

7.0 Risk Assessment for OP Pesticides and Results

Inputs

An assessment of the risks from the OP Pesticides was performed using the input files discussed in chapters 2.0, 3.0, 4.0, and 5.0 of this assessment with Version 2.0 of LifeLine™ Software. When running LifeLine™ Version 2.0, the user is prompted to make a number of decisions about how the model will operate, which sources will be assessed, which of the model outputs should be saved. These prompts occur in the “Analysis Preference” page and tabs. Details about these functions and their implications for the exposure/risk characterizations can be found in the Technical Manual provided with the LifeLine™ Software.

In the analysis of the OP pesticides, unless specified otherwise, the following options were selected:

- 10,000 individuals were simulated;
- The “evaluate full lives” was selected and the appropriate maximum age was entered;
- Reset Random Number Seed for each Person box is checked;
- CSFII Survey year was 94-96, 98;
- Water Consumption type was “all municipal water”;
- CSFII weights were not used;
- Probability that application preceded activity in microenvironment was set at 0.5;
- Probability that indoor applicator is adult female was set at 0.7;
- Probability that outdoor applicator is adult female was set at 0.3;
- Time playing with pet was set at 1 hr/day¹;
- Residence room length to width ratio was set at 2:3; and
- Residence halls and closets’ length to width ratios were set at 1:10.

Results

The following presentation of the results is intended to highlight some of the significant findings of the assessment. LifeLine™ produces exposure or risk assessments representative of the general US population. Therefore, a single national distribution is produced that reflects regional variation in residential and tapwater exposures. In addition, the findings are presented using a number of complementary measures of exposure and risk that together provide considerable insight into the nature of risks presented by the OP pesticides. However, this section does not

¹ As discussed in Section 5.0 an internal adjustment factor converts this value to a range of time spent with a pet.

claim to be an exhaustive presentation of analyses that are possible with LifeLine™ and the available data. One of the purposes of this report is to present the options for characterizing exposure and risk so that any interested individual can use the input files and LifeLine™ software to perform their own analyses.

The assessment begins with a discussion of the stability of the outputs. Then, the model's predictions for the effect of age and season on the cumulative OP dose (in Methamidophos equivalents) are presented. These predictions are used to identify key ages for more detailed inspection. Then the risks from the total cumulative doses for the key ages are presented. Once the total risks are presented, a drill down of the risks is performed using the ability of LifeLine to model route and source specific risks. Finally, a discussion of the effect of averaging time and seasonality on the risk estimate is presented.

Model Stability

When using probabilistic models it is important to define the stability the model's outputs. Model outputs will vary from run to run because of the probabilistic techniques employed in the model. The size of the variation will be determined by the number of iterations performed and by the inter-individual variation intrinsic to the parameters considered in the analysis.

The exposure or risk outputs are distributions of exposure or distributions of risk for the selected population. Estimates of the mean or median values in those distributions will tend to be more stable than predictions at the tails of the distribution, such as the 99.9th percentile. In order to investigate the stability of the outputs of the LifeLine™ Cumulative Risk Assessment for OP Pesticides, the model was run six times, using 10,000 iterations² per run. The values for select percentiles of the distribution of the random day Margin of Exposure (MOE) from the total exposures were determined for all two- year olds. As discussed in Chapter 6.0 a single random day is selected from the two-year old portion of each individual's exposure history. Thus, there are 10,000 random day measurements for two year olds. The results of these runs are presented in Table 7.1.

²An iteration in the LifeLine Software is one individual for which exposure and risk is calculated by source, route, as well as total of all sources and routes per day for every day of that individual's life. Thus, 10,000 iterations create a population of 10,000 individuals.

Run	Percentile		
	50	99	99.9
1	23000	360	23
2	24000	350	26
3	23000	360	25
4	25000	340	30
5	25000	320	33
6	24000	340	29
Coefficient of Variation	0.037	0.044	0.13

The values of the MOE’s at these percentiles are relatively constant but do vary from run to run. As expected, the coefficient of variation for the estimates increases as the percentiles increase. The six replicate values at the 99.9th percentile have a coefficient of variation of 0.13. Based on this finding, the values of the MOE’s at the higher percentiles are meaningful only to one significant figure.

Identification of Ages and Seasons of Interest

For each individual in the simulated population LifeLine™ calculates total (and route-dependent and source-dependent) exposures for each day. For each person, the assessment retains selected values for each season of life (seasonal average, maximum for the season, or a random value occurring during the season). Thus, for each season at each age, LifeLine™ can present a distribution of these exposures across the population (for that season at that age). The assessor can then view the population average total and source-specific exposures (or risk) for each season and age across all ages in the population. This can be done to view seasonal averages, seasonal maximums, or random days for each season. Ages are not combined into general age groupings. This allows the user to determine whether the exposure characteristics at any one age are of particular interest. Figure 7.1 presents the variation of the average seasonal exposure by age and season in 1000 individuals.

Figure 7.1 Effect of Age and Season on Average Food, Residential, Tapwater and Cumulative Doses

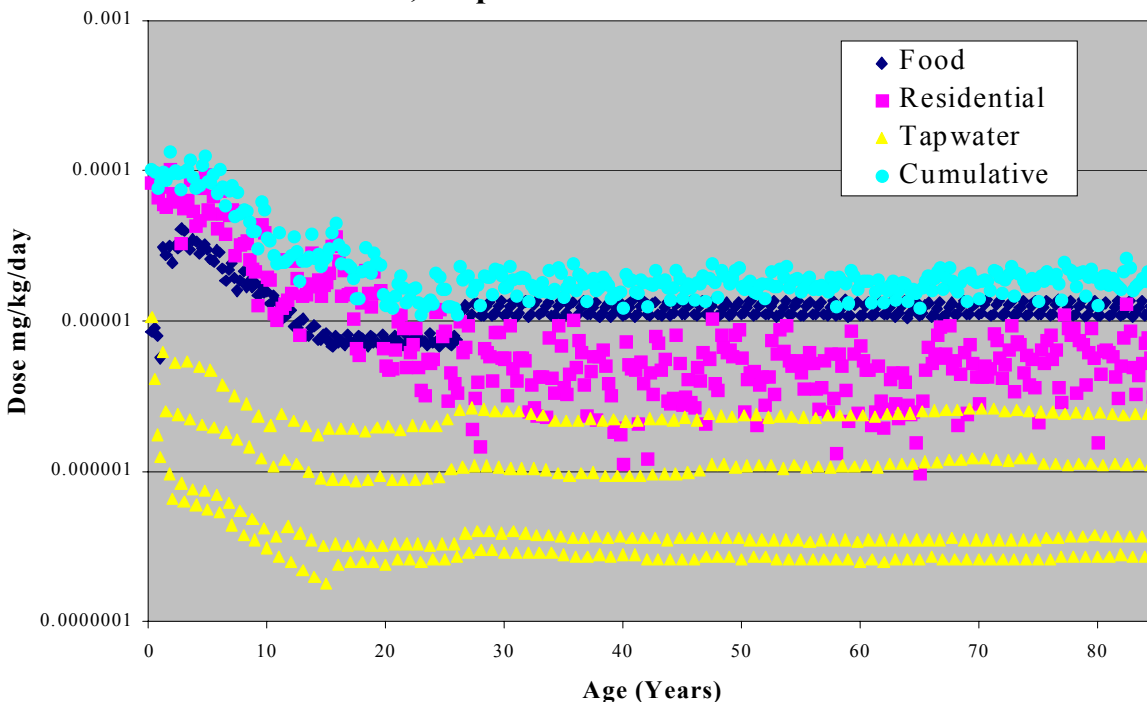


Figure 7.1 provides a number of insights into the variation of total exposure to OPs. The food and tapwater exposures (expressed per kg body weight) are higher for children than for adults. However, the age with the highest source-dependent exposure varies. Two-year olds have the highest average food exposure per unit body weight. Children below the age of one have the highest average tapwater, residential and total exposures. After age 27, there is very little age-dependent variation in exposure.

