Results from duplicate samples were averaged and corrected for temperature and humidity. No further details and were reported. Detection limits not reported.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of exposure were examined.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Japan at Chiba University.
	Metric 5:	Currency	Low	The year data were collected from 2-yr old cadavers (embalmed) was not reported; the study was published in 2016.
	Metric 6:	Spatial and Temporal Variability	Medium	Six cadaver dissections were evaluated, and duplicate air samples collected at five sequential stages of dissection.
	Metric 7:	Exposure Scenario	Medium	The exposure scenario is relevant for medical students who dissect cadavers preserved with formalin. Measurements were taken over the cadaver where inhalation exposure could occur; however, a single room configuration was used and other key parameters (e.g., ventilation) were not reported.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	In Figure 2, it is unclear to what the error bar refers (presumably the standard deviation of the mean of n = 6 duplicate sample averages). Raw data not reported. The study did not report overall concentrations, it is unclear how useful only each stage of concentrations are.
	Metric 9:	Quality Assurance	Low	Although sampling was described, the HPLC analysis was not, nor were QA procedures reported. Recoveries not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variation in HCHO vapors over cadavers was measured for five progressive stages of dissection for three male and three female cadavers. Otherwise, spatial conditions were the same and other relevant parameter values (e.g., room size) were not discussed. Limitations not reported.
Overall Quality Determination			Low	

Study Citation:		Hong, W.,ei, Meng, M., Xie, J., Gao, D., Zeng, Y., Ai, H.,ao, Chen, C., Huang, S., Zhou, Z. (2017). Investigation of the Pollution Level and Affecting Factors of Formaldehyde in Typical Public Places in Guangxi, China. Aerosol and Air Quality Research 17:2816-2828.		
HERO ID:		4460157		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Sampling site, equipment, calibration and storage were reported.
	Metric 2:	Analytical Methodology	Low	FDH was analyzed by the Chinese National Standard (GB/T 18204.26-2014). Detection limit not reported.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in China.
	Metric 5:	Currency	High	Samples were collected in 2014 and 2015
	Metric 6:	Spatial and Temporal Variability	High	Sixty samples with 4 scenarios and replicates.
	Metric 7:	Exposure Scenario	High	The study measured FDH in furniture markets, malls, hotels, and restaurants which is relevant for indoor exposure.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	No raw data. Table 1.
	Metric 9:	Quality Assurance	Medium	In order to ensure the reliability and accuracy of the results, the quantification of formaldehyde analysis was conducted in strict accordance with the operating procedures described in the standard methods (GB/T 18204.26-2014). However, recoveries are not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Gaps and limitations were not reported. Variation is measured in the standard values, correlation analysis and different sites studied.
Overall Quality Determination			High	

Study Citation:		Desauziers, V., Bourdin, D., Mocho, P., Plaisance, H. (2015). Innovative tools and modeling methodology for impact prediction and assessment of the contribution of materials on indoor air quality. 3:28.		
HERO ID:		4695416		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Sampling methodology described in terms of sampling equipment, procedures, sample storage, calibration (reference number 11, Tuduri et al., 2003) and duration and study site characteristics.
	Metric 2:	Analytical Methodology	High	Analytical methodology detailed in terms of analytic instrumentation, extraction with use of standard methods referenced (NF ISO 16000-3, 2011). Detection limits reported.
	Metric 3:	Biomarker Selection	N/A	Sampling for chemical of interest in air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sampling conducted within an office meeting room, classroom and a residence living room in France.
	Metric 5:	Currency	Medium	Sampling conducted September, 2012 through March, 2013.
	Metric 6:	Spatial and Temporal Variability	Low	Sampling conducted every two weeks for six months. Figure 2 indicates samplers located near varying furniture and materials sources of curtains, desks, floor, door, wall, chairs, melamine interactive board, white board and ceiling. Control sampling not detailed. Total number of samples not detailed (assumed to be once per sampling period). Replicate (n=3) samples noted for Table 3 residential air passive and active monitoring result comparison.
	Metric 7:	Exposure Scenario	High	Exposure sources discussed and presented with detail in Figure 2 for classroom passive emissions monitoring and active indoor air. Figure 3 and Table 1 detail exposure source rankings and building materials within classroom, respectively.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Formaldehyde concentration summary data as a mean and standard deviation for passive emissions and active indoor air results for residential setting in Table 3. Figure 2 results presented with only average passive and active sampling results for classroom setting. Frequency of detection and individual points not reported.
	Metric 9:	Quality Assurance	Low	Sampling and analytic quality assurance and control procedures not discussed, however sample analysis noted to be conducted according to standard methods. Recoveries not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability reported within statistical summary measure for residential, but not classroom, results (standard deviation). Brief discussion of potential study limitations.
Overall Quality Determination			Medium	

Study Citation:		Kim, S. Y., Kim, K. Y., Han, Y. S., Koo, J. W. (2010). Variation of indoor air quality in a new apartment building by bake-out. International Journal of Environmental Research 4:263-270.		
HERO ID:		4695423		
Domain	Metric	Rating	Comments	
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Low	Several sampling methods were not reported including the sampling equipment, storage conditions, and sampler calibration.
	Metric 2:	Analytical Methodology	Low	The LOD nor LOQ were reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Korea.
	Metric 5:	Currency	Medium	The study was conducted in 2006 and 2007.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	The number of samples pre house is not reported.
	Metric 7:	Exposure Scenario	Medium	The exposure source is not well characterized.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Low	Raw data were not reported.
	Metric 9:	Quality Assurance	Low	QA was not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Limitations were not reported.
Overall Quality Determination		Uninformative		

Study Citation:		Timofeeva, S. S., Timofeev, S. S. (2017). Ecological risks in residential premises arising from thermal insulation by pouring. Materials Science and Engineering 262		
HERO ID:		4719288		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Sampling methodology described in terms of sampling equipment, procedures and study site characteristics. Air sampling conducted in accordance with GOST R ISO 16000-1-2007 (active apartment air sampling) and 30255-95 (chamber insulation tests) standards. Some information, such as duration of sample storage, not detailed.
	Metric 2:	Analytical Methodology	Medium	Analytical methodology detailed in terms of analytic instrumentation with use of standard methods. Some information, such as recovery, not detailed.
	Metric 3:	Biomarker Selection	N/A	Sampling for chemical of interest in air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Sampling conducted in Irkutsk, Russia.
	Metric 5:	Currency	Medium	Sampling dates not reported. Publication date 2017.
	Metric 6:	Spatial and Temporal Variability	Medium	Active air sampling conducted within four apartments, two which had undergone repairs involving thermal insulation and two control apartments, within one apartment building. Sampling conducted for 20 minutes at 0.75 and 1.5 meters from floor of each room (four rooms) of apartment as detailed within Table 1.
	Metric 7:	Exposure Scenario	Medium	Exposure sources discussed in detail in terms of poured insulation. Experimental chamber sampling of insulation material used in exposed apartments for formaldehyde levels. Control apartments sampled.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Formaldehyde concentration summary data as a mean and standard deviation as presented within Table 1. Table 3 chamber test results report only single statistical summary measures. Frequency of detection not reported.
	Metric 9:	Quality Assurance	Low	Sampling and analytic quality assurance and control procedures not discussed, however sample analysis noted to be conducted according to standard methods.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability reported within statistical summary measure for apartment sampling results. Discussion of potential study limitations lacking.
Overall Quality Determination			Medium	

Study Citation:		Wagdi, D., Tarabieh, K., Abou Zeid, M. N. (2018). Indoor air quality index for preoccupancy assessment. Air Quality, Atmosphere and Health 11:445-458.		
HERO ID:		4742149		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate. Information such as the sampling procedure and sampler calibration is provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD or LOQ is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Cairo, Egypt.
	Metric 5:	Currency	High	The samples were collected in Jan/Feb of 2015.
	Metric 6:	Spatial and Temporal Variability	Low	Nine samples were collected; however, four were under construction and five were already built. No replicates were reported.
	Metric 7:	Exposure Scenario	Medium	The exposure scenario is characterized adequately. The data represent a relevant exposure scenario of airborne exposure to formaldehyde in residential rooms.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Raw data is present in Table 9, summary statistics are in Table 10.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not discussed and issues are not identified. The use of blanks, controls, and standards is not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability is absent. No standard deviations or coefficients of variance are provided.
Overall Quality Determination			Medium	

Study Citation:		Huang, L., Qian, H.,ui, Deng, S., Guo, J., Li, Y., Zhao, W., Yue, Y. (2018). Urban residential indoor volatile organic compounds in summer, Beijing: Profile, concentration and source characterization. Atmospheric Environment 188:1-11.		
HERO ID:		4914425		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Sampling methods, approaches, materials and storage reported.
	Metric 2:	Analytical Methodology	Medium	US. EPA Method TO-17 and TO-11A. Recovery samples not reported
	Metric 3:	Biomarker Selection	N/A	NA - air samples no biomarker needed.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in Beijing, China.
	Metric 5:	Currency	Medium	Data collected in 2013.
	Metric 6:	Spatial and Temporal Variability	Medium	Duplicates collected in 30% of the total samples.
	Metric 7:	Exposure Scenario	High	Indoor air residential.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	No raw data reported
	Metric 9:	Quality Assurance	Medium	QA/QC reported, blanks, standards, duplicates, except recoveries from internal standards that usually are part of TO-17 and TO-11A.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Examined sources of variability from the indoor environment. Compared to other studies and discussed the limitations and sources of uncertainty in their measurements.
Overall Quality Determination			High	

Study Citation:		Huang, Y., Su, T., Wang, L., Wang, N., Xue, Y., Dai, W., Lee, S. C., Cao, J., Ho, S. S. H. (2019). Evaluation and characterization of volatile air toxics indoors in a heavy polluted city of northwestern China in wintertime. Science of the Total Environment 662:470-480.		
HERO ID:		5431563		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Field blanks were used. Storage temp provided. Equipment calibration and flow rates provided. Detailed sampling procedures in other publications (Spaulding et al., 1999; Ho et al., 2011).
	Metric 2:	Analytical Methodology	Medium	Details on method shown in Dai et al., 2012, but relatively robust description provided. Limits only provided as a range.
	Metric 3:	Biomarker Selection	N/A	Paper reports chemical concentrations in environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	China
	Metric 5:	Currency	High	2016-2017
	Metric 6:	Spatial and Temporal Variability	High	44 samples from 11 homes.
	Metric 7:	Exposure Scenario	High	Questionnaire provided details to characterize the building and activity patterns of occupants. No known pollution sources near buildings.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	Mean and sd in main report. Individual samples appear o have been provided in SI. Conducted source apportionment for indoor sources.
	Metric 9:	Quality Assurance	Medium	Calibration curve was established. Precision was <25%. Recoveries not discussed.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Medium	Variability assessed via factor analysis. No discussion of uncertainties.
Overall Quality Determination			High	

Study Citation:		Dodson, R. E., Udesky, J. O., Colton, M. D., Mccauley, M., Camann, D. E., Yau, A. Y., Adamkiewicz, G., Rudel, R. A. (2017). Chemical exposures in recently renovated low-income housing: Influence of building materials and occupant activities. Environment International 109:114-127.		
HERO ID:		5755270		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Sampling methods are standard SOPs and are detailed in the paper and the SI.
	Metric 2:	Analytical Methodology	High	MRLs are tabulated. The paper and SI adequately discuss methodology.
	Metric 3:	Biomarker Selection	N/A	Testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Boston, MA.
	Metric 5:	Currency	Medium	Samples were collected from 2013-2014.
	Metric 6:	Spatial and Temporal Variability	High	10 pre-occupancy and >= 25 post-occupancy samples were collected. Duplicates were collected.
	Metric 7:	Exposure Scenario	Medium	Information on potential chemical use not discussed beyond describing the measured concentrations.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Summary statistics were reported, but no raw data were reported (unless provided in the SI).
	Metric 9:	Quality Assurance	High	The QAQC discussion was adequate.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	There was sufficient discussion on variability and uncertainty.
Overall Quality Determination			High	

Study Citation:		Williams, D. T., Otson, R., Bothwell, P. D. (1981). Formaldehyde levels in the air of houses containing urea-formaldehyde foam insulation. Canadian Journal of Public Health 72:331-334.		
HERO ID:		5943350		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The study used the NIOSH sampling method.
	Metric 2:	Analytical Methodology	Low	The study did not report an LOD. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	The metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Massachusetts.
	Metric 5:	Currency	Low	The study was published in 1981.
	Metric 6:	Spatial and Temporal Variability	High	The study reported >10 samples but no replicates.
	Metric 7:	Exposure Scenario	Low	This study monitored chemical levels but did not link the sources of exposure.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	High	The study reported raw data in Table 2.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination			Medium	

Study Citation:	van Netten, C. (1983). Analysis of sources contributing to elevated formaldehyde concentrations in the air in a new elementary school. Canadian Journal of Public Health 74:55-59.
HERO ID:	5944347

Domain	Metric	Rating	Comments
Domain 1: Reliability	Metric 1: Sampling Methodology	High	The study used the NIOSH chromotropic acid method.
	Metric 2: Analytical Methodology	Low	The study did not report an LOD or LOQ. Recovery samples were not reported.
	Metric 3: Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4: Geographic Area	High	This study was conducted in Langley, British Columbia (Canada).
	Metric 5: Currency	Low	The study was published in 1983.
	Metric 6: Spatial and Temporal Variability	Critically Deficient	The number of samples collected was not reported.
	Metric 7: Exposure Scenario	Low	The study did not characterized the source of exposure.
Domain 3: Accessibility/Clarity	Metric 8: Reporting of Results	Low	Raw data were not reported.
	Metric 9: Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty	Metric 10: Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.

Overall Quality Determination**Uninformative**

Study Citation:		Neamtiu, I. A., Cimpan, T., Zhou, J., Schiopu, I., Surcel, M., Lin, S. (2019). Monitoring and assessment of formaldehyde levels in residential areas from two cities in Romania. Reviews on Environmental Health 34:267-273.		
HERO ID:		5946237		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Air sampling equipment was reported in the methods. The procedures used by the study authors was reported. Sample storage conditions were not reported.
	Metric 2:	Analytical Methodology	Medium	The limit of detection was reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The samples in this study were collected in Romania.
	Metric 5:	Currency	High	The samples were collected from 2016 to 2018.
	Metric 6:	Spatial and Temporal Variability	High	There were >10 samples collected and there were replicates collected.
	Metric 7:	Exposure Scenario	Medium	The exposure source was reasonably well characterized. The sources of potential exposure were described. There were no exposure controls in place.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported in this study. There were summary statistics reported in Table 1.
	Metric 9:	Quality Assurance	Low	Limited QA was reported in this study.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	High	Gaps and limitations were reported.
Overall Quality Determination			Medium	

Study Citation:		Ankica, K., Ruzica, B. L., Natasa, K. (2003). Research of formaldehyde concentration in indoor air surrounding woodworking places. Wood Research 48:25-32.		
HERO ID:		5953495		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	The study indicated that the study authors used the HRN EN ISO 10882-1:2001 and German standards TRGS 533 (1992) method.
	Metric 2:	Analytical Methodology	Critically Deficient	The analytical methodology is not described, including analytical instrumentation (i.e., HPLC, GC).
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	Critically Deficient	It's not entirely clear where the study was conducted, most likely either Germany or Croatia.
	Metric 5:	Currency	Low	The date of sample collection was not reported but the study was published in 2003.
	Metric 6:	Spatial and Temporal Variability	Medium	Raw data are reported in Figure 2. Samples were collected in three different rooms and there were >10 samples.
	Metric 7:	Exposure Scenario	Medium	The study explored the links between woodworking and formaldehyde exposure but there were no statistical examinations of the links.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Raw data were reported in Table 2.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination		Uninformative		

Study Citation:		Huang, K., Song, J., Feng, G., Chang, Q., Jiang, B., Wang, J., Sun, W., Li, H., Wang, J., Fang, X. (2018). Indoor air quality analysis of residential buildings in northeast China based on field measurements and longtime monitoring. Building and Environment 144:171-183.		
HERO ID:		5957041		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some methods were not reported such as sample storage conditions
	Metric 2:	Analytical Methodology	Low	LOD nor LOQ were reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in China
	Metric 5:	Currency	High	Samples were collected in 2016 and 2017
	Metric 6:	Spatial and Temporal Variability	High	>10 samples were collected and there were replicates
	Metric 7:	Exposure Scenario	Medium	The exposure source was not well characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported
	Metric 9:	Quality Assurance	Low	Limited QA were reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Gaps and limitations were reported
Overall Quality Determination			Medium	

Study Citation:		Sung, M., Lee, S. M., in, Min, Y. (2013). Decreasing the formaldehyde concentration in indoor air by improving the adhesives used in engineered wood materials in Korean apartment buildings. Journal of Adhesion Science and Technology 27:671-682.		
HERO ID:		5962846		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Most sampling methods necessary for a study on indoor air were reported. The study did not report sample storage conditions or sampler calibration.
	Metric 2:	Analytical Methodology	Low	The LOD nor the LOQ were reported. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	The metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in South Korea.
	Metric 5:	Currency	Medium	The samples were collected between 2003 and 2007.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	Samples were collected from 2013 housing units over four years but the actual number of samples collected was not reported.
	Metric 7:	Exposure Scenario	High	The study explored the links between adhesives in engineered wood materials and formaldehyde concentrations.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Low	Raw data and limited descriptive statistics were reported.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps limitations or uncertainties.
Overall Quality Determination		Uninformative		

Study Citation:		Cho, H. M.,i, Lee, J., Wi, S., Kim, S. (2019). Field study on indoor air quality of wood remodeled welfare facilities for physical and psychological benefits. Journal of Cleaner Production 233:197-208.		
HERO ID:		5969217		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	The sampling methodology is clear and appropriate; however, details such as sampler calibration and sample storage are not provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is clear and appropriate; however, no LOD or LOQ is provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in South Korea.
	Metric 5:	Currency	High	Publication date is 2019. No sample collection date is provided.
	Metric 6:	Spatial and Temporal Variability	High	2 samples (see Table 3) for 12 locations = 24 samples total.
	Metric 7:	Exposure Scenario	Medium	The exposure scenario is formaldehyde in indoor air at welfare facilities remodeled with wood. This is an exposure scenario of interest for the chemical.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Mean concentrations are provided in Table 6. Raw data are not provided.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not discussed and issues are not identified. The use of blanks or controls is not reported.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent. No standard deviations or coefficients of variance are reported.
Overall Quality Determination		Medium		

March 2024

Formaldehyde

Monitoring

HERO ID: 6025746

Study Citation:		Garrett, M. H., Hooper, B. M., Hooper, M. A. (1997). Formaldehyde in Australian homes; levels and sources. Clean Air and Environmental Quality 31:28-32.		
HERO ID:		6025746		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Most sampling methods necessary for a study on indoor air quality were reported. Sampler calibration was not reported.
	Metric 2:	Analytical Methodology	Low	The study did not report the LOD nor the LOQ. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	The metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Australia.
	Metric 5:	Currency	Low	The study was conducted in 1994.
	Metric 6:	Spatial and Temporal Variability	High	Samples were collected from eighty houses and there were replicates for four occasions.
	Metric 7:	Exposure Scenario	High	The study statistically linked the presence of fiberboard, particleboard flooring, high temperatures, and older houses with elevated levels of formaldehyde.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported. The study reported the median, mean, and range.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination			Medium	

Study Citation:		Dudney, C. S., Gammage, R. B., Hawthorne, A. R., Morris, S. A., Womack (1983). Results of a forty-home indoor-air-pollutant monitoring study.		
HERO ID:		6027168		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	Medium	Most sampling methods necessary for a study on indoor air were reported. The study did not report sample storage conditions or sampler calibration.
	Metric 2:	Analytical Methodology	Critically Deficient	Acceptable analytical methods were not reported by this study.
	Metric 3:	Biomarker Selection	N/A	The metric is not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	The study was conducted in the United States.
	Metric 5:	Currency	Low	Data were collected in 1982 and 1983.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	The number of samples collected was not reported.
	Metric 7:	Exposure Scenario	Medium	The study did not characterize well the specific source of exposure.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Low	Raw data were not reported.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination		Uninformative		

Study Citation:		Hawthorne, A. R., Dudney, C. S., Tyndall, R. L., Vo-Dinh, T., Cohen, M. A., Spengler, J. D., Harper, J. P. (1989). Case study: Multipollutant indoor air quality study of 300 homes in Kingston/Harriman, Tennessee. ASTM STP 1002 :129-147.		
HERO ID:		6028171		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology	Medium	Most sampling methods for a study on indoor air were reported. The study did not report sampler calibration.
		Metric 2: Analytical Methodology	Low	The study did not report an LOD or an LOQ. Recovery samples were not reported.
		Metric 3: Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness		Metric 4: Geographic Area	High	This study was conducted in Kingston/Harriman, Tennessee.
		Metric 5: Currency	Low	The study was conducted in 1985 and 1986.
		Metric 6: Spatial and Temporal Variability	High	Samples were collected from 300 homes and replicates were collected.
		Metric 7: Exposure Scenario	Medium	The study described monitoring but did not examine or report links to sources of exposure.
Domain 3: Accessibility/Clarity		Metric 8: Reporting of Results	Medium	Raw data were not reported in this study.
		Metric 9: Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty		Metric 10: Variability and Uncertainty	Low	There were few gaps, limitations, and uncertainties reported in this study.
Overall Quality Determination			Medium	

Study Citation:		McGuire, M. T., Casserly, D. M., Greff, R. M. (1992). Formaldehyde concentrations in fabric stores. Applied Occupational and Environmental Hygiene 7:112-119.		
HERO ID:		6029260		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The study used NIOSH method 3500.
	Metric 2:	Analytical Methodology	Medium	The study reported the LOD. Recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric was not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	This study was conducted in Houston, Texas.
	Metric 5:	Currency	Low	The study was published in 1992.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	The number of samples collected is not clear.
	Metric 7:	Exposure Scenario	Low	This study was designed to compare methods and not to examine specific exposure scenarios.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Low	Raw data were not reported. Summary statistics were not reported.
	Metric 9:	Quality Assurance	Medium	The study reported NIOSH quality control methods. Recovery samples were not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination		Uninformative		

Study Citation:		Weintrub, L. N., Toal, B. F., Brown, D. R. (1989). Reassessment of formaldehyde exposures in homes insulated with urea-formaldehyde foam insulation. Applied Industrial Hygiene 4:147-152.		
HERO ID:		6029984		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The sampling method is clear and appropriate, and details such as sampler calibration are provided.
	Metric 2:	Analytical Methodology	Medium	The analytical method is clear and the LOD is provided. Few specific details about the analysis of formaldehyde are provided.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in Connecticut, US.
	Metric 5:	Currency	Low	Samples were collected from 1977-83.
	Metric 6:	Spatial and Temporal Variability	High	30 samples were collected.
	Metric 7:	Exposure Scenario	Medium	The exposure scenario is formaldehyde in indoor air due to UFFI in homes. The microclimate is well characterized.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Results were reported in Table II. The mean retest values are provided. Not all raw data is given.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not reported and issues were not identified. The use of blanks or controls is not discussed.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability is absent. No measures of variance are provided.
Overall Quality Determination			Medium	

Study Citation:		Azuma, M., Isoda, N., Kubo, H. (2015). Effects of Room Specifications and Lifestyles of Residents on Indoor Formaldehyde Concentrations - Formaldehyde Concentrations in Student Dormitories. 18:001.		
HERO ID:		6032423		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Low	Sampling methodology for formaldehyde air sampling within student dormitory just after renovation and with and without occupants under differing room and lifestyle characteristics with very brief details of detector tube active formaldehyde direct reading instruments as well as passive formaldehyde air sampling instrumentation. Additional details not provided.
	Metric 2:	Analytical Methodology	Low	Detection limits not reported. Analytical methodology described briefly for use of direct reading detector tube sampling, but detailed in terms of analytic instrumentation, storage and shipment for passive formaldehyde monitoring. Some details, such as calibration, not provided.
	Metric 3:	Biomarker Selection	N/A	Sampling for chemical of interest within air.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples collected in Nara City, Japan.
	Metric 5:	Currency	Low	Sampling conducted September through October of 2002, July of 2003 and September of 2009 (Table 3).
	Metric 6:	Spatial and Temporal Variability	Medium	Total number of rooms sampled reported as n=13 Results reported for each of n=13 dorm rooms as 24 hour average as well as average while student slept. Samplers placed within center of room at height of 120 centimeters. Detector tube sampling conducted for 30 minutes in each room, while passive samplers utilized for 24-hour sampling.
	Metric 7:	Exposure Scenario	Medium	Exposure sources for formaldehyde and characteristics affecting exposure included furniture, windows open versus closed, air conditioning use, floor heater use and time since construction. Measurements just prior to occupancy and without furniture utilized as controls.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Table 3 and Figure 1 results reported as averages only. Figure 2 included means and standard deviations. Raw data not reported.
	Metric 9:	Quality Assurance	Low	Quality assurance not detailed, however accuracy of detector tubes briefly mentioned.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Variability of results not reported within statistical summary measures within Table 3 and figure 1, however reported as standard deviation in figure 2. Potential study limitations not discussed.
Overall Quality Determination			Low	

Study Citation:		Byers, R. (1988). Results of Energy Use, Indoor Air Quality, and Ventilation Monitoring for RSDP Homes in Washington State. 1:15.		
HERO ID:		6112750		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	Low	Very limited and brief sampling methodology.
	Metric 2:	Analytical Methodology	Critically Deficient	No analytical method.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness	Metric 4:	Geographic Area	High	Samples were collected in Washington, US.
	Metric 5:	Currency	Low	Samples were collected 1985-1987.
	Metric 6:	Spatial and Temporal Variability	High	There were at least 62 samples per scenario, as shown in Table 7.
	Metric 7:	Exposure Scenario	Medium	The exposure scenario is formaldehyde in indoor air in homes. This scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Log-mean formaldehyde concentrations are provided in Table 7. No raw data is given.
	Metric 9:	Quality Assurance	Low	QA/QC measures were not discussed and issues were not identified.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Medium	The SD multiplier is given in Table 7. No discussion of variance is provided.
Overall Quality Determination		Uninformative		

Study Citation:		Godish, T., Rouch, J. (1987). Formaldehyde source interaction studies under whole-house conditions. Environmental Pollution 48:1-12.		
HERO ID:		6114303		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	The study used a modified NIOSH chromatropic acid method.
	Metric 2:	Analytical Methodology	Low	The study did not report the LOD and LOQ and recovery samples were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric was not applicable to the data source.
Domain 2: Representativeness	Metric 4:	Geographic Area	Critically Deficient	The geographic location is not reported, discussed, or referenced.
	Metric 5:	Currency	Low	The study was published in 1987.
	Metric 6:	Spatial and Temporal Variability	Medium	Eight samples were collected. There were no replicate samples collected.
	Metric 7:	Exposure Scenario	Low	This study mostly focused on the differences between real world and chamber studies.
Domain 3: Accessibility/Clarity	Metric 8:	Reporting of Results	Medium	Raw data were not reported by the study authors nor were extensive descriptive statistics.
	Metric 9:	Quality Assurance	Low	The study did not report QA.
Domain 4: Variability and Uncertainty	Metric 10:	Variability and Uncertainty	Low	The study did not report gaps, limitations, or uncertainties.
Overall Quality Determination		Uninformative		

