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A Computer Software Application for Managing Occupational Exposure Data

The Health Hazard Information Module is the U.S. Army's computer software application for managing occupational exposure data. The project mission is to utilize automated information systems technology to improve the overall effectiveness of industrial hygiene programs. Field industrial hygiene professionals document their survey methods, findings, conclusions, and recommendations with a portable, pen-based computer. Back at the office, the data are electronically transferred to a desktop workstation. Users can generate standard or customized reports in hard copy or electronic formats. Annually, users transfer their data to a corporate mainframe computer. The software incorporates appropriate information and represents an excellent template worth examining during the ongoing international effort to standardize occupational exposure data. Planned refinements include distributing the software to other Department of Defense agencies and making it commercially available for a nominal fee through the National Technical Information Service in the near future.

Keywords: computer application, data management, health hazard inventory, management information system, pen-based computer, software

In 1985 the U.S. Army began to standardize its automated methods of occupational health data collection, storage, retrieval, and use in the professional arenas of industrial hygiene, hearing conservation, and occupational medicine and nursing.⁽¹⁾ The resultant software became known as the Army Occupational Health Management Information System (OHMIS). Since the beginning of the OHMIS project, the Army has developed several versions and incorporated numerous improvements. Presently, the OHMIS software is implemented internationally at more than 400 sites, representing more than 1000 users. It consists of four components:^(2,3)

- the Health Hazard Information Module (HHIM) software
- the Hearing Evaluation and Audiometric Reporting System software
- the Medical Information Module software
- the corporate mainframe computer database.

The HHIM is the Army's computer software application for managing occupational exposure data. The project mission is to utilize automated information systems technology to improve the overall effectiveness of industrial hygiene programs. Industrial hygiene professionals use the

software to document workplace conditions, to manage their health hazard inventory, and to provide occupational health physicians and nurses with data that facilitate the assignment of appropriate, exposure-based, medical surveillance.⁽⁴⁾

The HHIM software is operational at more than 90 sites worldwide, on more than 200 pen-based computer (PBC) systems and more than 190 desktop workstation systems. It serves all active duty Army installations, some Army National Guard Bureau locations, the National Imagery and Mapping Agency, and the National Security Agency. The most recent addition includes three locations within the Army Corps of Engineers. The U.S. Army Center for Health Promotion and Preventive Medicine is the functional and operational proponent.

Industrial hygiene program managers use the software to make informed decisions after reviewing historical and/or current survey data, and to assist them in creating and revising their management plans.⁽⁵⁾ The software maintains a federally required health hazard inventory, and identifies potentially exposed populations and

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their representative exposure levels. The quantitative analyses of exposure data assist medical practitioners in planning appropriate medical surveillance.^{16,7} Use of the software reduces sampling and analytical costs and clinic visit costs by documenting employee populations that do not require (or require limited) industrial hygiene or medical monitoring.

The Microsoft® Windows 95™ (Redmond, Wash.) operating environment was selected as the recommended platform for the HHIM software due to its increased performance and enhanced stability when compared with Microsoft Windows 3.x™. Microsoft Office 4.3™ is recommended to allow users to generate customized reports using the Access™ application, to export data to Excel™ for statistical analyses, to market their industrial hygiene programs using PowerPoint™ slide shows, and to communicate with customers and colleagues using Word™ documents. Informix-SE® 6.00.WE3 (Informix Software, Inc., Menlo Park, Calif.) is the database engine that underlies the HHIM application. However, any open database connectivity (ODBC) compliant database package, combined with properly installed drivers [e.g., INTERSOLV® DataDirect™ ODBC Driver Pack 2.11 (INTERISOLV, Inc., Rockville, Md.)], can be used to access the software.

The minimum recommended desktop workstation hardware consists of:

- Intel® Pentium® (Intel Corp., Santa Clara, Calif.) 100 MHz processor
- 24 MB RAM
- 1.2 GB hard drive
- 150 MB Bernoulli® (Iomega Corp., Roy, Utah) drive
- 3.5-inch high-density disk drive
- personal computer (PC) card slots that conform to Personal Computer Memory Card International Association (PCMCIA) 2.1 standards and accept Type I, II, and III cards
- trimedia network card
- small computer system interface (SCSI) adapter card
- internal 8-speed CD-ROM
- external CD-ROM jukebox (six disks)
- Hewlett-Packard LaserJet™ 4+ (Hewlett-Packard Co., Palo Alto, Calif.) printer
- 28.8 kbps data/fax/voice modem
- soundboard and speakers
- parallel port
- RS-232C serial port
- 17-inch SVGA monitor
- keyboard and mouse
- uninterruptible power supply

The minimum recommended notebook and PBC hardware consists of:

- Intel Pentium 100 MHz processor
- 24 MB RAM
- 810 MB hard drive
- 3.5-inch high-density disk drive
- PC card slots that conform to PCMCIA 2.1 standards and accept Type I, II, and III cards
- 8-speed CD-ROM
- 28.8 kbps data/fax/voice modem
- soundboard and speakers
- parallel port and cable
- RS-232C serial port
- infrared serial port
- active matrix color display
- total weight less than 7.5 pounds

A PBC combines the functionality of a desktop computer with

the portability of a notebook computer. It is small and lightweight, but the rugged construction assures reliable operation even when the system is subjected to rough handling or hostile environments. A pen-based system is easily transported, functions like an electronic clipboard, and the user has quick access to data wherever the system is operated. Mastering the PBC requires a very short learning curve.

