11 Residential and Worker Exposure Duration, Individual vs. Population Cancer Risk, and Evaluation of Short Term Projects

11.1 Introduction

This chapter covers topics related to estimating cancer risk for facility-specific emissions under the Air Toxics Hot Spots program. The Hot spots statute mandates the assessment of cancer risks from airborne emissions of stationary sources to people living or working near a specific facility. The duration of exposure for residential and offsite worker receptors influences the estimate of cancer risk from a specific facility. In the past, cancer risk was estimated for the maximally exposed individual resident who was assumed to be at the point of highest exposure to emitted carcinogens 24 hours per day, 7 days per week for a lifetime. This is a health protective but not particularly realistic assumption. To address this problem, ARB and OEHHA evaluated information available on length of residence at a specific address to develop guidance on the duration of exposure for the residential exposure scenario.

Past risk assessments assumed a 40 year exposure duration for offsite workers based on little data. For the offsite worker exposure scenario, ARB and OEHHA evaluated information available on the length of time people work at the same location. Information on the percentage of time people are at home was also evaluated to provide an adjustment based on activity patterns for time away from home.

This chapter also discusses reporting and more explicitly considering population wide cancer risks separately from the traditional maximally exposed individual cancer risk estimate.

Finally, the chapter presents guidance to the Air Districts for evaluating cancer risks from short-term projects in their purview that are not Hot Spots facilities.

11.1.1 Residential Exposure Duration for Cancer Risk Assessment

An assumption of lifetime exposure duration (70 years) for the calculation of cancer risk is incorporated into the unit risk factors, inhalation cancer potency factors and oral cancer potency factors. The cancer potency factors and unit risk factors are estimated from data from long-term worker epidemiological studies or lifetime rodent studies. A lifetime cancer risk of 5×10^{-5} means that in a population of a million chronically exposed individuals, 50 excess cancer cases would be predicted. Since the cancer potency factors and unit risk factors are based on lifetime or very long-term studies, there are uncertainties in calculating less than lifetime risk.

A complicating factor in estimating cancer risk is the greater impact of early-in-life exposure. Analyses of available data on the influence of age-at-exposure on potency of carcinogens by OEHHA (OEHHA, 2009) and U.S.EPA (U.S.EPA, 2005, Barton et al.,

2005) indicate that early in life exposures to carcinogens are more potent than later in life exposures. This is discussed in detail in OEHHA (2009).

In order to address the issue of early-in life exposures, OEHHA has adopted a policy, based on the available scientific data, of weighting cancer risk from exposures from the third trimester to <2 yrs of age by a factor of ten, and exposures from age two to less than sixteen years by a factor of three (OEHHA, 2009). In addition to innate sensitivities to some carcinogens, children have greater exposures due to physiological and behavioral factors. As a result, a greater proportion of total lifetime risk is accrued by age 16 with lifetime exposure to a constant air concentration than was previously recognized.

Accumulation of risk over a lifetime is thus no longer assumed linear with increasing length of exposure to a constant dose, but depends on the age at exposure. To further complicate estimation of risk, exposure to a constant air contaminant concentration or soil contaminant concentration over time is also not linear. There are physiological and behavioral differences between adults and children, which results in children's doses (mg/kg body weight) being greater than adults at the same environmental contaminant concentration.

When estimating cancer risk from individual stationary facilities to nearby residents, exposure duration is an important determinant of cancer risk. Cancer risk for residents is also influenced by activity patterns. Exposure duration for the resident near a facility amounts to the time that resident lives in his or her house. Another important factor is the number of hours that the resident spends at his or her residence. This factor varies with age. Section 11.5 discusses available information to use in estimating exposure duration for residential exposure scenarios.

11.1.2 Offsite Worker Exposure Duration for Cancer Risk Assessment

Offsite workers near a stationary source of airborne emissions are treated as members of the public in the Hot Spots program. The length of time that a worker is on the job at a specific location determines the exposure duration and is directly proportional to the cancer risks estimated from a specific stationary source. In the past, OEHHA recommended a default of 40 years for employment tenure. OEHHA has examined the data on job tenure in the United States in order to develop a new data-derived high-end estimate of job tenure that would be public health protective without being unnecessarily conservative. These data are not perfect for this purpose but provide a useful basis for our new recommendation. Section 11.6 discusses available information to use in estimating exposure duration for offsite worker exposure scenarios.

The point estimate risk assessment approach (Tier 1 and 2) can be used with more than one estimate of resident chronic exposure duration to give multiple point estimates of cancer risk. For stochastic risk assessment (Tier 3 and 4), OEHHA recommends calculating separate cancer risk distributions for each fixed chronic exposure duration. An alternative approach would be to express the variability in exposure duration as a distribution of residency times and equate residency time to exposure duration. The variance in residency times would be propagated through the model and contribute to the variance in the cancer risk.

OEHHA does not recommend a distribution of residence times for our model (Tier III). Since each individual knows the length of time that he or she has resided near the facility, if the 9, 30 and 70-year cancer risks are presented the residents should have a better idea of his or her risk.