March 2024

Formaldehyde

Monitoring

HERO ID: 6154340

Study Citation:		Jamalunlaili, A., Qi, J. K., Tan, S. C., Tzer Hwai Gilbert, T., Win, S. Y. (2019). A field study of indoor air quality and occupant perception in experimental laboratories and workshops. Management of Environmental Quality 30:467-482.		
HERO ID:		6154340		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	The sampling methodology is clear and appropriate. No significant information is missing. Information such as the sampling procedure and sampler calibration is provided.
	Metric 2:	Analytical Methodology	Low	The analytical methodology is very limited and does not provide information such as the LOD or the LOQ, although the LOD is referenced in Table 5.
	Metric 3:	Biomarker Selection	N/A	Study is testing for the parent chemical in an environmental media.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	Samples were collected in Malaysia.
	Metric 5:	Currency	Medium	Samples were collected in 2014.
	Metric 6:	Spatial and Temporal Variability	Critically Deficient	Sample size is not reported.
	Metric 7:	Exposure Scenario	High	The exposure scenario is formaldehyde in indoor air of laboratories and workshops. The scenario is of interest for the chemical.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	The mean and range are provided in Table 5. Raw data are not provided.
	Metric 9:	Quality Assurance	Low	QA/QC measures are not discussed and issues were not identified. The use of blanks, controls, or standards was not reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	The characterization of variability is absent. No standard deviations or coefficients of variance were reported.
Overall Quality Determination			Uninformative	

Study Citation:		Lee, K., Choi, J. H., Lee, S., Park, H. J., Oh, Y. J., Kim, G. B., Lee, W. S., Son, B. S. (2018). Indoor levels of volatile organic compounds and formaldehyde from emission sources at elderly care centers in Korea. PLoS ONE 13:e0197495.		
HERO ID:		6200076		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
Metric 1:		Sampling Methodology	Medium	Sampling equipment and methods were described in sufficient detail, but certain aspects (e.g. duration of storage) were absent that are unlikely to have a substantial impact on results.
Metric 2:		Analytical Methodology	High	Analytical equipment and methods were described in sufficient detail, following an appropriate protocol (EPA method 8315A). Method detection limit was reported.
Metric 3:		Biomarker Selection	N/A	This study was testing for the parent chemical of interest in environmental media.
Domain 2: Representativeness				
Metric 4:		Geographic Area	High	This study was conducted in South Korea.
Metric 5:		Currency	Medium	The samples for this study were collected in 2007.
Metric 6:		Spatial and Temporal Variability	Medium	Indoor and outdoor air samples were collected at 30 different locations at four different times over the course of a year. Data collected was not explicitly stated to include replicates.
Metric 7:		Exposure Scenario	High	The surroundings and interior of each sampling location were well characterized to inform possible exposure routes and sources.
Domain 3: Accessibility/Clarity				
Metric 8:		Reporting of Results	High	Raw data were reported in online supplemental information. Summary statistics included geometric mean and standard deviation for all data points and for results stratified by various factors.
Metric 9:		Quality Assurance	Medium	QA measures included determination of breakthrough capacity, use of laboratory and field blanks, recovery of instrument reproducibility and thermal desorption, and method detection limits (MDL). Only results for MDL were reported, but were within reasonable limits.
Domain 4: Variability and Uncertainty				
Metric 10:		Variability and Uncertainty	High	Quantitative characterization of variability was reported, and robust discussion of spatiotemporal variability and of limitations was included, with minimal uncertainties.
Overall Quality Determination			High	

Study Citation:		Aguiar, L., Bonassi, S., Guimarães, L., Mendes, A., Mendes, D., Moroni, R., Neves, P., Pereira, C., Silva, S., Teixeira, J. P. (2015). Indoor air quality and thermal comfort in elderly care centers. Urban Climate 14:486-501.		
HERO ID:		6204264		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	High	Key sampling methods for collecting indoor air formaldehyde samples were reported.
	Metric 2:	Analytical Methodology	Low	The LOD nor LOQ were reported. Recovery samples were reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable to the data source.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The study was conducted in Portugal.
	Metric 5:	Currency	Medium	The data were collected from 2011 to 2013.
	Metric 6:	Spatial and Temporal Variability	High	There were more than 10 samples collected and there were replicate samples.
	Metric 7:	Exposure Scenario	Medium	The exposure source was not well characterized.
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported.
	Metric 9:	Quality Assurance	Low	Limited QA was reported.
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations were reported.
Overall Quality Determination			Medium	

Study Citation:		Li, X., Wang, Z., Zhang, X. (2019). Exposure level and influential factors of HCHO, BTX and TVOC from the interior redecoration of residences. Building and Environment 168:106494.		
HERO ID:		6220936		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology	Medium	Some methods were not reported such as sample storage conditions
	Metric 2:	Analytical Methodology	Low	LOD nor LOQ were reported
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representativeness				
	Metric 4:	Geographic Area	High	The samples were collected in China
	Metric 5:	Currency	High	The samples were collected in 2018
	Metric 6:	Spatial and Temporal Variability	High	>10 samples were collected as were replicates
	Metric 7:	Exposure Scenario	High	The exposure source was characterized
Domain 3: Accessibility/Clarity				
	Metric 8:	Reporting of Results	Medium	Raw data were not reported
	Metric 9:	Quality Assurance	Low	QA was not reported
Domain 4: Variability and Uncertainty				
	Metric 10:	Variability and Uncertainty	Low	Few gaps and limitations were reported
Overall Quality Determination			Medium	

Study Citation:		Matthews, T. G., Fung, K. W., Tromberg, B. J., Hawthorne, A. R. (1986). Surface emission monitoring of pressed-wood products containing urea-formaldehyde resins. Environment International 12:301-309.		
HERO ID:		22183		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling & testing are well-described.
	Metric 2:	Analytical Methodology	Medium	FSEM description is better described than vapor concentration analysis.
	Metric 3:	Biomarker Selection	N/A	No biomarkers identified.
Domain 2: Representative	Metric 4:	Testing Scenario	High	Testing scenarios seem appropriate for product testing and research house.
	Metric 5:	Sample Size and Variability	High	16 samples for each test house. For product testing there were 6 types of board for each of 3 manufacturers, with 6 tests per board.
	Metric 6:	Temporality	Low	Study was published in 1985.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Summary data are shown in Table 1, Table 3 and Fig. 2. Raw data may be available in a different study report. Summary statistics, but no raw data, are given for product testing while only raw data and no summary stats are given for research houses.
	Metric 8:	Quality Assurance	Medium	Measures of variance and correlations were evaluated and presented in Table 2 and Table 4, but few other QA measures were described.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	Variance was characterized and presented in Table 2 and Table 4 in the footnote. Some discussion of uncertainty and limitations.
Overall Quality Determination			Medium	

Study Citation:		Pickrell, J. A., Griffis, L. C., Mokler, B. V., Kanapilly, G. M., Hobbs, C. H. (1984). Formaldehyde release from selected consumer products: influence of chamber loading, multiple products, relative humidity, and temperature. Environmental Science and Technology 18:682-686.		
HERO ID:		22466		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methodology was described in the data source.
	Metric 2:	Analytical Methodology	Low	Analytical methodology was briefly described.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Testing scenario is appropriate for product testing.
	Metric 5:	Sample Size and Variability	Medium	8 pieces each of particle board and plywood were tested.
	Metric 6:	Temporality	Low	Study was published in 1984.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Chamber concentrations are presented graphically. Mean and average standard deviation for 3 tests are provided but difficult to reproduce without tabular concentration data. FDH release rate coefficients are provided in several tables without summary statistics.
	Metric 8:	Quality Assurance	Medium	Some QA/QC was performed and discussed in the text of study report.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	There was limited characterization of variability, but some discussion of uncertainty and limitations.
Overall Quality Determination			Low	

Study Citation:		Gesser, H. D. (1984). The reduction of indoor formaldehyde gas and that emanating from urea formaldehyde foam insulation (UFFI). Environment International 10:305-307.		
HERO ID:		22630		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	Sampling methodology is briefly discussed.
	Metric 2:	Analytical Methodology	Low	Analytical methodology is briefly discussed.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario is relevant to release from UFFI but not well described.
	Metric 5:	Sample Size and Variability	Low	Many samples over time as shown in Fig. 1, but no replicates are mentioned.
	Metric 6:	Temporality	Low	This study published was in 1985.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Data presented graphically in Fig. 1 and as a few samples with no summary statistics in Table 1.
	Metric 8:	Quality Assurance	Low	There was limited discussion of QA/QC.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	No measures of variance were given, and there was limited discussion of uncertainty and limitations.
Overall Quality Determination			Low	

Study Citation:		Dement, J. M., Smith, N. D., Hickey, J. L. S., Williams, T. M. (1984). An evaluation of formaldehyde sources, exposures and possible remedial actions in two office environments. 3:99-104.		
HERO ID:		22861		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Low	The authors do not include details of the sample collection, preparation, or treatment.
	Metric 2:	Analytical Methodology	Low	The authors mention the use of a dynamic dilution chamber for the emissions tests on samples of paneling, ceiling tiles, and carpet. The authors claim that they used a pararosaniline technique to measure formaldehyde emissions, but do not provide details on the process or quality control. They did suggest an appropriate detection limit of 0.02mg/m2/hr for the technique.
	Metric 3:	Biomarker Selection	N/A	Not applicable.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Critically Deficient	The authors obtained the samples from two office environments with known issues related to formaldehyde exposure. The authors do not describe the conditions of the reported test results (they mention that they found significant correlations between humidity and formaldehyde emissions, but they do not specify the variance from reported testing conditions). They do not clarify how many measurements contributed to the results shown (but they claimed to have conducted detailed studies).
	Metric 5:	Sample Size and Variability	Critically Deficient	The authors do not clarify the sample size. Since there were 12 modular units, I do not feel comfortable assuming that each unit contributed a sample of each type for the chamber tests.
	Metric 6:	Temporality	Low	The tests were conducted during the period 1981 through 1983; this is more than 15 years prior to the current year (2021).
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	The authors provide summary data (range
	Metric 8:	Quality Assurance	Low	The authors do not clarify any quality control or quality assurance methods for the experimental tests. The criteria for unacceptable seems to be if the article describes a known problem with quality, and I do not see evidence for that in the article.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The authors do not segregate the data to facilitate understanding variation in the sources of formaldehyde. The testing scenarios are not defined, and I cannot determine the sources of the reported values.
Overall Quality Determination			Uninformative	

Study Citation:		Mølhave, L. (1980). The effect of a chemical surface-treatment on formaldehyde emission from particleboards. <i>Holzforschung und Holzverwertung</i> 32:137-138.		
HERO ID:		22889		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methodology was described in the data source.
	Metric 2:	Analytical Methodology	Low	Analytical methodology was briefly described in the data source.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Stainless steel box with some controlled conditions; humidity was not regulated.
	Metric 5:	Sample Size and Variability	Medium	7 samples of particleboard, and the paper included replicates.
	Metric 6:	Temporality	Low	Study published in 1980.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Concentration raw data and summary statistics are provided in this paper.
	Metric 8:	Quality Assurance	Low	Limited discussion of QA/QC.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	Limited characterization of variability and uncertainty provided.
Overall Quality Determination		Low		

Study Citation:		Andersen, I., Lundqvist, G. R., Molhave, L. (1975). Indoor air pollution due to chipboard used as a construction material. Atmospheric Environment 9:1121-1127.		
HERO ID:		22912		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	The authors describe collecting fourteen boards and placing them in the test chamber, but they do not describe the sample treatment before the tests or the length of time between sample collection and the start of the tests.
	Metric 2:	Analytical Methodology	High	The authors used a chromotropic acid method to analyze the air samples from the chamber. The authors stated a reproducibility of plus or minus 5 percent. The authors include the limit of detection in the text on page 1 of the PDF.
	Metric 3:	Biomarker Selection	N/A	No biomarkers were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	High	The chamber study seems to be a common and appropriate method to determine the emissions of formaldehyde from particleboard.
	Metric 5:	Sample Size and Variability	High	The authors used 14 boards, combined, for the chamber test.
	Metric 6:	Temporality	Low	The article was published in 1975.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	The results are presented in graphics only. Figure 2 shows formaldehyde concentrations in the chamber air under one set of conditions temperature, humidity, and ventilation. Figures 3a, 3b, and 3c show the results for the three variables temperature, humidity, and ventilation. In the Figure 3 set, the data are shown as rectangles, not points.
	Metric 8:	Quality Assurance	High	The authors accounted for possible contamination in the chamber test.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The authors do not characterize the variability in the results or compare these results to other studies. The trends relevant to temperature and humidity were more conclusive than those relevant to ventilation; this indicates some constraint on variability.
Overall Quality Determination			Medium	

Study Citation:		Weschler, C. J., Hodgson, A. T., Wooley, J. D. (1992). Indoor chemistry: ozone, volatile organic compounds, and carpets. Environmental Science and Technology 26:2371-2377.		
HERO ID:		28411		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The authors describe the four types of carpet used in the test shown in Table 1, and generally describe the sample treatment prior to testing.
	Metric 2:	Analytical Methodology	Low	The authors used a high-performance liquid chromatography to measure the formaldehyde levels, but the authors did not provide an LOD.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	The chamber test for emissions from samples under controlled conditions is common and accepted. The introduction of ozone to the chamber was not strongly justified.
	Metric 5:	Sample Size and Variability	Low	Each value for formaldehyde in the three tables were derived from only one carpet sample in each experiment. Each air sample was collected over a three-hour period while the carpet was in the chamber, under several scenarios.
	Metric 6:	Temporality	Low	The article was published in 1992.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Raw data are presented in the three tables, but the data cannot be summarized, since distinct variables apply to each value.
	Metric 8:	Quality Assurance	Low	Quality issues are not identified or addressed by the authors.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The authors mention uncertainty in the total VOC measurements but do offer suggestions or replicate samples that would help to explain the variations.
Overall Quality Determination			Low	

Study Citation:		Girman, J. R., Apte, M. G., Traynor, G. W., Allen, J. R., Hollowell, C. D. (1982). Pollutant emission rates from indoor combustion appliances and sidestream cigarette smoke. Environment International 8:213-221.		
HERO ID:		34608		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methodology for environmental chamber was discussed in data source, and a schematic diagram is shown in Fig. 1.
	Metric 2:	Analytical Methodology	Low	FDH sampler is shown in Fig. 1, with little description.
	Metric 3:	Biomarker Selection	N/A	Not applicable.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Testing conditions are appropriate to scenario for indoor use of gas space heater. Some conditions were varied.
	Metric 5:	Sample Size and Variability	Medium	At least 19 tests were conducted on 8 heaters. Sample size is moderate (i.e., 5 to 10 samples).
	Metric 6:	Temporality	Low	>15 years; published in 1982.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Average emission rates were presented in Table 3, while Tables 4 and 5 appear to show individual data points (emission rates and calculated concentrations, respectively).
	Metric 8:	Quality Assurance	Low	QA/QC was not directly discussed.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	Characterization of variability was not discussed although replicate tests were performed for some heaters. Limited discussion of uncertainty and limitations.
Overall Quality Determination			Low	

Study Citation:		Leovic, K., Whitaker, D., Northeim, C., Sheldon, L. (1998). Evaluation of a test method for measuring indoor air emissions from dry-process photocopiers. Journal of the Air and Waste Management Association 48:915-923.		
HERO ID:		40839		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Collection and analysis method for concentration data was from USEPA compendium of ambient air methods. Evaluation of large chamber test method was evaluated in this study.
	Metric 2:	Analytical Methodology	High	Collection and analysis method for concentration data was from USEPA compendium of ambient air methods, using appropriate analytical equipment. Specifics were not mentioned in study but can be found in reference.
	Metric 3:	Biomarker Selection	N/A	Not applicable.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Test conditions are representative of a scenario for indoor air emissions from a photocopier, with limited test conditions.
	Metric 5:	Sample Size and Variability	Medium	4 samples tested, with duplicates for each.
	Metric 6:	Temporality	Low	Published in 1998; >15 years old.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Emission rates are provided, with some summary data.
	Metric 8:	Quality Assurance	Medium	QA/QC goals and results for chamber test were detailed in study; specific QA/QC measures for analysis were not provided.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Limited characterization of variability for relatively small number of samples; %RSD for interlab precision was provided, with discussion of uncertainty and limitations.
Overall Quality Determination			Medium	

Study Citation:		Kelly, T. J., Smith, D. L., Satola, J. (1999). Emission rates of formaldehyde from materials and consumer products found in California homes. Environmental Science and Technology 33:81-88.		
HERO ID:		47368		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methodology for handling products and test chamber methodologies are well-described in the source document and references, incl. ASTM.
	Metric 2:	Analytical Methodology	High	Analytical methodologies were well-described in source document and references for continuous FDH monitoring and EPA TO-5 method.
	Metric 3:	Biomarker Selection	N/A	Not applicable.
Domain 2: Representative	Metric 4:	Testing Scenario	High	Test products represent diverse categories of consumer products; chamber conditions for typical and elevated levels were selected.
	Metric 5:	Sample Size and Variability	High	Testing was performed on 55 consumer products, with 2 sets of test conditions. 10 duplicate tests were run concurrently on separate samples.
	Metric 6:	Temporality	Low	Study was conducted in the late 1990's; >15 years.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	High	Individual data points for FDH emission rates were provided. Summary statistics weren't reported in tables, but were shown graphically for some product types in Fig. 1.
	Metric 8:	Quality Assurance	Medium	Many QA/QC measures were reported and discussed in the report.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	High	Measures of variability for duplicate testing and a combined uncertainty for chamber conditions and chemical measurements were reported and discussed.
Overall Quality Determination		High		

Study Citation:		Hodgson, A. T., Wooley, J. D., Daisey, J. M. (1993). Emissions of volatile organic compounds from new carpets measured in a large-scale environmental chamber. Journal of the Air and Waste Management Association 43:316-324.		
HERO ID:		76255		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methods did not reference a publicly available SOP but methodology was described and included all pertinent information.
	Metric 2:	Analytical Methodology	Low	Analytical methods are more fully described in a different article. Analytical methods are briefly discussed with some information missing. The detection limit was not found to be reported.
	Metric 3:	Biomarker Selection	N/A	Not applicable.
Domain 2: Representative	Metric 4:	Testing Scenario	High	Testing conditions closely represent relevant exposure scenarios, study also included four different typical carpet products.
	Metric 5:	Sample Size and Variability	High	Four different carpets; with 10 different samples taken at different time points
	Metric 6:	Temporality	Low	Sources of tested items are not current (over 15 years ago).
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	All data appears to be reported, but some is reported in a graphical format making exact numerical value difficult to interpret.
	Metric 8:	Quality Assurance	Low	QA/QC techniques and results were not directly discussed, but can be implied through the study's use of replicate samples.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	High	Uncertainties, limitations, and data gaps have been identified (see discussion in the conclusion).
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Experimental

HERO ID: 78715

Study Citation:		Molhave, L., Dueholm, S., Jensen, L. K. (1995). Assessment of exposures and health risks related to formaldehyde emissions from furniture: a case study. Indoor Air 5:104-119.		
HERO ID:		78715		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Low	Sampling conditions and methodology are only briefly discussed.
	Metric 2:	Analytical Methodology	Critically Deficient	Analytical methodology is described as only using "theacetyl-acetone method" and cross check using a permeation standard. However there is no mention analytical instrumentation.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The testing scenario of formaldehyde exposure from furniture represents a relevant exposure scenario however testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Medium	Sample size is not explicitly stated however it can be inferred from tables that a large enough sample size was used and replicates were performed.
	Metric 6:	Temporality	Low	This study was published in 1995. The tested items are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Results are provided in figures as point value concentrations. No summary statistics or measures of central tendency are provided.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Uninformative	

Study Citation:		Reiss, R., Ryan, P. B., Koutrakis, P., Tibbetts, S. J. (1995). Ozone reactive chemistry on interior latex paint. Environmental Science and Technology 29:1906-1912.		
HERO ID:		78727		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology and Conditions	Medium	The sampling methodology, as briefly described, seemed appropriate. The authors described the application of the paint to the tube (to be analyzed in the chamber) and the tube treatment before the experiments began. The authors did not describe how they obtained the paints, but said that they obtained four brands; the information in Table 3 suggests that some of the paint samples were older than new. The authors do not describe the storage treatment of the aged paint. The authors also did not control for paint thickness in the tube, although they claim that thickness affects emissions.
		Metric 2: Analytical Methodology	Medium	The authors refer to a cited study (Lawrence and Koutrakis, reference 10) for the details on the analytical method. I am presuming that this was appropriate, although the authors do not provide any details on calibrations or controls for contamination (although the test results did not show formaldehyde in the blanks). The authors provide the LOD for formaldehyde in Table 1.
		Metric 3: Biomarker Selection	N/A	Not applicable.
Domain 2: Representative		Metric 4: Testing Scenario	Medium	The authors intended to use the tube experiments to determine VOC formation and then use that information to extrapolate to indoor air environments. The coating of the tube with paint seems to be an erratic way of establishing the sample, and it is unclear how this could be compared to painting a surface in a real scenario.
		Metric 5: Sample Size and Variability	Low	I do not see evidence that any of the experiments involved more than one sample of the paint type. Each of the samples was involved in three sub-experiments. Experiments C9 and C10 were replicates.
		Metric 6: Temporality	Low	The article was published in 1995, which is more than 15 years prior to the current year (2021).
Domain 3: Accessibility/Clarity		Metric 7: Reporting of Results	High	The authors present raw test results in Table 4.
		Metric 8: Quality Assurance	Medium	The authors do not mention laboratory recoveries for the ion chromatography method used. The authors did analyze blanks and use the results for some of the tests (not formaldehyde). The authors did not mention testing an empty tube.
Domain 4: Variability and Uncertainty		Metric 9: Variability and Uncertainty	Low	The authors describe several ways that the experimental technique had elements that may have introduced variability in the results. The test results from the replicates were quite different for formaldehyde, but the authors could not explain the causes for the differences.
Overall Quality Determination			Medium	

Study Citation:		Crump, D. R., Yu, C. W. F., Squire, R. W., Atkinson, M. (1996). Small chamber methods for characterizing formaldehyde emission from particleboard. Characterizing Sources of Indoor Air Pollution and Related Sink Effects :211-224.		
HERO ID:		80252		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	The authors describe the sample acquisition and treatment adequately.
	Metric 2:	Analytical Methodology	Medium	The authors claimed a standard, BS EN 120:1992, for the perforator test used in the study which was common in Europe at the time. This method has since been shown to lack specificity.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not applicable.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	The authors assert that the chamber results do not represent the conditions in an indoor environment; part of the study is to determine the extent of variation and consider the reasons for the differences.
	Metric 5:	Sample Size and Variability	High	The number of samples which can be extrapolated from study designs described in the text for each test were at least 10.
	Metric 6:	Temporality	Low	The article was published in 1996.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	The summary provided in Table 1 has mean, standard deviation, and relative standard deviation. Limits of detection for the different studies are presented in the text (page 4 of the PDF). The authors did not state that all samples had detectable levels of formaldehyde, the figures in the document suggest that the range of data results was clustered. The authors commented that a problem with the BRE chamber test was the high detection limit needed; this implies that formaldehyde was not detected in every sample.
	Metric 8:	Quality Assurance	Low	The authors controlled for several variables in the tests. For the chamber studies, the authors identified several areas where the experimental methods, equipment problems and sampling errors introduced variation in the results. For the second part of the study which uses a model to try to determine the conditions needed for steady-state, the authors suggest that the accuracy of the results is challenged by the variation in the data.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	For the chamber tests, the authors demonstrate variability in the results and show repeatability. Unfortunately, the authors also claim that variability was introduced with errors in sampling; the effects of these differences cannot be segregated in the results.
Overall Quality Determination			Medium	

Study Citation:		Sallsten, G., Gustafson, P., Johansson, L., Johannesson, S., Molnar, P., Strandberg, B., Tullin, C., Barregard, L. (2006). Experimental wood smoke exposure in humans. Inhalation Toxicology 18:855-64.		
HERO ID:		97958		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sample storage conditions were not reported.
	Metric 2:	Analytical Methodology	Low	LODs were not reported and there was limited description of analytical methodology.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Wood smoke was introduced into a chamber with personal and stationary sampling. Testing was conducted under one set of temperature and relative humidity conditions. Two smoke dilution ratios were used for the experiments (one for each of the two wood smoke sessions).
	Metric 5:	Sample Size and Variability	Medium	Two stationary and 3 personal sample measurements were used for each of the two sessions.
	Metric 6:	Temporality	Medium	Source(s) of tested items is less consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Individual data points are reported and medians are provided in the text.
	Metric 8:	Quality Assurance	Low	QA/QC procedures not discussed but implied through the study's used of standard laboratory protocols.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	There is some discussion of variability, uncertainties, and data gaps.
Overall Quality Determination			Medium	

Study Citation:		Coleman, B. K., Destailats, H., Hodgson, A. T., Nazaroff, W. W. (2008). Ozone consumption and volatile byproduct formation from surface reactions with aircraft cabin materials and clothing fabrics. Atmospheric Environment 42:642-654.		
HERO ID:		603575		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The authors describe the types of materials selected for the tests, the sizes of samples, and their time in service if the product was used on an airplane before testing. The authors did not describe the sample treatment between acquisition and testing.
	Metric 2:	Analytical Methodology	Low	The authors describe the equipment used for formaldehyde analysis, but they do not provide the limit of detection for the analysis.
	Metric 3:	Biomarker Selection	N/A	Biomarkers are not applicable
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	The authors tested common materials used on airplanes, and included some samples that had been in service on airplanes. The protocol for testing clothing was not directly correlated with airplane cabins, but thought to be relevant to the clothing worn by passengers.
	Metric 5:	Sample Size and Variability	Low	The authors tested one sample of new and used material of each type. Sample size wasn't specified.
	Metric 6:	Temporality	Medium	The article was published in 2008.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	The results for concentrations of formaldehyde are only presented as a graphic (Figure 3).
	Metric 8:	Quality Assurance	High	The authors did not describe issues with the quality of the experiments. The authors controlled for chamber conditions. They also measured and corrected for conditions in the chamber without the samples.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	High	The authors expected variability in the experiment results and quantified the results of analysis for variations in a separate side study with subsets of samples.
Overall Quality Determination			Medium	

Study Citation:		Wang, H., Morrison, G. C. (2006). Ozone-initiated secondary emission rates of aldehydes from indoor surfaces in four homes. Environmental Science and Technology 40:5263-5268.		
HERO ID:		695487		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology and Conditions	High	USEPA Method TO-11a is used for FDH sampling and analysis. Description and diagram of sampling and test setup are provided in data source and Supplemental Information, including diagram of field emission chamber for testing surfaces.
		Metric 2: Analytical Methodology	High	USEPA Method TO-11a is used for FDH sampling and analysis.
		Metric 3: Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative		Metric 4: Testing Scenario	Medium	Four surfaces were measured in 3 test houses.
		Metric 5: Sample Size and Variability	Low	One FDH sample per surface per house was tested. Samples were collected at 2 time intervals for secondary emissions. The tables in the Supporting Information report secondary emission rates with standard deviations, but do not clearly describe the number of samples.
		Metric 6: Temporality	Low	The paper was published in 2006.
Domain 3: Accessibility/Clarity		Metric 7: Reporting of Results	Low	Individual data points are not provided. Summary statistics in the tables appear to be mean and standard deviation.
		Metric 8: Quality Assurance	Medium	Discussion of QA/QC includes leakage rate for tracer analysis. QA/QC issues for other analytes were identified and discussed, but no QA/QC issues were identified for FDH.
Domain 4: Variability and Uncertainty		Metric 9: Variability and Uncertainty	Medium	Standard deviations are provided. There is limited discussion of uncertainty and limitations.
Overall Quality Determination		Medium		