Figure 7.1 also presents the seasonal variation in the exposures. Where a source of exposure varies with the season, exposures will show a regular pattern of variation. This pattern is very evident in this assessment for tapwater, with the highest exposures occurring during spring and summer. This suggests that investigating the tapwater exposures that occur during the spring will be important.

While much smaller, there is also a regular pattern evident in the exposures from food. This occurs though the same residues are being modeled as if they were occurring year round (see Chapter 3.0). The variation in exposure is occurring because children and adults eat more foods containing OP residues in the fall than in the spring. Exposures from residential exposures to OP pesticides did not suggest any seasonal pattern.

In summary, LifeLine™ Version 2.0 does not predefine the age groups and seasons that are to be investigated. Instead the user determines the age and seasons that are of most interest to the decisionmaker. For the EPA and the assessment of cumulative risk of OP pesticides, that interest is focused to times at which individuals are at most risk, and to those sources dominating the contributions to those risks.

Based on Figure 7.1, three ages have been chosen for detailed examination in this report: ages <1, 2 and 28. Age <1 will be examined because it had the highest average tapwater and residential exposures³. Age 2 will be examined because it had the highest food exposures. Finally age 28 will be examined which is representative of all ages >27 and because it includes the doses that result from exposures to the adult residential applicator.

Calculation of Margins of Exposures (MOE) for Total Daily Exposures for the Selected Age Groups Using Different Analysis Options

The estimate of the Margin of Exposure (MOE) for an individual at a given age, and for the distribution of the MOEs for a population of that age, will vary depending on the type of exposure output used. In this report two types of exposure output were investigated, the random day and the annual (or in some cases the seasonal maximum). In the following figure, the MOEs are based on the random day exposures. This option generates the distribution of the total exposures on a randomly selected day from each of the three years <1, 2, and 28. See Chapter 6.0 for additional discussion of this output of LifeLine™. Figure 7.2 presents the MOEs calculated from these total daily exposures (random annual day) for the top 10 percent of the population for each of the three age groups. The figure shows that the top 1% (the 99th percentile) of children ages <1 and 2 have MOEs of less than 100. In contrast, for adults age 28 the MOEs at the 99.9th percentile are greater than 100. The <1-year olds have MOEs slightly lower than the two-year olds. However, this difference may not be significant.

Figure 7.3 presents the distribution of MOEs for the top 10 percent of the population at each of the three age groups; however, this distribution uses a second and complementary characterization of risk, the maximum day MOE. As discussed in Chapter 6.0 the maximum annual exposure MOE is the MOE associated with the highest total daily dose that occurs to an individual on any of the 365 days of the year. As the figure shows, at least 10% of the population of any of the three ages will have a MOE that is < 100 on at least one day of the year.

³The use of dose in the selection of the critical ages is only a guide since other factors such as the route specific point of departures may make doses that occur from certain sources more important than other sources.

Figure 7.2 Distribution of Total MOEs at Three Ages <1, 2, and 28 (Random Day)

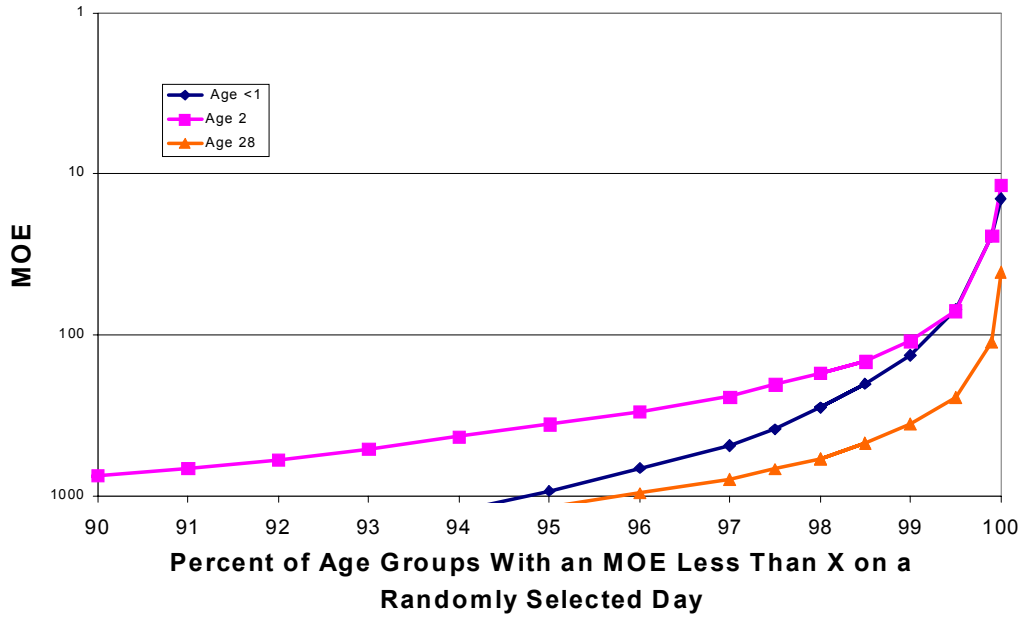
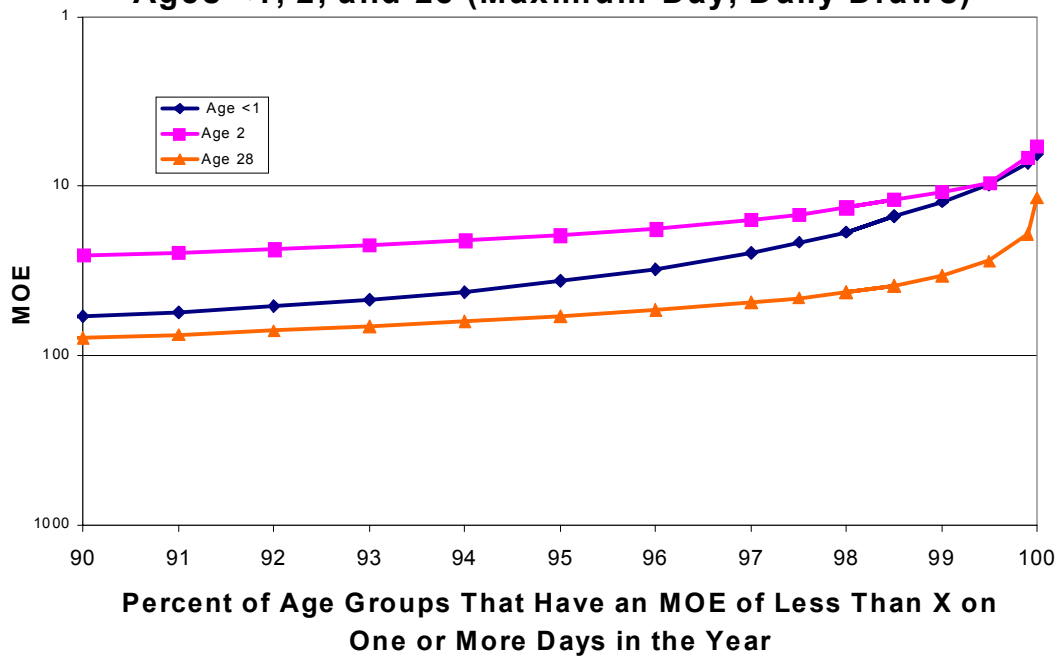


Figure 7.3 Distribution of Total MOEs at Three Ages <1, 2, and 28 (Maximum Day, Daily Draws)



Characterizing the Uncertainty in the Maximum Annual Risk Estimates Caused by a Lack of Longitudinal Data

Estimating the maximum daily total dose for an age group requires the model to predict the longitudinal pattern of a person's exposures over time (longitudinal exposures). Data employed by the LifeLine™ model to describe daily activities and eating patterns are derived from studies that measured these parameters for many people over single days, not from longitudinal studies where the diet or activities of the same individuals are monitored over many days (or a year). These data are arranged by the model to simulate the individual's consumption over time. Details of these techniques are contained in the Technical Manual for LifeLine™ that accompanies the software.