11.2 Recommendations

11.2.1 Exposure Duration for Estimating Cancer Risk in the Residential and Offsite Worker Exposure Scenarios

OEHHA is recommending that an exposure duration (residency time) of 30 years be used for individual cancer risk determination for the maximally exposed individual resident (MEIR) (Table 11.1). This should provide adequate public health protection against individual risk. Note that the 30 year exposure duration starts in the third trimester to accommodate the increased susceptibility of exposures in early life (OEHHA, 2009), and would apply to both the point estimate and stochastic approaches. Reducing the residency time assumption from 70 years to 30 years will however reduce the protection for the population. Thus, we have recommendations below (Section 11.1.3) for specifically evaluating population cancer risk from facility emissions.

As supplemental information in the risk assessment for the MEIR scenario, OEHHA is recommending that point estimate and stochastic risk estimates also be presented for 9 and 70-year exposure durations, both starting in the third trimester. This will help convey the message to the public that cancer risk is proportional to the duration of exposure (i.e., length of residency near the facility). Different communities may have different patterns of residency duration and the pattern within the community may need to be considered by the risk manager.

Although the data for determining residency duration is less than perfect, it is likely that 30 years is a reasonable estimate of the 90th or 95th percentile of residency duration in a population. Thus, a 30-year residency time is consistent with recommendations for other risk assessment variates in our model. In addition, it should be noted that accounting for the greater potency of early-in-life exposure using the Age Sensitivity Factors (OEHHA, 2009) means that a smaller fraction of lifetime risk is incurred after age 30.

Note that there is an assumption that after the person moves, he or she is no longer significantly exposed to the emissions from the facility in question. However the larger the isopleths of cancer risks, the greater the probability that the person could be moving into a residence still impacted by the facility. As the size of the cancer risk isopleths increases, the probability that population risk will be more important in terms of public health increases (see discussion in Section 11.7).

OEHHA recommends, based on the available data, that 25 years be used as a reasonable estimate of the 95th percentile of employment duration for the Hot Spots program. Thus, for estimating cancer risk for the offsite worker scenario, a 25 year exposure duration should be used.

The time that a person is away from his or her residence can mean either no exposure to a small facility's emissions, or in the case of a facility with a large isopleth footprint, continuing significant exposure. The available California data do not determine distance from residence during time away from residence (Appendix L). This makes it difficult to come up with a general recommendation, protective of public health, for evaluating risk to the residential MEI during the time that a person is away from the residence. However, OEHHA notes it is appropriate to consider the fraction of time people spend at home as an adjustment for exposure to carcinogens (Table 11.2)

A large fraction of lifetime (70-year) cancer risk and an even larger fraction of the cancer risk for the first 30 years in life is incurred during the first 16 years of life because of the higher risk of early in life exposure. A good fraction of the time away from residence will be spent at school for the first sixteen years of life. Many California schoolchildren attend a local neighborhood school. Therefore, OEHHA is recommending that time away from residence be considered as away from facility emissions (no facility cancer risk) for facilities that do not have a school within the 1×10^{-6} or greater cancer risk isopleth. We recommend no adjustment for time away from residence when there are schools inside the 1×10^{-6} (or greater) cancer risk isopleth. The larger facilities with multiple emissions sources are most likely to have schools within the 1×10^{-6} isopleth and are more likely to cause significant exposure to people while they are away from their residences.

11.2.2 Activity Patterns and Time Spent at Home

OEHHA and ARB evaluated information from activity patterns databases to estimate the percentage of the day that people are home (discussed in Appendix L). This information can be used to adjust exposure duration and risk from a specific facility's emissions, based on the assumption that exposure to the facility's emissions are not occurring away from home. Table L.6 in Appendix L shows the number of minutes spent at home, statewide in California, and the percentage of total time spent at home as well. Ages 0 to 2 spend 85% of their time at home, ages 2 through 15 spend 72% of the their time at home, and ages greater than 15 spend 73% of their time at home (Table 11.2). The data used to determine these percentages were collected by the California Department of Transportation in 2000 and 2001 (Cal Trans, 2001). The time away from the home includes vacations.

11.2.3 Recommendations for Presenting Population Risks

Clear separation of individual risk and population risk and their separate evaluation will be helpful in risk communication and could result in better public health protection and more equitable risk management decisions (further discussed in Section 11.7). The cancer risk estimate based on a 70-year residential exposure does not account for an important aspect of population risk. In particular, large facilities with multiple stacks can dilute emissions over a large area that impact thousands of individuals and theoretically cause a large number of cancer cases, but because of the dilution, the cancer risk estimate for the maximally exposed individual resident, which is what most risk management decisions are based upon, is below a level of concern. A small facility with a single stack, impacting very few individuals due to more concentrated emissions can exceed individual risk limits set by the air districts, thus triggering notification and other measures. The large facility may in fact have a much greater public health impact (greater number of cancer cases) when population risk is considered. There are different methods that can be used as measure of population burden, based on a lifetime (70 year) cancer risk estimate. Calculating cancer burden as described below is one method. The number of individuals residing within a 1 X 10^{-6}, 1 X 10^{-5}, and/or 1 X 10^{-4} isopleth is another potential measure of population burden (OEHHA, 2003). OEHHA recommends this latter approach for the Hot Spots risk assessments to more explicitly consider population-wide cancer risks from facility emissions. This metric is more easily understood, and provides a metric for population-wide cancer risks that can inform risk management decisions. Cancer burden can also be presented, based on a 70 year lifetime risk estimate.

