

Thompson, 1992) will be applied to analyze the data. Confidence intervals on the estimate of the arithmetic mean will also be determined. The extent of new monitoring to be conducted will depend on a) the extent of existing data, b) its applicability to the job(s) of interest, and c) the variability of exposures and the desired precision of current estimates of mean exposures. These aspects will not be known until the field data collection is underway.

Job-Exposure Matrix (JEM) and Individual Subject Exposure Matrix. Many occupational exposure assessments for epidemiology applications have applied a job-exposure matrix design (Gamble and Spirtas 1976). A series of standard facility types and job titles and time periods are developed. Then, based on historic monitoring data or retrospective estimation, exposures are provided for the cells in the matrix. Then, subjects' work histories are linked to the standard jobs and thus to exposure. JEMS have particular appeal in an industry where there are many workers who fit a relatively short list (compared to number of study subjects) of standard facilities and jobs. This JEM approach has been used for a major exposure assessment project in China (Dosemeci 1994), but the validity of those results has been critiqued (Budinsky 1999), with one of the issues being the rather broad industry and job categories used. For the disease progression study, subjects (cases, controls) will be recruited from Shanghai area hospitals, and there is no *a priori* reason to expect them to all arise from a narrow range of jobs and industries. Rather, there will likely be a broad group of industries and jobs, perhaps to the point of each subject representing a unique facility and/or job combination. Thus, for planning, the presumption is that each study subject will require his or her own unique exposure assessment. So, the efficiencies of a JEM with a standard set of jobs are unlikely to be widely applicable for characterizing the exposures of the exposed subjects. New exposure monitoring data will be collected for the subject, if returned to the same job as before study recruitment. Otherwise, monitoring of other workers in the same job(s) previously held by the subject will be used to estimate the subject's exposure. Monitoring of multiple workers will be undertaken as a means of evaluating the inter-worker variability (Rappaport, 1993).

Sampling to Define Long-Term Average (LTA) Exposure. Expected variability plays a large role in the number of samples needed to estimate an arithmetic mean to a desired level of certainty. The arithmetic mean is the preferred estimate for a long-term average exposure (Rappaport 1991). An individual exposure measurement from one day is not a reliable estimate of a worker's weekly, monthly, or annual average exposure (Hewett 1995). If we have limited data for an operation but enough so that we can estimate the geometric standard deviation (and not reject log-normality), then we can estimate the number of samples needed to define the arithmetic mean to a desired level of accuracy. However, substantial relaxing of usual criteria may be needed in order to set an achievable survey size. Resources available for monitoring may impact feasibility of meeting rigorous statistical design criteria. With this potential constraint in mind, the following provides an analysis of sampling requirements for different levels of certainty. Hewett (1995) provided the following estimates (Table 25.1). The range arises in part from uncertainty of the assigned GSD.

Table 25.1. Number of Survey Samples to Define the Arithmetic Mean (AM)
For an Exposure Group

GSD	Target Accuracy for AM		
	+/- 20%	+/- 30%	+/- 50%