Study Citation:		Yamashita, S., Kume, K., Horiike, T., Honma, N., Fusaya, M., Ohura, T., Amagai, T. (2010). A simple method for screening emission sources of carbonyl compounds in indoor air. Journal of Hazardous Materials 178:370-376.		
HERO ID:		927415		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The study is a combination of standard protocols (chamber study with active samplers and a partially open door) and a new technique.
	Metric 2:	Analytical Methodology	High	The authors describe the laboratory equipment and provide the LOD. For the bookcase portion of the experiment, the authors tested samples without needing sub-samples, so normal sub-sample preparation or storage concerns did not apply.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The authors sampled intact wood-base materials (not cut sub-samples) for the portion of the study (bookcase) that has reported data. The authors describe the testing conditions. Temperature and relative humidity were not controlled in the chamber studies; also, ventilation was supplied through a partially open door on the chamber; these are unusual variations on chamber techniques. The ECSMS sampler is still being tested for reliability, so I decided that a medium rank was appropriate.
	Metric 5:	Sample Size and Variability	Low	Each measurement of formaldehyde concentration (Table 4) was determined by one ECSMS sampler per location; the air measurement in the chamber (Table 3) derived from one sample collected after 40 hours of incubation.
	Metric 6:	Temporality	Medium	The article was published in 2010, which is between five and fifteen years prior to the current year (2021).
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	The authors present the raw data from the chamber experiments with the bookcase (passive ECSMS; Table 4) and the air (active; Table 3). Note that emission rates are calculated (see page 5 of the PDF). The authors list the measured Formaldehyde emissions at different distances from the boards (MDF and PB); raw data are presented in the text on page 5.
	Metric 8:	Quality Assurance	Low	The authors did not present the results of the initial test to assess the reliability of the ECSMS system (passive vs. actual from the desiccator), which was intended to establish the reliability of the new system. I assessed this as a significant gap in the presentation.The authors conducted the chamber studies with a partially open door and did not control for temperature or humidity.The authors did measure background levels in the chamber before the experiments and deduct these levels from the test results.The authors correlated the modeled passive and actual active measurements of the bookcase in the portion of the study that compared readings from August and October tests and found good agreement.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The authors did not present the results of the initial test to assess the reliability of the ECSMS system (passive vs. actual from the desiccator), which was intended to establish the reliability of the new system. Also, the measurements for one MDF section (site 14) were significantly different from measurements collected from the other side of the same board (site 17); the authors did not acknowledge or try to explain this difference. Other measures of variation indicated generally good correlations.The authors found variability between the August and October sample results and did not test for the effects of temperature and humidity on the emissions of formaldehyde, nor did they refer to other studies that may have supported their assumption that these two factors could explain the differences between the sampling periods.
Overall Quality Determination			Medium	

Study Citation:		Gerald liu, Z., Berg, D. R., Vasys, V. N., Dettmann, M. E., Zielinska, B., Schauer, J. J. (2010). Analysis of C1, C2, and C10 through C33 particle-phase and semi-volatile organic compound emissions from heavy-duty diesel engines. Atmospheric Environment 44:1108-1115.		
HERO ID:		1006636		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methodology is discussed. Engine exhaust samples were collected. A schematic diagram of the sample collection apparatus provided in Figure 1.
	Metric 2:	Analytical Methodology	Low	Gaseous VOCs including aldehydes (formaldehyde) were analyzed. Gaseous samples were collected on TD tubes and DNPH and XAD cartridges. TD tubes analyzed by modified NIOSH method 2549; GC/MS. DP-NPH cartridges analyzed by HPLC/UV. XAD cartridges analyzed by GC/MS. Detection limit not reported for formaldehyde.
	Metric 3:	Biomarker Selection	N/A	Biomarker is not used.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Data represent a relevant exposure scenario; exhaust emissions collected from diesel engines from two different model years (2004 and 2007).
	Metric 5:	Sample Size and Variability	Low	Sample size is not specified. The article indicated that calibrations were run every 10 samples to verify accuracy.
	Metric 6:	Temporality	Medium	Publication date is 2010 (11 years); however, a comparison of diesel engines used in the study were from 2004 and 2007 (14-17 years).
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	Table 2 reports formaldehyde emissions from a 2004 and a 2007 diesel engine. Supplemental information available but were not provided.
	Metric 8:	Quality Assurance	Medium	The article references another study for the detail discussion of the QA/QC procedures for the source dilution sampling system (SDS).
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Uncertain is reported as the standard error of the test results in Table 2.
Overall Quality Determination			Medium	

Study Citation:		Guarieiro, L. L. N., Pereira, P., Torres, E. A., Da Rocha, G. O., De Andrade, J. B. (2008). Carbonyl compounds emitted by a diesel engine fuelled with diesel and biodiesel–diesel blends: Sampling optimization and emissions profile. Atmospheric Environment 42:8211-8218.		
HERO ID:		1059935		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The investigators used a common and acceptable method to collect samples of exhaust from diesel engines (settled on a dynamometer) via impingers with 2,4-DNPH and describe their efforts to optimize the method for the tests.
	Metric 2:	Analytical Methodology	High	The investigators employed a HPLC-UV detector system to analyze the samples; this is a common and acceptable apparatus for the type of sample used. The investigators provide the LOD in the article.
	Metric 3:	Biomarker Selection	N/A	The experiments did not require the use of biomarkers.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The investigators describe some of the variables in the experiments, but they did not clarify the conditions of temperature or humidity for the tests, or the intervals between the tests, or the order in which the different fuels were tested.
	Metric 5:	Sample Size and Variability	Low	The investigators analyzed each sample in duplicate, and might have conducted more than one test for each fuel type; however, this is not specified. One sample would be acceptable for a controlled test.
	Metric 6:	Temporality	Medium	This study was published in 2008.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	The investigators report a value and a standard deviation for emissions for residual oil biodiesel and one value for the emission factors applicable to different biodiesel–diesel mixtures. The investigators do not describe the numbers of samples that contribute to these values, nor do they provide the raw data from the tests.
	Metric 8:	Quality Assurance	Medium	The investigators do not clarify whether there were any quality issues with the tests. They clarified that the laboratory blanks did not have detectable levels of target contaminants. They do not describe calibration for the equipment or conducting tests for laboratory recoveries.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The investigators include detailed descriptions of variability. The authors characterize uncertainty and suggest some cautions with data from experiments of this type.
Overall Quality Determination			Medium	

Study Citation:		Yrieix, C., Dulaurent, A., Laffargue, C., Maupetit, F., Pacary, T., Uhde, E. (2010). Characterization of VOC and formaldehyde emissions from a wood based panel: results from an inter-laboratory comparison. Chemosphere 79:414-419.		
HERO ID:		1063139		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	All sampling was conducted under standard protocols. The authors do not clarify the sampling details for the different laboratories (e.g., number of sub-samples involved in the tests and conditions for testing replicates).
	Metric 2:	Analytical Methodology	Low	The authors claim (on page 3 of the PDF) that the laboratories used different equipment, but they do not provide details. The ISO 16000-3 method stipulates that the air samples be collected adsorbent DNPH cartridges and analyzed by high performance liquid chromatography (HPLC) with detection by ultraviolet absorption.The authors do not report the LOD for formaldehyde in the article.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The chamber tests are a common and acceptable method for measuring formaldehyde from wood-based samples. The authors do not describe the differences between the different laboratories (although they should have all followed a standard protocol); the authors allude to differences and the results indicate significant variations among laboratories).
	Metric 5:	Sample Size and Variability	High	The sample sizes are six for the results in Table 3 and 26 for the results in Tables 3 and 5. The authors do not describe the sampling techniques used by the different laboratories, but I presume that if they followed a standard protocol, the sample treatment was appropriate.
	Metric 6:	Temporality	Medium	The studies were conducted in 2008 and 2009; this time period is between five and fifteen years prior to the current year (2021).
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	The authors do not present raw data results.The authors sent each laboratory four samples and requested replicate measurements for the six laboratories. The authors state (in Section 2.5) that they received results from 13 tests; I presume, then, that the results reflect one record for each sampling event (at 3d and 28d).The authors did not clarify the techniques used or the fate of the results for the replicates; they do mention calculating a standard deviation with a parenthetical note about the replicates, so I presume that the results include an average of the two replicates for each test.
	Metric 8:	Quality Assurance	Medium	The authors did not clarify quality issues in the article. The authors did not clarify that the laboratories conducted recovery tests or controls. I am presuming that following the standard protocols would have at least mandated these tests. The authors claim that each laboratory conducted a duplicate test.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The authors anticipated heterogeneity in the panel and tested the panel via six sub-samples for variations in formaldehyde concentrations (emitted) before sending sub-samples to the six laboratories.The authors calculated a relative standard deviation of repeatability (within a laboratory) and reproducibility (among laboratories). The deviation results for formaldehyde were low for repeatability (2.5%) and relatively high (17.1 to 23.8%) for aldehydes, in general. The authors claim that the high variation among laboratory results is not unexpected for the standard used (ISO 16000-3).
Overall Quality Determination			Medium	

Study Citation:		Carteret, M., Pauwels, J. F., Hanoune, B. (2012). Emission factors of gaseous pollutants from recent kerosene space heaters and fuels available in France in 2010. Indoor Air 22:299-308.		
HERO ID:		1290538		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Sampling Methodology and Conditions	High	The samples for carbonyls are collected on DNPH cartridges; this is common and acceptable. The authors describe the collection sources for the fuels and claim that the two space heaters used were selected at random from a commercial source.	
	Metric 2: Analytical Methodology	Medium	The authors describe the analytical equipment used and specify the conditions. The authors provide the LOD for carbonyls (in Table 2). The authors do not mention calibration or recoveries for carbonyls.	
	Metric 3: Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.	
Domain 2: Representative	Metric 4: Testing Scenario	Low	The authors employed a high air exchange rate to accommodate one of the heaters (a wick heater, to maintain a temperature below approximately 40 degrees Celsius); the consequence of this setting is that the test conditions no longer matched the typical scenarios for use in a residence. The authors designed the experimental chamber to draw ambient air from the laboratory through the chamber during the burning tests. The authors tested the incoming air for VOCs during the burning tests, but did not report the measurements or state whether the background measurements were deducted from the measurements determined from the interior of the chamber. They suggest, without explicit evidence, that they checked for variations in the background (they assumed no significant change). It is unclear the extent to which the results may be inaccurate for the concentrations of VOCs in the fuels. The authors did test for background concentrations of carbonyls (unspecified conditions) 30 minutes before the burning tests.	
	Metric 5: Sample Size and Variability	Low	The average sample size for the summaries provided in Table 5 (all tests) is 3.9; the range is 3 to 6.	
	Metric 6: Temporality	Medium	The article was published in 2011, which is between five and fifteen years prior to the current year (2021).	
Domain 3: Accessibility/Clarity	Metric 7: Reporting of Results	Medium	The authors provide the summaries of calculated emission factors for formaldehyde in the tests (Table 5). The summaries include the mean and standard deviation and the number of samples per summary.	
	Metric 8: Quality Assurance	Medium	The authors do not describe issues with quality in the experiment. The authors do not describe testing for recoveries or any control tests for the analytical processes. The authors claim to have monitored VOCs inside and outside the chamber (to detect variations in background concentrations), but do not specify that they also monitored carbonyls in the same way. The authors measured the background carbonyl concentrations in the chamber 30 minutes before the heater was turned on (I presume that this was before every test); the authors do not present the results of the background tests or explain whether they deducted the background measurements from the measured concentrations.	
Domain 4: Variability and Uncertainty	Metric 9: Variability and Uncertainty	Low	The authors describe issues of variability between their results and those of other studies, but they do not provide an explanation for the differences except to suggest that the newer equipment and different fuels used (the two main variables in the experiment) may have contributed to the differences seen. Specific to carbonyls, the authors describe the variation among results as having a large dispersion; the results varied significantly even among tests of the same fuel (this suggests that there are many variables in the experimental process that are not being controlled well).	

Overall Quality Determination**Medium**

Study Citation:		Risholm-Sundman, M. (1999). Determination of formaldehyde emission with field and laboratory emission cell (FLEC)–recovery and correlation to the chamber method. Indoor Air 9:268-272.		
HERO ID:		1314028		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	The author used standard methods for the chamber tests (Swedish standard SS 27 02 36 for sampling). The author collected formaldehyde with a DNPH cartridge in the FLEC (a small, portable method). This may be the first published report for this method. The DNPH medium for collection is common and acceptable. The samples for the FLEC tests are stored in the open, with maintained temperature and humidity. The sample treatment for the chamber tests is not explained. The author also does not describe the source of the building materials.
	Metric 2:	Analytical Methodology	Low	The author used standard methods for the chamber tests (European standard ENV 717-1 and Swedish standard SS 27 02 36 for analysis) and prENV 13419-2 for the FLEC tests. The DNPH samples collected for the FLEC tests were analyzed with HPLC. The author provides a citation for the DNPH statement, and I presume that this approach is appropriate.The author describes the capacity range for the DNPH cartridge; I surmised that this represented the Method Detection Limits for the FLEC tests. The author did not provide the limit of detection for the chamber tests (acetylacetone method).The author conducted recovery tests with the FLEC and the chamber devices. The results indicated high recoveries for both methods.
	Metric 3:	Biomarker Selection	N/A	Not measured.
Domain 2: Representative	Metric 4:	Testing Scenario	High	The author is comparing the approaches and results for a portable (FLEC) method with a common chamber method, with the detection and measurement of formaldehyde as the target compound. This may be the first time that the author has published results for the FELC method, so I reduced the testing rank to medium, due to lack of proven reliability with the new method.
	Metric 5:	Sample Size and Variability	Medium	The author does not indicate the sample number for the chamber tests; I presume that it was one sample per test. The author provides the sample number (measurements) for the FLEC tests documented in Table 4.
	Metric 6:	Temporality	Low	The article was published in 1999, which is more than 15 years prior to the current year (2021).
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	The author does not provide the raw data results for the FLEC tests. The information provided in Table 4 as the results only has one value for each FLEC test, although there are several measurements in each case. I could assume that the values given for the formaldehyde emissions are the means of measurements collected during the relevant tests; the author should have specified this.The author also describes the information in Table 4 as measured emissions, but the devices measure concentration – emissions are calculated. The author does not provide the formulas used to derive the respective emission rates.
	Metric 8:	Quality Assurance	High	The author tested for recoveries and background. The author deducted the measurements for background from the measurements used in the calculations for emission rates.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The author describes some variability in the results for formaldehyde measurements in parquet flooring with the FLEC device (near joints vs. away from joints). The author found good correlations between the emissions results of the FLEC tests and the chamber tests, overall (see Figure 1). The author did not compare these results with results from other studies.
Overall Quality Determination			Medium	

Study Citation:		Priha, E. (1996). Formaldehyde Release from Resin-Containing Wood Board Dusts: Evaluation of Methods to Determine Formaldehyde. Applied Occupational and Environmental Hygiene 11:465-470.		
HERO ID:		1316564		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The authors collected samples of wood boards and dust from local sources (Finland). The sample collection and treatment were controlled by the study protocols.
	Metric 2:	Analytical Methodology	High	The purpose of the article was to compare three analytical methods for measuring formaldehyde leached from wood dust. The authors describe the three methods with appropriate detail. Limits of detection are provided in Table 1.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to study.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The data likely represent the relevant exposure scenario (i.e., population/scenario/media of interest). One or more key pieces of information may not be described but the deficiencies are unlikely to have a substantial impact on the characterization of the exposure scenario.
	Metric 5:	Sample Size and Variability	Low	The authors created three replicates for each test.
	Metric 6:	Temporality	Low	The article was published in 1996, which is more than 15 years prior to the current year (2021).
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	The authors provide the average of the three replicates for each test in Table 4. The authors do not provide the ranges or the standard deviations.
	Metric 8:	Quality Assurance	High	The authors included recovery tests in their study; the results were satisfactory. Baseline tests would not apply to this study.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	High	The authors describe and explain variability in the results from this study (among sample types and methods). They also qualitatively compare the results with those of other studies.
Overall Quality Determination			Medium	

Study Citation:		Brown, S. K. (1999). Chamber Assessment of Formaldehyde and VOC Emissions from Wood-Based Panels. Indoor Air 9:209-215.		
HERO ID:		1511621		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	The authors described the sample board preparations with specific details. The formaldehyde in the chambers was collected in a sodium bisulfite solution in a bubbler. This technique is common and acceptable.
	Metric 2:	Analytical Methodology	Low	The authors used the Australian Standard AS 2365.6–1995 for analysis. The authors did not provide the applicable detection limit in the article.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	The chamber method is a common and acceptable approach to measuring the formaldehyde emissions in commercial products. The authors tested two common wood-based products and a collection of new office furniture in separate experiments.
	Metric 5:	Sample Size and Variability	Low	The authors tested three samples from the boards and the collection of office furniture once for each of the experiments.
	Metric 6:	Temporality	Low	The article was published in 1999, which is more than 15 years prior to the current year (2021).
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	The authors provide the results for short-term (Table 2) and long-term (Table 4) formaldehyde concentrations and emission factors (Table 3). There is only one result per test, so summaries are not applicable.
	Metric 8:	Quality Assurance	Low	The authors did not describe tests for recoveries or blanks, or clarify whether the results of these tests influenced the results of the experiments (e.g., corrections).
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The authors demonstrate variability in the whole board with the results of the experiments on the sub-samples. The authors assessed that the average of the three measurements (as a substitute for the whole board) correlated well with the results of the whole boards used in the room scenario. The authors do not describe whether these results from any single experiments are characteristic of the qualities of boards, in general, by comparing with other studies.
Overall Quality Determination			Medium	

Study Citation:		Groah, W. J., Bradfield, J., Gramp, G., Rudzinski, R., Heroux, G. (1991). Comparative response of reconstituted wood products to European and North American test methods for determining formaldehyde emissions. Environmental Science and Technology 25:117-122.		
HERO ID:		1512137		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology and Conditions	High	The authors compared the results from simultaneous chamber tests following the standard European WK1 and North American FTM-2 methods and conditions.
		Metric 2: Analytical Methodology	Low	The different tests involved different types of analysis: chromotropic acid or pararosalinine. Both of these methods are common in the analysis for formaldehyde. The authors state the limit of sensitivity of the chromotropic method in passing (0.01 ppm); they do not specify the limit for the pararosalinine method.
		Metric 3: Biomarker Selection	N/A	Not relevant to study.
Domain 2: Representative		Metric 4: Testing Scenario	High	The chamber method is a common and acceptable approach to measuring the formaldehyde emissions in commercial products. The authors test use and compare the results from large and small chambers.
		Metric 5: Sample Size and Variability	Low	The number of sub-samples in each test ranged from three to eight. The authors included only one composite sample per large chamber experiment. The dessicator (small chamber) tests included separate tests for the same number of sub-samples in the large-chamber tests (three and eight); I presume that the perforator tests involved the same number of sub-samples from the same boards that were used in the desiccator tests.
		Metric 6: Temporality	Low	The article was published in 1991, which is more than 15 years prior to the current year (2021).
Domain 3: Accessibility/Clarity		Metric 7: Reporting of Results	Low	The authors present the results as one value per large-chamber experiment (one sample); thus, summaries are not applicable. For the small chamber studies, the authors provide the average of the studies (eleven) or one, as described. For the values that represent the average, the authors do not provide the range of data from the tests or the standard deviation.
		Metric 8: Quality Assurance	Medium	The authors do not describe issues with quality in the experiment. The authors do not describe background tests for the chambers, but they did control for formaldehyde in the incoming air to maintain levels below 0.01 ppm..
Domain 4: Variability and Uncertainty		Metric 9: Variability and Uncertainty	Medium	The authors generally found good agreement in the study results and, thus, did not need to describe effects of variability. The comparisons with the perforator tests did reveal variability, and the authors surmised that the small sample (unit) size in these tests may have introduced the variability observed.
Overall Quality Determination			Medium	

Study Citation:		Kim, J. A., Kim, S., Kim, H. J., Kim, Y. S. (2011). Evaluation of formaldehyde and VOCs emission factors from paints in a small chamber: the effects of preconditioning time and coating weight. Journal of Hazardous Materials 187:52-57.		
HERO ID:		1512511		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Study used the 20-L small chamber method, the standard method for measuring emissions of VOC and formaldehyde in Korea (Ministry of Environment).
	Metric 2:	Analytical Methodology	Low	LODs were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to study.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Test conducted under constant conditions for temperature and humidity. The test measured emissions of formaldehyde under various curing times and coating weights.
	Metric 5:	Sample Size and Variability	Low	3 samples analyzed.
	Metric 6:	Temporality	Medium	Article published in 2010
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Raw data not provided; emission rates provided in graphical form, some ranges provided in text. Measures of variation or central tendency not reported.
	Metric 8:	Quality Assurance	Low	QA/QC measures not reported but can be implied based on the use of standard analytical methods.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	No discussion of data gaps, limitations or uncertainties.
Overall Quality Determination			Low	

Study Citation:		Kim, S., Kim, J. A., An, J. Y., Kim, H. J., Kim, S. D., Park, J. C. (2007). TVOC and formaldehyde emission behaviors from flooring materials bonded with environmental-friendly MF/PVAc hybrid resins. Indoor Air 17:404-415.		
HERO ID:		1512515		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology and Conditions	High	The paper provided adequate discussion of sampling methodology of engineered flooring bonded with MF/PVAc hybrid resin to determine and compare the effect of PVAc content. There were five different composition blends with MF resin/PVAc content ratios of 0%, 30%, 50%, 70% and 100%, by weight of MF resin. There were three species of fancy veneers, beech, oak, and walnut, were bonded by cold and hot press.
		Metric 2: Analytical Methodology	High	More than adequate discussion/variety of analytical methods used in the study. Discussion included 20-L chamber, field and laboratory emission cell (FLEC), VOC analyzer and standard formaldehyde emission test (desiccator method).
		Metric 3: Biomarker Selection	N/A	A biomarker was not used in this study.
Domain 2: Representative		Metric 4: Testing Scenario	Medium	A 20-L chamber was used in this study because it has been standardized in Korea. Testing was not conducted under a broad range of conditions but adequate based on multiple techniques utilized to measure emissions.
		Metric 5: Sample Size and Variability	Low	There were five different composition blends with MF resin/PVAc content ratios of 0%, 30%, 50%, 70% and 100%, by weight of MF resin, across three fancy veneer types: beech, oak and walnut. No mention of replicate tests.
		Metric 6: Temporality	Medium	The paper was published in 2007.
Domain 3: Accessibility/Clarity		Metric 7: Reporting of Results	Medium	Data is present in graphical form, but raw data is not presented.
		Metric 8: Quality Assurance	Medium	Multiple techniques have been covered with varying degree of quality assurance or control. The 20-L chamber has the most quality control measures in place to maintain constant conditions.
Domain 4: Variability and Uncertainty		Metric 9: Variability and Uncertainty	Medium	Adequate discussion was provided about high level of variability of emissions across analytical techniques. The formaldehyde emission results by the 20-L small-chamber and FLEC methods showed a similar tendency with the results from the desiccator method.
Overall Quality Determination			Medium	

Study Citation:		Pang, S. K., Cho, H., Sohn, J. Y., Song, K. D. (2007). Assessment of the emission characteristics of VOCs from interior furniture materials during the construction process. Indoor and Built Environment 16:444-455.		
HERO ID:		1513097		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methods described using Tenax-TA tubes and various cartridges; no authoritative source but appears scientifically sound
	Metric 2:	Analytical Methodology	Low	GC/MS and HPLC analysis methodology described with instrumentation and environmental parameters included; air exchange measured using Korean 2004-80 test method; LOD not reported
	Metric 3:	Biomarker Selection	N/A	Biomarker not used
Domain 2: Representative	Metric 4:	Testing Scenario	Low	Exposure from building materials under given conditions represents a normal exposure scenario but may be particular to the Korean test house and products used
	Metric 5:	Sample Size and Variability	Medium	10 samples taken for each house (samples at different stages, e.g. wallpaper installation, plywood installation)
	Metric 6:	Temporality	Low	Study conducted in 2005 using materials available at that time
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Formaldehyde concentrations provided only in graph; 1,4DCB concentrations not provided. Single emission factors given for each chemical for each room
	Metric 8:	Quality Assurance	Low	Some measured concentrations compared against predicted concentrations for other chemicals for validation; no replicate samples or discussion of QA/QC methods
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	Variability captured in materials used across the different houses; no discussion of uncertainties
Overall Quality Determination			Low	

Study Citation:		Wang, S. Y., Yang, T. H., Lin, L. T., Lin, C. J., Tsai, M. J. (2008). Fire-retardant-treated low-formaldehyde-emission particleboard made from recycled wood-waste. Bioresource Technology 99:2072-2077.		
HERO ID:		1513852		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	The authors created particleboard from recycled and waste construction materials with two types of resins under several ratios of application. The samples for analysis were collected by the standard method (distilled water in a dish) for desiccator tests.
	Metric 2:	Analytical Methodology	Low	The authors mentioned using the desiccator method with the acetylacetone method for detection. This is one of the common methods for collecting formaldehyde. The authors did not provide the limit of detection for formaldehyde in the article.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	The authors tested nine sub-samples of the manufactured particleboards in the desiccator in the one test. The 24-hour test provides a simple, one-time measure of formaldehyde concentrations. The authors calculated the emissions with an equation (provided on page 3 of the PDF).
	Metric 5:	Sample Size and Variability	Low	The authors included only one sample, consisting of nine sub-samples, in each desiccator experiment.
	Metric 6:	Temporality	Medium	The article was published in 2008, which is between five and fifteen years prior to the current year (2021).
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	The authors present the results as one value for each desiccator experiment (one sample); thus, summaries are not applicable.
	Metric 8:	Quality Assurance	Medium	The authors do not describe issues with quality in the experiment. The authors do not describe any control tests for the desiccator.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The authors test variability in the low formaldehyde emissions in their manufactured boards under several different ratios of resin types. They claim that the calculated emissions from these tests are less than the 1.5 mg/L needed to comply with the F-3 standard of Chinese National Standard (CNS) 2215; the authors do not compare the emission results with those from other studies.
Overall Quality Determination			Medium	

Study Citation:		Wiglusz, R., Nikel, G., Igielska, B., Sitko, E. (2002). Volatile Organic Compounds Emissions from Particleboard Veneered with Decorative Paper Foil. Holzforschung 56:108-110.		
HERO ID:		1513892		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Tested particleboard products and operating conditions of the test chamber are described in the paper. Sampling methodology appears to be appropriate, with brief descriptions of air sampling, flow rate, and sample duration and intervals.
	Metric 2:	Analytical Methodology	Medium	The Polish Standard 1992, a colorimetric p-rosaniline method, was used for analysis. This method was only briefly described in the text but the method reference was provided. The LOD was provided in the text.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this paper.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The data likely represent a relevant exposure scenario for emissions from particleboard, but Polish products may be different than those sold in the US.
	Metric 5:	Sample Size and Variability	Low	Emissions from 3 particleboard products were tested over 6 time intervals, as shown in Figure 1. The number of samples and replicates was not reported, but initial emissions for 2 of the products are reported with standard deviation, so it can be inferred that replicate tests were performed.
	Metric 6:	Temporality	Low	The paper was received in 2000 and published in 2002.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Summary statistics that appear to be mean and standard deviation of initial emissions (mg/m3) are provided in the text for 2 of the particleboard products. The results are presented graphically in Figure 1 for all 3 products over time, without the standard deviations. The number of measurements for each product is not reported.
	Metric 8:	Quality Assurance	Low	QA/QC measures and results were not directly discussed but are implied through the study's use of standard field and laboratory protocols.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability is very limited. Uncertainty, limitations and data gaps are not discussed.
Overall Quality Determination			Low	