11.2.4 Recommendations for Exposure Duration for Short-term projects

We recommend that exposure from projects less than 6 months be assumed to last 6 months (e.g., a 2-month project would be evaluated as if it lasted 6 months). Exposure from projects lasting less than two months would not be evaluated for cancer risk. We recommend that exposure from projects lasting more than 6 months be evaluated for the duration of the project. In all cases the exposure should be assumed to start in the third trimester to allow for the use of the Age Sensitivity Factors (OEHHA, 2009). Thus, if the District is evaluating a proposed 5-year mitigation project at a hazardous waste site, the exposure duration for the residents would be from the third trimester through the first five years of life. The exposure duration for the offsite worker scenario would be five years in this case.

Table 11.1 Summary of Recommendations for Exposure Duration

Receptor	**Recommendation**
Resident	30 years[a]
Resident (supplemental Information)	9 years for central tendency; 70 years for maximum
Worker	25 years

[a] All durations start with exposure in the third trimester to accommodate use of the Age Sensitivity Factors for early life exposure to carcinogens

Table 11.2 Recommendations for Time Away from Residence for Evaluating Cancer Risk for Facilities Without a School Within the $1x10^{-6}$ (or greater) Cancer Risk Isopleth[1]

Age Range	Fraction of Time at Residence
3rd Trimester<2	0.85
2<16	0.72
16-30	0.73

[1] Facilities with a school within the $1 X10^{-6}$ (or greater) cancer risk isopleth should use 1 as the fraction of time at the residence for ages 3rd trimester to less than age 16.

11.3 Cancer Risk Algorithm and Exposure Duration

The following equations for cancer risk can accommodate different exposure durations:

9-year exposure duration - Calculation of Cancer Risk from the Third Trimester to Age Nine:

$$\text{Cancer Risk} = [(ADD_{\text{third trimester}} \text{ X CPF X } 10) \text{ X } 0.3 \text{ yrs/70 yrs}] + [(ADD_{0 \text{ to } <2\text{yrs}} \text{ X CPF X } 10) \text{ X } 2 \text{ yrs/70 yrs}] + [(ADD_{2 < 9\text{yrs}} \text{ X CPF X } 3) \text{ X } 7 \text{ yrs/70 yrs}] \text{ X FAH}$$

30-year exposure duration - Calculation of Cancer Risk from Third Trimester to Age 30:

$$\text{Cancer Risk} = [(ADD_{\text{third trimester}} \text{ X CPF X } 10) \text{ X } 0.3 \text{ yrs/70 yrs}] + [(ADD_{0 \text{ to } <2\text{yrs}} \text{ X CPF X } 10) \text{ X } 2 \text{ yrs/70 yrs}] + [(ADD_{2 < 16\text{yrs}} \text{ X CPF X } 3) \text{ X } 14 \text{ yrs/70 yrs}] + [(ADD_{16 < 30\text{yrs}} \text{ X CPF X } 1) \text{ X } 14\text{yrs/70 yrs}] \text{ X FAH}$$

Lifetime (70 year) exposure duration - Calculation of Cancer Risk from Third Trimester to Age 70:

$$\text{Cancer Risk} = [(ADD_{\text{third trimester}} \text{ X CPF X } 10) \text{ X } 0.3 \text{ yrs/70 yrs}] + [(ADD_{0 \text{ to } <2\text{yrs}} \text{ X CPF X } 10) \text{ X } 2 \text{ yrs/70 yrs}] + [(ADD_{2 < 16\text{yrs}} \text{ X CPF X } 3) \text{ X } 14 \text{ yrs/70 yrs}] + [(ADD_{16 < 70\text{yrs}} \text{ X CPF X } 1) \text{ X } 54 \text{ yrs/70 yrs}] \text{ X FAH}$$

where: ADD = Average Daily Dose, mg/kg-d, for the specified time period (estimated using the exposure variates presented in the TSD)

CPF = Cancer Potency Factor $(mg/kg\text{-}d)^{-1}$

Age Sensitivity Factor third trimester to less than 2 years = 10

Age Sensitivity Factor age 2 to less than 16 years = 3

Age Sensitivity Factor age 16 to less than 70 years = 1

FAH = Fraction of time at home

ED = Exposure duration, in years

1×10^{-6} = Conversion factor ($\mu g/m^3$) to (mg/L)

AT = Averaging time (period over which exposure is averaged, in years); for carcinogenic effects, the averaging time is 70 years = 25,500 days

Adjustment for exposure less than 365 days/year (e.g., 350 out of 365 days a year to allow for a two week period away from home each year for the residential exposure scenario, or worker exposures of eight hours per day, 5 d/week for the offsite worker exposure scenario) can be factored into the equation using the EF term.

