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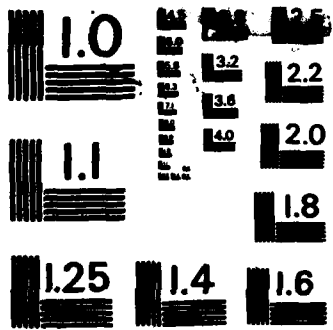
COMPUTERS IN HEMATOLOGY: IMPLEMENTATION IN AN  
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# LEUKEMIA IN HEMATOLOGY: IMPLEMENTATION IN AN OCCUPATIONAL HEALTH CLINIC

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COMPUTERS IN HEMATOLOGY: IMPLEMENTATION  
IN AN OCCUPATIONAL HEALTH CLINIC

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SUMMARY

The Naval Health Research Center in collaboration with the Naval Weapons Center (NWC), China Lake, California, is currently conducting a hematological monitoring program for all NWC employees. An automated blood cell analyzer and auxiliary computer equipment are efficiently handling the production and analysis of large amounts of hematological data. These data are combined with information obtained through questionnaires. Analysis is performed using SPSS and computer graphic packages.

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## INTRODUCTION

The Naval Health Research Center in San Diego in collaboration with the Naval Weapons Center (NWC), China Lake, is currently conducting a hematological monitoring program for all NWC employees. This project is both an ongoing occupational health program and a research project. The program has several objectives which include the development of a hematological profile of the work force at NWC and an evaluation of the health significance of this profile.

This project developed in response to concerns expressed by the Navy, NWC employees, and nearby residents of NWC and following the recommendation of the Center for Disease Control (CDC) that a large-scale study was needed. This recommendation resulted from preliminary studies which CDC carried out.

In 1977, CDC was contacted and informed of an apparent clustering of leukemia in children in Ridgecrest, California, the community that borders the Naval Weapons Center (1). CDC conducted a study in which they determined that in a five-year period six cases of leukemia had appeared in children under 19 years of age living in Ridgecrest. Only 1.3 cases would have been expected in a population of that community's size. However, no cases were determined to have occurred in the previous five-year period.

CDC could not determine any common casual factors for the six cases so, as a result, the cluster was considered to be a random clustering in time. Because of its close proximity to Ridgecrest, NWC was interested in the CDC study. As a result of this interest, CDC reviewed the hematological records of 860 NWC employees who were involved in an ongoing Occupational Health Program at NWC (2). CDC determined 66 cases of leukopenia (low white blood cell counts), 35 of which were chronic, developing over a 20-year period. Following the CDC study, the Navy concluded that there was a need for sustained surveillance for evidence of myelosuppression among the NWC work force and that this surveillance should be extended to all employees of NWC.

## STUDY DESIGN

### Data Collection

In response to the conclusions of CDC, data collection began in February 1982 for the "White Blood Cell Count Study" at NWC. The study requests, on a voluntary basis, the participation of all NWC employees. There are approximately 4,500 civilian and military employees at NWC. Each participant is requested to answer a short questionnaire and to give a sample of blood.

The questionnaire completed by each participant obtains personal data from the individual including, name, social security number, age, race, sex, a brief smoking history, and a limited NWC work history. The work history ascertains the time period, work location, and job title(s) held for the entire period that the employee worked at NWC. This questionnaire is completed at the time the blood sample is drawn.

All blood samples are collected between 8:30 a.m. and 11:00 a.m. Rigid scheduling is necessary because variation in white blood cells from hour-to-hour has been observed in a number of studies (3, 4,5). Each sample, as it is drawn, is immediately tagged with an adhesive label that has a bar code number which can be optically read by electronic equipment. This bar code number is also affixed to the questionnaire, entered into a blood sample log, and affixed to the laboratory report form. This code, in conjunction with the individual's social security number on preprinted labels, allows for the rapid and accurate reporting of results. The primary limitation to the usefulness of the bar code as an identifying number is that with the present equipment bar codes can be read optically only to

999, making it impossible to assign a unique bar code number to each study participant, as would be desirable.

The introduction of a program such as this one would naturally overload the existing capabilities of the small branch medical clinic at NWC. Automation was the practical approach to the large-scale hematological analysis required by this project. A Technicon H6000, an automated blood cell analyzer, was acquired. This machine is a self-contained blood analysis and computer system. It optically reads the bar code number applied to the blood sample, stains, and fixes a microscopic slide that can be viewed should the need arise. It also performs a complete blood cell count and reports the results in two ways--as a printed copy and electronically onto a video screen.

All information generated by the Technicon is available immediately. The printed results, which include information concerning the functional status of the machine, is produced as each sample is analyzed. The results and information indicating functional status can be viewed at the same time on a video screen by a laboratory technician.

The Technicon is interfaced directly with a VAX 11/750 computer located elsewhere at NWC and data are transferred electronically directly to the VAX 11/750. This latter operation eliminates the need for any manual data entry of the results of the blood analysis. As a result, the speed and accuracy with which data are stored is greatly enhanced. This capacity also allows for the rapid, accurate, and convenient linking of individual blood analyses with data concerning personal characteristics and job-related activities obtained by questionnaire.