The lack of longitudinal data for both the dietary record and daily activity patterns introduces uncertainty to the exposure assessment. A perspective on the size of this uncertainty can be obtained by taking two different approaches for modeling longitudinal exposures. One approach is to hold a dietary intake record steady for an individual for an entire season (Seasonal Draw) but drawing new residue values daily from the full distribution of residues that could be on the foods in that record. This assumes that a person could eat the same diet for every day of the season, but the foods could contain different levels of the pesticide. In addition under this approach, two activity patterns are selected (one for week days and one for weekend days). These records are repeated for each week day and weekend day of the season. Thus, the child performs the same weekly cycle of activities throughout the season with only the residues on residential media varying.

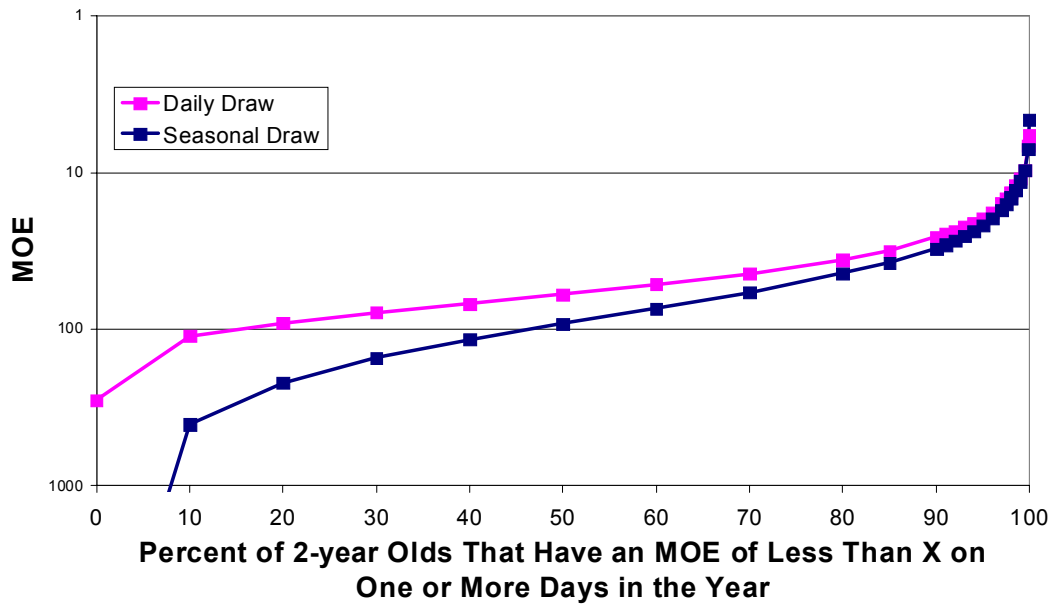
The second approach is to choose a different dietary record on every day (Daily Draw). Under this option a new dietary record and activity pattern is drawn every day. This assumes that the person chooses a unique diet every day, uninfluenced by the menu from the day before (no leftovers) and a new activity pattern. Additional information on the two options can be found in the LifeLine Technical Manual.

Neither of these approaches represents a fully plausible model of an individual's longitudinal behavior. However, the first approach will tend to underestimate the daily variation of an individual since the daily diet and activities will be held constant for long periods of time. The second approach will tend to overestimate variation since it will include both inter day variation and inter individual variation. If the difference between the results produced by the two scenarios is small, it suggests that the uncertainty due to the lack of longitudinal data is likely to be small.

Figure 7.4 presents the distributions of the MOE associated with the maximum daily exposure for two-year olds using the Seasonal and Daily Draw. As the figure shows, there are some differences between the two distributions; however, the differences at the upper percentiles are small. This suggests that the absence of longitudinal data does not change the finding that a substantial fraction of the 2 year olds will have an MOE of less than 100 during one or more

days of a year.

Figure 7.4 Effect of Daily and Seasonal Draws on the Distribution of Maximum Total MOEs at Age 2



Because, the two-year old age group had doses similar to the <1 age group and were higher than the 28 year olds and because the doses from food were the highest in the two-year age group, the remainder of the analyses in this report will focus on the population of two-year olds. The findings in these sections will not necessarily be applicable to other age groups.

Seasonality and the Total MOEs in Two-year Olds

Figures 7.5 and 7.6 present the variation in MOEs calculated for the two-year olds’ total daily exposure calculated from either the random day or maximum day. As the figures show there is little indication of seasonal variation. However, as shown in figure 7.1, the dominant source of exposure for children was residential which did not have a strong seasonal correlation. Thus, seasonality will also be addressed in the analysis of the risks from the food and tapwater sources of exposure (see below).

Figure 7.5 Effect of Season on Total MOEs at Age 2 (Random Day)

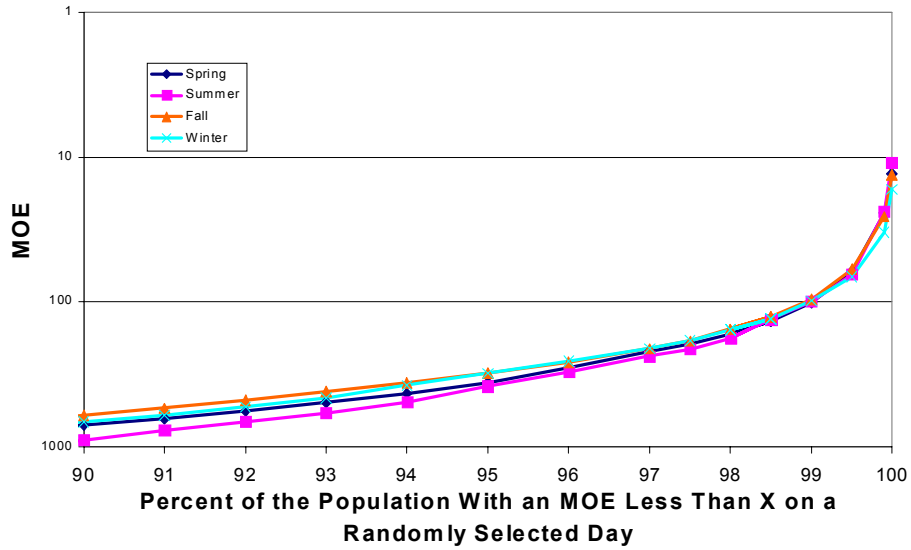
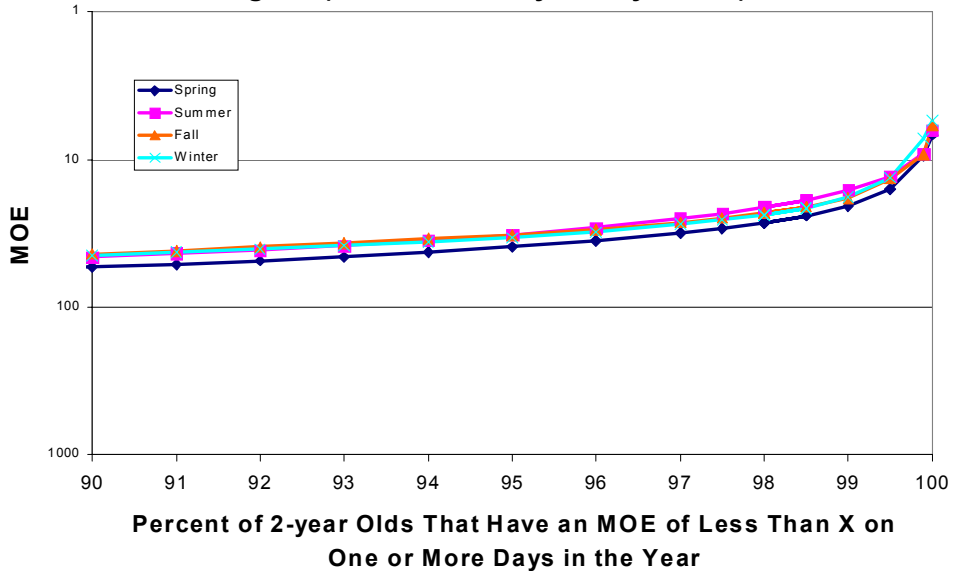


Figure 7.6 Effect of Season on Total MOEs at Age 2 (Maximum Day, Daily Draw)



Determination of Source and Route Contributions to the Total MOE for Two-year Olds

LifeLine tracks both the total MOE (MOE corresponding to the total daily exposure) and the MOEs that occur by each of the three routes of exposure (oral, dermal, and inhalation) and the three sources of exposure (food, tapwater, and residential exposure) for each individual.

