pling designs as cluster sampling, adaptive cluster, or composite sampling should be sought. Environmental researchers should count on sampling professionals or statisticians to perform accurate sampling design.

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A RETROSPECTIVE CHEMICAL EXPOSURE ASSESSMENT OF BENZENE AND CARBON TETRACHLORIDE FOR A UNITED STATES NAVAL SHIPYARD.

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A retrospective chemical exposure assessment of workers at the Portsmouth Naval Shipyard (PNS) has been completed as part of a multisite case-control study of leukemia mortality and external radiation. A method was developed to assign exposure scores based on year, job title, and shop utilizing an exposure weighting factor: 1, 0.5, 0.1, 0.01, and 0. The weighting factor was assigned for each year, job title, and shop based upon knowledge of work activities, chemical monitoring and inventory data, engineering controls, and personal protective equipment. A work history database was created from shipyard employment records. The 363 original job titles were collapsed into 88 job titles. The 177 PNS subjects were employed at various times between 1917 and 1998, and 80 (45.2%) were classified as solvent exposed for at least one year at PNS. An exposure score was calculated for each year, job title, and shop combination for both benzene and carbon tetrachloride by multiplying the exposure level weighting factor (WF) by the duration (D) in hours per day, and the frequency (F) in days per year, $\Sigma(WF*D*F)_{job/shop}$. The average annual exposure score (AAES) for years with a minimum of 10 subjects peaked in 1945 with a combined solvent score of 233. The highest AAES for benzene and carbon tetrachloride occurred in 1945 and 1940, respectively. Cumulative benzene scores were greatest for painters, and cumulative carbon tetrachloride scores were greatest for electricians. The most frequent job titles were pipefitter, electrician, and laborer. The exposure scores, normalized to current occupational limits, will be used to compare the study subjects across the multisite study. Exposure scores are not intended to directly represent actual exposures; they are used to categorically rank the study subjects across the multiple sites.

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A HISTORICAL CHEMICAL EXPOSURE STRATEGY DEVELOPED TO ANALYZE EXPOSURES OF LABORATORY WORKERS AT SAVANNAH RIVER SITE.

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Chemical exposure scores were developed as part of a cohort mortality epidemiologic study exploring associations among causes of deaths and exposures to external ionizing radiation, internal radiation, and chemicals. Historical chemical exposure strategies were developed for chemical laboratory workers (CLWs) employed between 1951 and 1974 at the Savannah River Site to determine relative levels of chemical exposure, and to classify the exposure into two chemical categories. Work histories were compiled using available information from medical and personnel records. The 1143 study subjects had 85 unique CLW job titles which were collapsed into 12 chemical laboratory job titles with the most frequent being chemist, chemical engineer, and lab supervisor. The exposure assessment strategy involved calculation of chemical exposure scores for CLWs using number of days employed along with weighting factors for collapsed job title and decade. Job title weighting factors of 0.01, 0.006, 0.003, and 0.0005 were based on evaluation of the frequency of hands-on activities with chemicals. Decade weighting factors of 3, 2.5, 2, and 1 were developed through a comprehensive review of process descriptions, chemical inventories, and limited industrial hygiene monitoring data and the decreases reflect improvements in laboratory technique, instrumentation, engineering controls, and increased safety awareness through time. Exposures were classified into two categories based on department function and chemical utilization: (1) primarily inorganic, or (2) probable organic. Individual chemical exposure scores along with categories of exposure will be used in risk models for the epidemiologic study. The chemical exposure score provides a tool for ranking subjects' potential for exposure; it is not intended to provide actual exposure estimates for study subjects.

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DEVELOPMENT AND VALIDATION OF AIR SAMPLING METHODS FOR THE PHARMACEUTICAL INDUSTRY: THE NEED FOR A STANDARDIZED PROCEDURE.

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Effective employee protection in the pharmaceutical workplace is reliant on sound industrial hygiene and engineering decisions and the basis for sound decisions is accurate sampling data. However, accurate sampling data can only be generated using a well-validated sampling and analytical method. To date there is no universally accepted protocol for the development and validation of air sampling methods for the pharmaceutical industry. Due to the substantial differences in current method validation practices, sampling data can vary considerably depending on which lab's "validated method" is used for analysis. In a current study, a survey concerning method development procedures was conducted among six labs that participate in the Pharmaceutical Round Robin Proficiency Testing Program. The survey focused on method validation topics, including: validation range, sample extraction, sample extract stability and evaluation of air sensitivity, storage stability, and field sampling. Survey results showed that the typical method validation range spanned from 0.0005 times the occupational exposure limit (OEL) to 16 times the OEL. Although five of the six labs surveyed employed in-cassette extraction, only four of the labs evaluated extract stability, for study times varying from one to five days. Although all six labs performed air sensitivity and storage stability studies, the procedures varied significantly in the concentration level, storage conditions, and storage times studied. Only two of the six labs performed field evaluations to assess the validity of the sampling method under field conditions. Based on actual method development data, there is solid evidence to support the importance of in-cassette extraction and the need to thoroughly evaluate sample and extract stability. Data suggests that failure to thoroughly validate a sampling method can lead to significant negative bias in sampling data. The noted method validation inconsistencies warrant efforts to develop a pharmaceutical air sampling protocol that is universally accepted.