#### Quality Control

Quality control is maintained during the analysis procedure by two primary methods: (1) indicators of machine functional status provided by the Technicon and (2) a comparison of results obtained from an independent evaluation performed on a different machine.

The Technicon provides a number of indicators or "laboratory flags" of system operation for each sample analyzed. These can be viewed by the laboratory technician and corrective measures can be taken if the machine is not functioning properly.

In order to evaluate the validity of the Technicon findings and ascertain the degree of comparability with other more commonly used analysis techniques, a sample of specimens are also analyzed on a Coulter Counter ZBI.

The Coulter Counter uses a different counting principle and, for our purposes, provides a total WBC count. Every fourth blood sample drawn and tested on the Technicon is also analyzed on the Coulter Counter. This analysis is performed without knowledge of the results obtained on the Technicon. This systematic sampling allows for monitoring of quality control throughout the analytical process. We have found a high degree of correlation between the two machines ( $r = 0.92$ ). However, there is a slight, though statistically significant, difference in means of 370 cells per  $\text{mm}^3$ .

#### Data Analysis

The use of high technology-high capability blood analysis equipment brings with it the production of great quantities of data. This study was originally envisioned as a study of total white blood cell counts; while this remains the study's main focus, the Technicon provides a great deal of additional information that can be used to enhance our understanding. For example, the Technicon identifies five major cell lines that make up the total white blood cell count. It also provides detailed information concerning red blood cells, including hematocrit and hemoglobin concentrations, and it

provides a blood platelet count.

Data from the Technicon, as mentioned before, are electronically stored in a VAX 11/750. The data collected by questionnaire are manually entered into the same computer. These two files are then merged into one working file. These data are stored in a format suitable for analysis using the Statistical Package for the Social Sciences (SPSS). A magnetic tape containing this working file is produced at the NWC computing facility and sent to the Naval Health Research Center in San Diego. At the Research Center files are created and edited from a CRT and analysis is performed on an IBM 360 computer, accessed through a local computer contractor. IBM TSO and SPF Command languages are used to manipulate these files. Data analysis is performed using SPSS which provides a comprehensive package of statistical procedures that allows many different types of data analysis in a simple, convenient, and efficient manner.

Presently computer graphics are being used to summarize our analyses. The two primary graphics packages are the IBM Interactive Chart Utility (ICU) and TELLAGRAF. Both of these systems are flexible, easy to use, conversational computer graphic systems that produce relatively high quality graphics quickly. Both systems are well suited to the types of descriptive displays, such as line graphs and bar charts, that can be used to visually describe the hematological profile of different groups encountered in this study. The results can be printed on a desk top printer. Figure 1 is an example of a line graph produced using ICU. The figure shows the differences in distribution of white blood cell counts in Never Smokers and Current Smokers at NWC. The original of this graph is in color. Other methods for distinguishing lines, such as dotted or dashed lines, are also available. Currently, these systems cannot be interfaced directly to SPSS so the data to be displayed must be manually entered.

The figure effectively presents the markedly different distributions of white blood cell counts in Current Smokers and in those who have never smoked. The mean WBC count for Never Smokers is 6,000 cells per  $\text{mm}^3$ , and for Current Smokers 8,600 cells per  $\text{mm}^3$ --a difference of 2,600 cells. Smokers have a higher white blood cell count and a more dispersed and irregular distribution pattern.

It is useful to compare the findings in our population with data that currently exist for other population groups. A survey, titled the National Health and Nutritional Examination Survey (HANES) conducted by the National Center for Health Statistics, supplies a population-based sample of white blood cell counts that serves as a useful comparison group. Figure 2 shows a computer produced bar graph of mean white blood cell counts by smoking status for both the NWC population and the HANES survey population. The higher mean WBC count for smokers can be seen to be present in both populations. The similarity of means for smokers in the NWC population ( $8.6 \times 10^3$  cells) and the HANES survey ( $8.3 \times 10^3$  cells) is immediately apparent. The somewhat lower WBC counts for nonsmokers in the NWC population as compared with the HANES population is also apparent in this type of display.

A useful adjunct to the data obtained in this study would be occupational exposure data ascertained during an employee's career. Accurate exposure data are difficult to obtain through questionnaire methods alone. Inaccurate and incomplete recall and an unawareness of occupational exposures by interviewees can bias results in unpredictable ways. Readily available, accurate, and complete exposure information would greatly strengthen the ability to elucidate etiologic relationships between work environments or exposures and disease.