Figures 7.7 and 7.8 present the contributions of the three routes of exposure for two-year old children during the fall using the random day and maximum day MOE. For this population the oral MOEs reflect the exposures from food, tapwater, and incidental hand to mouth contact with residues on turf. The dermal MOEs represent the does from dermal contact with residues on turf. The inhalation MOEs are due to indoor inhalation exposure from DDVP pest strips.

Figure 7.7 Route Specific and Total MOEs for Age 2 - Fall (Random Day)

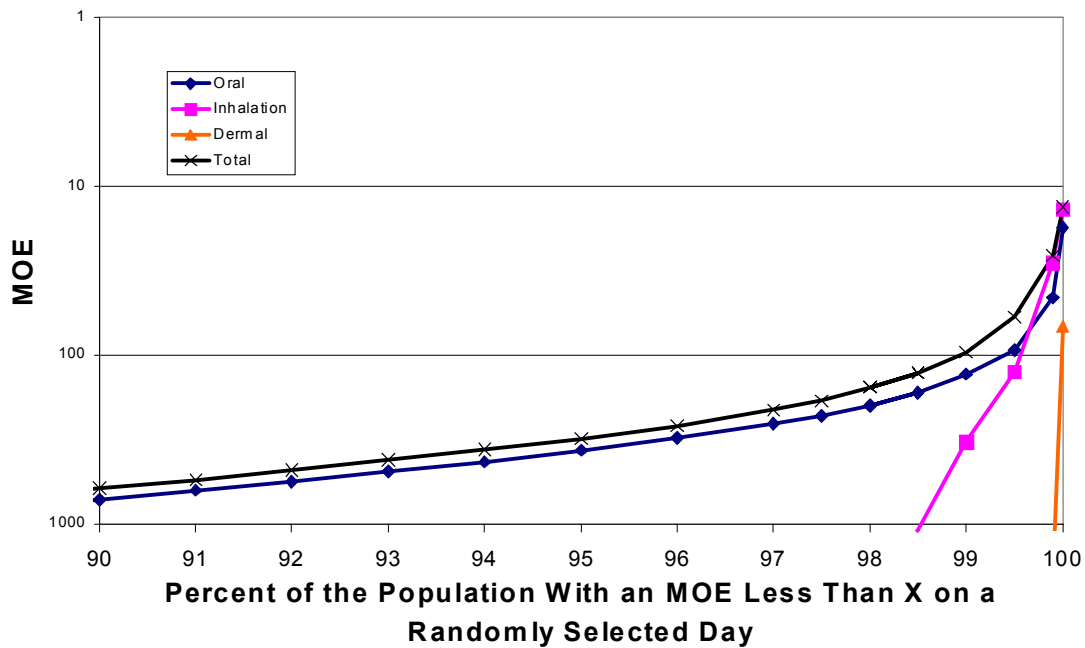
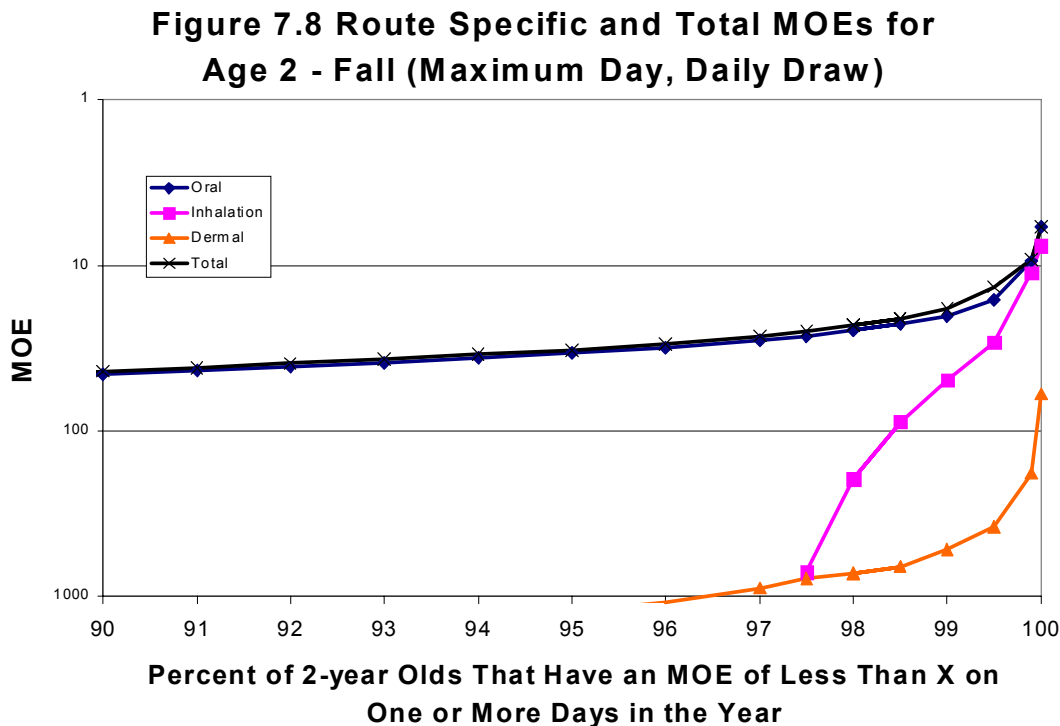


Figure 7.7 shows that in two-year old children, both oral and inhalation exposures will result in some portion of the population having random day MOEs of less than 100. Dermal exposures are lower and do not yield an MOE of less than 100, even at the 99.9th percentile of the population of two year olds.

Figure 7.8 shows route contribution for the maximum day MOEs in two-year old children. For the maximum annual day, the total exposure is dominated by exposures from the oral route but inhalation exposures also result in maximum day MOEs below 100. Dermal exposures are lower and do not result in a maximum day MOE less than 100 at the 99.9th percentile.

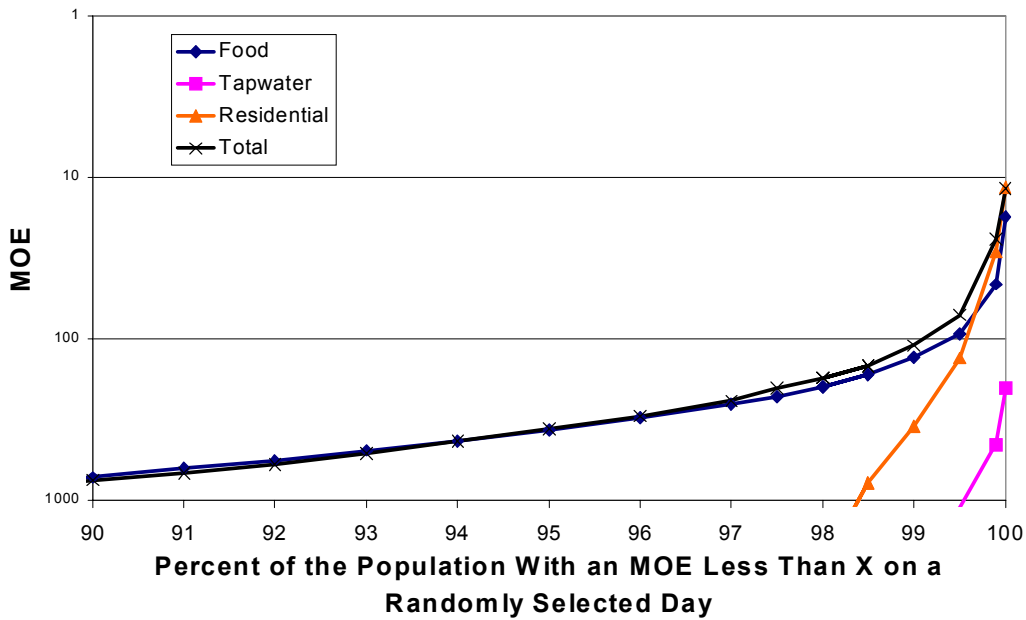


The MOEs from all three sources food, residential, and tapwater can also be plotted on the same graph to show the relative contribution that each source makes to the individual’s total exposure. Figures 7.9 and 7.10 present the source contribution to the total MOEs of two year olds for the random day and maximum day MOEs. The dominant exposure sources driving the MOE values are residential and food for analyses using random day or the maximum day. Tapwater has little impact on the Total MOEs in either type of analysis.