11.4 Available Studies for Evaluating Residency Time and Exposure Duration for the Residential Exposure Scenario

11.4.1 National Studies

Israeli and Nelson (1992) used information from the American Housing Survey (AHS) for the United States for 1985 and 1987 (Bureau of the Census, 1987; 1989) to develop a distribution of average total residence time for all U.S. residents. Finley et al. (1994) calculated more of the percentiles for the data presented by Israeli and Nelson (1992). The mean of the distribution presented by Israeli and Nelson (1992) is 4.6 years. In addition, distributions are presented for subpopulations such as renters and owners, and for regions of the country. The study clearly shows that homeowners have a much greater average residency time than renters and therefore may be a more at risk population from exposure to emissions of a nearby facility. The average residency time for the Western region was lower than for the entire U.S. population.

The authors note that with the methodology they used, there could be repeated sampling or over-sampling of a population of frequent movers. This methodology would also tend to overemphasize the more frequent short duration residency periods that have been found to occur from approximately age twenty to thirty by the Bureau of Census (1988). The Israeli and Nelson (1992) study has information on various categories such as renters, homeowners, farm, urban and rural populations, and large geographic regions such as the West. OEHHA staff did not consider the Israeli and Nelson (1992) study to be appropriate for determining an appropriate residency time to use in less-than-lifetime exposure scenarios in the Air Toxics “Hot Spots” program.

The Israeli and Nelson (1992) study does not examine the effect of socio-economic status on residency times. Many facilities in the Air Toxics “Hot Spots” program are located in areas surrounded by low socioeconomic status populations. OEHHA has published a framework for assessing cumulative impacts, *Cumulative Impacts - Building a Scientific Foundation* (2010), which established the need to take into account socioeconomic factors in risk assessment. As the methodology for doing so evolves, OEHHA will update the Exposure Assessment and Stochastic Analysis Technical Support Document as appropriate.

Johnson and Capel (1992) used a Monte Carlo approach for determining residency occupancy periods. Their methodology can incorporate population information about location, gender, age, and race to develop a mobility table based on US Census data. The mobility table contains the probability that a person with the demographic characteristics considered would not move. A mortality table is also used which determines the probability that a person with the demographic characteristics considered would die. Some of the results from this study are presented in Table 11.3.

Although the published methodology can be used to determine mobility for different income groups, the published tables are for the entire U.S. population. In addition, as is pointed out in the study, the Monte Carlo methodology employed in the study uses the same probability of moving for persons who have resided in their current residence for extended periods as for those who have recently moved in. The data collected by the U.S. Census does not indicate where the individuals queried move to, other than broad descriptions such as “in county”, “out of county”, “within metropolitan area”, and so forth. This problem is common to all of the studies discussed. As a result, it is difficult to define residence time within a zone of impact for those who do not move very far (e.g., within the same apartment complex, neighborhood, or town). The conclusions of this study are similar to the results that the U.S. EPA (1997) reached using the AHS study (Bureau of the Census, 1993) (Table 11.3).

The U.S. EPA (1997) has reviewed the studies presented above. In addition, the U.S. EPA (1997) reviewed the results of the 1991 AHS (Bureau of the Census, 1993). The U.S. Bureau of the Census (1993) conducted a survey using 55,000 interviews, which covered homeowners and renters. Black, white and Hispanic ethnic groups were represented in this study. The U.S. EPA used the information available in this study to determine a distribution of the percent of households who have lived at their current address for several ranges of years. The median and 90th percentiles of this distribution are 9.1 and 32.7 years, respectively. The methodology used to derive the distribution was not specified in the report (U.S. EPA, 1995). Based on the studies by Israeli and Nelson (1992), Johnson and Capel (1992), and their analysis of the U.S. Bureau of the Census (1993), U.S. EPA recommends a central tendency estimate of 9 years, and a high-end estimate of 30 years for residency time.

11.4.2 California-Specific Data on Residency Time

Appendix L used data from The Integrated Public Use Microdata Series (IPUMS-USA) to evaluate residency time. IPUMS-USA consists of more than fifty samples of the American population drawn from fifteen federal censuses and from the American Community Surveys (ACS). ACS is a nationwide survey that collects and produces population and housing information every year from about three million selected housing unit addresses across every county in the nation (ACS). IPUMS-USA samples, which draw on every surviving census from 1850-2000 and the 2000-2009 ACS samples, collectively constitute the quantitative information on long-term changes in the American population. These records for the period since 1940 only identify geographic areas with equal or larger than 100,000 residents (250,000 in 1960 and 1970) (IPUMS-USA).The IPUMS-USA identifies the date moved into the residence and therefore a cumulative distribution of length of time that population has lived in the current residence can be constructed from these data. Figure L2 shows that 91% of the population has lived in their current residence for 29 years or less. This means that only 9% of the population has lived more than 29 years in his or her current residence.