Study Citation:		Chang, J. C., Fortmann, R., Roache, N., Lao, H. C. (1999). Evaluation of low-VOC latex paints. Indoor Air 9:253-258.		
HERO ID:		1514841		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sample storage conditions and calibration of samplers were not discussed.
	Metric 2:	Analytical Methodology	Medium	There was not a lot of details regarding the analytical methodology; but LODs were reported.
	Metric 3:	Biomarker Selection	N/A	Not relevant.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	High	Multiple data points (>10) were collected during the 50-hr test
	Metric 6:	Temporality	Low	Article published in 1999
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Concentrations at various time intervals during the test are reported in graphic form.
	Metric 8:	Quality Assurance	Low	QA/QC measures not reported but implied through the use of standard laboratory methods.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Limited discussion of variability in concentrations among the paints used.
Overall Quality Determination			Medium	

Study Citation:		Kolarik, B., Gunnarsen, L., Logadottir, A., Funch, L. (2012). Concentrations of Formaldehyde in new Danish Residential Buildings in Relation to WHO Recommendations and CEN Requirements. Indoor and Built Environment 21:552-561.		
HERO ID:		1551845		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The authors describe the sample treatments before testing; procedures included careful attention to maintaining sample integrity similar to new conditions. The authors do not describe the sample collection for either test method used in the chamber studies (one is common, and the the other may be novel).
	Metric 2:	Analytical Methodology	Low	For the chamber studies, the authors used a Skalar SA 9101 online process analyser (www.skalar.com) specially modified to measure formaldehyde. The authors do not describe how this technique works or whether it had been used successfully in a peer-reviewed study. I do not have any context for giving this method a high rank, although my brief research suggests that this device is used in the Netherlands. For the final (steady-state) measurement, the authors also used the standard acetylacetone method as a means of detecting formaldehyde levels lower than the method detection limit of the Skalar system.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	The chamber method is a common and acceptable approach to measuring the formaldehyde emissions in commercial products. The authors maintained constant temperature, humidity, air exchange rates, and ventilation rates during the tests.
	Metric 5:	Sample Size and Variability	Medium	I presume that the authors included only one sample per chamber experiment; however, the authors did not clarify the number of sub-samples used collectively in each sample.
	Metric 6:	Temporality	Medium	The article was published in 2012, which is between five and fifteen years prior to the current year (2021).
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	The authors present the results as one value per chamber experiment (one sample); thus, summaries are not applicable.
	Metric 8:	Quality Assurance	Medium	The authors do not describe issues with quality in the experiment. The authors do not describe any control tests for the chamber (e.g., background or empty-chamber samples).
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The authors compare the results of the chamber studies with some results from other studies for some of the materials. The authors assessed that the measurements were comparable or lower than the earlier findings. The authors chose two studies from 1999 for the comparisons and in one case, claimed that the differences in manufacturing standards may have accounted for the differences with no evidence. I could not gain access to the two articles to review them for the type of equipment they used (I doubt that the California study used the Skalar technique).
Overall Quality Determination			Medium	

Study Citation:		Fan, J., Tang, Y. J., Feng, S. L. (2002). Determination of formaldehyde traces in fabric and in indoor air by a kinetic fluorimetric method. International Journal of Environmental Analytical Chemistry 82:361-367.		
HERO ID:		1579130		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Low	The sample material is only described as cloth. The authors do not describe how or where they obtained the sample, or how the sample was treated prior to testing.
	Metric 2:	Analytical Methodology	Medium	This is the first reporting of the method tested (kinetic fluorometric method). The authors compare the results with those obtained by the acetylacetone method (which is common) and find good agreement among the two methods' results.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Low	The testing requires heating the sample to 65 degrees C (149 F) for four hours. This may be acceptable for the testing, but it is unrealistic for comparisons to typical commercial uses.
	Metric 5:	Sample Size and Variability	Medium	The reported sample size is five for the results in Table 2, and there are four tests. Note that the results from the four tests are significantly different; the differences may derive from the sample type, but this is not suggested. The authors were most concerned with the comparisons among the techniques.
	Metric 6:	Temporality	Low	The article was published in 2002, which is more than 15 years prior to the current year (2021).
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	The authors do not report raw results. Table 2 has the mean and relative standard deviation of experiments using the two test methods.
	Metric 8:	Quality Assurance	Medium	The authors do not describe issues with quality in the experiment. The authors did not describe tests for recoveries or blanks in the fabric experiments (they did include blanks when calibrating the kinetic fluorometric method).
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The authors present results for four tests and do not describe the differences between the test conditions that created such divergent results. The authors do test the results of the kinetic fluorometric method (novel) with those of the common acetylacetone method and find good agreement.
Overall Quality Determination			Low	

Study Citation:		Beck, S. W., Stock, T. H. (1990). An evaluation of the effect of source and concentration on three methods for the measurement of formaldehyde in indoor air. American Industrial Hygiene Association Journal 51:14-21; discussion 22.		
HERO ID:		1944068		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Widely-accepted sampling and analysis methods were used, with modifications described in the text and/or provided in references. Sampling equipment, calibration curves, and storage conditions were addressed.
	Metric 2:	Analytical Methodology	Medium	Widely-accepted sampling and analysis methods were used, with modifications described in the text and/or provided in references. Analytical instrumentation and calibration curves were discussed. Analytical ranges were provided, and results were discussed relative to detection limits, but specific detection limits were not reported for each method.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Test conditions represent relevant exposure scenario for high, medium, and low concentrations particleboard emissions. Samples from each source for each method at each concentration level were collected at the same time so that conditions would be the same.
	Metric 5:	Sample Size and Variability	Medium	Four replicates were collected for each source material at each concentration level for each of the three methods.
	Metric 6:	Temporality	Low	The paper was published in 1990.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	High	Individual data points were reported, along with mean, standard deviation and coefficient of variation.
	Metric 8:	Quality Assurance	Medium	The study applied and documented QA/QC measures, such as for instrument calibration and variability between samples, methods and concentrations levels. Recovery data was not reported.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	High	The study characterizes variability for samples, methods and concentration levels. There is also discussion of uncertainty, limitations and data gaps.
Overall Quality Determination			Medium	

Study Citation:		Knudsen, H. N., Clausen, P. A., Wilkins, C. K., Wolkoff, P. (2007). Sensory and chemical evaluation of odorous emissions from building products with and without linseed oil. Building and Environment 42:4059-4067.		
HERO ID:		1952834		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Study uses CLIMPAQ test chambers to evaluate VOC emissions from various consumer products.
	Metric 2:	Analytical Methodology	Medium	DNPH method is used for sampling & analysis; some description is provided in Section 2.5.3. Additional information might be included in general study references listed at end.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative	Metric 4:	Testing Scenario	Low	CLIMPAQ test chamber is a known testing system; however, study seems primarily concerned with odors and Danish acceptability ratings, which may diverge from exposure concentration scenarios.
	Metric 5:	Sample Size and Variability	Low	1 sample result is reported in Table 2 (max. FDH concentration). In Section 2.5.3 it says 1201 carbonyl samples were collected in duplicate, but only the one value is reported.
	Metric 6:	Temporality	Low	This study was published 2007.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Only 1 data point is provided (maximum FDH air concentration in chamber over 51 weeks). No other individual sample results or summary statistics are provided, other than number of samples.
	Metric 8:	Quality Assurance	Low	QA/QC not directly discussed.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	Characterization of variance is absent for FDH.
Overall Quality Determination			Low	

March 2024

Formaldehyde

Experimental

HERO ID: 1953616

Study Citation:		Sidheswaran, M., Chen, W., Chang, A., Miller, R., Cohn, S., Sullivan, D., Fisk, W. J., Kumagai, K., Destailats, H. (2013). Formaldehyde emissions from ventilation filters under different relative humidity conditions. Environmental Science and Technology 47:5336-5343.		
HERO ID:		1953616		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The sampling methodology is clear and appropriate. Details such as sampling equipment, conditions and calibration were provided. Sample storage was not discussed.
	Metric 2:	Analytical Methodology	High	The sampling methodology is clear, detailed and appropriate. Analytical instrumentation, extraction procedures and LOD were descibed.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	Testing conditions closely represent relevant exposure scenarios. FDH emissions from HVAC fiberglass and polyester filters were tested at various conditions, including low and high emission rates, 4 relative humidities, and with and without tackifier.
	Metric 5:	Sample Size and Variability	Medium	Figure 2 on p. 4 of 8 shows average (of duplicates) emission rates from 12 filter tests. Figure 3 shows emission rates from testing under different conditions. Table S1, p. 2 of 4 of Supporting Information provides a matrix listing the filter types and conditions for each test.
	Metric 6:	Temporality	Medium	The study was published in 2013.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Individual data points are not reported. Average emission rates (ug/m2-hr) are shown graphically in Figures 2, and the estimated uncertainty was determined as shown in Equation 1 of the SI.
	Metric 8:	Quality Assurance	Medium	QA/QC results, such as blanks and replicate testing, were applied and documented. Other QA/QC measures were not directly discussed but are implied through the study’s descriptions of field and laboratory protocols and data analysis.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The study characterizes variability using Equation 1 of the Supporting Information. Uncertainty, limitations and data gaps are discussed.
Overall Quality Determination			Medium	

Study Citation:		Elia, V. J., Messmer, R. A. (1992). Evaluation of methods for estimating formaldehyde released from resin-containing paper and wood product dusts. American Industrial Hygiene Association Journal 53:632-638.		
HERO ID:		1958980		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling and analytical methods are widely accepted colorimetric methods. Leaching procedures were also described. Storage conditions, sampling equipment and calibration were described in the paper, and references were provided.
	Metric 2:	Analytical Methodology	Low	Sampling and analytical methods are widely accepted colorimetric methods. Detailed descriptions of analytical instrumentation and QA/QC measures were provided in the paper, along with method references. Detection limits were not reported.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this paper.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Dust from wood products and paper products was collected from various manufacturing processes but could be representative of DIY or hobby use of these products.
	Metric 5:	Sample Size and Variability	High	Wood products with UF Resin have 6 or 7 samples for analysis by different methods. See Table I for number of samples for each sample matrix/product.
	Metric 6:	Temporality	Low	The paper was published in 1992.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Individual data points are not reported. Summary statistics include mean and coefficient of variation. Minimum and maximum concentrations or range of values was not reported.
	Metric 8:	Quality Assurance	High	The study applied appropriate QA/QC measures. Replicate sampling, blanks and spike recoveries are discussed and/or reported (see Table III).
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	High	The study characterizes variability as described by the coefficient of variation for FDH in wood products dusts, as shown in Table I. CV is also reported for FDH derived from leach tests of wood product dusts using the acetylacetone method as a function of temperature, as shown in Table IV.
Overall Quality Determination			Medium	

Study Citation:		Hedberg, E., Kristensson, A., Ohlsson, M., Johansson, C., Johansson, P. A., Swietlicki, E., Vesely, V., Wideqvist, U., Westerholm, R. (2002). Chemical and physical characterization of emissions from birch wood combustion in a wood stove. Atmospheric Environment 36:4823-4837.		
HERO ID:		1960794		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology and Conditions	High	Sampling and experimental setup are described in detail in Section 2, Figure 1 and Table 1. Samples were collected on DNPH cartridges.Characteristics of the birch wood and wood stove used in the test burns are also described in detail.
		Metric 2: Analytical Methodology	Medium	Analytical methodology is appropriate and well-described. HPLC was used, and LOD was reported, but specifics of calibration and other QA/QC measures were not discussed.
		Metric 3: Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative		Metric 4: Testing Scenario	Medium	This study is representative of burning of birch wood in wood stoves under typical conditions. The tests took place in Norway but the specific type of wood and stove (from US company) are described. There was some variation in air flow between tests, and specific conditions are not matched with the individual test results.
		Metric 5: Sample Size and Variability	Low	The number of samples for aldehydes was reported as n=4.
		Metric 6: Temporality	Low	This paper was published in 2002.
Domain 3: Accessibility/Clarity		Metric 7: Reporting of Results	Medium	The average, median, minimum and maximum are reported in Table 2. Individual data points are not provided.
		Metric 8: Quality Assurance	Low	QA/QC results were not directly discussed but are implied through the study’s use of standard field and laboratory protocols.
Domain 4: Variability and Uncertainty		Metric 9: Variability and Uncertainty	Medium	There was limited characterization of variability and some discussion of uncertainty, limitations and data gaps. It was stated that standard deviation was not reported because it was unlikely that the samples were normally distributed. There was some discussion of variation in flow rates.
Overall Quality Determination			Medium	

Study Citation:		Kang, D., Choi, D., Lee, S., Yeo, M. S., Kim, K. (2010). Effect of bake-out on reducing VOC emissions and concentrations in a residential housing unit with a radiant floor heating system. Building and Environment 45:1816-1825.		
HERO ID:		1962157		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Study gives thorough explanation of methodology, as specified by the IAQ Act. Authors describe equipment, procedures, and include photos for reference.
	Metric 2:	Analytical Methodology	Low	Methodology is mentioned (HPLC) but not described in detail and detection limits are not mentioned at all.
	Metric 3:	Biomarker Selection	N/A	Biomarkers are not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	High	Experiments included two different testing scenarios (chamber study and on-site study) to encompass different temperature/conditions. Materials studied were chosen to reflect those used in the scenario of interest.
	Metric 5:	Sample Size and Variability	High	Greater than 10 samples for chamber study and on-site emissions rates.
	Metric 6:	Temporality	Medium	Study was published in 2010.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Only raw point values are provided, but summary statistics are not provided.
	Metric 8:	Quality Assurance	Low	There are no specific quality measures mentioned or discussed but can be implied through the detailed sampling design and protocol.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	There is limited discussion of limitation or gaps in data and there are no measures of variance.
Overall Quality Determination			Medium	

Study Citation:		Yuan, C. S., Lin, Y. C., Tsai, C. H., Wu, C. C., Lin, Y.,uS (2009). Reducing carbonyl emissions from a heavy-duty diesel engine at US transient cycle test by use of paraffinic/biodiesel blends. Atmospheric Environment 43:6175-6181.		
HERO ID:		1972440		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Testing was conducted according to CFR 40 Part 86 Subpart N, the US-HDD Transient Cycle, and exhaust samples were collected according to USEPA Method 18. The experimental setup is shown in Figure 1. Sampling protocols such as equipment, procedures, conditions and sample storage and handling were described.
	Metric 2:	Analytical Methodology	High	Analytical protocols were clear and appropriate, with descriptions of instrumentation, calibration, recovery samples and determination of IDLs.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	Results from the US-HDD transient cycle test are representative because test conditions cover a full range of load and speed conditions.
	Metric 5:	Sample Size and Variability	Low	Five tests were run with different biodiesel fuel blends. Replicate sampling was not mentioned.
	Metric 6:	Temporality	Medium	The paper was published in 2009.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Individual data points are reported. No summary statistics were provided.
	Metric 8:	Quality Assurance	High	The study applied and documented QA/QC measures such as blanks and laboratory recoveries. No QA/QC issues were identified.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The study has limited characterization of variability, in terms of standard deviations for recovery efficiencies and determination of IDLs. However, no measures of variability were provided for emissions test results.
Overall Quality Determination			Medium	

Study Citation:		Nielsen, G. D., Hammer, M., Hansen, L. F. (1997). Chemical and biological evaluation of building material emissions .3. Screening of a low-emitting fibrous acoustic insulation material. Indoor Air 7:33-40.		
HERO ID:		1985227		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	Samples were collected and analyzed according to the Draeger Formaldehyde method, but only limited description was provided in the text. The test setup was also described and referenced.
	Metric 2:	Analytical Methodology	Medium	Samples were collected and analyzed according to the Draeger Formaldehyde method. LOD and quantitation range were reported.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The data from this Danish study likely represent relevant exposure scenarios for FDH emissions from fibrous acoustic plates, but it is unclear whether the acoustic plates tested are representative of products used in the US.
	Metric 5:	Sample Size and Variability	Low	Emissions from acoustic plates were tested under three loading conditions and 2 ventilation rates. Replicate tests for each condition were not performed.
	Metric 6:	Temporality	Low	The paper was accepted for publication in 1996 and published in 1997.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	All sample results were ND. The LOD (<0.25 mg/m3) was provided, so it can be inferred that individual sample results and average are <0.25 mg/m3.
	Metric 8:	Quality Assurance	Low	QA/QC measures and results are not directly discussed but are implied through the study’s use of standard field and laboratory protocols.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The study has limited characterization of variability. Standard deviation was reported for the quantitative range of the method, but all results were ND. There is little discussion of limitations and data gaps.
Overall Quality Determination			Low	

Study Citation:		Schripp, T., Salthammer, T., Wientzek, S., Wensing, M. (2014). Chamber studies on nonvented decorative fireplaces using liquid or gelled ethanol fuel. Environmental Science and Technology 48:3583-3590.		
HERO ID:		2230062		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	There is a very detailed description of the sampling methods including test chamber specifications, temperature/ humidity controls, images of the chamber, and calibration of the chamber.
	Metric 2:	Analytical Methodology	High	Extraction methods, analytical instrumentation calibration, LoD, and recovery rates are all discussed.
	Metric 3:	Biomarker Selection	N/A	Biomarkers are not relevant to this study.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The study uses 4 different ethanol fireplace types and 8 different fuels which represent a variety of relevant exposure scenarios and tests under 9 fireplace fuel/ combinations. However, does not test under different microenvironments.
	Metric 5:	Sample Size and Variability	Low	The study had nine samples across different fuel and fireplace conditions. Replicate tests were not preformed.
	Metric 6:	Temporality	Medium	The study was published in 2014.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	The minimum, maximum and mean are reported for each fuel/fireplace combination but are incomplete otherwise. Individual data points not reported.
	Metric 8:	Quality Assurance	Medium	There is robust discussion of QA/QC in regard to sampling instrumentation, calibration, use of standards, but does not discuss laboratory storage or pre-exposure samples.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	There is no measure of variability but some discussion of limitations/ areas of further research.
Overall Quality Determination			Medium	

Study Citation:		Jarnstrom, H., Saarela, K., Kalliokoski, P., Pasanen, A. L. (2007). Reference values for structure emissions measured on site in new residential buildings in Finland. Atmospheric Environment 41:2290-2302.		
HERO ID:		2443430		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	The Field and Laboratory Emission Cell (FLEC) was described and referenced. FLEC is included ISO 16000-10, 2006b.
	Metric 2:	Analytical Methodology	Medium	A spectrometric acetylacetone method was briefly described, and the reference name was provided in German. The LOD was reported.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	Test conditions were representative of newly constructed residential buildings in Finland, for testing of emissions from M1-class building materials.
	Metric 5:	Sample Size and Variability	Medium	Samples of PVC flooring, parquet flooring, ceiling, and wall materials were tested in 7 newly constructed buildings over 3 time intervals, as shown in Table 1 and the text at the end of Section 2.1. Specific emission rates (mean and range) for a large number of samples were presented in Table 2, but the exact number of samples was not stated. The number of samples is shown in Table 4 (n=6/4/10/9, for PVC/parquet/ceiling/wall, respectively) for mean SERs for the 12-month-old building to be used as reference values.
	Metric 6:	Temporality	Low	The buildings tested in the study were built between 1999-2002, with testing intervals through 2003.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	Individual data points are not reported. Summary statistics include mean and range for SERs, as shown in Tables 2 and 4. The 95th percentile values for 12-month emission rates are also shown in Table 4, but standard deviation was not determined for any of the data sets.
	Metric 8:	Quality Assurance	Medium	There is limited discussion of QA/QC measures and results, such as correction for field blanks. However appropriate use of QA/QC measures is implied through the study's use of standard field and laboratory protocols.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The study has limited characterization of variability, with results reported as a range. The mean is presented without standard deviation. Statistical correlations were also determined for different variables.
Overall Quality Determination			Medium	

Study Citation:		Matthews, T. G., Hawthorne, A. R., Daffron, C. R., Corey, M. D., Reed, T. J., Schrimsher, J. M. (1984). Formaldehyde surface emission monitor. Analytical Chemistry 56:448-454.		
HERO ID:		2444112		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Detailed description of development, evaluation, testing and use of FSEM. Other methods used for comparison are fully described and have reference citations.
	Metric 2:	Analytical Methodology	High	Analytical method is described and referenced.
	Metric 3:	Biomarker Selection	N/A	NA.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	FDH levels were consistent with US residences and designed to simulate chamber tests.
	Metric 5:	Sample Size and Variability	High	Test homes involved testing of 14 products, wit replicates; FSEM testing for 5 UFFI panels with replicates.
	Metric 6:	Temporality	Low	>15 years; published in 1984.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	FDH emissions results are reported as mean with standard deviation. Individual sample results are not provided.
	Metric 8:	Quality Assurance	Medium	Various QA/QC checks were performed during evaluation of the FSEM method.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	High	The study characterizes variability for the FSEM test as well as other methods used for comparison. Results and test parameters are presented as mean with standard deviation.
Overall Quality Determination		High		

Study Citation:		Maddalena, R., Russell, M., Sullivan, D. P., Apte, M. G. (2009). Formaldehyde and other volatile organic chemical emissions in four FEMA temporary housing units. Environmental Science and Technology 43:5626-5632.		
HERO ID:		2591662		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Article and supplemental files provide detailed description of sampling methods used. Air samples for VOCs were collected and analyzed following the U.S. Environmental Protection Agency (USEPA) MethodTO-17 (14).
	Metric 2:	Analytical Methodology	High	Article and supplemental files provide detailed description of analytical methods used. Air samples for VOCs were collected and analyzed following the U.S. Environmental Protection Agency (USEPA) MethodTO-17 (14).
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	FEMA Temporary Housing Units were subject of this study and represent realistic exposure scenarios relevant to the TSCA FDH risk evaluation.
	Metric 5:	Sample Size and Variability	Low	4 samples taken. Replicate tests not identified.
	Metric 6:	Temporality	Medium	Sampling wasconducted on November 14, 2007.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	High	Clear and detailed. No inconsistencies or errors found.
	Metric 8:	Quality Assurance	High	This is detailed in the supplemental file.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	"Although the convenience sample of four THUs is notstatistically representative of the entire fleet of FEMA THUs,this study offers a preliminary assessment of the effect ofTHU design and material choices on indoor concentrationsof VOCs. This study did not fully address the temperatureand humidity effects on material emissions. At hightemperature and relative humidity, emissions of formaldehydeare expected to increase, and temperature is alsoexpected to influence VOC emissions."-Authors
Overall Quality Determination			High	

Study Citation:		Shinohara, N., Kai, Y., Mizukoshi, A., Fujii, M., Kumagai, K., Okuizumi, Y., Jona, M., Yanagisawa, Y. (2009). On-site passive flux sampler measurement of emission rates of carbonyls and VOCs from multiple indoor sources. Building and Environment 44:859-863.		
HERO ID:		2608028		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Sampling protocol was not based on a available SOP, but sampling methods were clear and appropriate. All pertinent sampling information was included.
	Metric 2:	Analytical Methodology	Low	Analytical methods were not based on a available SOP, but methodology is clear and appropriate. Some pertinent information was missing: limit of detection.
	Metric 3:	Biomarker Selection	N/A	The authors analyzed air samples.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Testing conditions are relevant to exposure scenario, but it was not conducted under a variety of conditions.
	Metric 5:	Sample Size and Variability	Medium	emission fluxes and estimated concentrations from n=7 different indoor sources, without replicates.
	Metric 6:	Temporality	Low	The study was conducted in 2003.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	Only raw data was reported. Summary statistics were not included.
	Metric 8:	Quality Assurance	Low	QA/QC techniques were not directly discussed but can be implied through the protocols in place in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The study has limited discussion of key uncertainties, limitations, and data gaps in the discussion. Variability was not characterized.
Overall Quality Determination			Medium	

Study Citation:		Kim, S., Cho, B. (2013). Influence of VOC and formaldehyde emission from tile adhesives on their indoor concentrations in buildings. Journal of Adhesion Science and Technology 27:699-709.		
HERO ID:		2660357		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methods and conditions used by the authors followed the widely accepted and standardized protocols defined in ISO 16000-9, ASTM D 5116-10, and JIS A 1901.
	Metric 2:	Analytical Methodology	High	Analytical methods for calculating emission rates followed the widely accepted and standardized procedures in ASTM D5116-10.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken.
	Metric 5:	Sample Size and Variability	Low	A moderate sample size can be inferred based on figures and text. However, no replicates were conducted.
	Metric 6:	Temporality	Medium	Tested items are less consistent with when current exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Emission rates and concentrations are reported in table 2 and figure 5 however no summary statistics are reported.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Medium		

Study Citation:		Gunschera, J.,an, Mentese, S., Salthammer, T., Andersen, J.,anRud (2013). Impact of building materials on indoor formaldehyde levels: Effect of ceiling tiles, mineral fiber insulation and gypsum board. Building and Environment 64:138-145.		
HERO ID:		2705508		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Good descriptions of large and small controlled chamber test setup and sampling methodologies, with reference citations provided.
	Metric 2:	Analytical Methodology	Medium	Analytical methodology included continuous monitoring of FDH, with discontinuous sampling & analysis by a different method as a control. Descriptions and references were provided for both techniques.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Large and small controlled chamber testing of FDH emission, diffusion and adsorption/desorption from various building materials.
	Metric 5:	Sample Size and Variability	Medium	Continuous monitoring results are only shown graphically. Several experiments with <10 discrete samples.
	Metric 6:	Temporality	Medium	5-15 years old; published in 2013.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Individual data points are shown graphically with no tabular data summary. Table 2 shows FDH concentrations at each step of one study.
	Metric 8:	Quality Assurance	Medium	Some discussion of QA/QC.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Limited discussion of variability, uncertainty and limitations.
Overall Quality Determination			Medium	

Study Citation:		Colombo, A., De Bortoli, M., Pecchio, E., Schauenburg, H., Schlitt, H., Vissers, H. (1990). Chamber testing of organic emission from building and furnishing materials. Science of the Total Environment 91:237-250.		
HERO ID:		2814448		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Detailed description of sampling methodology - chamber test setup, test materials, and sample collection.
	Metric 2:	Analytical Methodology	Medium	Modified DNPH method was used for FDH sample collection and analysis; reference likely includes additional details on instrumentation.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Small chamber test seems appropriate for emissions testing of building materials; some limitations are discussed.
	Metric 5:	Sample Size and Variability	Low	Duplicate samples of 3 building materials.
	Metric 6:	Temporality	Low	> 15 years old; study published in 1990.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Individual data points not provided; mean and standard deviation reported.
	Metric 8:	Quality Assurance	Medium	QA/QC was discussed in terms of maintaining chamber conditions, VOC recoveries, and analysis of duplicate samples.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	High	Standard deviation was reported for tested products and some chamber conditions. Limitations of empirical best-fit model were discussed.
Overall Quality Determination			Medium	