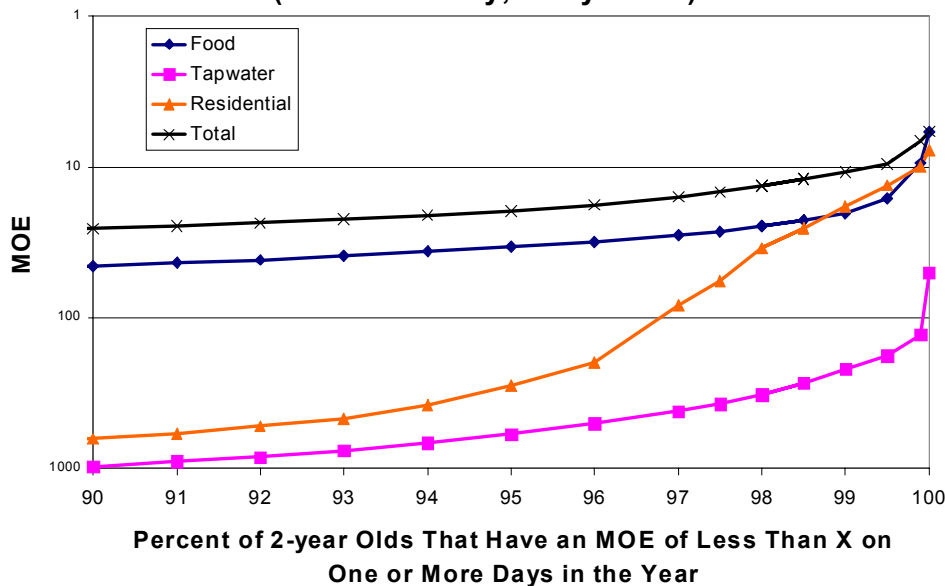
A comparison of figures 7.7 with 7.9 and 7.8 with 7.10 make it clear that food is the dominant source of the oral exposures and that inhalation is the dominant exposure route resulting from

residential sources of pesticide. Therefore, food and DDVP pest strips are the two sources of exposure that result in MOE values of less than 100, for either the random day or the maximum day MOE. Residential uses, other than pest strips, did not result in either random day or maximum day MOEs below 100 at the 99.9th percentile of the population of two-year olds. On an annual basis tapwater did not result in either random day or maximum day MOEs below 100 at the 99.9th percentile of the population of two-year olds. See the discussion of the seasonal variation in MOEs in the section below.

Figure 7.9 Source and Total MOEs for Age 2 (Random Day)



**Figure 7.10 Source and Total MOEs for Age 2
(Maximum Day, Daily Draw)**



Averaging Time Analyses: Impacts on MOEs and Inferences for Exposure Durations

LifeLine™ Version 2.0 allows the user to average the exposures across any duration of time between 2 and 365 days. This technique yields 365 exposure (or risk) values in a year, but each value represents an average of X continuous days of exposure. (Details of these options are contained in the Technical Manual that accompanies the software.) This technique permits consideration of two important scenarios.

First, it permits the assessor to produce exposure assessments for chemicals that express a toxicological endpoint only if exposure is maintained above a given level for some period of time. Short term peaks of exposure are not necessarily toxicologically significant. In these cases risk measures based on daily exposures are not necessarily meaningful. Therefore LifeLine allows the assessor to investigate the MOEs that would occur if the average dose over multiple days were used as the basis of the MOE.

A second reason for investigating doses over multiple days is to gain insight into the frequency of high exposures in an individual’s life. If one creates distributions of 1-day and 21-day and compares the results, the more similar the profiles, the more likely that peaks of exposure occur frequently. If they are very different, it is likely that any peak of exposure is infrequent. (The average across 21 days with one high peak will be quite different from the average across 21 days containing many days of high peaks).

In this section, doses for three averaging periods (7-day, 14-day, and 21-day) are estimated and used to calculate the corresponding MOE values. These values are presented along with the MOEs based on single day exposures. Figures 7.11 and 7.12 present the MOEs from random day and maximum day analyses using the single day and the three averaging times.

Figure 7.11 Effect of Increasing the Averaging Period on Total MOEs for Age 2 (Random Day)

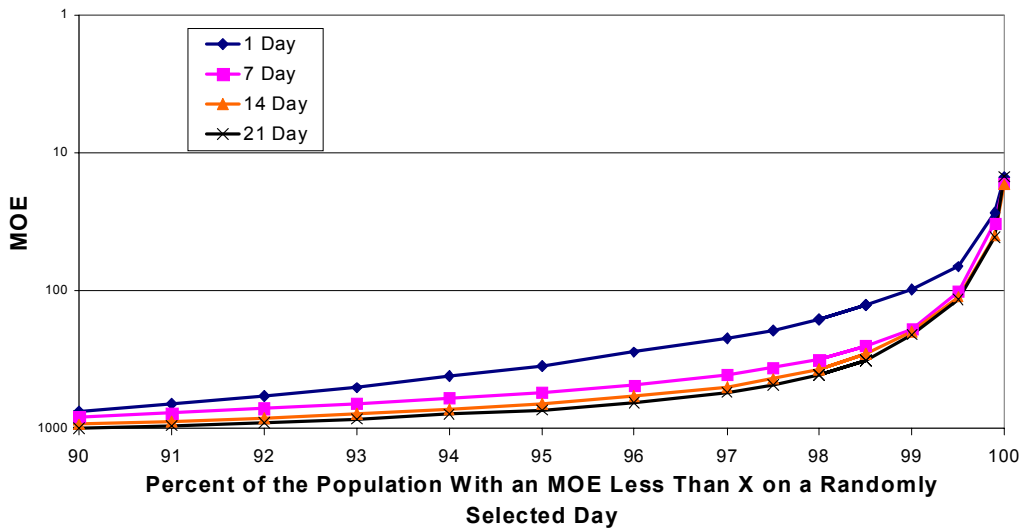
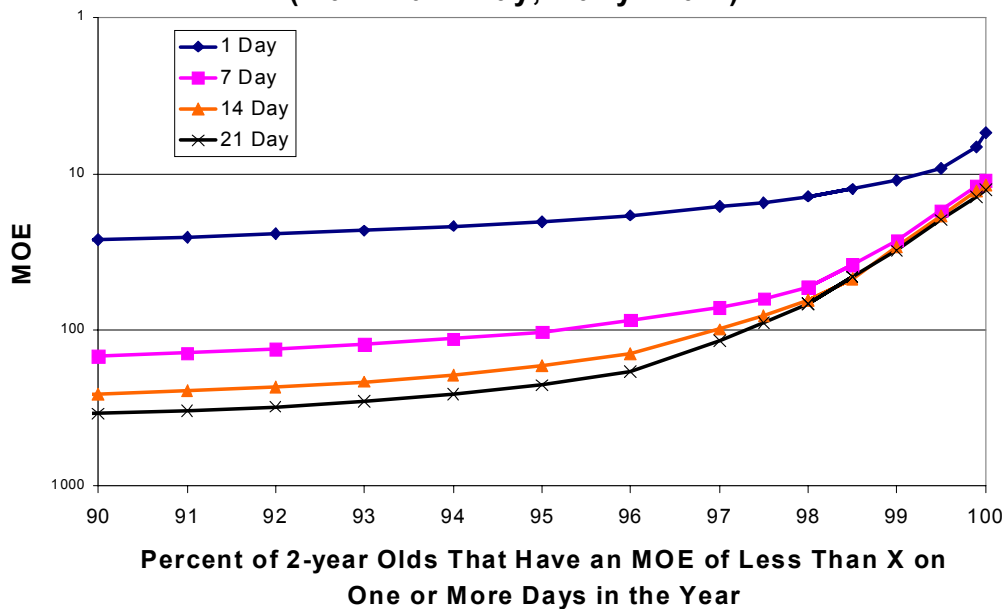


Figure 7.12 Source and Total MOEs for Age 2 (Maximum Day, Daily Draw)



In both figures, one can observe an increase in the MOEs as the length of the averaging times increases. The impact of the increased averaging time on the MOE is more pronounced for the analysis using maximum day than with the analysis using random day.