Table 11.3 Summary of Studies of United States Residency Times (in Years)

Israeli and Nelson (1992)	1.4, 23.1 (50th and 95th percentile)
Johnson and Capel (1992)	2.0, 9.0, 33 (5th, 50th and 95th percentile)
U.S. EPA (1997); evaluation of BOC (1993) data	9.1, 32.7 (50th, 90th percentile)
CARB Analysis of IPUMS data (Appendix L)	29 (91^{st} percentile)

11.5 Available Studies for Assessing Job Tenure and Exposure Duration for the Offsite Worker Exposure Scenario

11.5.1 Key National Studies on Job Tenure

The data with respect to job tenure in the United States are mainly cross sectional for determining a Tier 1 default. However, there are some longitudinal data. The purpose of the Census Bureau's Survey of Income and Program Participation (SIPP) is to collect information on source and amount of income, labor force participation, program participation and eligibility, and general demographic characteristics, to measure the effectiveness of existing federal, state, and local programs. The data were collected to estimate future costs and coverage for government programs, such as food stamps, to provide improved statistics on the distribution of income and measures of economic well-being; and to evaluate the effectiveness of federal, state, and local programs.

Like NHANES, the SIPP sample is a multistage-stratified sample of the U.S. civilian non-institutionalized population. Individuals selected for the survey, along with others who live with them, are interviewed once every 4 months over a 48-month period. To spread the work evenly over the 4-month reference period for the interviewers, the Census Bureau randomly divides each panel into four rotation groups. Each rotation group is interviewed in a separate month. Four rotation groups constitute one cycle, or wave, of interviewing, for the entire panel.

The first SIPP panel began interviews in 1983. During the period 1984-1993, a new panel of households was introduced each year in February. In 1990, the Committee on National Statistics (CNSTAT) at the National Research Council reviewed SIPP protocols and made recommendations, many of which were implemented in 1996 and continue to be followed today. In the current version, SIPP is a longitudinal survey that consists of 12 waves of 4 months (4 rotations) each, resulting in a 4-year non-overlapping, continuous cycle, with sample size ranging from approximately 14,000 to 36,700 interviewed households. Included in the SIPP database is information about employment, such as number of concurrent jobs, starting and ending dates of jobs, types of employment, employment income and unemployment compensation, and reasons for leaving a job.

OEHHA analyzed the most recent set of SIPP job data from Wave 1 of the 2008 SIPP survey to evaluate the distribution of employment tenure among employed people in a nationally representative sample. SIPP participants were asked when they started working for a current or most recent past employer, and when they stopped working for that same employer. We disregarded data pertaining to second jobs for individuals who had more than one job at a time. We calculated job duration using job start and end dates, and used an end date of December 31, 2008 for those who were still employed at the same job. We ran frequency distributions of years on the job and years on the job by age using the FREQUENCY and SURVEYFREQ procedures in SAS version 9.1.3 (Table 11.4).

Table 11.4 Employment Tenure by Years on the Job from the Survey of Income and Program Participation (SIPP), 1996-2008

Years on the Job	Percent of Total					
	1996-2008	1996-2008 Summary	2008 Only	2008 Summary	2008 Cumulative Total 0 to 100%	2008 Cumulative Total 100 to 0%
N	**150,017**	**150,017**	**45,363**	**45,363**	**-**	**-**
0	12.67		19.42			100
1	17.87		13.15			
2	10.34		9.87			
3	7.86		7.53			
4	6.06	54.79	5.41	55.38	55.38	44.62
5	5.09		4.58			
6	4.34		3.62			
7	3.48		3.72			
8	3.30		3.87			
9	2.47	18.67	2.59	18.39	73.77	26.23
10	2.82		3.20			
11	2.08		1.93			
12	1.84		1.75			
13	1.59		1.70			
14	1.52	9.84	1.33	9.91	83.68	16.32
15	1.59		1.40			
16	1.45		1.12			
17	1.22		0.94			
18	1.30		1.27			
19	1.05	6.61	1.05	5.78	89.46	10.54
20	1.23		1.34			
21	0.86		0.90			
22	0.82		0.91			
23	0.83		0.84			
24	0.75	4.48	0.63	4.62	94.08	5.92

Table 11.4 Employment Tenure by Years on the Job from the Survey of Income and Program Participation (SIPP), 1996-2008

Years on the Job	Percent of Total					
	1996-2008	1996-2008 Summary	2008 Only	2008 Summary	2008 Cumulative Total 0 to 100%	2008 Cumulative Total 100 to 0%
25	0.70		0.62			
26	0.64		0.47			
27	0.53		0.50			
28	0.57		0.72			
29	0.43	2.87	0.45	2.75	96.83	3.17
30	0.51		0.62			
31	0.37		0.38			
32	0.30		0.30			
33	0.23		0.26			
34	0.23	1.65	0.30	1.87	98.7	1.3
35	0.22		0.26			
36	0.17		0.17			
37	0.13		0.16			
38	0.11		0.17			
39	0.09	0.72	0.12	0.88	99.58	0.42
40	0.08		0.12			
41	0.07		0.06			
42	0.04		0.05			
43	0.04		0.06			
44	0.03	0.25	0.02	0.31	99.89	0.11
45	0.02		0.03			
46	0.01		0.01			
47	0.01		0.01			
48	0.02		0.03			
49	0.01	0.08	0.01	0.09	99.98	0.02
50	0.01		0.01			
51-70	0.044	0.044	0.02	0.02	100	

11.5.2 Supporting Studies

11.5.2.1 Current Population Survey

The Bureau of Labor Statistics (BLS) collects extensive information on the U.S. labor force through the ongoing Current Population Survey (CPS). The CPS is a monthly survey of about 60,000 households that provides data on the labor force status, demographics, and other characteristics of the civilian noninstitutional population ≥16 years of age. One part of the survey includes questions about employee tenure, which is a measure of how long workers had been with their current employer at the time of the survey (BLS, 2008a). Information on employee tenure has been obtained from supplemental questions to the current CPS every two years since 1996. The percent distribution by tenure with current employer is shown in Table 11.5. The data refer to the sole or principal job of full- and part-time workers. All data exclude the incorporated and unincorporated self-employed.