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QUANTITATIVE AND QUALITATIVE ASSESSMENT OF ROOM CLEANLINESS POST SPILL CLEAN UP USING CLEANING TECHNIQUES USED FOR HIGHLY POTENT PHARMACEUTICALS.

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The risk assessment of potential exposures from particulates with low OELs often requires analytical air monitoring which is both time consuming and costly.

The study aim was to determine the effectiveness of internally developed spill cleaning procedures to adequately reduce surface and airborne residues to acceptable low concentrations such that analytical confirmation testing would not necessarily be required. A number of controlled "non-visible" and "visible" spill scenarios were created using a placebo material, milled lactose monohydrate. Particulate dispersion methodologies were developed to reproducibly contaminate room surfaces to a non-visible surface loading of 1–4 $\mu g/cm^2$, as measured by Petri settling plate analytical analysis. Visible spill scenarios included the particulate dispersion with additional prescribed liquid slurry spills. Trained personnel cleaned the rooms using fog/misting and repeated deluge rinsing internally developed procedures. Cleaning effectiveness was quantified by analysis of both surface swab and aggressive air monitoring samples. A qualitative evaluation of the efficiency of both cleaning methods was also completed using a fluorescent tracer dye.

Similar conclusions were observed from both the qualitative and the quantitative study, demonstrating comparable surface cleaning efficiencies for both procedural techniques, with 10^4 to 10^5 reductions from pre-contamination levels.

Horizontal surfaces proved more difficult to clean than vertical surfaces and had significantly more variability in results and lower efficiencies. Variability in cleaning efficiencies

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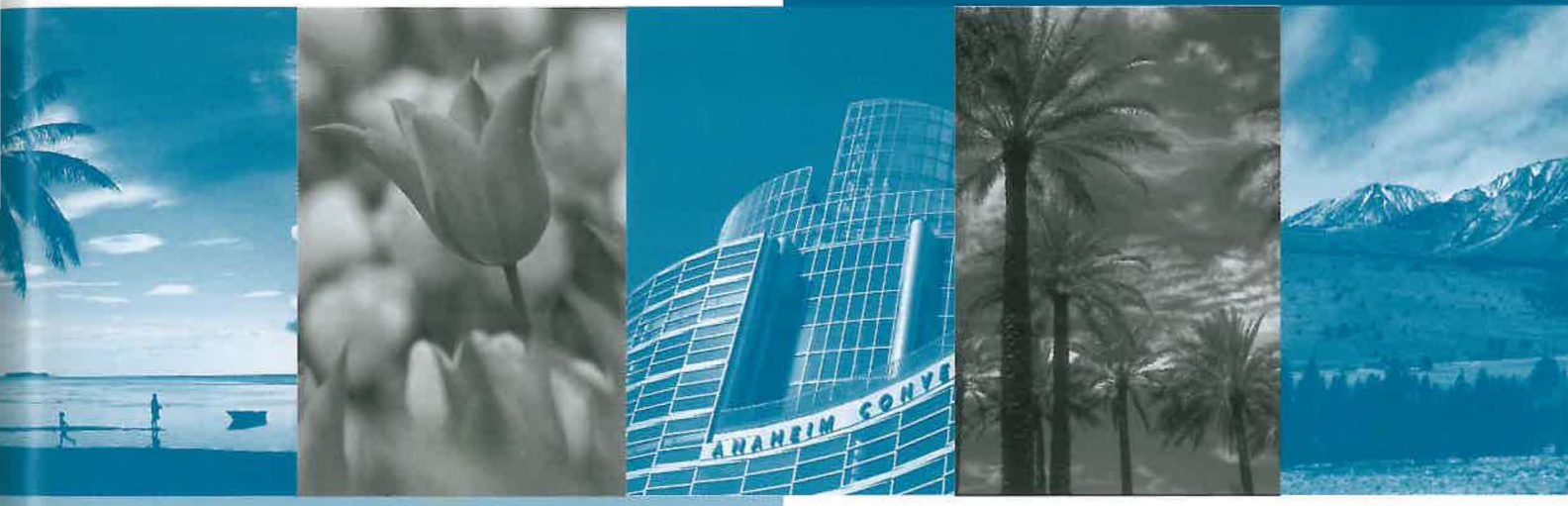

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