Also, the difference between MOEs from 1-day and 7-day average analyses are greater than the differences between the 7-, 14-, and 21-day averages. This suggests that within the total daily exposures, there are differences from day-to-day within a week, but also there are exposures that are constant over 21 days.

These findings can be explained by looking at the impact of increased averaging time on MOEs for each of the two major sources of exposure (food and pest strips) separately. Figures 7.13 and 7.14 show that there is a dramatic and continual increase in the MOEs with increased averaging time for the food exposures. Figures 7.15 and 7.16 present the impact of increasing the averaging period for residential exposures. In contrast to the food exposures, these figures that increasing the averaging period has little effect on the higher percentiles of the distribution of residential MOEs.

Figure 7.13 Effect of Increasing the Averaging Period on Dietary MOEs for Age 2 (Random Day)

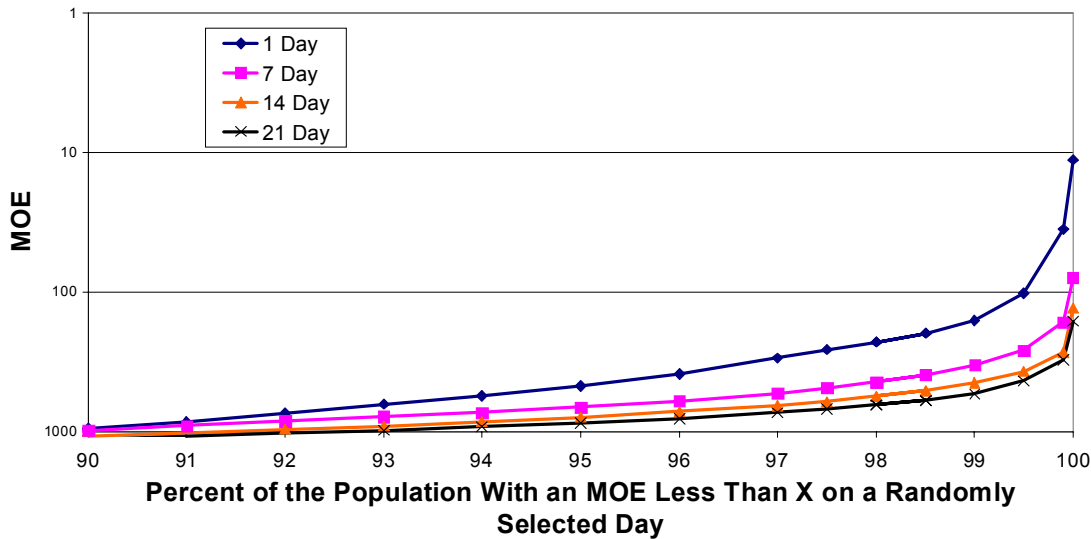


Figure 7.14 Effect of Increasing the Averaging Period on Dietary MOEs for Age 2 (Maximum Day, Daily Draw)

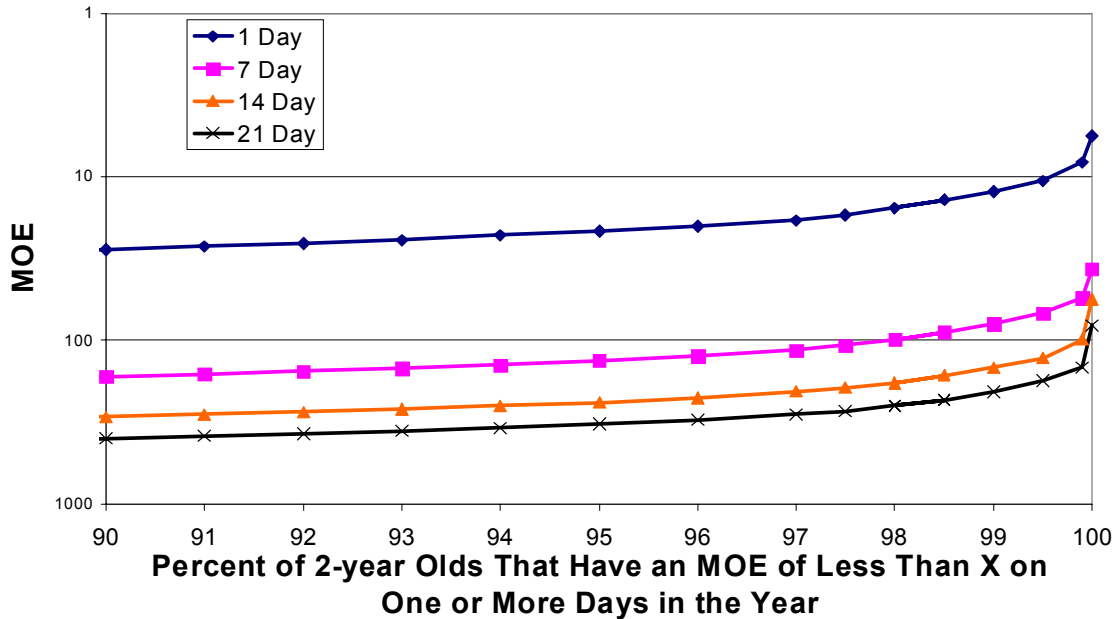


Figure 7.15 Effect of Increasing the Averaging Period on Residential MOEs for Age 2 (Random Day)

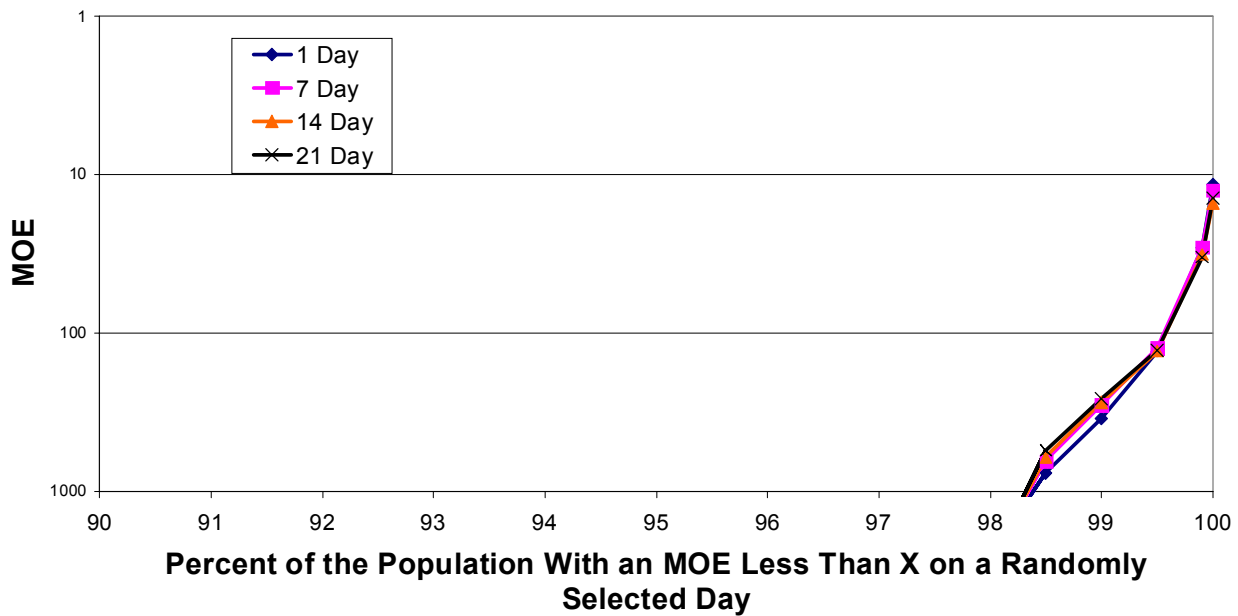
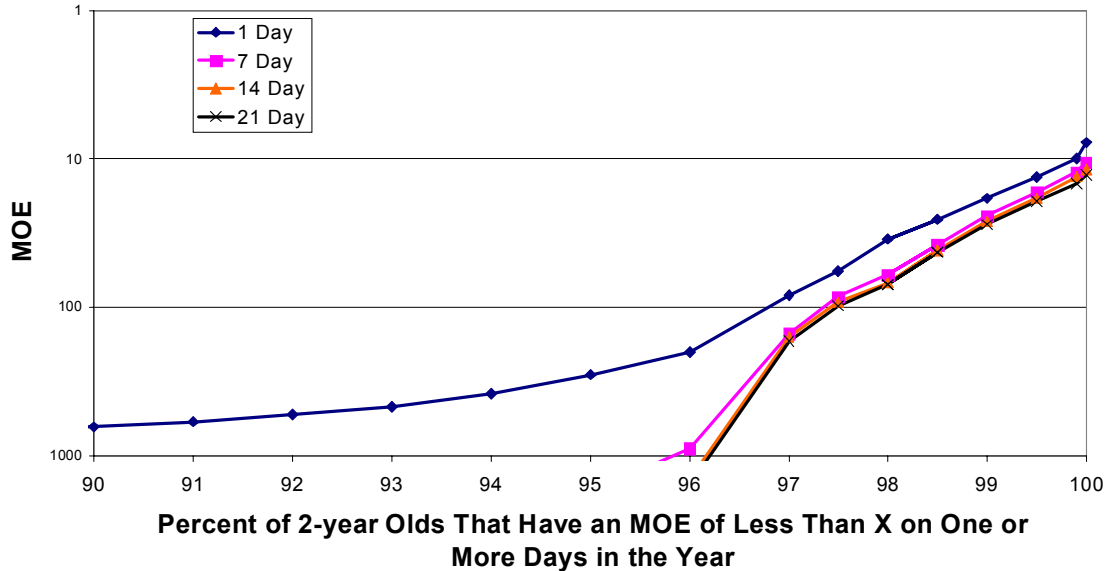