Study Citation:		Roffael, E. (2008). On the release of volatile acids from wood-based panels - chemical aspects. Holz als Roh- und Werkstoff 66:373-378.		
HERO ID:		2862454		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	Sampling method is only briefly discussed.
	Metric 2:	Analytical Methodology	Medium	Determination of FDH release by flask method EN 717-3.
	Metric 3:	Biomarker Selection	N/A	Not relevant.
Domain 2: Representative	Metric 4:	Testing Scenario	Low	Lab testing of wood pulp and fiberboard (German study). Limited testing, limited conditions.
	Metric 5:	Sample Size and Variability	Low	Appears to be single sample for pulp and boards processed with 2 techniques.
	Metric 6:	Temporality	Medium	Study is 5-15 years old; published 2008.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Appears to be single data point per sample (4 samples). No summary statistics presented or discussed.
	Metric 8:	Quality Assurance	Low	QA/QC not directly discussed.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	Characterization of variability is absent.
Overall Quality Determination			Low	

Study Citation:		Hodgson, A. T., Rudd, A. F., Beal, D., Chandra, S. (2000). Volatile organic compound concentrations and emission rates in new manufactured and site-built houses. Indoor Air 10:178-192.		
HERO ID:		2994962		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The sampling protocol is from ASTM. The chamber size and material are mentioned, along with the temperature, relative humidity, and sampling duration.
	Metric 2:	Analytical Methodology	Low	Methods are cited as EPA Method TO-11 but are not well described other than mentioning HPLC. No LODs are reported.
	Metric 3:	Biomarker Selection	N/A	Biomarkers are not relevant to this study.
Domain 2: Representative	Metric 4:	Testing Scenario	Low	The testing scenario of the chamber study is not well characterized.
	Metric 5:	Sample Size and Variability	Low	Single sample size is acceptable for chamber studies.
	Metric 6:	Temporality	Low	The study was published in 2000.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Raw data is not provided. Summary statistics include mean, SD, and range, dates of data set. Study does not include number of samples in the data set, frequency of detection, or testing for outliers. For emissions testing, there is one point value provided.
	Metric 8:	Quality Assurance	Low	QA/QC measures are not discussed but can be implied through standard protocols.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	SD is provided for concentrations but discussion of limits of the findings are absent.
Overall Quality Determination		Low		

Study Citation:		Niculescu, M., Ghituleasa, C., Mocioiu, A. M., Nicula, G., Surdu, L., Tanasescu, G. (2013). Evaluations of formaldehyde emissions in clothing textiles. Industria Textila 64:111-114.		
HERO ID:		3001257		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Uses ISO method for sampling and analysis.
	Metric 2:	Analytical Methodology	High	Uses ISO method for sampling and analysis.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	A wide variety of clothing items from various countries (majority from Romania) was sampled; representative of Romanian market.
	Metric 5:	Sample Size and Variability	High	26 items of children's clothing were sampled (161 items total)
	Metric 6:	Temporality	Medium	Study was published in 2013; 5-15 years old.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Individual data points are reported in a bar graph that can likely be read as the nearest whole numbers.
	Metric 8:	Quality Assurance	Low	QA/QC not directly discussed.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	Characterization of variability is absent.
Overall Quality Determination		Medium		

Study Citation:		Costarramone, N., Cantau, C., Desauziers, V., Pécheyran, C., Pigot, T., Lacombe, S. (2016). Photocatalytic air purifiers for indoor air: European standard and pilot room experiments. Environmental Science and Pollution Research 24:12538-12546.		
HERO ID:		3457988		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	Emission testing was performed as part of a European standardization committee effort. The BEF experimental platform with building materials and furnishings as source materials, was described in the text and the setup was shown in Figure 1b. Air flow rate, temperature and relative humidity were reported. An instantaneous air sampling method was used.
	Metric 2:	Analytical Methodology	Low	Analysis was by GC/MS VARIAN 1200Q. The analytical method used for the BEF experimental platform testing was only very briefly described and was associated with instantaneous sampling. The study was associated with CEN so appropriate analytical methods were likely followed even though details were not presented.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The data represent a relevant exposure scenario. Actual conditions were recorded and were similar throughout the tests.
	Metric 5:	Sample Size and Variability	Low	Initial and final sample concentrations for testing of 2 different photocatalytic air purifiers were reported.
	Metric 6:	Temporality	High	Paper was submitted and published online in 2016.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Four data points for two air purifiers were reported in the text. One value is called a maximum but the values are presented as a change over time as opposed to a range.
	Metric 8:	Quality Assurance	Low	QA/QC measures and results were not directly discussed.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability is absent.
Overall Quality Determination			Low	

Study Citation:		da Silva, C. F. F.,P, Rana, C., Maskell, D., Dengel, A., Ansell, M. P., Ball, R. J. (2016). Influence of eco-materials on indoor air quality. Green Materials		
HERO ID:		4:72-80. 3462986		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Con- ditions	High	Sampling methods follow the standardized procedures described in BS EN ISO 16000-9:2006.
	Metric 2:	Analytical Methodology	High	Analytical methods and instrumentation follows the standardized procedures described in BS EN ISO/IEC 17025:2005.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	The article discusses analysis of 15 samples which is considered a large sample size however, there are no mention of replicates.
	Metric 6:	Temporality	High	The data presented in this paper represents current exposures.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Area specific formaldehyde emission rates are provided in a figure and briefly stated in text. There is a maximum value listed but otherwise no measures of central tendency or variance are described.
	Metric 8:	Quality Assurance	Medium	There are brief discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is very briefly discussed but there are no statistical measures of variance present.
Overall Quality Determination			Medium	

Study Citation:		Abbass, O. A., Sailor, D. J., Gall, E. T. (2017). Effect of fiber material on ozone removal and carbonyl production from carpets. Atmospheric Environment 148:42-48.		
HERO ID:		3464476		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The sampling methods and conditions described follows the protocols outlined in the standardized ISO 16000-9 method.
	Metric 2:	Analytical Methodology	Low	Analytical methods and instrumentation are clear described however there is no mention of detection limits or recoveries.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Medium	The paper discusses 6 samples that were each tested 3 times to serve as replicates.
	Metric 6:	Temporality	High	The data presented in this paper represents current exposures.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	The results are provided as point value emission rates for each fiber type. These values are described in text that reference figure 5. No summary statistics are provided for the data.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The last paragraph before conclusions discusses variability of results and comparison with other studies. Data analysis section calculated an estimate of uncertainty.
Overall Quality Determination		Medium		

Study Citation:		Martin, V. B., Smith, C. B., Gupta, B. S. (1998). Identification of source emissions from finished textile fabrics. Textile Chemist and Colorist 30:15-19.		
HERO ID:		3561750		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Two sampling methods are used and one cites AATCC Method 112 while the other gives a description of the sampling methodology. Corrections had to be made using the known test and weather conditions.
	Metric 2:	Analytical Methodology	Critically Deficient	No LODs are reported. The static method used Drager direct reading tubes for analysis while the AATCC method lists no instrumentation or analysis information.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	A standard conditioning practice was used to prepare the samples and is relevant to the exposure scenario. There were two testing conditions, dried and cured.
	Metric 5:	Sample Size and Variability	Low	Two testing methods were used per sample, with different finish and fabric concentrations.
	Metric 6:	Temporality	Low	This paper was published in 1998.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Critically Deficient	Summary stats are not provided and it appears concentrations were corrected for the weather and testing conditions. The uncorrected data is not available.
	Metric 8:	Quality Assurance	Low	Two analytical methods are used to test if the other is reliable. No QA/QC measures are discussed but standard practices are used.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	No standard deviation or mention of variance is given, but there are several comparisons to the median for different samples and there is discussion of trends.
Overall Quality Determination		Uninformative		

Study Citation:		Plaisance, H., Vignau-Laulhere, J., Mocho, P., Sauvat, N., Raulin, K., Desauziers, V. (2017). Volatile organic compounds concentrations during the construction process in newly-built timber-frame houses: source identification and emission kinetics. Environmental Science: Processes & Impacts 19:696-710.		
HERO ID:		3864192		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The sampling methodology is very detailed and includes the materials and cartridges used, temperature, humidity and sample surface area.
	Metric 2:	Analytical Methodology	Low	LODs are only reported for one portion of the experiment. HPLC was used to analyze the samples. Various instrumentation used are provided as well as citations of the methodology used.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The exposure scenario was well represented by the tests conducted, although they were not conducted under a variety of conditions. There were tests conducted to examine how the actual set up of products may effect their emissions rates.
	Metric 5:	Sample Size and Variability	Low	Sample size differed across measurements, with emissions rates being taken at 3 different times for 5 samples, and then one emission rate sample for each of 20 products.
	Metric 6:	Temporality	High	This reference was published in 2017.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Summary stats are only given for the occupational portions of the testing. The emissions rates tests are raw data only.
	Metric 8:	Quality Assurance	Medium	Several QA/QC procedures are discussed such as background and control samples, monitoring for escapes during the experiment and the use of standard methods. Gaps and limitations of the study were discussed in limited amounts and mostly centered on the possibility of cross contamination.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	Standard deviations and characterizations of variance are not given. There is some uncertainty to the source of formaldehyde, but this is seen as a limitation of the study and not a major source of uncertainty.
Overall Quality Determination		Medium		

Study Citation:		Jiang, C., Li, D., Zhang, P., Li, J., Wang, J., Yu, J. (2017). Formaldehyde and volatile organic compound (VOC) emissions from particleboard: Identification of odorous compounds and effects of heat treatment. Building and Environment 117:118-126.		
HERO ID:		3870467		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling protocol was not based on a publicly available SOP but was clear, appropriate and included pertinent sampling information.
	Metric 2:	Analytical Methodology	Low	Analytical methods were not based on a publicly available SOP but were described but was missing some pertinent information. No detection limit was found.
	Metric 3:	Biomarker Selection	N/A	Parent chemical was the focus of the study, instead of metabolites.
Domain 2: Representative	Metric 4:	Testing Scenario	High	Testing conditions likely to represent a relevant exposure scenario and included testing at different conditions (different temperatures).
	Metric 5:	Sample Size and Variability	Medium	Concentrations taken at 5 different time points (for the four different temperatures).
	Metric 6:	Temporality	Medium	Particleboard samples were obtained between 5-15 years ago.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	High	Raw data can be found reported in the supplemental material.
	Metric 8:	Quality Assurance	Low	QA/QC not directly discussed but can be implied through the studies use of replicate samples.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	Limited discussion included on uncertainties, limitations, and data gaps have been identified. Section 3.2 includes text of the missing effects of humidity.
Overall Quality Determination			Medium	

Study Citation:		Rahman, M. A., Rossner, A., Hopke, P. K. (2017). Occupational exposure of aldehydes resulting from the storage of wood pellets. Journal of Occupational and Environmental Hygiene 14:417-426.		
HERO ID:		3870738		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The sampling methodology is cited as similar to another paper and some details such as flow rate and instrumentation are given.
	Metric 2:	Analytical Methodology	Medium	LODs are given, although it is unclear if all parts of the measurements contain the same LODs. GC/MS was used with a 5977A MSD, Agilent Technologies instrument.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The experimental samples were set up to mimic actual storage temperatures and amount of time. They were not tested under a variety of conditions, but were in a typical storage container.
	Metric 5:	Sample Size and Variability	Low	Only one sample is taken in each of the two bins, but replicate analysis of samples does occur.
	Metric 6:	Temporality	High	This paper was published in 2017.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Only a range is reported in text, and no other summary stats.
	Metric 8:	Quality Assurance	Low	QA/QC measures are not discussed but standard methods are used and the design is meant to decrease
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	There are no standard deviations or characterization of uncertainty.
Overall Quality Determination			Low	

Study Citation:		Lee, Y. K., Kin, H. J. (2012). The effect of temperature on VOCs and carbonyl compounds emission from wooden flooring by thermal extractor test method. Building and Environment 53:95-99.		
HERO ID:		4442291		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	The sampling methodology is described in detail and sampling equipment, temperature, humidity and duration were all explained. A thermal extractor (TE, Gerstel) was used for sampling.
	Metric 2:	Analytical Methodology	Low	HPLC was used to analyze the samples. No LODs were given for formaldehyde but other methods did have limits discussed.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The exposure scenario is relevant to the use of engineered and laminate flooring. Three temperatures were tested, but all other environmental factors were controlled for.
	Metric 5:	Sample Size and Variability	Low	Two flooring types were each tested at 3 temperatures. No replicate tests were conducted.
	Metric 6:	Temporality	Medium	This paper was published in 2011.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Only raw data is provided.
	Metric 8:	Quality Assurance	Low	QA/QC measures are not discussed, but detailed and standard practices were used.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	There is discussion of variability and possible explanations. Limitations and gaps in the data are not greatly discussed or identified.
Overall Quality Determination			Low	

Study Citation:		Que, Z.,eLi, Wang, F.,eiBin, Li, J. Z., Furuno, T. (2013). Assessment on emission of volatile organic compounds and formaldehyde from building materials. Composites Part B: Engineering 49:36-42.		
HERO ID:		4442298		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methodology is standard EN 717-1 [10] method and is explained in detail with temperature, humidity, sample volume all given.
	Metric 2:	Analytical Methodology	Low	Spectrophotometry was used for analysis with a Shimane UV-3600 and the direct reading device, Interscan Toxic Gas Analyzer portable model 4150-2. No LODs were given.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Testing scenario is relevant to the exposure scenario and the micro environment was highly controlled. Tests were not conducted under a range of conditions, but on a range of products.
	Metric 5:	Sample Size and Variability	Low	There were two measurements per product, each measured with a different instrument and as either an emission rate or a concentration. These are not replicates and there were 9 products.
	Metric 6:	Temporality	Medium	The paper was written in 2012 and published in 2013
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	No summary statistics are reported.
	Metric 8:	Quality Assurance	Medium	QA/QC issues are not identified and no controls are mentioned. Standard and strict sampling and analytical methodology are applied.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	There are no measures of variability given but variations are discussed. Limitations and gaps are not identified.
Overall Quality Determination			Low	

Study Citation:		Schaeffer, V. H., Bhooshan, B., Chen, S. B., Sonenthal, J. S., Hodgson, A. J. (1996). Characterization of Volatile Organic Chemical Emissions From Carpet Cushions. Journal of the Air and Waste Management Association 46:813-820.		
HERO ID:		4442302		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Descriptions of the small chamber screening test were provided in the article. ASTM D5116 and a peer-reviewed test method from the EPA Carpet Policy Dialogue (reference 6) were used for the large chamber emissions testing.
	Metric 2:	Analytical Methodology	Medium	Descriptions of the analytical methodology are provided in the article, but no specific method is referenced.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	Small chamber and large chamber emission tests were performed at appropriate test conditions to simulate indoor use of carpet cushions.
	Metric 5:	Sample Size and Variability	Low	No significant quantities of FDH (<5 ug/m2-hr) were released by any of the carpet cushion samples. This was stated in the text of the paper but not reported quantitatively in tables or figures, but it can be inferred that this was the screening (small chamber testing) result for every cushion sample.
	Metric 6:	Temporality	Low	Carpet cushion samples were collected between February and September 1993.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	See Metric 5 - it can be inferred that the FDH emission concentration for individual data points AND arithmetic average of small chamber testing for each type of cushion was <5 ug/m2-hr.
	Metric 8:	Quality Assurance	Medium	Some QA/QC measures are described for the analytical method.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	There was limited discussion of uncertainty, limitations and data gaps for the overall experiment but not specifically for FDH.
Overall Quality Determination			Medium	

Study Citation:		Risholm-Sundman, M., Larsen, A., Vestin, E.,wa, Weibull, A. (2007). Formaldehyde emission - Comparison of different standard methods. Atmo-spheric Environment 41:3193-3202.		
HERO ID:		4442303		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology and Con- ditions	High	Eight FDH emission testing methods from different countries were compared as detailed in Table 1: EN 717-1, EN 717-2, and EN 717-3 from Europe; JIS A 1901, JIS A 1460, and JIS 233 from Japan; and ISO/CD 12460 (international standard). Test method descriptions and conditions are detailed in the paper.
		Metric 2: Analytical Methodology	Low	Eight FDH emission testing methods from different countries were compared as detailed in Table 1: EN 717-1, EN 717-2, and EN 717-3 from Europe; JIS A 1901, JIS A 1460, and JIS 233 from Japan; and ISO/CD 12460 (international standard). Test method descriptions and conditions are detailed in the paper. Analytical instru-mentation and techniques are described briefly, as photometric determination.
		Metric 3: Biomarker Selection	N/A	Biomarkers were not addressed in this study.
Domain 2: Representative		Metric 4: Testing Scenario	High	Scenario is representative of testing FDH emissions from several wood products by different methods under different conditions. Methods used were primarily from Europe and Japan, so may not be as representative of US testing.
		Metric 5: Sample Size and Variability	High	Several different sample sets were reported, for comparison of methods, as well as for intralaboratory and inter-laboratory testing for EN 717-1, EN 717-2 and JIS A 1460. Replicate sampling and analysis were conducted.
		Metric 6: Temporality	Medium	The paper was accepted for publication in 2006. One of the intralaboratory studies was conducted July 2004-January 2005.
Domain 3: Accessibility/Clarity		Metric 7: Reporting of Results	Medium	Individual data points were reported in Table 3 for the method comparison without summary statistics. Mean FDH emission results for intra-laboratory and inter-laboratory studies are shown in the key of Figures 1-3, and percent coefficients of variation for these studies is shown in Table 2.
		Metric 8: Quality Assurance	Medium	The study applied QA/QC measures associated with the standard test methods, but documentation was limited. Intra- and inter- laboratory reproducibility was reported and discussed at length.
Domain 4: Variability and Uncertainty		Metric 9: Variability and Uncertainty	Medium	Variability was characterized as intra- and interlaboratory reproducibility (percent coefficient of variability). There was also some discussion of variations in results from differences in test conditions specific to the differ-ent methods, and variation of relative humidity in desiccator tests.
Overall Quality Determination			Medium	

Study Citation:		Vaisanen, T., Laitinen, K., Tomppo, L., Joutsensaari, J., Raatikainen, O., Lappalainen, R., Yli-Pirila, P. (2018). A rapid technique for monitoring volatile organic compound emissions from wood-plastic composites. Indoor and Built Environment 27:194-204.		
HERO ID:		4641934		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The sampling methods are well described and include storage information, temperature and humidity control, equipment descriptions and detailed methods descriptions.
	Metric 2:	Analytical Methodology	Low	Analytical equipment is listed, but no LODs are given.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	High	The testing scenario is relevant to the exposure scenario. The microenvironment is controlled and two experiments were run to determine how time and materials impact emissions.
	Metric 5:	Sample Size and Variability	Low	11 samples were taken during the timed portion of the experiment, while 7 different materials each had one sample. No replicates were performed.
	Metric 6:	Temporality	High	This paper was published in 2018.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Raw data is reported without summary stats.
	Metric 8:	Quality Assurance	Low	QA/QC measures are not directly discussed. The standard and detailed experimental design did address them by design.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Standard deviations are given and discussed for some of the samples. There is limited discussion of gaps or limitations of the study.
Overall Quality Determination			Medium	

Study Citation:		Ng, L., Poppendieck, D., Dols, W. S., Emmerich, S. J. (2018). Evaluating indoor air quality and energy impacts of ventilation in a net-zero energy house using a coupled model. 24:124-134.		
HERO ID:		4646215		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Sampling Methodology and Conditions	Medium	Other papers are cited as references to using the chamber set-up. All are academic. Sampling conditions such as airflow, temperature and chamber size are given, but storage conditions, equipment and calibration information are missing.
		Metric 2: Analytical Methodology	Critically Deficient	Analytical instrumentation is not given for the chamber test samples. Other previous studies use of spectrophotometric monitors and the like are listed, but none for the chamber test.
		Metric 3: Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative		Metric 4: Testing Scenario	Medium	The testing scenario is applicable to the exposure scenario and tests several materials at various temperatures.
		Metric 5: Sample Size and Variability	Low	28 experiments were run. 5 to test cabinetry, 6 to test flooring and 16 to test plywood. It is unclear if each test was at a different temperature. If they were each at various temperatures, there are no replicate samples specified. In figure 2 the plywood samples may have replicates, but not the cabinetry or flooring.
		Metric 6: Temporality	High	This paper was published in 2018.
Domain 3: Accessibility/Clarity		Metric 7: Reporting of Results	Low	Figure 2 reports individual data points. No summary statistics are reported in the paper.
		Metric 8: Quality Assurance	Low	QA/QC issues are not directly addressed, but standard laboratory procedures are well defined and the experimental design appears to address any potential issues.
Domain 4: Variability and Uncertainty		Metric 9: Variability and Uncertainty	Medium	Limitations and possible gaps in knowledge from the data are discussed.
Overall Quality Determination		Uninformative		

Study Citation:		Chang, J. C., Guo, Z., Fortmann, R., Lao, H. C. (2002). Characterization and reduction of formaldehyde emissions from a low-VOC latex paint. Indoor Air 12:10-16.		
HERO ID:		4678102		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Air samples were collected using EPA Method IP-6A in EPA facilities designed for chamber testing. Extensive sampling conditions were given such as temperature, humidity, surface area and air exchange rate.
	Metric 2:	Analytical Methodology	Low	No LODs or LOQs are reported. Samples were analyzed with a Hewlett Packard 1090 high-performance liquid chromatograph and calibrated for formaldehyde.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Testing was done under one set of conditions which are representative of the amount of product used and the amount of time at which exposure could possible occur after use.
	Metric 5:	Sample Size and Variability	Medium	Sample size is not explicitly stated in the paper, but raw data is presented in a figure and it is assumed from that. Due to overlap of points, it is likely sample size is above 10 per scenario, but each point cannot accurately be counted.
	Metric 6:	Temporality	Low	This paper was published in 2002.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Raw data is reported, but due to the data points overlapping in the figure the data is likely uncertain if digitized. No summary stats are reported.
	Metric 8:	Quality Assurance	High	QA/QC measures were taken throughout the experiment such as daily instrument performance checks. No issues were identified that would impact the results.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	Standard deviations and measures of variability are not given. There is some discussion of limitations and explanations of why the experimental results followed a specific pattern.
Overall Quality Determination		Medium		

Study Citation:		Wang, J. X., Shen, J., Lei, C. S., Feng, Q. (2014). Volatile organic compound and formaldehyde emissions from Populus davidiana wood treated with low molecular weight urea-formaldehyde resin. Journal of Environmental Biology 35:989-994.		
HERO ID:		4683819		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Sampling methods followed the standardized procedures defined in ISO 16000-9 and 16000-6.
	Metric 2:	Analytical Methodology	High	Analytical methods and instrumentation are well defined and following the standardized procedures described in ASTM D 6007-02.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	A small sample size can be inferred based on the formaldehyde data presented in figure 3.
	Metric 6:	Temporality	High	The data presented in this paper represents current exposures.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Results are provided in figure 3 as point value, however no summary statistics for formaldehyde are provided.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Medium	

Study Citation:		Timofeeva, S. S., Timofeev, S. S. (2017). Ecological risks in residential premises arising from thermal insulation by pouring. Materials Science and Engineering 262		
HERO ID:		4719288		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	The sampling methods for the indoor air tests cite GOST R ISO. The sampling methods for the product content have citations to government regulations and methodology documents. GOST 30255-95 Method is also cited as part of the methods for sampling and analyzing the product concentrations.
	Metric 2:	Analytical Methodology	Low	LODs are not reported. A IGS-98 Comet-M series gas meter was used to analyze the sample in a climatic chamber.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Control apartments were sampled, as well as those in which repair work had been completed. The product content was tested based on samples taken from apartments where repair work has occurred. Testing conditions are not well-defined.
	Metric 5:	Sample Size and Variability	Low	2 samples were taken for each product and location combination. These are possibly replicate samples, if the temperature above is assumed to be the same for each sample.
	Metric 6:	Temporality	High	Sampling occurred in 2016 and the article was published in 2017.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Summary statistics are not reported, only raw data.
	Metric 8:	Quality Assurance	Low	QA/QC was not directly discussed but only standard methods were used and cited.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	Product content was measured as a way to understand findings of the indoor air study. Gaps and limitations are not discussed. There is discussion of application of results to indoor air results, extrapolating out main source of formaldehyde.
Overall Quality Determination			Low	

Study Citation:		An, J.,aeY, Kim, S., Kim, H. J., Seo, J. (2010). Emission behavior of formaldehyde and TVOC from engineered flooring in under heating and air circulation systems. Building and Environment 45:1826-1833.		
HERO ID:		4722095		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Sampling methodology is clearly defined including tabulated sampling conditions and explicit descriptions of sampling procedures and equipment.
	Metric 2:	Analytical Methodology	High	Analytical methodology including detection limits and instrumentation is described and follows the procedures used in the ASTM D5116 standard guide.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Testing conditions are provided and explained however exposure controls including pre-exposure and background measurements are absent from this study.
	Metric 5:	Sample Size and Variability	Low	The authors report that only one sample was used for each of the conducted tests.
	Metric 6:	Temporality	Medium	Tested items are less consistent with recent exposure studies.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Results are primarily displayed in the form of figures and no summary statistics are present in the paper.
	Metric 8:	Quality Assurance	Medium	No QA/QC issues have been identified by the authors, however it can be implied that there were no significant QA/QC for this study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this study.
Overall Quality Determination			Medium	

Study Citation:		Thredgold, L., Gaskin, S., Heath, L., Pisaniello, D., Logan, M., Baxter, C. (2019). Understanding skin absorption of common aldehyde vapours from exposure during hazardous material incidents. Journal of Exposure Science and Environmental Epidemiology		
HERO ID:		5024659		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methodology is clearly defined and the authors provide the applicable test conditions for this study including temperature, relative humidity and exposure durations.
	Metric 2:	Analytical Methodology	High	Analytical methodology was conducted following the MDHS102-HSE: Aldehydes in Air procedures. Instrumentation including the use of a HPLC-UV and limits of detection values are presented in the study.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Testing conditions closely represent relevant exposure scenarios and include pre-exposure samples, microenvironments, and source of exposures. However, tests are not conducted under a broad range of different conditions.
	Metric 5:	Sample Size and Variability	Medium	The authors report a sample size and replicate test of at least 3 or more samples for each exposure variable.
	Metric 6:	Temporality	High	The data presented in this paper represents current exposures.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Authors provided some summary statistics including means and standard deviations in figures and ranges in text. Other summary statistics are absent.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Medium	

