1

Table 5-27. Extra risk estimates per ppm based on ECs[a]

2

Cancer type	BMR[b]	Outcome	EC (ppm)[c]	BMR/EC$_{BMR}$ (per ppm)[c]
nasopharyngeal cancer	0.0005	mortality	0.15	3.3×10^{-3}
		incidence	0.074	6.8×10^{-3}
Hodgkin lymphoma	0.0005	mortality	0.15	3.3×10^{-3}
		incidence	0.051	9.8×10^{-3}
leukemia	0.005	mortality	0.22	2.3×10^{-2}
		incidence	0.16	3.1×10^{-2}
Total cancer[d]		mortality		$2.4 \times 10^{-2\ d}$
		incidence		$4.7 \times 10^{-2\ d}$

3
4 [a]Based on all person-years. Values based on exposed person-years only would be virtually identical.
5 [b]BMR = benchmark response, i.e., extra cancer risk level used to calculate the ECs and LECs.
6 [c]To convert ppm to $\mu g/m^3$, multiply by 1,230; to convert ppm^{-1} to $(\mu g/m^3)^{-1}$, divide by 1,230.
7 [d]The extra risk estimates per ppm for total cancer are not derived from ECs but rather from the calculations of
8 combined cancer risk at 0.1 ppm presented in Section 5.2.4 (see Table 5-20 for mortality and Table 5-21 for
9 incidence). The sums of the MLEs of risk from Tables 5-20 and 5-21, multiplied by 10 to convert from per 0.1
10 ppm to per ppm, correspond to the extra risk estimates per ppm calculated from the ECs (in that they are based on
11 MLEs and not bounds) but they are not equivalent to the sum of the EC-based values because those are calculated
12 at different ECs and the MLEs of risk are all calculated at a common exposure level of 0.1 ppm.
13
14
15 combined with age-specific exposure estimates when estimating cancer risks from early-life
16 (<16 years age) exposure. The ADAFs and their age groups may be revised over time. The
17 most current information on the application of ADAFs for cancer risk assessment can be found at
18 www.epa.gov/cancerguidelines.
19   For inhalation exposures, assuming ppm equivalence across age groups (i.e., equivalent
20 risk from equivalent exposure levels, independent of body size) and using the preferred unit risk
21 estimate of 6.6×10^{-5} per $\mu g/m^3$ from Section 5.4.3, the calculation is fairly straightforward. For
22 example, the ADAF-adjusted total cancer unit risk estimate for a constant lifetime exposure level
23 is calculated as shown in Table 5-28.
24   This 70-year risk estimate of 1.1×10^{-4} for a constant exposure of 1 $\mu g/m^3$ calculated in
25 Table 5-28 is equivalent to a lifetime unit risk of 1.1×10^{-4} per $\mu g/m^3$ (0.13/ppm), adjusted for
26 early-life susceptibility, assuming a 70-year lifetime and constant exposure across age groups.
27 As mentioned above, for risk assessments based on specific exposure assessments, application of
28 **Table 5-28. Total cancer risk from exposure to a constant formaldehyde**

1   **exposure level of 1 μg/m³ from ages 0–70 years**
2

Age group	ADAF	Unit risk (per μg/m³)	Exposure concentration (μg/m³)	Duration adjustment	Partial risk
0 to < 2 years	10	6.6×10^{-5}	1	2 years/70 years	1.9×10^{-5}
2 to < 16 years	3	6.6×10^{-5}	1	14 years/70 years	4.0×10^{-5}
≥ 16 years	1	6.6×10^{-5}	1	54 years/70 years	5.1×10^{-5}
				Total risk =	1.1×10^{-4}

3
4   (Note that the partial risk for each age group is the product of the values in columns 2–5 [e.g.,
5     $10 \times (6.6 \times 10^{-5}) \times 1 \times 2/70 = 1.9 \times 10^{-5}$], and the total risk is the sum of the partial risks.)
6
7
8 the ADAFs is to be combined with age-specific exposure estimates when estimating cancer risks
9 from early-life (<16 years age) exposure. Further example calculations can be found in EPA's
10 *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens*
11 (U.S. EPA, 2005b).
12   In addition to the uncertainties discussed above for the inhalation unit risk estimate, there
13 are uncertainties in the application of ADAFs to adjust for potential increased early-life
14 susceptibility. The ADAFs are general default factors, and it is uncertain to what extent they
15 reflect increased early-life susceptibility for exposure to formaldehyde, if, in fact, early-life
16 susceptibility is increased as assumed. To some extent, the unit risk estimates for Hodgkin
17 lymphoma and leukemia already reflect some partial increased risk from early-life exposure
18 because the life-table programs include background rates for childhood cancers. However, the
19 impact of this partial increased risk is negligible compared to the effect of the ADAFs on the
20 final risk estimate. For example, eliminating the background rates up to age 16 from the life-
21 table programs decreases the lifetime extra risks at the PODs by about 0.5% for leukemia and
22 about 1.2% for Hodgkin lymphoma. The ADAFs, on the other hand, increased the lifetime unit
23 risk estimate by about 66%.
24
25 **5.4.5. Conclusions: Cancer Inhalation Unit Risk Estimates**
26   As presented in Section 5.4.3, the preferred (plausible upper bound) cancer unit risk
27 estimate for formaldehyde exposure in this assessment is the total cancer risk estimate of
28 **8.1×10^{-2} per ppm (6.6×10^{-5} per μg/m³) based on (adult) human data for NPC, Hodgkin**
29 **lymphoma, and leukemia.**