Figure 7.16 Effect of Increasing the Averaging Period on Residential MOEs for Age 2 (Maximum Day, Daily Draw)



Thus, considering the reason for the differences in MOE profiles as one changes the averaging duration can provide insight into the exposures associated with key sources of the exposure. Exposures from pest strips do not vary from day-to-day. Thus, there is little difference between the single day and a 21-day average exposure for the same individual. In contrast, food exposures do vary from day to day because of differences in the foods consumed and residue concentrations.

The derivation of longer term averages requires the modeling of longitudinal patterns of exposure. Since there are no dietary surveys tracking intakes over multiple consecutive days, LifeLine™ Version 2.0 allows the determination of the size of the uncertainty in the estimates of longer term averages by allowing two options for longitudinal modeling, daily sampling and seasonal sampling. (Chapter 3 also contains a discussion of these options.) Figures 7.13 and 14 are based on daily sampling that is likely to overestimate inter-individual variation. Figures 7.17 and 7.18 present the same averaging analyses for food exposure and risk using seasonal sampling. This approach is likely to underestimate longitudinal variation.

Figure 7.17 Effect of Increasing Averaging Period on Residential MOEs Age 2 (Random Day, Seasonal Draw)

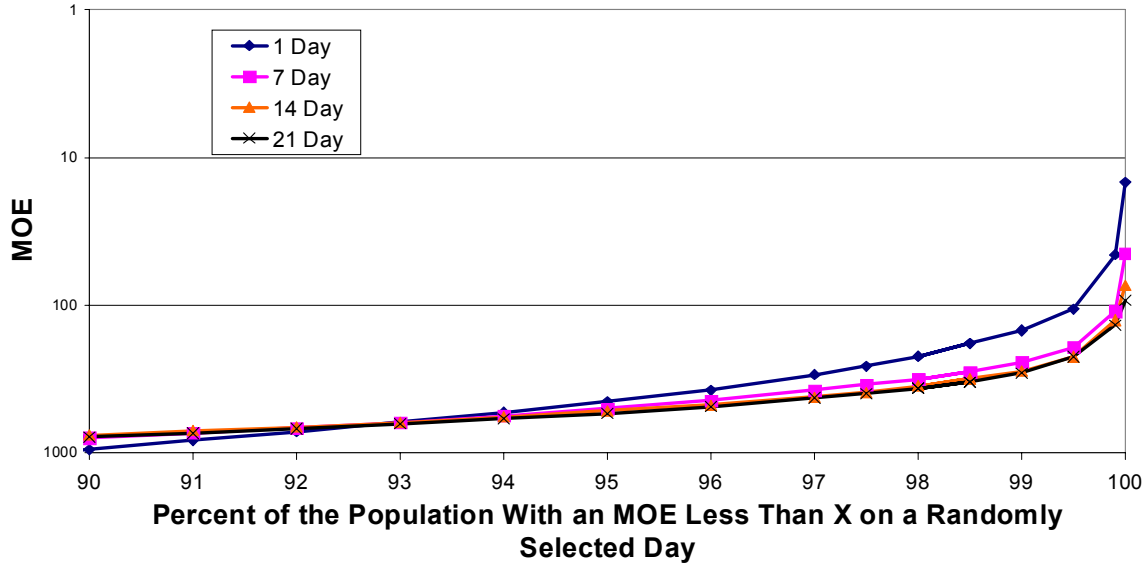
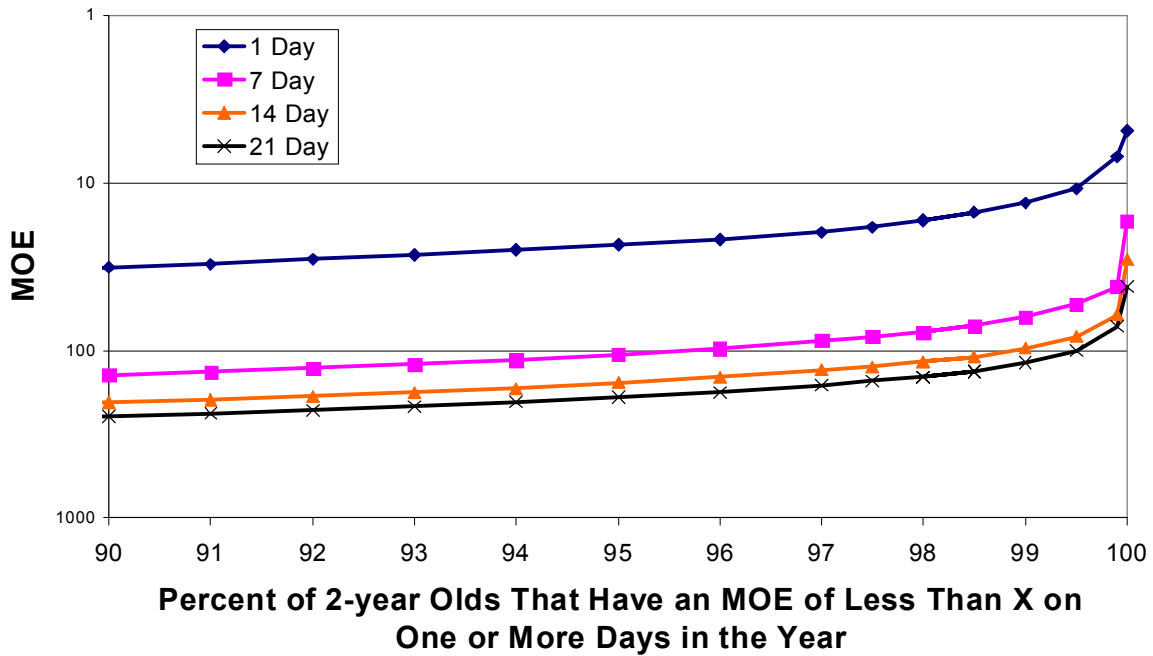


Figure 7.18 Effect of Increasing Averaging Period on Residential MOEs Age 2 (Maximum Day, Seasonal Draw)



A comparison of figures 7.13 with 7.17 and 7.14 with 7.18 shows that using the seasonal draw reduces the impact of increasing the averaging period but the reduction in the impact is not dramatic for this case (at most a factor of two.) Under either assumption, the random day 7-day average at the 99.9th percentile is greater than 100 and the maximum day 21-day average at the 99.5th percentile is greater than 100.