Study Citation:		Leigh, I. E. (1996). Novel mini-chamber procedure for screening insulation for emission of formaldehyde and other VOCs. ASTM Special Technical Publication :67-74.		
HERO ID:		5466496		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The authors follow the widely accepted MBTH sampling methodology and procedures which measures total aldehydes.
	Metric 2:	Analytical Methodology	Low	Analytical methodology and instrumentation is briefly discussed however, there are no detection limits listed in this study.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Testing scenarios are described as different approaches that are then tested under a range of different temperature and RH conditions. However, no pre exposure samples were collected.
	Metric 5:	Sample Size and Variability	Low	The two types of products tested in this study have a sample size of 4 and 3 respectively.
	Metric 6:	Temporality	Low	The source of tested items in this study is not consistent with current or recent exposures.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Raw data is tabulated in the paper but no summary statistics are reported.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Davis, A. Y., Zhang, Q., Wong, J. P. S., Weber, R. J., Black, M. S. (2019). Characterization of volatile organic compound emissions from consumer level material extrusion 3D printers. Building and Environment 160		
HERO ID:		5645091		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	The authors provided some cursory descriptions of the 3D printers (five) and filaments (20), but did not mention sample handling, or storage treatment, or care to avoid contamination.
	Metric 2:	Analytical Methodology	High	The authors followed publically available protocols (EPA, ISO, ASTM) for the analytical techniques. The authors mention a range for the detection limits for most VOCs and state a limit of quantification for the study (page 3 of the PDF)
	Metric 3:	Biomarker Selection	N/A	A biomarker was not used in this study.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The chamber study used purified air with a 3% humidity level. This is not compatible with the model scenarios of personal space, residential setting, and classroom setting. The authors did not suggest the extent to which this may have complicated the predictions of exposure.
	Metric 5:	Sample Size and Variability	Low	The experimental results for formaldehyde are based on sample sizes of 1, 2, 9, or 12. The authors did not clarify that they analyzed replicates.
	Metric 6:	Temporality	High	The article was published in 2019.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	The authors include sample size, frequency of detection, mean, min, and max (Table 3), but they do not indicate the measure of variation for samples sizes larger than one. Raw data are not provided.
	Metric 8:	Quality Assurance	Medium	The authors mention baseline samples. They do not mention recoveries or adjusting for recoveries. They do not mention laboratory controls.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The authors claim variability in the results relative to other studies (illustrated in Figure 3) due to a lack of standard testing methods. There is little to suggest that the methods and approach of this study are particularly better than others.
Overall Quality Determination		Medium		

Study Citation:		NATL PARTICLEBOARD ASSOC, (1985). Letter from National Particleboard Association to USEPA submitting product emission information with attachments.		
HERO ID:		5901010		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Critically Deficient	Sampling methods are not described in this paper.
	Metric 2:	Analytical Methodology	Critically Deficient	Analytical methods are not provided in this paper.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Low	The testing conditions are relevant to consumer product exposures.
	Metric 5:	Sample Size and Variability	Critically Deficient	Sample size is not reported in this paper.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Results are provided in tables and figures and include some summary statistics
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Uninformative		

Study Citation:		Margosian, R. (1990). Initial formaldehyde emission levels for particleboard manufactured in the United States. Forest Products Journal 40:19-20.		
HERO ID:		5937165		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The authors describe that they followed the sampling procedures provided by the ASTM testing methods.
	Metric 2:	Analytical Methodology	High	Analytical methodology in this paper followed the widely accepted NIOSH 3500 chromotropic acid method.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario is likely to represent a relevant exposure scenario however, microenvironments and exposure controls are absent from this paper.
	Metric 5:	Sample Size and Variability	High	The sample size of homes tested is large enough to represent the scenario of interest and includes replicates.
	Metric 6:	Temporality	Low	tested items are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Average summary statistics are tabulated in the paper however other measures of central tendency and variance are absent.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Medium	

Study Citation:		Varghese, J., Patel, S. K., Gore, A. V., Mistry, P. R. (1987). Effect of pretreatments and dyeing on formaldehyde release by dyed finished cotton fabric. Colourage 34:21-28.		
HERO ID:		5938069		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	Sampling methodology is only briefly discussed and cites specific method information is described elsewhere in other papers.
	Metric 2:	Analytical Methodology	Low	The analytical methods used in this paper follow the procedures described in the Japanese Law 112-197310 method and the AATCC Test Method 112-1982. However, there is no detection limits provided in this paper.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario of emissions from treated fabrics likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	10 samples were described in this study which is a large enough sample size to represent a scenario of interest however there were no replicate tests conducted.
	Metric 6:	Temporality	Low	This study was published in 1987. The tested items are not consistent with when current or recent exposures are expected
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Results are provided in tables as point value emissions and releases. There are no summary statistics or any measures of central tendency provided.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Griffis, L. C., Pickrell, J. A. (1983). Effect of sample conditioning and chamber loading on rate of formaldehyde release from wood products in a desiccator test. Environment International 9:3-7.		
HERO ID:		5938920		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	The sampling protocol used in this study is scientifically sound references the Japanese Industrial Standard Desiccator Method for part of their sampling methods. The study is missing details on sample storage conditions although this is unlikely to have a significant impact on the results.
	Metric 2:	Analytical Methodology	Medium	The authors clearly define all analytical instrumentation used in this study and include detection limits. However, recovery samples and instrument calibration is absent from the paper.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	This study is conducted under a broad range of exposure conditions and likely represents a relevant exposure scenario. However, pre-exposure measurements and microenvironments are largely absent from this paper.
	Metric 5:	Sample Size and Variability	Low	The authors report a sample size of 6 which is a moderate sample size however no replicate tests were conducted.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	This paper does not include any summary statistics and reports data as point values in figures 1-5 and table 1.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Traskmorrell, B. J., Andrews, B. A. K., Graves, E. E., Pakarinen, D. R. (1991). A laboratory scale dynamic chamber test for formaldehyde in air from finished fabrics. Textile Chemist and Colorist 23:35-39.		
HERO ID:		5940179		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methodology and procedures are generally appropriate and include sample preparation and storage conditions but are missing key sampling conditions and instrumentation.
	Metric 2:	Analytical Methodology	High	Analytical methods used in this paper follow the AATCC TestMethod 112 and steady state formaldehyde analysis procedures.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	This study conducts a broad range of tests under different exposure scenarios described by figures 3-5. However, exposure controls and microenvironments are not present.
	Metric 5:	Sample Size and Variability	High	Sample size is large enough to represent a relevant exposure scenario of interest and the authors state that enough samples were used to create duplicates for each test.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Results for the different exposure tests are in figures 3-6. Standard deviations are provided in text however these are the only provided summary statistics present in the paper.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Medium		

Study Citation:		Voncina, B., Bezek, D., le Marechal, A. M. (2002). Eco-friendly durable press finishing of textile interlinings. 10:68-71.		
HERO ID:		5940915		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	Sampling methodology and instrumentation is only briefly discussed in the paper.
	Metric 2:	Analytical Methodology	High	The analytical methods used in this study follows the widely accepted Japan Law 112 standard for testing formaldehyde in textiles.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The paper conducts tests over a broad range of exposure scenarios however other key elements including microenvironments and pre-exposure measurements are largely absent.
	Metric 5:	Sample Size and Variability	Medium	Sample size is not explicitly stated in the text however, table 2 includes the results which displays 9 samples with unique measurements.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Mean and standard deviation summary statistics are tabulated in the paper however other summary statistics and measures of central tendency are absent.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Medium	

Study Citation:		van Netten, C. (1983). Analysis of sources contributing to elevated formaldehyde concentrations in the air in a new elementary school. Canadian Journal of Public Health 74:55-59.		
HERO ID:		5944347		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling conditions, procedures and equipment are described in this study however, sample storage and performance are largely absent.
	Metric 2:	Analytical Methodology	High	The authors used the widely accepted NIOSH chromatographic acid analytical method.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	This study was conducted under a broad range of conditions and the exposure sources are clearly defined however, exposure controls are largely absent.
	Metric 5:	Sample Size and Variability	Low	Sample size is not explicitly stated but can it can be inferred from the tables 1 and 2 that 1 sample of each item was tested at different temperatures.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Results are provided in tables 1 and 2 as point values. No summary statistics are described in this paper.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Wayland, R. L., Smith, L. W., Hoffman, J. H. (1981). Low-formaldehyde finishing in production. Textile Research Journal 51:302-309.		
HERO ID:		5945602		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methodology and conditions follow the widely accepted and scientifically sound AATCC Test Method 112-1975 for testing formaldehyde in fabrics.
	Metric 2:	Analytical Methodology	Low	Analytical methods are briefly mentioned however instrumentation is not explicitly defined and is difficult to infer. There is also little mention of the test chamber that was used.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Critically Deficient	Testing scenario is not exposure relevant, product concentrations are not being tested and instead effluent air forced through fabric is being tested along with formaldehyde evolution potentials which is not exposure relevant.
	Metric 5:	Sample Size and Variability	Low	sample size is not explicitly stated but can be inferred by the fabrics described in the tables.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Results include 8 hour averages and maximum values but no other summary statistics.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Uninformative		

Study Citation:		Milota, M. R., Mosher, P. (2006). Emissions from western hemlock lumber during drying. Forest Products Journal 56:66-70.		
HERO ID:		5945959		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methodology and conditions are discussed and are generally appropriate and scientifically sound, for both obtaining wood samples and experimental procedures.
	Metric 2:	Analytical Methodology	Low	Analytical testing and methodology followed the EPA Method 25A and described in NCASI Method CI//WP-98.01. Detection limits not reported.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario for wood products. However, there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	The authors used a moderate sample size in this study which can be inferred by Table 1. No replicates are reported.
	Metric 6:	Temporality	Low	Items tested between 1998-2005 and are less consistent with recent exposures.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Table 1 includes point values and one mean summary statistics is listed in text in the paper on page 70.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Variability is characterized by seasonal analysis. Limitations not reported.
Overall Quality Determination			Low	

Study Citation:		Meyer, B., Boehme, C. (1997). Formaldehyde emission from solid wood. Forest Products Journal 47:45-48.		
HERO ID:		5946058		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Low	Sampling methodology is only briefly discussed and does not represent the best sampling methods and protocols.
	Metric 2:	Analytical Methodology	High	The authors followed the widely accepted gas analysis methods described in DIN 52 368 and EN 717-2.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	Sample size is moderately large enough with 5 different lumber types however no replicate tests were performed.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Table 2 and figures 1-5 include point values but no summary statistics are provided.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Reinhardt, R. M., Harper, R. J. (1984). A comparison of aftertreatments to lower formaldehyde release from cottons crosslinked with various finishing agents. Journal of Coated Fabrics 13:216-227.		
HERO ID:		5946529		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	Sampling conditions and methodology is only briefly discussed and is missing key elements of a scientifically sound sampling protocol.
	Metric 2:	Analytical Methodology	High	Formaldehyde emissions were analyzed following the standardized procedures described in the AATCC Test Method 112-1982.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken.
	Metric 5:	Sample Size and Variability	Low	A moderate sample size can be inferred however, no replicate tests were discussed or performed.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Results are provided in tables as point values throughout the study. No summary statistics or measures of central tendency are described.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Saffari, M. (2011). Effects of hardener type and particles size on formaldehyde emission pollution. 8:242-244.		
HERO ID:		5946626		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Low	Sampling methodology and conditions are only briefly discussed. Missing information is likely to have a substantial impact on the results.
	Metric 2:	Analytical Methodology	Low	Analytical instrumentation is provided however, analytical methodology is only briefly discussed.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	The sample size reported is small, one large and one small chip size. The data are likely to poorly represent the scenario of interest.
	Metric 6:	Temporality	Medium	Tested items are less consistent with when current exposures are expected.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Data is all provided in figures that would require digitization. No summary statistics are defined in this paper.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Matthews, T. G., Wilson, D. L., Thompson, A. J., Mason, M. A., Bailey, S. N., Nelms, L. H. (1987). Interlaboratory comparison of formaldehyde emissions from particleboard underlayment in small-scale environmental chambers. Journal of Air Pollution Control Association 37:1320-1326.		
HERO ID:		5946798		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The sampling methodology is discussed in depth for the 2 separate methods and information such as sample size, temperature and humidity controls are given. Sample storage is also discussed prior to treatment.
	Metric 2:	Analytical Methodology	Low	CEA instruments were used and are cited. LODs are not discussed.
	Metric 3:	Biomarker Selection	N/A	Biomarkers are not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario is relevant to exposure but there was only a change in air flow and surface area when testing various conditions.
	Metric 5:	Sample Size and Variability	Medium	4 test series were conducted with between 1 and 5 specimens per test. The analytical methods took continuous measurements that were reported as averages and standard deviations.
	Metric 6:	Temporality	Low	Particle board was purchased in 1984 and stored until 1985.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	No raw data is reported, but summary stats are reported as averages and standard deviations.
	Metric 8:	Quality Assurance	High	A QA/QC procedure was written and followed for this entire experiment. Many QA/QC measures are undertaken such as calibration, testing at 2 different laboratories and controls.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Variability is characterized through standard deviation, and linear regression modeling. Limitations are discussed and the chambers used for the experiment were identified as a possible, but not large, limitation to the study.
Overall Quality Determination			Medium	

Study Citation:		Myers, G. E., Nagaoka, M. (1981). Emission of formaldehyde by particleboard - Effect of ventilation rate and loading on air-contamination levels. Forest Products Journal 31:39-44.		
HERO ID:		5948238		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methodology is cited from another paper and some testing conditions, such as temperature and humidity are given.
	Metric 2:	Analytical Methodology	Low	Limits are not discussed, but the analytical methods are briefly described. The analytical instrumentation is not given, but the methods are cited from another paper.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The boards used are relevant and the equilibrium tests would predict real world values.
	Metric 5:	Sample Size and Variability	Low	Only one sample is measured per board set, but this is a product chamber test.
	Metric 6:	Temporality	Low	This study was published in 1981.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Only raw data is reported and no summary stats are given. Table 1 appears to have data for all three board sets but is missing the D under board set.
	Metric 8:	Quality Assurance	Low	QA/QC measures are not addressed, but standard sampling practices are followed.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	There is a comparison of the concentrations to board A unaged, although there are no variability measures such as standard deviation. There is limited discussion of gaps and limitations.
Overall Quality Determination		Low		

Study Citation:		Harper, R. J., Andrews, B. A. K., Harris, J. A., Reinhardt, R. M., Vail, S. L., Bathija, A. P., Ulsamer, A. G. (1984). Formaldehyde release from labeled and unlabeled cross-linked cotton and cotton-polyester fabrics. Agricultural Research Service, Agricultural Research Results, Southern Series. No 17		
HERO ID:		5950203		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling method is described in some detail and cites methodology from peer-reviewed sources. These methods are fairly old and may be slightly out of date.
	Metric 2:	Analytical Methodology	Low	Analytical methods are discussed and cited, but instrumentation used is not well described. There is an explanation of how the methods quantify FDH. Limits of detection are discussed, but not specifically given.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	High	The testing scenario encompasses a standardized sample treatment and a wide variety of possible product conditions from use and cleaning.
	Metric 5:	Sample Size and Variability	Low	There are 3 samples per scenario, but many combinations of after treatment, pre-treatment and testing method.
	Metric 6:	Temporality	Low	This study was published in 1984.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Raw data and averages are reported.
	Metric 8:	Quality Assurance	Low	QA/QC is not specifically mentioned, but the study use cited and well-known sources for sample preparation and analysis.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	There are discussions of various variations across aftertreatments, storage times etc. Discussion of limitations and gaps of this study and others is limited.
Overall Quality Determination			Low	

Study Citation: Ghani, A., Bawon, P., Ashaari, Z., Wahab, M. W., Hua, L., eeS, Chen, L.,umWei (2017). Addition of propylamine as formaldehyde scavenger for urea formaldehyde-bonded particleboard. Wood Research 62:329-334.

HERO ID: 5951195

Domain	Metric	Rating	Comments
Domain 1: Reliability	Metric 1: Sampling Methodology and Conditions	Medium	Sampling methodology JIS A 1460:2001 was used and conditions used to prepare samples were given, but no discussion of sampling conditions.
	Metric 2: Analytical Methodology	Low	Analytical methodology JIS A 1460:2001 was used. LODs were not reported.
	Metric 3: Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4: Testing Scenario	Medium	Five resin dosages were tested to compare across products, but variations in test conditions were not measured.
	Metric 5: Sample Size and Variability	Critically Deficient	Only one emission rate was measured per resin dose.
	Metric 6: Temporality	High	This paper was published in 2017.
Domain 3: Accessibility/Clarity	Metric 7: Reporting of Results	Low	Only raw data is reported.
	Metric 8: Quality Assurance	Low	QA/QC measures are not discussed, but standard methods were applied.
Domain 4: Variability and Uncertainty	Metric 9: Variability and Uncertainty	Low	Limitations and gaps are not discussed, but variation across resin dosages is discussed.

Overall Quality Determination

Uninformative

Study Citation:		Chen, W., Mendell, M., Li, N.,a, Kumagai, K. (2018). Formaldehyde emissions from seams and cut edges of laminate flooring: Implications for emission testing protocols and exposure estimation. Building and Environment 143:652-660.		
HERO ID:		5952378		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methodology is clearly described including procedures and conditions. However, sampler performance and calibration is largely absent.
	Metric 2:	Analytical Methodology	High	Analytical methods and instrumentation are explicitly outlined and formaldehyde concentrations were standardized following the ASTM D6007-14 procedures.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken.
	Metric 5:	Sample Size and Variability	Medium	Sample size is moderate, eight test samples are described and outlined in Table 2.
	Metric 6:	Temporality	High	The data presented in this paper represents current exposures.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Concentration results are reported in figures and emission factors are in tables however there are no description of summary statistics or other measures of central tendency.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is only briefly discussed in this paper and there is no statistical measure of variability.
Overall Quality Determination			Medium	

Study Citation:		Christensen, R., Robitschek, P., Stone, J. (1981). Formaldehyde emission from particleboard. Holz als Roh- und Werkstoff 39:231-234.		
HERO ID:		5952398		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	Sampling methodology is only briefly described.
	Metric 2:	Analytical Methodology	Low	Analytical methods and instrumentation are briefly discussed however there is no mention of detection limits.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	The authors report 3 test samples which is a small sample size and there is no discussion of replicate tests.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Results are tabulated in Table 1 and 2. Table 1 includes means while Table 2 include point value concentrations. No other summary statistics are provided.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Wiglusz, R., Sitko, E., Nickel, G., Jarnuszkiewicz, I., Igielska, B. (2002). The effect of temperature on the emission of formaldehyde and volatile organic compounds (VOCs) from laminate flooring - case study. Building and Environment 37:41-44.		
HERO ID:		5953624		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling conditions are described in Table 1 however sampling methods are not extensively detailed.
	Metric 2:	Analytical Methodology	Low	Analytical methodology is very briefly discussed and detection limits are described in section 2.2.1.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	The authors describe 2 different samples that were used in this study.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	The formaldehyde emission rates are reported in figure one as point values and will require digitization to extract. No summary statistics or measures of central tendency are described.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Andrews, B. A. K., Harper, R. J. (1980). Formaldehyde release—Are current test methods realistic?. Textile Research Journal 50:177-184.		
HERO ID:		5953984		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methods follow both AATCC test method 124-1975 and AATCC test method 92-1974 which are widely widely accepted.
	Metric 2:	Analytical Methodology	High	Analytical methodology and instrumentation used in this study follows the procedures described in the AATCC 112-1975 and the Japanese Law 112-1973 formaldehyde release methods.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	A small sample size can be inferred from the test results shown in the figures.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Results are presented in tables as point value concentrations. No summary statistics or other measures of central tendency are provided.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Medium	

Study Citation:		Aldag, N., Gunschera, J.,an, Salthammer, T. (2017). Release and absorption of formaldehyde by textiles. Cellulose 24:4509-4518.		
HERO ID:		5955448		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sampling methods and conditions followed the standardized EN ISO 14184-1 procedures.
	Metric 2:	Analytical Methodology	High	Analytical methods and instrumentation for the chamber emission test follow the standardized and widely accepted ISO 16000–9 protocols.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken.
	Metric 5:	Sample Size and Variability	Low	The sample size in this study is large enough to represent a relevant exposure scenario however there is no mention of replicates conducted.
	Metric 6:	Temporality	High	The data presented in this paper represents current exposures.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Chamber test results are tabulated in table SI2 in the supplementary information. However there are no summary statistics provided or other measures of central tendency.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Medium	

Study Citation:		Zhu, X. D., Liu, Y., Shen, J. (2016). Volatile organic compounds (VOCs) emissions of wood-based panels coated with nanoparticles modified water based varnish. Holz als Roh- und Werkstoff 74:601-607.		
HERO ID:		5956543		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sample storage conditions and sampler calibration were not reported.
	Metric 2:	Analytical Methodology	Low	Analytical methodology described but LODs were not reported.
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Testing conducted using various treatments under constant temperature and humidity conditions.
	Metric 5:	Sample Size and Variability	High	30-minute samples collected over a period of 28 days; experiment was repeated 3 times.
	Metric 6:	Temporality	High	Source of tested items appeared to be current; article published in 2016
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Average concentrations (and standard deviations) were reported; supplementary raw data not provided.
	Metric 8:	Quality Assurance	Low	QA/QC measures and results were not provided.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	Standard deviations provided; there was no discussion of uncertainties or limitations.
Overall Quality Determination		Medium		

Study Citation:		Zhou, X., Liu, Y., Song, C., Wang, X., Wang, F., Liu, J. (2019). Modelling and testing of VOC source suppression effect of building materials modified with adsorbents. Building and Environment 154:122-131.		
HERO ID:		5957147		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The chamber test is described in detail in the paper, Supplementary Material and associated references.
	Metric 2:	Analytical Methodology	Medium	The htV-m Formaldemeter (PPM Technology), a portable, direct-reading instrument, was used for measuring formaldehyde emission in the environmental chamber. The measurement range, accuracy, and resolution were described in the Supplementary Material.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The data likely represent a relevant exposure scenario for medium density particleboard modified with adsorbent materials and tested under controlled conditions. Testing was performed at a controlled temperature and humidity over time for various blending ratios, in airtight and ventilated chambers.
	Metric 5:	Sample Size and Variability	Medium	Three replicates were tested for unmodified and 4 types o modified particleboard. However, variability among the replicates was not reported.
	Metric 6:	Temporality	High	The study was published in 2019.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Individual data points were not reported. Experimental results (emitted concentrations) are reported in Figures 4, 9 and 10, and in the text, without standard deviations or error bars, and without a description of summary statistics. Replicate testing was performed for each type of particleboard in each experiment, but only the standard deviation between experimental (measured) and calculated (modeled) results is reported.
	Metric 8:	Quality Assurance	Low	QA/QC measures and results were not directly discussed but no issues were identified.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The study has limited characterization of variability between experimental and modeled concentrations. There is some discussion of uncertainty, limitations and data gaps.
Overall Quality Determination			Medium	

Study Citation:		Miyamoto, K., Grigsby, W., Tohmura, S. I. (2019). Using renewables in panelboard resins to influence volatile organic compound emissions from panels. Journal of Wood Chemistry and Technology 39:166-177.		
HERO ID:		5958640		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	Sample preparation and testing conditions were very detailed and cited previously peer-reviewed studies.
	Metric 2:	Analytical Methodology	Low	Analytical methods are detailed and described HPLC and GCMS analysis with specific instrumentation. LODs are not reported.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Several plywood of various materials were tested but the scenario itself was the same throughout.
	Metric 5:	Sample Size and Variability	Low	Two samples were taken per plywood manufacture.
	Metric 6:	Temporality	High	This paper was published in 2019.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Only raw data is reported.
	Metric 8:	Quality Assurance	Medium	QA/QC measures are not explicitly discussed, but both sample preparation and testing scenarios were extremely detailed and followed standard protocols.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	No measures of variability are given, but variation between products and possible sources are discussed.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Experimental

HERO ID: 5960898

Study Citation:		Reeves, W. A., Day, M. O., Mclellan, K. R., Vigo, T. L. (1981). Formaldehyde release in formaldehyde-finished and resin-finished fabrics. Textile Research Journal 51:481-485.		
HERO ID:		5960898		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling and analysis were performed in accordance with the American Association of Textile Chemists and Colorists (AATCC) test method 112-1975. This method has been updated several times since the study was performed. Fabric sample characteristics were described in the text and Table I.
	Metric 2:	Analytical Methodology	Low	Total formaldehyde was analyzed according to AATCC 112-1975, and formaldehyde releases were determined using a referenced method (Bacon et al 1957). Both are quantitative colorimetric methods, but specific information on instrumentation and sensitivity was not provided in the paper itself.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in the reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	Cotton and polyester blend fabrics treated with formaldehyde and DMDHEU finishes were representative of this type of fabric as tested in the 1980's over several storage intervals and wash cycles.
	Metric 5:	Sample Size and Variability	Low	Two fabric types with 5 different finishes were tested over 5 wash cycles and 4 storage intervals. Replicates were not identified.
	Metric 6:	Temporality	Low	The paper was published in 1981.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	It appears that individual data points are presented graphically in Figures, 1, 2 and 3 (and Tables I and II for subsets of data). No summary statistics are reported, except conclusions in text about lowest or highest result for a particular fabric or test condition.
	Metric 8:	Quality Assurance	Low	QA/QC measures and results were not directly discussed, but are implied through the study's use of a standard AATC method.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability is absent.
Overall Quality Determination			Low	

Study Citation:		Reeves, W. A., Day, M. O. (1983). Resin finished fabrics with low formaldehyde release. Journal of Coated Fabrics 13:50-58.		
HERO ID:		5960903		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	The sampling methods and conditions follow the widely accepted and standardized AATCC Test method 112-1978.
	Metric 2:	Analytical Methodology	High	The analytical methods follow the widely accepted and standardized AATCC method 114-1978.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken.
	Metric 5:	Sample Size and Variability	Critically Deficient	Sample size is not reported in this study and is very difficult to infer based on figures alone.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Results are presented in figures as point value concentrations. No summary statistics or other measures of central tendency are provided.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Uninformative		

Study Citation:		Pereira, F., Pereira, J., Paiva, N., Ferra, J., Martins, J. M., Magalhaes, F. D., Carvalho, L. (2016). Natural additive for reducing formaldehyde emissions in urea-formaldehyde resins. Journal of renewable materials 4:41-46.		
HERO ID:		5962726		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	The investigators do not describe the sampling method other than to say that they followed the European standard for the perforatormethod. Board sample handling and preparation are not presented. Sample collection for formaldehyde is not described.
	Metric 2:	Analytical Methodology	Low	The investigators do not describe the analytical method other than to say that they followed the European standard for the perforatormethod. The authors did not provide the LOD for the tests.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Low	The investigators do not describe the testing conditions except to clarify the variables that affected the soy protein within the boards.
	Metric 5:	Sample Size and Variability	Low	The investigators do not clarify the numbers of samples collected and tested for each experiment. One sample would be adequate for a test of product concentration.
	Metric 6:	Temporality	High	The source of the tested items is consistent with current exposures, as determined by an article date that is less than five years prior to the start of the program.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	The investigators present one value for each experiment. It is not clear whether each experiment involved more than one test of the product.
	Metric 8:	Quality Assurance	Medium	The investigators do not identify any problems with quality issues. The authors do not describe any preparations to control for contamination or to run tests as blanks.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The investigators briefly characterize the variation and limitations in the study results.
Overall Quality Determination		Low		

Study Citation:		Sung, M., Lee, S. M., in, Min, Y. (2013). Decreasing the formaldehyde concentration in indoor air by improving the adhesives used in engineered wood materials in Korean apartment buildings. Journal of Adhesion Science and Technology 27:671-682.		
HERO ID:		5962846		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	High	ISO 16,00-9 and JIS A1901 were both cited for sampling methodology and the methods were very detailed.
	Metric 2:	Analytical Methodology	Low	LODs were not provided, but HPLC was used to analyze the samples.
	Metric 3:	Biomarker Selection	N/A	Biomarkers were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	11 different products were tested under a single set of conditions across 7 days.
	Metric 5:	Sample Size and Variability	Low	Each product was measured twice daily and results were given for days 1, 3 and 7.
	Metric 6:	Temporality	Medium	This paper was published in 2013.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Only raw data appears to be provided.
	Metric 8:	Quality Assurance	Medium	QA/QC measures were not discussed, but detailed and well-cited methodologies were used.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	There is a brief discussion of variability across products and the possible reasons behind this.
Overall Quality Determination			Medium	