Table 11.5 Distribution of Employed Wage and Salary Workers by Tenure with Current Employer and Age, Males and Females Combined, January 2008 From BLS CPS

Age Group (yrs)	Number employed (in thousands)	Percent Distribution by Tenure with Current Employer							
		≤12 mo	13 to 23 mo	2 yrs	3 to 4 yrs	5 to 9 yrs	10 to 14 yrs	15 to 19 yrs	≥20 yrs
≥16	129,276	22.9	7.4	5.6	16.9	20.2	10.6	6.2	10.3
16-19	5,200	73.8	11.5	7.5	7.0	0.3	- [a]	-	-
≥20	124,076	20.8	7.2	5.5	17.3	21.0	11.0	6.4	10.7
20 - 24	13,139	49.9	13.2	10.2	20.4	6.4	<0.05	-	-
25 - 34	29,097	28.2	10.4	8.5	23.4	23.5	5.4	0.6	<0.05
35 - 44	30,150	17.1	6.6	4.8	18.1	25.5	15.3	8.2	4.5
45 - 54	30,151	12.9	4.4	3.5	13.7	21.6	14.4	9.9	19.4
55 - 64	17,242	9.4	4.3	2.6	11.2	19.7	14.1	10.9	27.8
≥65	4,297	8.9	2.5	2.8	10.6	18.9	16.6	10.4	29.2

[a] Dash represents zero or rounds to zero.

The tenure question in the CPS was designed specifically as a gauge of employment security. Tenure durations beyond 20 years were not computed for Table 11.5, possibly due to the definition of a “lifetime” job lasting at least 20 years by Hall (1982). Thus, longer tenure employment statistical analysis was not considered necessary.

The BLS also presented longitudinal data for median employee tenure by age over the years 1996 to 2008 (Table 11.6). Other distributional percentiles for this tenure data were not presented in the report.

Table 11.6 Median (50th Percentile) Years of Tenure with Current Employer for Employed Wage and Salary Workers by Age 1996 to 2008, Males and Females Combined, from BLS

Age Group (yrs)	1996	1998	2000	2002	2004	2006	2008
≥16	3.8	3.6	3.5	3.7	4.0	4.0	4.1
16 - 17	0.7	0.6	0.6	0.7	0.7	0.6	0.7
18 - 19	0.7	0.7	0.7	0.8	0.8	0.7	0.8
20 - 24	1.2	1.1	1.1	1.2	1.3	1.3	1.3
≥25	5.0	4.7	4.7	4.7	4.9	4.9	5.1
25 - 34	2.8	2.7	2.6	2.7	2.9	2.9	2.7
35 - 44	5.3	5.0	4.8	4.6	4.9	4.9	4.9
45 - 54	8.3	8.1	8.2	7.6	7.7	7.3	7.6
55 - 64	10.2	10.1	10.0	9.9	9.6	9.3	9.9
≥65	8.4	7.8	9.4	8.6	9.0	8.8	10.2

A number of factors can affect employee tenure, including the age profile among workers, type of occupation, and changes in the number of hires and separations with time. The most apparent effect on employee tenure is the age of the worker. As expected, length of tenure to one's employer is strongly related to the age of the worker. For example, in Table 11.6 the median tenure for employees age 55 to 64 in 2008 was 9.9 years, almost four times the tenure (2.7 years) for workers age 25 to 34. Younger working age participants tend to be a more mobile work force. Younger participants also have not accumulated enough working years with any one employer to be considered long-term tenured workers. As workers age, both job stability increases and the number of years since the worker initially began working increases resulting in more workers with jobs that will last 20 years or more.

An earlier study by Farber (1995) used the raw data from the CPS to calculate a distribution of employment-based job duration. Table 11.7 presents the median (50th percentile) and 0.9 quantile (90th percentile) results based on the 1993 CPS findings for tenure with current employer. Although the quantile job tenure results were generated in 1993, the longitudinal median tenure findings in Table 11.6 suggest there has been little change in the numbers since the 1990s.

Table 11.7 Median (50th Percentile) and 0.9 Quantile Job Tenure (in Years) with Current Employer in 1993, Males and Females Combined

Job Tenure Quantiles	Age Category (Years)			
	25-34	35-44	45-54	55-64
Median	3.2	5.8	9.5	12.4
0.9	9.7	17.5	25.2	31.5

The main limitation using the CPS to estimate occupational duration at a single location is that the job tenure question asks for years spent with current employer (i.e., the job is still in progress), rather than completed job duration where there is a start and end date. However, the survey covers the entire span of working years from age 16 to 70+ years. In particular, the oldest groups of participants represent those workers at or near retirement age with a full work history. In addition, Nardone et al. (1997) observed that similar job tenure percentiles were obtained when comparing young workers from both the CPS and NLSY79 surveys (see below).