## CONCLUSION

In summary, in a large-scale hematological survey conducted at the Naval Weapons Center, China Lake, California, an automated blood cell analyzer and auxiliary computer equipment are efficiently handling the production and analysis of large amounts of medical data. An automated blood cell analyzer, the Technicon H6000, provides detailed hematological data that are immediately available in printed copy to the clinician and also are stored electronically for aggregate analysis. Through electronic interfacing with a large computer system, the data produced by the Technicon can be combined with questionnaire data obtained from study participants and manually entered into the computer system. Analysis is facilitated by use of SPSS and easy to use computer graphic programs.

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Distrib. of White Blood Cell count for current & never smokers  
 Prelim. analysis of 1st 1168 participants  
 at NWC & China Lake 1982

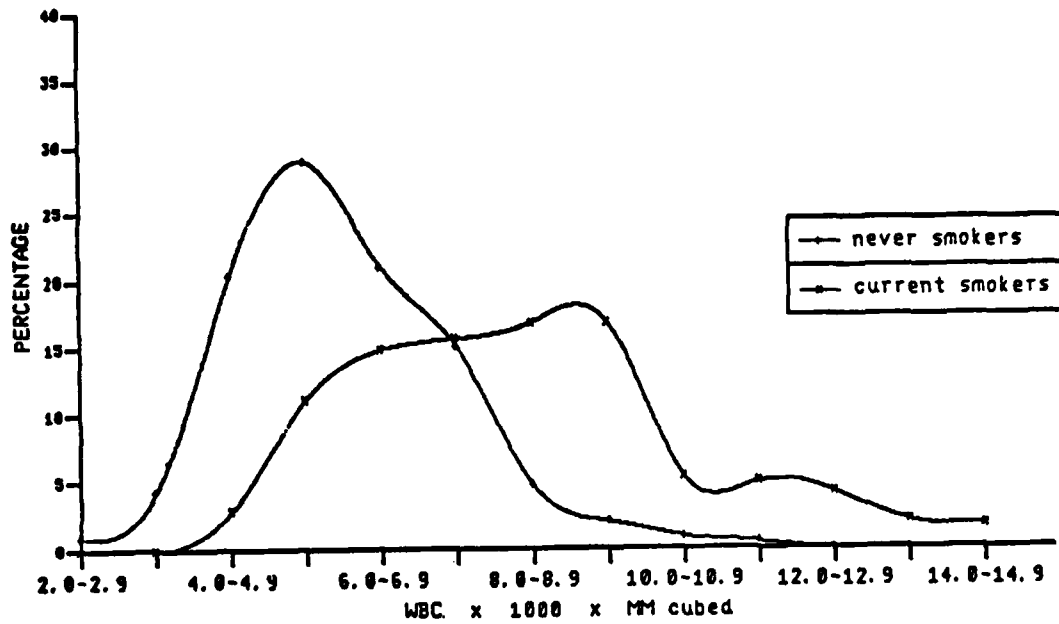


Figure 1

MEAN WBC COUNT BY SMOKING STATUS.  
 NWC AND HANES SURVEY, 1982  
 PRELIMINARY ANALYSIS OF FIRST 1168 PARTICIPANTS

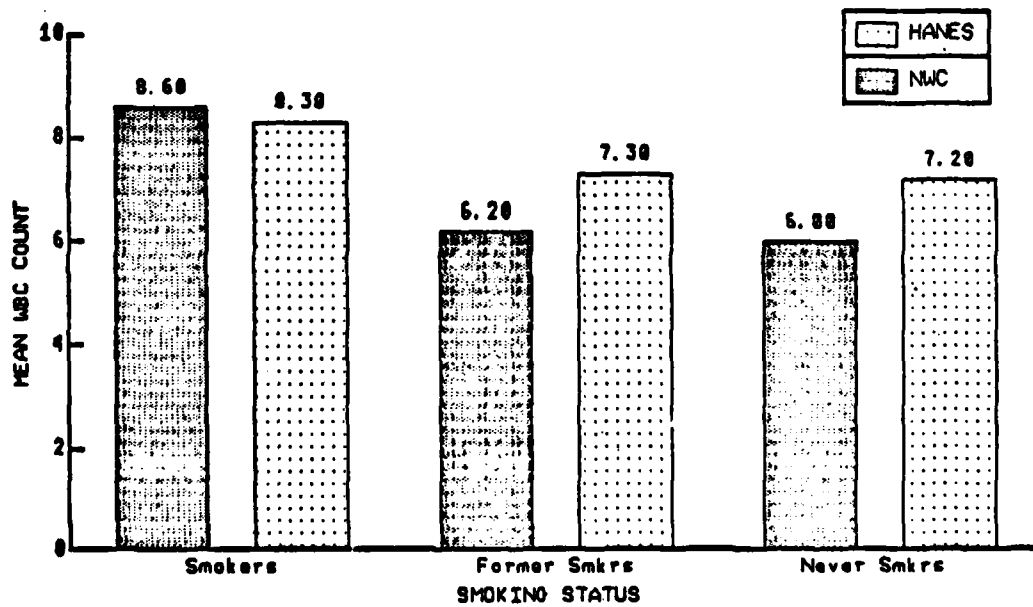


Figure 2.

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