Study Citation:		Grigsby, W., Tohmura, S. I., Miyamoto, K. (2018). Assessing panelboard volatile organic compound emission profiles through renewables use. Forest Products Journal 68:359-364.		
HERO ID:		5964529		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Performance/calibration of sampler not reported.
	Metric 2:	Analytical Methodology	Low	LODs were not reported.
	Metric 3:	Biomarker Selection	N/A	Not Applicable
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	Chamber testing conducted under constant temperature and humidity conditions.
	Metric 5:	Sample Size and Variability	Low	Replicate tests were not performed.
	Metric 6:	Temporality	High	The exact chamber testing year was not specified but this paper was received for publication in April 2018.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Raw data not provided; replicate tests were not conducted therefore summary statistics were not available.
	Metric 8:	Quality Assurance	Low	QA/QC measures not discussed but assumed based on the use of standard lab methods.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	There is some discussion of variability among the various types of wood panels used.
Overall Quality Determination			Low	

Study Citation:		Chew, L. T., Ong, C. L. (1989). Formaldehyde emission from Malaysian wood-based panels. Journal of Tropical Forest Science 1:336-340.		
HERO ID:		6008518		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	The investigators only briefly describe the material sample treatment for each method, and they do not describe the preparations of the samples for analysis, but they intended to follow three standard methods.
	Metric 2:	Analytical Methodology	Low	The investigators do not clarify which of the two techniques they used to measure the formaldehyde concentrations for the WKI bottle method or the perforator method (iodometric or spectrophotometric). The investigators only briefly describe that spectrophotometry is used for the samples tested with the desiccator method. The authors do not clarify a LOD for any of the methods.
	Metric 3:	Biomarker Selection	N/A	The experiments did not require the use of biomarkers.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The investigators provide the test conditions for the desiccator method, which is the only acceptable method from the study, based on the results of the evaluation.
	Metric 5:	Sample Size and Variability	Medium	The investigators did not clarify whether they used more than one sample for the desiccator test; one sample is acceptable for a chamber test.
	Metric 6:	Temporality	Low	The source of the tested items is not consistent with current exposures, as determined by an article date that is more than fifteen years prior to the start of the program.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	The investigators provide the raw data. Summary statistics were not provided but could be calculated.
	Metric 8:	Quality Assurance	Medium	The investigators do not describe any quality issues with the tests. They did not report testing for background concentrations.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	The investigators identify and suggest explanations for the variations found in the results.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Experimental

HERO ID: 6008525

Study Citation:		Inoue, A., Ono, H. K., Chiba, Y. (1991). Prediction of formaldehyde concentrations in air originating from wood-based materials: Comparison of desiccator method with chamber method and perforator method. Bulletin of the Forestry and Forest Products Research Institute 0:21-34.		
HERO ID:		6008525		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Low	The investigators did not clarify the source of the material or the storage methods before for each test. The investigators did not describe the methods for obtaining the samples for testing formaldehyde concentrations for the desiccator and perforator testing, but they mention following two standard methods. The investigators refer to a cited study in reference to most detailsfor the chamber tests.
	Metric 2:	Analytical Methodology	Low	The authors mention that they followed standards for the desiccator and the perforator methods, but they do not provide any details about the analysis. The authors mention the approach used to determine the concentration of formaldehyde in the chamber tests but provide no details. The authors do not provide the LOD for any of the methods used.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Low	The investigators generally describe the test conditions for thetwo sets of chamber studies, but the explanations are not clearly presented. The specifications of the chamber were described in a report of a previous study by the primary author. The investigators do not describe the conditions for the perforator and desiccator tests; these are presumed to follow the specifications in the standard methods.
	Metric 5:	Sample Size and Variability	Low	The investigators do not clearly describe the number of samples used in each experiment. For the perforator and desiccator tests, they do not describe the samples, but these may be required by the test standards. For the chamber tests, they clarify the board sizes with the results, but they do not clearly describe the sample variables in the methods section.
	Metric 6:	Temporality	Low	The source of the tested items is not consistent with current exposures, as determined by an article date that is more than fifteen years prior to the start of the program.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	The investigators provide one value for each test. They do not clarify if more than one test contributed to each value. The information relative to each test is scattered throughout the report.
	Metric 8:	Quality Assurance	Low	The investigators do not describe how they cleared the chambers of contaminants or whether they conducted background tests. They do not describe any control tests for the experiment or measurement methods.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	The investigators acknowledge variation in the results and assess that the ranges are comparable with other studies.
Overall Quality Determination			Low	

Study Citation:		Bilsback, K. R., Dahlke, J., Fedak, K. M., Good, N., Hecobian, A., Herckes, P., L'Orange, C., Mehaffy, J., Sullivan, A., Tryner, J., Van Zyl, L., Walker, E. S., Zhou, Y., Pierce, , J. R., Wilson, A., Peel, J. L., Volckens, J. (2019). A Laboratory Assessment of 120 Air Pollutant Emissions from Biomass and Fossil Fuel Cookstoves. Environmental Science and Technology 53:7114-7125.		
HERO ID:		6060243		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	The sampling protocol is mentioned and cites another source for full details. In this study, the sampling schematic and instrumentation are provided but lacks details of sampling duration sample storage, and calibration.
	Metric 2:	Analytical Methodology	Low	Limits of detection are not provided, only the number of samples below the LOD.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Critically Deficient	Some details are missing such as microenvironment conditions and amount of chemical used are not discussed. Background samples are collected. Cookstove smoke constituents including formaldehyde is beyond scope for the TSCA HCHO risk evaluation.
	Metric 5:	Sample Size and Variability	Medium	There are 87 total emissions tests. Sample size was 3-4 for number of replicates for each stove/fuel combination.
	Metric 6:	Temporality	High	This paper was published in 2019.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Raw data is not provided, so averages cannot be reproduced. Median and interquartile range are provided.
	Metric 8:	Quality Assurance	Medium	Procedures to minimize contamination, filter blanks, and background samples are mentioned and can be assumed to be quality assurance measures. Discussion of laboratory storage is lacking.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Medium	Medians and interquartile ranges are provided but there is lack of discussion around limitations.
Overall Quality Determination		Uninformative		

Study Citation:		Carver, M. N. (1988). Formaldehyde emission rates from carpeting in the home environment. Clothing and Textiles Research Journal 6:49-55.		
HERO ID:		6112667		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methods and conditions are clearly discussed and are generally appropriate however there is no mention of sampler performance and calibration although this is unlikely to have a significant impact on the results.
	Metric 2:	Analytical Methodology	Low	The analytical methods are described by the authors however there is no mention of detection limits.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken.
	Metric 5:	Sample Size and Variability	Low	40 samples were described in this paper which is a large sample size however no replicate tests were conducted.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Results are provided in tables as point values, minimum and maximum values are reported in text. No other measures of central tendency are described.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Low	

Study Citation:		Godish, T., Rouch, J. (1987). Formaldehyde source interaction studies under whole-house conditions. Environmental Pollution 48:1-12.		
HERO ID:		6114303		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methods and conditions are clearly defined and are generally appropriate however this little mention of sampler performance and calibration.
	Metric 2:	Analytical Methodology	High	The analytical methods used in this study follow the widely accepted procedures described in the NIOSH chromatropic acid method.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	High	The testing scenario represents a relevant exposure scenario. Pre-exposure samples are provided and all other testing conditions and parameters are detailed.
	Metric 5:	Sample Size and Variability	Low	The paper describes testing 8 different samples which is considered a moderate sample size however there are no replicates conducted in this test.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Medium	Results are provided in tables as mean value concentrations, no other summary statistics or any measures of central tendency are described.
	Metric 8:	Quality Assurance	Medium	There is no explicit discussions of QA/QC issues, but it can be inferred from the available information and cited references that there were no significant QA/QC issues.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Medium		

Study Citation:		Plaisance, H., Mocho, P., Gross, A., Desauziers, V. (2019). Potential of static sampling using solid-phase microextraction for the assessment of formaldehyde sorption on building materials. Atmospheric Environment 218		
HERO ID:		6120927		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	High	Sampling methodology and experimental setup were described in detail, with references citing previous studies.
	Metric 2:	Analytical Methodology	Medium	Validation and performance testing of the SPME method was conducted, with results for blanks, LODs and reproducibility shown in Section 3.1. Samples were analyzed using GC-MS with FID for comparison and calibration. Recoveries were not discussed.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Medium	The data likely represent a relevant exposure scenario for sorption and emissions of formaldehyde associated with floor covering materials. Experiments included blank conditions and addition of formaldehyde to the test cell.
	Metric 5:	Sample Size and Variability	Medium	Five types of floor covering were tested with duplicate sampling.
	Metric 6:	Temporality	High	The paper was published in 2019.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	Average and range are reported for concentrations and sorption coefficients in Table 6. Individual data points are shown for concentrations of 2 floor coverings as shown in Figure 7.
	Metric 8:	Quality Assurance	Medium	Method performance results are shown in Section 3.1. Various QA/QC measures and results were reported for blanks, LOD, reproducibility (RSD).
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Measures of variability are provided in terms of RSD for method development and for sorption coefficients. Only a range was provided for concentrations. Uncertainty, limitations and data gaps were also discussed.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Experimental

HERO ID: 6149211

Study Citation:		Gandolfo, A., Marque, S., Temime-Roussel, B., Gemayel, R., Wortham, H., Truffier-Boutry, D., Bartolomei, V., Gligorovski, S. (2018). Unexpectedly high levels of organic compounds released by indoor photocatalytic paints. Environmental Science and Technology 52:11328-11337.		
HERO ID:		6149211		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Medium	The paints sampled, experimental setup and sampling methodology are well-described and referenced. Sample storage conditions are not discussed for this continuous monitoring method.
	Metric 2:	Analytical Methodology	Medium	Proton transfer reaction-time of flight-Mass Spectrometry (PTR-TOF-MS) was used for analysis. HPLC-UV analysis of DNPH cartridges were used for comparison and to develop a correction factor for PTR-MS. Calibration, sensitivity and analytical instrumentation were discussed but recoveries and extraction techniques weren't described.
	Metric 3:	Biomarker Selection	N/A	Biomarkers of interest were not addressed in this reference.
Domain 2: Representative				
	Metric 4:	Testing Scenario	High	Control samples of paint, as well as different formulations of paint containing titanium nanoparticles were tested under various conditions (humidity, temperature, light).
	Metric 5:	Sample Size and Variability	High	Testing involved triplicate sampling/analysis under 4 conditions, for 4 sets of parameters.
	Metric 6:	Temporality	High	The paper was published in 2018.
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Medium	Individual data points were not reported. Results were presented as summary statistics in Tables S4-S8. Standard deviations were reported (with assumed mean) in tables, and error bars were shown in figures.
	Metric 8:	Quality Assurance	Medium	QA/QC topics such as calibration, controls and sensitivity were discussed, but specific measures and results were not described or reported. Detection sensitivity for formaldehyde was low and influenced by humidity, so a laboratory calibration was performed to characterized detection sensitivity.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Medium	Results were reported with standard deviations. There was limited discussion of uncertainties, limitations and data gaps.
Overall Quality Determination			High	

Study Citation:		Pinchevska, O., Smidriaková, M. (2016). WOOD PARTICLEBOARD COVERED WITH SLICES MADE OF PINE TREE BRANCHES. 58:67-74.		
HERO ID:		6174873		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
	Metric 1:	Sampling Methodology and Conditions	Low	Minimal description of sampling as the tested wood pieces were created; needed more description of the size/shape/origin of wood pieces and composite wood utilized in the experimental pieces
	Metric 2:	Analytical Methodology	Low	Minimal description; references methodology of other sources without a complete description. No LOD/LOQ
	Metric 3:	Biomarker Selection	N/A	This metric is not applicable because it was irrelevant to the study.
Domain 2: Representative				
	Metric 4:	Testing Scenario	Low	relevant to indoor exposure to formaldehyde but only pertinent to manufacture potential
	Metric 5:	Sample Size and Variability	Low	sample size <5; tested four treatment scenarios and one untreated
	Metric 6:	Temporality	Medium	> 5 years old; publication date of 2016
Domain 3: Accessibility/Clarity				
	Metric 7:	Reporting of Results	Low	Raw data as it is not indicated that more than one sample was run for each treatment scenario. Figure 4 Results of formaldehyde emission testing by the desiccator method is the only usable result but as a percentage comparator
	Metric 8:	Quality Assurance	Low	Minimal discussion; article notes that the testing method used to test formaldehyde emission in the furniture and flooring industries, the desiccator method, is the most basic method. This method is quick, inexpensive and simple to carry out (KIM et al. 2010). Results of the desiccator and chamber methods have showed good correlation (PARK et al. 2011). The formaldehyde emission measured by chamber method is directly proportional to the desiccator method (KIM et al. 2007).
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	Minimal characterization of variability and uncertainty; article notes that the results correspond exactly to the results of KIM et al. (2007).
Overall Quality Determination			Low	

Study Citation:		Bekhta, P., Lyutyy, P., Ortynska, G., Sedliacik, J. (2017). FORMALDEHYDE, PHENOL AND AMMONIA EMISSIONS FROM WOOD/RECYCLED POLYETHYLENE COMPOSITES. 59:107-112.		
HERO ID:		6199401		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Medium	Sampling methods and conditions are only briefly discussed. Sampler information and sample storage conditions are absent.
	Metric 2:	Analytical Methodology	High	Analytical methods followed the procedures outlined in the widely accepted EN 717-1.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Medium	The testing scenario likely represents a relevant exposure scenario however there were no background or pre-exposure samples taken and testing was not conducted under a broad range of conditions.
	Metric 5:	Sample Size and Variability	Low	At least four samples were used with different panel ratios however no replicates were discussed.
	Metric 6:	Temporality	High	This study was published in 2017. The tested items appear to be current.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Results are provided, however there are no summary statistics or any measure of central tendency.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty				
	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination			Medium	

Study Citation:		Formaldehyde Institute, (1984). Source of formaldehyde released from UF resin wood products.		
HERO ID:		6574575		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Sampling Methodology and Conditions	Low	Sampling methods and conditions are only briefly described. Definitive sampling procedures are largely absent.
	Metric 2:	Analytical Methodology	Critically Deficient	There is no mention of analytical methods and instrumentation.
	Metric 3:	Biomarker Selection	N/A	No biomarkers of interest were addressed in this reference.
Domain 2: Representative	Metric 4:	Testing Scenario	Low	The test scenario likely represents consumer exposures however there is very little detail on the testing parameters.
	Metric 5:	Sample Size and Variability	Critically Deficient	Sample size is not explicitly stated and is difficult to infer based on the table alone.
	Metric 6:	Temporality	Low	Tested samples are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 7:	Reporting of Results	Low	Average values are presented in tables however no other measures of central tendency or variance are present.
	Metric 8:	Quality Assurance	Low	There is no explicit discussions of QA/QC issues and recoveries are not mentioned in the study.
Domain 4: Variability and Uncertainty	Metric 9:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Uninformative		

Study Citation:		QuanTech, (2021). American Healthy Homes Survey, final report: Data documentation.		
HERO ID:		9416854		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	Sampling methodology including sampling materials, storage and field blanks reported in https://omb.report/icr/201912-2539-001/doc/97310801 , and https://www.hud.gov/sites/dfiles/HH/documents/AHHS%20II_Lead_Findings_Report_Final_29oct21.pdf
	Metric 2:	Analytical Methodology	High	Widely accepted analytical methodology including sample preparation, detection limits and analytical method reported in https://omb.report/icr/201912-2539-001/doc/97310801
Domain 2: Representative	Metric 3:	Geographic Area	High	Columns B, C and D from the ahhs2_haz_db excel file reports the sample location including city, state and zip code. Samples were collected nationwide USA.
	Metric 4:	Temporal	High	The AHHS II was conducted from March 2018 - June 2019
	Metric 5:	Exposure Scenario	High	The survey measured indoor air formaldehyde concentrations in nationwide homes.
Domain 3: Accessibility/Clarity	Metric 6:	Availability of Database and Supporting Documents	Medium	The database is widely accepted, and a user guide is available which describes all of the data fields. The database is not available to the public from a single download.
	Metric 7:	Reporting Results	High	The database does not report summary of statistics, only point values in column E . While the data are well organized, since the data originates from numerous different entities (states).
Domain 4: Variability and Uncertainty				
	Metric 8:	Variability and Uncertainty	Low	Variability and Uncertainty details were not included.
Overall Quality Determination			High	

Study Citation:		U.S. EPA, (2022). Ambient Monitoring Technology Information Center (AMTIC) - Ambient Monitoring Archive for HAPs.		
HERO ID:		11195094		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Sampling Methodology	High	Widely accepted sampling methodologies, the sampling frequency, duration, and description of sampling collection are reported in columns SAMPLING_FREQUENCY_CODE, DURATION_DESC, and SAMPLE_COLLECTION_DESC.
	Metric 2:	Analytical Methodology	High	Analytical methodology described at the SAMPLE_ANALYSIS_DESC column. A description of all the methods is reported in the compendium: https://www.epa.gov/amtic/compendium-methods-determination-toxic-organic-compounds-ambient-air .
Domain 2: Representative	Metric 3:	Geographic Area	High	Data was collected in the United States. Columns MONITOR_LATITUDE and MONITOR_LONGITUDE report the exact monitoring location.
	Metric 4:	Temporal	High	The database reports data from 1990-2020.
	Metric 5:	Exposure Scenario	High	The exposure scenario is the measurement of key hazardous air pollutants across cities, regions and specific areas of interest.
Domain 3: Accessibility/Clarity	Metric 6:	Availability of Database and Supporting Documents	High	The database is widely accepted, and guidance materials are available which describes all of the data fields.
	Metric 7:	Reporting Results	High	The database is organized, and key information is readily accessible. Raw data is provided in the output file, and a summary of statistics is presented here: https://www.epa.gov/system/files/documents/2022-10/AMA2020_annual.xlsx
Domain 4: Variability and Uncertainty	Metric 8:	Variability and Uncertainty	High	Variability reported in the annual statistics as variance of daily averages and percentiles. Uncertainty reported as data qualifiers.
Overall Quality Determination			High	

Study Citation:		Weng, M., Zhu, L., Yang, K., Chen, S. (2010). Levels, sources, and health risks of carbonyls in residential indoor air in Hangzhou, China. Environmental Monitoring and Assessment 163:573-581.		
HERO ID:		1064213		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Methodology	High	The assessment measured formaldehyde concentrations in midtown and suburban apartment indoor residential rooms and outdoors during summer and winter in Hangzhou, China according to described U.S. EPA methods with quality assurance, replicate samples and calibration details reported and utilization of U.S. EPA methods for sample analyses. Additional indoor formaldehyde concentrations in summer and winter were estimated according to U.S. EPA calculations. The analytical methods is brief and detection limits are not reported.
Domain 2: Representative		Metric 2: Exposure Scenario	Medium	Exposure scenarios likely represent the scenarios of interest as details such as room of sampling for both urban and suburban areas in summer and winter reported for sampling effort. Some details, such as sampling date or year, lacking however study published in 2010.
Domain 3: Accessibility/Clarity		Metric 3: Documentation of References	Medium	References generally appear to be from publicly available and peer reviewed sources. References are available for all reported data, inputs, and defaults.
Domain 4: Variability and Uncertainty		Metric 4: Variability and Uncertainty	Low	Study characterization of variability (geometric standard deviation, range) is presented within tables and text as well as different settings and seasons measured. A detailed discussion of the potential data and methodological gaps is lacking.
Overall Quality Determination			Medium	

PUBLIC RELEASE DRAFT – DO NOT CITE OR QUOTE
March 2024

Formaldehyde

Completed Exposure Assessment

HERO ID: 2535460

Study Citation:		Ho, S. S. H., Ip, H. S. S., Ho, K. F., Ng, L. P. T., Dai, W. T., Cao, J., Chan, C. S., Ho, L. B. (2014). Evaluation of hazardous airborne carbonyls on a university campus in southern China. Journal of the Air and Waste Management Association 64:903-916.		
HERO ID:		2535460		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	High	The assessment used scientifically sound techniques to evaluate formaldehyde in indoor environments, including sampling equipment, calibration, site description and storage conditions. Analytical methods, extraction, instrument and detection limits reported.
Domain 2: Representative	Metric 2:	Exposure Scenario	Medium	The data closely represent relevant general exposure scenarios related to indoor airborne formaldehyde in universities from southern China from different settings. Study was published in 2014 in China so it might not completely reflect current conditions.
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data, inputs, and defaults. References generally appear to be from publicly available and peer reviewed sources.
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	Medium	Variability was characterized (SD) and through analysis of different settings. There is little discussion of uncertainties and limitations.
Overall Quality Determination			High	

PUBLIC RELEASE DRAFT – DO NOT CITE OR QUOTE
March 2024

Formaldehyde

Completed Exposure Assessment

HERO ID: 2598599

Study Citation:		Weng, M., Zhu, L., Yang, K., Chen, S. (2009). Levels and health risks of carbonyl compounds in selected public places in Hangzhou, China. Journal of Hazardous Materials 164:700-706.		
HERO ID:		2598599		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	High	The authors used scientifically sound techniques and assumptions, including sampling equipment, calibration, site details and storage conditions. Analytical methods, extraction, instrument and limit of detection reported.
Domain 2: Representative	Metric 2:	Exposure Scenario	Medium	The data closely represent relevant exposure scenarios related to airborne formaldehyde in different settings. However, sampling was done in 2006 in Hangzhou, China and many not represent current conditions.
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data, inputs, and defaults. References generally appear to be from publicly available and peer reviewed sources.
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	Medium	Variability was characterized (SD, range) and through analysis of different settings. Uncertainties and limitations were not discussed.
Overall Quality Determination			High	

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March 2024

Formaldehyde

Completed Exposure Assessment

HERO ID: 3362355

Study Citation:		Rovira, J., Roig, N., Nadal, M., Schuhmacher, M., Domingo, J. L. (2016). Human health risks of formaldehyde indoor levels: An issue of concern. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances & Environmental Engineering 51:357-363.		
HERO ID:		3362355		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Methodology	Medium	The authors used appropriate techniques to evaluate the risk of airborne formaldehyde exposure in Spain, including sampling equipment, site details and storage conditions. Sampling calibration missing. Analytical methods, extraction, instrument and detection limit reported.
Domain 2: Representative		Metric 2: Exposure Scenario	Medium	The data likely represent relevant exposure scenarios related to airborne formaldehyde in Spain, but the study sample size limits the findings applicability to other scenarios. Sampling year is 2014, which may represent current conditions.
Domain 3: Accessibility/Clarity		Metric 3: Documentation of References	High	References are available for all reported data, inputs, and defaults. References generally appear to be from publicly available and peer reviewed sources.
Domain 4: Variability and Uncertainty		Metric 4: Variability and Uncertainty	High	Variability was characterized (IQR, range) as well as sampling different settings. Limitations described.
Overall Quality Determination			High	

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March 2024

Formaldehyde

Completed Exposure Assessment

HERO ID: 3476957

Study Citation:		Ho, S., Cheng, Y.,an, Bai, Y.,i, Ho, K., Dai, W., Cao, J., Lee, S. C., Huang, Y.,u, Ip, H., Deng, W., Guo, W.,ei (2016). Risk Assessment of Indoor Formaldehyde and Other Carbonyls in Campus Environments in Northwestern China. Aerosol and Air Quality Research 16:1967-1980.		
HERO ID:		3476957		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	High	The assessment used scientifically sound techniques, including sampling methods, equipment, calibration and storage conditions. Analytical methods, extraction, instrument and detection limit reported.
Domain 2: Representative	Metric 2:	Exposure Scenario	Medium	Data closely represent relevant exposure scenarios related to indoor airborne formaldehyde in different settings. However, sampling occurred in 2010 and 2011 in a university based China and may not reflect current conditions.
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data, inputs, and defaults. References generally appear to be from publicly available and peer reviewed sources.
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	High	Variability was characterized (SD) as well as analysis of different settings. Uncertainties and limitations were discussed.
Overall Quality Determination			High	

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March 2024

Formaldehyde

Completed Exposure Assessment

HERO ID: 4170930

Study Citation:		Chen, X., Li, F., Liu, C., Yang, J., Zhang, J., Peng, C. (2017). Monitoring, human health risk assessment and optimized management for typical pollutants in indoor air from random families of university staff, Wuhan City, China. Sustainability 9		
HERO ID:		4170930		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	Medium	The assessment used proper techniques and assumptions, including sampling methods, equipment, calibration and site details. Analytical methods and instrument reported. Missing information such as storage conditions and limit of detection.
Domain 2: Representative	Metric 2:	Exposure Scenario	Medium	
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data, inputs, and defaults. References generally appear to be from publicly available and peer reviewed sources.
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	Medium	Variability was characterized (range, SD) as well as analysis of different settings. Uncertainties and study limitations were not discussed.
Overall Quality Determination			Medium	

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March 2024

Formaldehyde

Completed Exposure Assessment

HERO ID: 4641587

Study Citation:		Dai, W., Zhong, H., Li, L., Cao, J., Huang, Y., Shen, M., Wang, L., Dong, J., Tie, X., Ho, S. S. H., Ho, K. F. (2018). Characterization and health risk assessment of airborne pollutants in commercial restaurants in northwestern China: Under a low ventilation condition in wintertime. Science of the Total Environment 633:308-316.		
HERO ID:		4641587		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1: Methodology	High	The assessment used scientifically sound techniques, including sampling site details, equipment and collection followed methodTO-11A established by the United States Environmental ProtectionAgency. Analytical methods, extraction, instrument and detection limits reported.	
Domain 2: Representative	Metric 2: Exposure Scenario	Medium	The data likely represent relevant exposure scenarios in restaurants. However, sampling is from 2011 and 2012 in China and might not reflect current conditions.	
Domain 3: Accessibility/Clarity	Metric 3: Documentation of References	High	References are available for all reported data, inputs, and defaults. References generally appear to be from publicly available and peer reviewed sources.	
Domain 4: Variability and Uncertainty	Metric 4: Variability and Uncertainty	Medium	Variability was characterized through analysis of different foods and meal times. There is no discussion of uncertainties or limitations.	
Overall Quality Determination		High		

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Formaldehyde

Completed Exposure Assessment

HERO ID: 5017891

Study Citation:		Ferreira, D. C., Nicolli, K. P., Souza-Silva, É. A., Manfroí, V., Zini, C. A., Welke, J. E. (2018). Carbonyl compounds in different stages of vinification and exposure risk assessment through Merlot wine consumption. Food Additives & Contaminants: Part A: Chemistry, Analysis, Control, Exposure & Risk Assessment 35:2315-2331.		
HERO ID:		5017891		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	High	The techniques are scientifically sound and well described.
Domain 2: Representative	Metric 2:	Exposure Scenario	Critically Deficient	The exposure scenarios are not of interest for the HCHO risk evaluation.
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data.
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	Medium	Variability was characterized (SD, error bars), did not discuss uncertainties and limitations.
Overall Quality Determination		Uninformative		

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Formaldehyde

Completed Exposure Assessment

HERO ID: 5942589

Study Citation:		Park, J. Y., Lim, M., Lee, K., Ji, K., Yang, W., Shin, H. S., Lim, H., Lee, H., An, J. (2019). Consumer exposure and risk assessment to selected chemicals of mold stain remover use in Korea. Journal of Exposure Science and Environmental Epidemiology		
HERO ID:		5942589		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	High	The assessment used appropriate techniques that are scientifically sound.
Domain 2: Representative	Metric 2:	Exposure Scenario	High	The data closely represent relevant exposure scenarios involving mold stain removers.
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data.
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	Medium	Limited characterization of variability (range), discussed uncertainties and limitations (e.g., assumed adsorption rate of 100%).
Overall Quality Determination			High	