Comparison of this survey with the SIPP shows that for the first 20 years of employment beginning at age 15 or 16 years, the tenure percentages are almost identical. The CPS shows that 10.3 percent of participants beginning at age 16 are still with their current employer after 20 years. The SIPP (Table 11.4) estimates 10.54 percent of participants are still with their current employer after 20 years.

11.5.2.2 National Survey of Youth 1979

The BLS also collects employment duration data from a separate survey called the National Survey of Youth 1979 (NLSY79). A unique feature of this survey is that it collects the beginning and ending dates of all jobs held by a respondent so that a longitudinal history can be constructed of each respondent's work experience. The NLSY79 is a nationally representative sample of 12,686 young men and women who were 14 to 22 years of age when first surveyed in 1979. The estimates in the current release of data for 2006-2007 contain the first 22 rounds of the survey since 1979 (BLS, 2008b).

The respondents in the NLSY79 are still relatively young, ages 41 to 50 in 2006-07. As the cohort continues to age, information that is more complete will become available. Thus, the current release covers only the period while the respondents were ages 18 to 42; older participants in the study are not included because sample sizes were still too small to provide statistically reliable estimates for age groups >42.

As part of the NLSY79, the duration of employment with a single employer for all jobs started from age 18 to 42 in 1978-2006 is estimated. A job is defined in the survey as an uninterrupted period of work with a particular employer. Jobs are therefore employer-based, not position-based. However, if a respondent indicates that he or she left a job but in a subsequent survey returned to the same job, it is counted as a new job.

Individuals were surveyed annually from 1979 to 1994 and biennially since 1994. In 2006-07, 7,654 individuals responded to the survey, for a retention rate of 77 percent. Only these individuals are included in the estimates in this release. All results are weighted using the 2006-07 survey weights that correct for the oversampling, interview nonresponse, and permanent attrition from the survey. When weighted, the estimates represent all persons born in the years 1957 to 1964 and living in the U.S. when the survey began in 1979 (Table 11.8). Not represented are U.S. immigrants who were born from 1957 to 1964 and moved to the United States after 1979.

Table 11.8 Duration of Employment Relationships with a Single Employer for All Jobs Started from Age 18 to Age 42 in 1978-2006 by Age at Start of Job

Age Group (yrs)	Cumulative Percent Distribution of Duration of Completed Employment Relationships					Percent of jobs ongoing in 2006
	<1 yr	<2 yrs	<5 yrs	<10 yrs	<15 yrs	
18 - 22	72.3	85.2	94.1	97.1	98.0	1.3
23 - 27	59.2	75.9	88.8	94.0	95.7	3.5
28 - 32	52.5	69.7	85.5	91.6	93.6	6.2
33 - 37	42.8	60.7	80.6	88.2	88.9	11.1
38 - 42	30.5	46.6	65.1	ND	ND	30.2

ND - No data. Estimates are not presented for these categories because most sample members were not yet old enough at the time of the 2006-07 survey to have completed jobs of these durations.

Unlike the CPS results, the job duration data in the NLSY79 report are based on starting and ending dates for jobs with a single employer. A limitation of the data is that the survey is still ongoing. Hence, some of the numbers in Table 11.8 will change as the survey is periodically updated, particularly for the most recent findings. Presumably, additional information will also be available for long-term employment in future surveys (i.e., duration of completed employment 15 to <20 yrs).

11.5.2.3 Comparison of the CPS and the NLSY79

Job durations the CPS report were compared by Nardone *et al.* (1997) with a similar cohort of individuals from the NLSY79 data as a yardstick to examine the quality of the CPS data. Specifically, the most recent job tenure data from the NLSY79 28- to 36-year old workers collected in 1993 were compared to the CPS findings for the same age group. Despite the differences in data collection methods between the CPS and NLSY79, the differences in the job tenure distributions were quite small (Table 11.9). Little difference is found at the 90th percentile, with CPS job tenure registering 11.22 years and that of the NLSY79 11.13 years. Overall, Nardone et al. (1997) concluded that the CPS data appear to provide an adequate approximation of the tenure distribution among young workers.

Table 11.9 Distribution of Years of Tenure Among 28- to 35-year old Workers, Current Population Survey (CPS) and National Longitudinal Survey of Youth 1979 (NLSY79), Males and Females Combined

Job Tenure Quantiles	Percentile				
	10th	25th	50th	75th	90th
CPS	0.04	1.04	3.34	7.00	11.22
NLSY79	0.37	1.13	3.46	7.03	11.13

11.6 Individual Resident Cancer Risk vs. Residential Population Risk

A threshold dose for cancer risk for almost all carcinogens cannot be established. Therefore, risk managers must establish a cancer risk that is considered acceptable or de minimus through the political process. Most risk assessments estimate cancer risk at the worker point of maximum exposure (Maximum Exposed Individual Worker or MEIW) and the residential point of maximum exposure (MEIR). This ensures that individual risk is measured at the point with the estimated highest air concentrations of cancer-causing chemicals. The acceptable risk level for individual cancer risk varies in different Federal and State programs from 1×10^{-6} to 1×10^{-4}. In the Hot Spots program, a 1×10^{-5} level for notification is a common standard for the Air Districts. The District may have different levels for permitting, or requiring additional pollution control devices for existing facilities.