Seasonal Variation of Food and Tapwater Residues

As discussed above there is little demonstration of seasonal variation from consideration of the MOE's from total exposure (all sources). However, this is in part due to the lack of seasonal variation in the exposure from pest strips in the residence.

Figures 7.19 and 7.20 present the distributions of random and maximum day MOEs from food exposures during different seasons. Figure 7.19 shows only a slight variation with the season. However, this seasonal difference occurs at MOEs close to 100. Thus the difference suggests that the fraction of the population with an MOE of less than 100 will be larger in the fall. Figure 20 show a stronger seasonal effect on MOEs, with food exposures during the in the fall yielding MOEs about one third smaller than those from other seasons. As discussed in Chapter 3.0, the seasonal variation results presented in this analysis are due only to seasonal changes in diet, not seasonal changes in residues. Had seasonal changes in residues been considered, the seasonal variation in food exposure may have been larger.

Figure 7.19 Effect Season on Dietary MOEs Age 2 (Random Day)

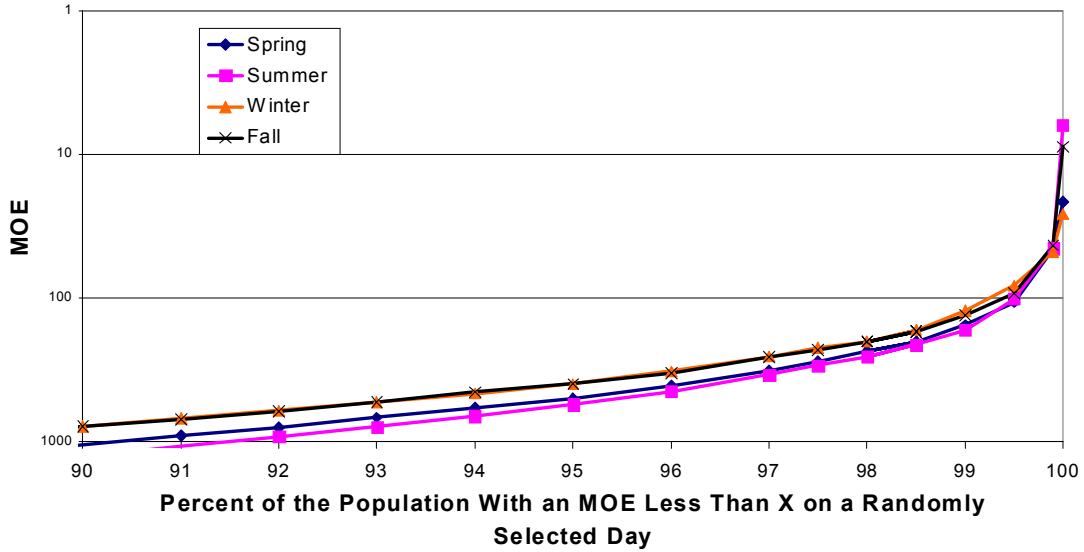
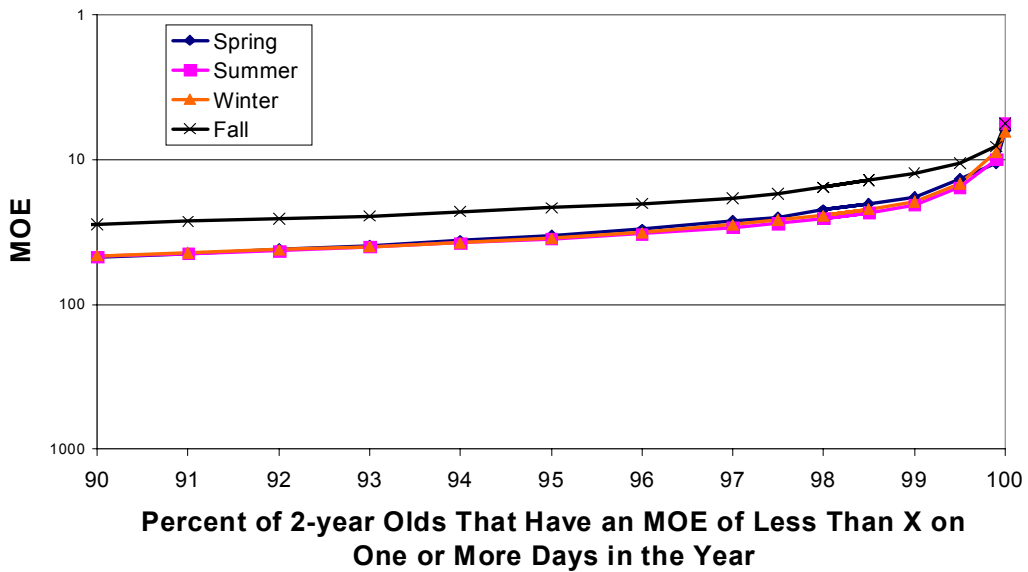


Figure 7.20 Effect Season on Dietary MOEs Age 2 (Maximum Day, Daily Draw)



Figures 7.21 and 7.22 present the distributions of random day and maximum day MOEs from tapwater exposures during different seasons. The variation in tapwater MOEs with the season was very significant with spring exposures resulting in MOEs that were more than 10 fold lower than fall MOEs. However, even in the spring, tapwater was not a concern on a national basis even during spring. While not investigated in this report, residues of pesticides vary from region to region in the nation. Had a regional analysis been performed, a different pattern of MOEs may have been identified.

Figure 7.21 Effect Season on Tapwater MOEs Age 2 (Random Day)

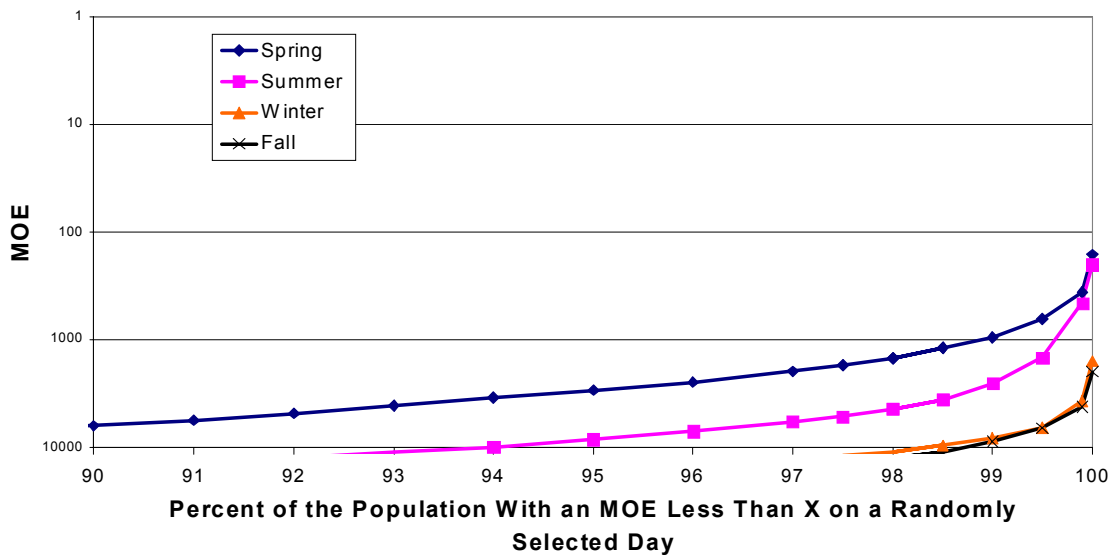


Figure 7.22 Effect Season on Tapwater MOEs Age 2 (Maximum Day, Daily Draw)