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Formaldehyde

Completed Exposure Assessment

HERO ID: 5973739

Study Citation:		Chang, T., Wang, J., Lu, J., Shen, Z., Huang, Y.,u, Sun, J., Xu, H., Wang, X.,in, Ren, D., Cao, J. (2019). Evaluation of Indoor Air Pollution during the Decorating Process and Inhalation Health Risks in Xi'an, China: A Case Study. Aerosol and Air Quality Research 19:854-864.		
HERO ID:		5973739		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	High	The authors used proper techniques and assumptions for the evaluation.
Domain 2: Representative	Metric 2:	Exposure Scenario	Medium	Data may represent relevant exposure scenarios related to indoor airborne formaldehyde in residences from Xi'an, China, but the small sample size limits their generalization.
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data in the manuscript.
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	Medium	The authors characterized variability (SD bars), but did not discuss limitations and uncertainties.
Overall Quality Determination		High		

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Formaldehyde

Completed Exposure Assessment

HERO ID: 6111216

Study Citation:		Thai, V. N., Tokai, A. (2011). Preliminary risk assessment posed by formaldehyde residues in clothing to Vietnamese consumers. Journal of Environmental Protection 2:379-386.		
HERO ID:		6111216		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Methodology	High	The assessment used proper techniques and assumptions for formaldehyde exposure through inhalation and dermal contact
Domain 2: Representative	Metric 2:	Exposure Scenario	High	The data closely represent relevant exposure scenarios related to dermal and inhalation exposure to formaldehyde from clothing
Domain 3: Accessibility/Clarity	Metric 3:	Documentation of References	High	References are available for all reported data in the manuscript
Domain 4: Variability and Uncertainty	Metric 4:	Variability and Uncertainty	High	Variability was characterized (SD), and uncertainties were discussed by the authors
Overall Quality Determination			High	

March 2024

Formaldehyde

Modeling

HERO ID: 21675

Study Citation:		Meyer, B., Hermanns, K. (1985). Reducing indoor air formaldehyde concentrations. Journal of the Air and Waste Management Association 35:816-821.		
HERO ID:		21675		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Mathematical Equations	Critically Deficient	Although some inputs are provided, equations are not and the theory behind the model is not described enough to allow the equation to be recreated.
	Metric 2:	Model Evaluation	Low	There are equations given that are cited, but they are not for the extractable data. It is unclear if the equations used were assessed.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	The conditions used in this paper are well-cited and relevant, but the paper was published in 1985 and use products from 1979-1983.
	Metric 4:	Model and Model Documentation Availability	Low	The equations are not provided and unable to be located elsewhere.
Domain 3: Accessibility/Clarity	Metric 5:	Model Inputs and Defaults	Medium	Inputs are discussed and referenced. They are described for each scenario and seem appropriate.
	Metric 6:	Variability and Uncertainty	Medium	There is some discussion of variation among different climates, or scenarios not modeled. The goal of the paper is to discuss how different factors affect emissions and areas not modeled are still considered.
Overall Quality Determination		Uninformative		

Study Citation:		Meyer, B. (1986). Formaldehyde exposure from building products. Environment International 12:283-288.		
HERO ID:		22181		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	Key equations are provided with reference citations.
	Metric 2:	Model Evaluation	Medium	The calculated FDH concentration profile was evaluated as compared to the measured FDH concentrations from controlled testing in a mobile home.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	Study from >15 years ago (1985).
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	High	Models are well-described with sufficient documentation in data source and references.
	Metric 5:	Model Inputs and Defaults	Low	Model inputs and defaults are generally identified, referenced and described, but FDH emissions data used to determine predicted conc in Fig. 4 are not provided.
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Medium	High seasonal and diurnal variability can cause large changes in indoor air levels; limited discussion of uncertainty.
Overall Quality Determination			Medium	

Study Citation:		Matthews, T. G., Fung, K. W., Tromberg, B. J., Hawthorne, A. R. (1986). Surface emission monitoring of pressed-wood products containing urea-formaldehyde resins. Environment International 12:301-309.		
HERO ID:		22183		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	Widely accepted steady-state concentration model derived from a time-dependent mass balance equation.
	Metric 2:	Model Evaluation	Medium	The modeled FDH concentrations are compared to measured FDH concentrations.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	Study conducted >15 years ago (published 1986).
	Metric 4:	Model and Model Documentation Availability	High	Sufficient documentation in data source and references.
Domain 3: Accessibility/Clarity	Metric 5:	Model Inputs and Defaults	Medium	Model inputs and defaults are generally identified, referenced and described.
	Metric 6:	Variability and Uncertainty	High	Table 3 footnote gives CVs for FDH FSEM emission rates and measured concentrations. Fit of linear regression of FSEM-modeled FDH concentrations and measured concentrations is detailed in Table 4, with discussion of uncertainty and limitations on p. 308.
Overall Quality Determination		Medium		

Study Citation:		Andersen, I., Lundqvist, G. R., Molhave, L. (1975). Indoor air pollution due to chipboard used as a construction material. Atmospheric Environment 9:1121-1127.		
HERO ID:		22912		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	Medium	Equations provided for estimating concentration and emissions of formaldehyde from particle board (chipboard); theories described and appear scientifically sound.
	Metric 2:	Model Evaluation	High	Calculated concentrations compared directly against field and laboratory measurements with the same inputs; agreement with laboratory measurements better than field, but agreement ok if based on the mean data.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	Exposure to formaldehyde in homes from particle board is a relevant scenario, but the data are based on 1975 samples in Danish homes.
	Metric 4:	Model and Model Documentation Availability	High	Equations are provided for concentration and intermediate estimates; description provided of linear regression and fit for constants.
Domain 3: Accessibility/Clarity	Metric 5:	Model Inputs and Defaults	Medium	Inputs to concentration equations identified in text, not tabulated. No sources as they are measured or calculated.
	Metric 6:	Variability and Uncertainty	Medium	Discussion of variability and uncertainty in the differences between field, laboratory, and calculated concentrations; statistical tests conducted to evaluate influence of age, temperature, and humidity to explain variability. Limited discussion of limitations.
Overall Quality Determination		Medium		

Study Citation:		Panzhauser, E., Mahdavi, A. (1993). A computational model for the prediction and evaluation of formaldehyde concentration in residential buildings. American Society for Testing and Materials special technical publication, no. 1205 :197-210.		
HERO ID:		28689		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Mathematical Equations	High	The paper appears to include some sort of mathematical derivation for formaldehyde concentrations.
		Metric 2: Model Evaluation	Low	The concentration figures in the paper seem to be intended to evaluate the model against some plausible real-world conditions.
Domain 2: Representative		Metric 3: Exposure Scenario	Medium	This is an older article, and some of the specifics of the model are based on products available in Austria, but the theoretical underpinnings should be applicable.
Domain 3: Accessibility/Clarity		Metric 4: Model and Model Documentation Availability	High	Equations are provided which seem to be the basis of the model.
		Metric 5: Model Inputs and Defaults	Low	Table 1 includes some boundary conditions that seem to have been used as inputs, but the source of these is uncertain.
Domain 4: Variability and Uncertainty		Metric 6: Variability and Uncertainty	Low	No specific discussion of variability or uncertainty, though the model seems to intended to account for a broad range of conditions.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Modeling

HERO ID: 28840

Study Citation:		Little, J. C., Hodgson, A. T., Gadgil, A. J. (1994). Modeling emissions of volatile organic compounds from new carpets. Atmospheric Environment 28:227-234.		
HERO ID:		28840		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	Equations provided for each step of the fitting process; not from trusted or authoritative sources but appear scientifically sound.
	Metric 2:	Model Evaluation	Medium	Predicted values (C0) fit against experimental data with relative agreement.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	Formaldehyde emissions from carpets reflect a relevant scenario, but the data acting as the basis for the model and initial C0 prediction are from 15+ years ago.
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	High	Equations are provided and citations provided for basis of experimental data.
	Metric 5:	Model Inputs and Defaults	Medium	Model parameters tabulated, based on concentration data plotted from previous study.
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Medium	Uncertainties discussed in least squares residuals, degrees of freedom and goodness of fit of the model to experimental data. Variability in multiple carpet samples, but formaldehyde discussed for only carpet 3. Behavior and sensitivity of model briefly discussed.
Overall Quality Determination			Medium	

Study Citation:		Molhave, L., Dueholm, S., Jensen, L. K. (1995). Assessment of exposures and health risks related to formaldehyde emissions from furniture: a case study. Indoor Air 5:104-119.		
HERO ID:		78715		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	A US-EPA exposure model and equation are provided by the authors. This is a scientifically sound and widely accepted model.
	Metric 2:	Model Evaluation	High	This model is a standardized US-EPA model which has undergone extensive model evaluation.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	This study was published in 1995. The tested items are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	Low	Some model documentation provided in text however full documentation from citations is not easily accessible with simple searches.
	Metric 5:	Model Inputs and Defaults	Medium	Model inputs and defaults are provided and referenced however explicit descriptions of each model input is absent.
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Low	The characterization of variability and uncertainty is absent from this paper.
Overall Quality Determination		Medium		

Study Citation:		Baez, A. P., Padilla, H. G., Garcia, R. M., Belmont, R. D., Torres Mdel, C. (2004). Measurements of carbonyls in a 13-story building. Environmental Science and Pollution Research 11:400-404.		
HERO ID:		106705		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	Inhalation dose equation provided from ATSDR.
	Metric 2:	Model Evaluation	High	Trusted source (ASTDR) with requirements for peer review.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	Exposure to formaldehyde in office buildings is relevant scenario, but data are based in Mexico City from 1998.
	Metric 4:	Model and Model Documentation Availability	High	Equations and inputs are provided as necessary.
Domain 3: Accessibility/Clarity	Metric 5:	Model Inputs and Defaults	Medium	ID inputs provided, mostly with citations.
	Metric 6:	Variability and Uncertainty	Medium	Concentrations measured and ID calculated for male/female at four locations. Some discussion of variability in results and uncertainties around the maintenance and repair of air conditioning systems.
Overall Quality Determination		Medium		

Study Citation:		Yamashita, S., Kume, K., Horiike, T., Honma, N., Fusaya, M., Ohura, T., Amagai, T. (2010). A simple method for screening emission sources of carbonyl compounds in indoor air. Journal of Hazardous Materials 178:370-376.		
HERO ID:		927415		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Mathematical Equations	Medium	Equation provided for predicted concentrations in a room based on emission amounts, area of source, and air exchange rate. Not an authoritative source but appears scientifically sound.
		Metric 2: Model Evaluation	High	Predicted concentrations compared against measured concentrations for the same scenario in the experiment with good agreement.
Domain 2: Representative		Metric 3: Exposure Scenario	Medium	Exposure to formaldehyde from pressed wood consumer products (bookcase) reflects relevant scenario; data for 2007 may be slightly outdated.
Domain 3: Accessibility/Clarity		Metric 4: Model and Model Documentation Availability	High	Concentrations and emissions data provided to follow methodology
		Metric 5: Model Inputs and Defaults	Medium	All inputs are provided for predicted concentration values but not clearly tabulated or delineated; V and N must be found in text separately from emissions data provided.
Domain 4: Variability and Uncertainty		Metric 6: Variability and Uncertainty	Low	Limited discussion of uncertainties or limitations. CVs provided for concentrations measured in analytical method used to validate the model; variability exhibited in location of sampling and time period (August/October).
Overall Quality Determination			Medium	

Study Citation:		Kolarik, B., Gunnarsen, L., Logadottir, A., Funch, L. (2012). Concentrations of Formaldehyde in new Danish Residential Buildings in Relation to WHO Recommendations and CEN Requirements. Indoor and Built Environment 21:552-561.		
HERO ID:		1551845		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	The basic air concentration equation is given as Equation 1.
	Metric 2:	Model Evaluation	Medium	This is not specifically cited or discussed, but the model is of a type that appears frequently in the literature.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	This study is more than five years old, and is based in part on data regarding products available in Denmark; it may not be fully applicable to current US scenarios.
	Metric 4:	Model and Model Documentation Availability	High	The concentration modeling equation is provided in this paper.
Domain 3: Accessibility/Clarity	Metric 5:	Model Inputs and Defaults	High	The model inputs are based on data collected in this study.
	Metric 6:	Variability and Uncertainty	Medium	There is some discussion of uncertainty in regards to the experimental data collection (used for the inputs).
Overall Quality Determination			Medium	

Study Citation:		Lu, H., Wen, S., Feng, Y., Wang, X., Bi, X., Sheng, G., Fu, J. (2006). Indoor and outdoor carbonyl compounds and BTEX in the hospitals of Guangzhou, China. Science of the Total Environment 368:574-584.		
HERO ID:		2443638		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	The equation used is simple, but it is scientifically sound and from the EPA.
	Metric 2:	Model Evaluation	High	The equation used is from the US EPA guidelines for exposure assessment.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	Monitoring data used as inputs were collected in 2004 and the paper is representative of hospitals in China.
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	High	The paper itself gives the equation, inputs and how they determined their inputs. The guidelines cited are free to download.
	Metric 5:	Model Inputs and Defaults	High	All of the inputs used are described and cited or an explanation for their use is given. All inputs are reasonable for the scenario of interest.
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Medium	There is little discussion of the models limitations, but other similar scenarios are used to compare to the modeled values.
Overall Quality Determination			High	

Study Citation:		Matthews, T. G., Hawthorne, A. R., Daffron, C. R., Corey, M. D., Reed, T. J., Schrimsher, J. M. (1984). Formaldehyde surface emission monitor. Analytical Chemistry 56:448-454.		
HERO ID:		2444112		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	Equation 3 used for calculating formaldehyde concentration in air.
	Metric 2:	Model Evaluation	High	Concentration modeling equation based on surface areas and emission factors. Modeled results are compared to monitoring results from real buildings.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	This is an older paper (published more than 15 years ago) but the experimental materials are from the US.
	Metric 4:	Model and Model Documentation Availability	High	The modeling equation is given in the paper.
Domain 3: Accessibility/Clarity	Metric 5:	Model Inputs and Defaults	High	Inputs described. Input values seem to be taken from associated chamber testing.
	Metric 6:	Variability and Uncertainty	Medium	There is some discussion of variability in regards to the associated chamber testing.
Overall Quality Determination			High	

Study Citation:		Maddalena, R., Russell, M., Sullivan, D. P., Apte, M. G. (2009). Formaldehyde and other volatile organic chemical emissions in four FEMA temporary housing units. Environmental Science and Technology 43:5626-5632.		
HERO ID:		2591662		
Domain		Metric	Rating	Comments
Domain 1: Reliability				
Metric 1:		Mathematical Equations	Medium	The equation is given and reasonable, but not cited. This is a common and appropriate equation.
Metric 2:		Model Evaluation	Low	Model evaluation is not mentioned, but the equation is common.
Domain 2: Representative				
Metric 3:		Exposure Scenario	Medium	Testing was conducted in 2009 in FEMA trailers produced in 2005. The scenarios were consistent with likely use of the trailers.
Domain 3: Accessibility/Clarity				
Metric 4:		Model and Model Documentation Availability	High	The equation is provided in the paper with an explanation of the inputs.
Metric 5:		Model Inputs and Defaults	High	All inputs are measurements taken from the monitoring section of the paper.
Domain 4: Variability and Uncertainty				
Metric 6:		Variability and Uncertainty	Low	There is limited discussion of variation and limitations of the study.
Overall Quality Determination			Medium	

Study Citation:		Shinohara, N., Kai, Y., Mizukoshi, A., Fujii, M., Kumagai, K., Okuizumi, Y., Jona, M., Yanagisawa, Y. (2009). On-site passive flux sampler measurement of emission rates of carbonyls and VOCs from multiple indoor sources. Building and Environment 44:859-863.		
HERO ID:		2608028		
Domain	Metric	Rating	Comments	
Domain 1: Reliability	Metric 1:	Mathematical Equations	Medium	Not a widely accepted source, but equations are provided to describe the methodology from equilibrium mass balance to estimating concentrations from emission rates and outdoor concentrations (eq 4)
	Metric 2:	Model Evaluation	Medium	Measured concentrations compared to predicted concentrations; formaldehyde levels were comparable but other predicted concentrations were generally higher than measured data
Domain 2: Representative	Metric 3:	Exposure Scenario	Medium	Estimated concentrations for residential environment; reasonable consumer exposure scenario settings but set in Japan (primarily may influence outdoor concentrations which are used in the model)
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	High	Equations are provided and can be followed with given inputs
	Metric 5:	Model Inputs and Defaults	High	Inputs are all identified with explanations of estimations or measurements for their values
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Medium	Variability in estimates from different sources (outdoor, wall, desk, flooring, door, closet, ceiling, carpet) but only one environment setting; some discussion on uncertainties related to gap between measured and estimated concentrations
Overall Quality Determination		Medium		

Study Citation:		Mccready, D., Arnold, S. M., Fontaine, D. D. (2012). Evaluation of Potential Exposure to Formaldehyde Air Emissions from a Washing Machine Using the IAQX Model. Human and Ecological Risk Assessment 18:832-854.		
HERO ID:		2995846		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	The IAQX model is a widely accepted EPA method. Equations are provided and theory is discussed.
	Metric 2:	Model Evaluation	High	The paper compares 3 models in EPA's Simulation Toolkit for Indoor Air Quality and Inhalation Exposure (IAQX), and evaluates the results using a mass balance check and sensitivity analysis. Results are also compared with experimental data and other studies and models such as the EFAST CEM model prediction from EPA 2006 and EPA 2008b.
Domain 2: Representative	Metric 3:	Exposure Scenario	Medium	The paper was published in 2012.
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	High	The model and documentation are publicly available in the user's guide (USEPA 2000a).
	Metric 5:	Model Inputs and Defaults	High	Model inputs and defaults are provided for Models 12, 15, and 52a and 52b, as described in Table 2 (instantaneous emission model), Table 3 (constant emission model), Table 7 (evaporation models), Table 5 (mass transfer 52a) and Table 6 (mass transfer 52b).
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	High	Variability and uncertainty are discussed in the Uncertainty section starting on p. 18 of 24. A sensitivity analysis was performed.
Overall Quality Determination		High		

Study Citation:		Ng, L., Poppendieck, D., Dols, W. S., Emmerich, S. J. (2018). Evaluating indoor air quality and energy impacts of ventilation in a net-zero energy house using a coupled model. 24:124-134.		
HERO ID:		4646215		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	Explicit equations are not provided however the authors describe using a CONTAM model for this study which is a scientifically sound and widely accepted model.
	Metric 2:	Model Evaluation	High	Model evaluation is very clearly outlined and explicitly detailed in the model verification portion of this paper.
Domain 2: Representative	Metric 3:	Exposure Scenario	High	This study was published in 2018. The modeled items appear to be current and represent relevant exposures.
	Metric 4:	Model and Model Documentation Availability	High	Model documentation is provided within the available data source.
Domain 3: Accessibility/Clarity	Metric 5:	Model Inputs and Defaults	Medium	Model inputs are generally identified and described in table 2 however its unclear if these inputs meet high data quality standards.
	Metric 6:	Variability and Uncertainty	Medium	Characterization of variability is provided as simulated standard deviations and uncertainties are generally described in text.
Overall Quality Determination		High		

Study Citation:		Davis, A. Y., Zhang, Q., Wong, J. P. S., Weber, R. J., Black, M. S. (2019). Characterization of volatile organic compound emissions from consumer level material extrusion 3D printers. Building and Environment 160		
HERO ID:		5645091		
Domain		Metric	Rating	Comments
Domain 1: Reliability		Metric 1: Mathematical Equations	High	An equation for estimated exposure concentration is found in section 2.5.
		Metric 2: Model Evaluation	Medium	The approach seems to be based on a standard method, but these have not necessarily been applied to 3D printers previously.
Domain 2: Representative		Metric 3: Exposure Scenario	High	This is a recent study (less than 5 years old) and the 3D printers used in the experiment seem to be models commercially available in the US.
Domain 3: Accessibility/Clarity		Metric 4: Model and Model Documentation Availability	High	The equations are provided, and the required input variables are described.
		Metric 5: Model Inputs and Defaults	Medium	Most of the inputs seem to be provided in this paper, and are generally cited to reference sources or previous peer-reviewed works.
Domain 4: Variability and Uncertainty		Metric 6: Variability and Uncertainty	Medium	There is a discussion of variability based on experimental design and how it might apply to the results of this study.
Overall Quality Determination			High	

March 2024

Formaldehyde

Modeling

HERO ID: 5943658

Study Citation:		Matthews, T. G., Reed, T. J., Tromberg, B. J., Daffron, C. R., Hawthorne, A. R. (1985). Formaldehyde emission from combustion sources and solid formaldehyde-resin-containing products - Potential impact on indoor formaldehyde concentrations. Advances in Chemistry Series 210:131-150.		
HERO ID:		5943658		
Domain	Metric		Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	All mathematical equations are provided and explicitly detailed throughout the study.
	Metric 2:	Model Evaluation	Medium	The authors discuss some model evaluation through qualitative means.
Domain 2: Representative	Metric 3:	Exposure Scenario	Low	This study was published in 1985. The modeled items are not consistent with when current or recent exposures are expected.
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	High	There is sufficient model documentation available for this study in the provided appendices.
	Metric 5:	Model Inputs and Defaults	High	Model inputs and defaults are all provided and explicitly described and defined.
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Medium	There is only limited discussion of uncertainty, knowledge gaps and characterization of variability.
Overall Quality Determination			Medium	

March 2024

Formaldehyde

Modeling

HERO ID: 5950617

Study Citation:		Dong, H., Yue, G., Li, M. (2016). Characteristics of formaldehyde emission from indoor crib. 3:283-287.		
HERO ID:		5950617		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	Mathematical equations for the models are provided and explicitly defined.
	Metric 2:	Model Evaluation	Medium	There is limited discussion of data evaluation provided by the authors.
Domain 2: Representative	Metric 3:	Exposure Scenario	High	This study was published in 2016. The modeled items appear to be current with relevant exposures.
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	Low	Model documentation is very limited and does not provide anything more than the actual equations themselves.
	Metric 5:	Model Inputs and Defaults	Low	Equations are provided however model inputs and defaults are very vague and not explicitly described or identified.
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Medium	Some discussions of uncertainty and only limited characterization of variability is provided.
Overall Quality Determination		Medium		

Study Citation:		U.S. EPA, (2016). Formaldehyde from composite wood products: Exposure assessment for TSCA Title VI Final Rule.		
HERO ID:		11181057		
Domain		Metric	Rating	Comments
Domain 1: Reliability	Metric 1:	Mathematical Equations	High	FIAM-pwp is the model used and it was developed by the USEPA. This is relevant as a model because it calculates indoor concentrations at steady state conditions.
	Metric 2:	Model Evaluation	High	It is not mentioned in the paper if the model has undergone evaluation, but it is cited to the USEPA and has an appendix dedicated to its use.
Domain 2: Representative	Metric 3:	Exposure Scenario	High	This paper was published in 2016 and uses relevant model inputs. It exposure concentrations in a variety of living situations and climate zones across the US.
Domain 3: Accessibility/Clarity	Metric 4:	Model and Model Documentation Availability	Low	The model's user guide is easily available, but the model is not on the EPA's website.
	Metric 5:	Model Inputs and Defaults	High	Model inputs are clearly described and given in various forms. There is some discussion of how output of model is useful and a sensitivity analysis was run.
Domain 4: Variability and Uncertainty	Metric 6:	Variability and Uncertainty	Medium	There a lengthy discussion on variability and many factors are compared in the model. There is a gap in data that was filled with estimated factors that could make data uncertain.
Overall Quality Determination			High	

Glossary of Select Terms for Data Evaluation Tables

Table 282: Glossary of Select Terms for Data Evaluation

Term	Definition
AATCC	American Association of Textile Chemists and Colorists
AHHS	American Health Homes Survey
AS	Australian Standard
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BEF	Biodiversity-Ecosystem Functioning Experiment
BS	British Standards
BTEX	Benzene, Toluene, Ethyl Benzene, and Xylenes
CA	California
CEM	Consumer Exposure Model
CNS	Chinese National Standard (CNS)
CO ₂	Carbon Dioxide
CV	Coefficient of Variation
DCB	Dichlorobenzene
DF	Detection Frequency
DNPH	Dinitrophenylhydrazine
DNSH	Dansylhydrazine
DS	Denmark
ECMS	Electronically Controlled Sensor Measurement System
EFAST	Exposure and Fate Assessment Screening Tool
EN	European Normalization
EOHSI	Environmental and Occupational Health Sciences Institute
EPA	Environmental Protection Agency
EU	European Unit
F	Fahrenheit
FDH	Formaldehyde
FEMA	Federal Emergency Management Act
FID	Flame Ionization Detector
FLEC	Field and Laboratory Emission Cell
FSEM	Facilities, Security, and Emergency Management
GC	Gas Chromatography
GSD	Geometric Standard Deviation
h or hr	Hour
HPLC/HPLQ	High Performance Liquid Chromatography
HCHO	Formaldehyde
IAQ	Indoor Air Quality
IAQX	Indoor Air Quality and Inhalation Exposure
ISO	International Standards Organization
JIS	Japanese Industrial Standard

Continued on next page ...

Glossary of Select Terms for Data Evaluation Tables

Table 282 ...continued from previous page

Term	Definition
LC	Liquid Chromatography
L	Liter
LOD	Limit of Detection
LOQ	Limit of Quantification
MA	Massachusetts
MCN	Maternal/Child Nursing
mg	milligram
m ²	Meter squared
m ³	Cubic meter
μ	Micro-
MDF	Medium-Density Fibreboard
MDL	Method Detection Limit
MF	Melamine-Formaldehyde
MRL	Method Reporting Limit
MS	Mass Spectrometry
n	Sample Size
N/A	Not Applicable
NCASI	National Council for Air & Stream Improvement
ND	Non-Detect
NELAP	National Environmental Laboratory Accreditation Program
NIOSH	National Institute of Occupational Safety and Health
NO _x	Nitric Oxide
NYC	New York City
NYCCAS	New York City Community Air Survey
OQD	Overall Quality Determination
OSHA	Occupational Safety and Health Administration
PAKS	Passive Aldehydes and Ketones Sampler
PEMS	Performance Measurement System
PB	Particle Board
PM	Particulate Matter
ppm	Parts per million
PTR-TOF-MS	Proton Transfer Reaction-Time of Flight-Mass Spectrometry
PVAc	Poly(vinyl acetate)
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RH	Relative Humidity
RSD	Relative Standard Deviation
SD	Standard Deviation
SE	Standard Error
SI	Supplemental Information
SM	Supplemental Material
SOP	Standard Operating Procedure

Continued on next page ...

Glossary of Select Terms for Data Evaluation Tables

Table 282 ...continued from previous page

Term	Definition
SPE	Solid Phase Extraction
SPME	Solid Phase Micro-Extraction
TD	Thermal Desorption
TE	Thermal Extractor
TN	Tennessee
TO	Toxic Organics
TSCA	Toxic Substances Control Act
TSGS	Two-Step Randomized Gauss-Seidel
THU	Temporary Housing Unit
UFFI	Urea Formaldehyde Foam Insulation
UK	United Kingdom
US or USA	United States of America
UV	Ultraviolet
VOC	Volatile Organic Compound
VIS	Visible Spectroscopy
WIT	World Information Transfer