The previous OEHHA recommendation of estimating cancer risk for a 70-year residency as a default is health protective for individual risk and provides a degree of population risk public health protection as well. Basing risk management on the cancer risk estimated for a 70 year exposure duration helps reduce the chances a person will experience a cancer risk greater than the acceptable limit (e.g., 10^{-5}) if he or she moves within the isopleths of another similar-risk facility. However, a 70-year residency default also confuses the two concepts of individual risk and population risk. The cancer potency factors are based on the risk to a population, either the population of workers in an occupational study or a population of animals. Yet it is applied to a person or a few people living at the estimated point of maximum impact (the MEI). On the other hand, whether or not a single person is residing at the MEI location over 70 years, there is an assumption in considering population risk that someone will always be living at the MEI location. Thus, in terms of population risk it is irrelevant that the risk at that location is spread over different individuals over time (see discussion below of population versus maximally exposed individual risk).

The individual cancer risk approach has some inherent limitations in terms of protecting public health. A small facility with a single stack can impact a few individuals with an individual cancer risk that is unacceptable, whereas a large facility may have an individual cancer risk that is below the acceptable limit for individual risk but exposes many more people. This large facility can cause more potential cancer cases than the smaller facility and thus have a greater public health impact.

For large facilities with multiple sources such as refineries, ports or rail yards, the population impacts are the primary public health concern. A population risk metric is a better measure of the public health impact and efficacy of proposed control measures. For example, dispersal of repair operations with high diesel emissions in a rail yard will lower individual risk but will not impact population risk. Such a dispersal of operations would not affect the number of cancer cases that would be predicted, but would spread the risk over a larger number of people. Individual risk is a poor metric for progress in public health protection in this example.

To evaluate population risk, regulatory agencies have used the cancer burden as a method to account for the number of excess cancer cases that could occur in a population. The population burden can be calculated by multiplying the cancer risk at a census block centroid times the number of people who live in the census block, and adding up the cancer cases across the zone of impact. A census block is defined as the smallest entity for which the Census Bureau collects and tabulates decennial census information; it is bounded on all sides by visible and nonvisible features shown on Census Bureau maps. The centroid is defined as the central location within a specified geographic area (U.S. Department of Commerce, 1994).

The cancer burden is calculated on the basis of lifetime (70 year) risks. It is independent of how many people move in or out of the vicinity of an individual facility. The number of cancer cases is considered independent of the number of people exposed, within some lower limits of exposed population size, and the length of exposure (within reason). If 10,000 people are exposed to a carcinogen at a concentration with a $1X10^{-5}$ cancer risk for a lifetime the cancer burden is 0.1, and if 100,000 people are exposed to a 1×10^{-5} risk the cancer burden is 1.

There are different methods that can be used as measure of population burden. The number of individuals residing within a 1×10^{-6}, 1×10^{-5}, and/or 1×10^{-4} isopleth is another potential measure of population burden (OEHHA, 2003).

11.7 Factors That Can Impact Population Risk – Cumulative Impacts

Although the Hot Spots program is designed to address the impacts of single facilities and not aggregate or cumulative impacts, there are a number of known factors that influence the susceptibility of the exposed population and thus may influence population risk. Socioeconomic status influences access to health care, nutrition, and outcome after cancer diagnosis. Community unemployment can affect exposure and residency time near a facility. Factors that affect the vulnerability of the population are discussed in the report *Cumulative Impacts Building a Scientific Foundation* (OEHHA, 2010). Information on many of these factors is relatively easy to obtain on a census tract level. The OEHHA recommends that these types of factors be considered by the risk manager, along with the quantitative measures of population risk. OEHHA is in the process of developing guidance on quantification of the impact of these factors.

11.8 Cancer Risk Evaluation of Short Term Projects

The local air pollution control districts sometimes use the risk assessment guidelines for the Hot Spots program in permitting decisions. Frequently, the issue of how to address cancer risks from short term projects arises.

Cancer potency factors are based on animal lifetime studies or worker studies where there is long-term exposure to the carcinogenic agent. There is considerable uncertainty in trying to evaluate the cancer risk from projects that will only last a small fraction of a lifetime. There are some studies indicating that dose rate changes the potency of a given dose of a carcinogenic chemical. In others words, a dose delivered over a short time period may have a different potency than the same dose delivered over a lifetime.

The OEHHA's evaluation of the impact of early-in-life exposure has likely reduced some of the uncertainty in evaluating the cancer risk to the general population for shorter-term exposures, as it helps account for susceptibility to carcinogens by age at exposure (OEHHA, 2009). Thus, we have recommended for short term exposures that the risk assessment start at the third trimester for cancer risk calculation.

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