DATA FLOW

Local user responsibilities include data collection and entry, report generation, and data download. Corporate responsibilities include data upload, mainframe data abstraction, and mainframe data utilization.

Step I: Data Collection and Entry

Industrial hygiene professionals document their survey methods, findings, conclusions, and recommendations with a portable handheld PBC. The software codes the data automatically while in the field. Industrial hygienists return to their offices, connect the PBC to the desktop workstation system, and transfer the coded data electronically by way of specialized communications software (i.e., Microsoft Direct Cable Connection™ and Microsoft Dial-Up Adapter™). Users can transfer historical survey data from the desktop workstation to the PBC prior to conducting another survey, or transfer updated and/or new survey data from the PBC to the desktop workstation after completing a survey. The two-way data transfer feature can significantly decrease data collection and entry workload, and improve overall effectiveness.

Step II: Standard Report Generation

To respond quickly to common information needs, each user generates standard reports by merely selecting the desired report(s) through the Report Wizard tool. There are 38 predefined standard reports.

Step III: Customized Report Generation

The relational database structure, the Microsoft Access database query tool, and the user-defined links between the 23 predefined tables combine to facilitate the creation of an endless array of customized reports that exceed the needs of virtually every customer.

Step IV: Data Download and Upload

Annually, the users download their local data, and the OHMIS programmers upload the information to the corporate mainframe computer. "Compliance" with the data call is achieved when a site provides current data in the requested electronic format that can be successfully loaded onto the mainframe. "Noncompliance" occurs when a site (a) is missing data for the data call year, (b) ignores the data call request, (c) is required to resubmit its data (e.g., because of inappropriate electronic format), (d) is experiencing data transfer problems (e.g., because of software or hardware difficulties), or (e) does not have an industrial hygiene, occupational health, or safety professional assigned to manage the HHIM program.

Compliance statistics are calculated at the conclusion of each data call. The Army industrial hygiene program has experienced a mean compliance rate of 65% (maximum of 79% in 1992; minimum of 44% in 1990). The maximum compliance rate has been attributed to the implementation of hardware and software enhancements. In an effort to achieve a goal of 100% compliance,

better desktop workstation and pen-based computer hardware were in place prior to the 1997 data call; these factors resulted in the second highest compliance rate of 74%. These improvements, new software, growing user enthusiasm, and loyalty to the Department of Defense (DoD) and Army industrial hygiene programs may further increase the data call compliance rate for 1998.

Step V: Corporate Mainframe Data Abstraction and Utilization

The OHMIS Database Analyst readily accesses the corporate mainframe data and regularly generates high-quality tailored reports by developing programs in SAS® (SAS Institute, Inc., Cary, N.C.). The local and corporate data have assisted industrial hygiene, occupational health, safety, and environmental programs worldwide in determining the potential impact of occupational exposure limit reduction, developing management indicators, creating policy documents, determining program funding, improving compliance with Occupational Safety and Health Administration and Environmental Protection Agency standards, and conducting government and academic research.¹⁵ During 1993–1996, the Database Analyst and the Programming Team created 33, 99, 120, and 93 reports annually.

DISCUSSION

Corporate Mainframe Distribution Statistics

As of January 1997, the corporate mainframe database contained 187,517 industrial hygiene surveys performed Armywide and entered into the HHIM software at 138,876 operations representing 326,014 potentially exposed personnel. (Historical note: As of January 1996 the corporate mainframe database contained 164,570 industrial hygiene surveys performed and entered into the software at 124,611 operations representing 302,981 potentially exposed personnel; and as of March 1995 it contained 142,719 industrial hygiene surveys performed and entered into the software at 109,294 operations representing 277,126 potentially exposed personnel.) The distribution of operations by risk assessment category was 0.8% critical, 3.9% serious, 27.9% moderate, 25.6% minor, and 41.8% negligible (or null). The distribution of potentially exposed personnel by category was 52.2% military, 40.5% civilian, 6.2% local national, 0.6% contractor, and 0.5% other. The distribution of potentially exposed personnel by gender was 81.6% male and 18.4% female. The distribution of 31,492 air samples was 49.3% breathing zone and 50.7% general area; only 6.6% of the time-weighted average results exceeded the action level for the documented exposure assessment criteria (i.e., referenced occupational exposure limits). The distribution of approximately 25,451 noise samples was 70.3% sound level meter, 29.4% noise dosimeter, and only 0.3% octave band analyzer. The air and noise sampling data identify a need to collect fewer general area air samples and sound level meter samples, and to obtain more breathing zone air samples and noise dosimetry samples to capture individuals' actual exposures. The corporate mainframe database contained 7,451 bulk samples.

Potential Hazards

As of January 1997 the top 50 potential hazards encountered Armywide consisted of chemical (60%), physical (36%), and biological (4%) stressors. The top five potential hazards (i.e., continuous noise, eye hazards, foot hazards, heavy lifting, and flying projectiles) are primarily physical in nature; carbon monoxide (at number six overall) is the number one chemical stressor Armywide (see

TABLE I. Top Six Potential Hazards Encountered Armywide (as of January 1997)

Hazard	Operations	% of Total Operations
1. Continuous noise	45,777	33.0
2. Eye hazards	29,970	21.6
3. Foot hazards	21,494	15.5
4. Heavy lifting	21,234	15.3
5. Flying projectiles	17,947	12.9
6. Carbon monoxide	12,609	9.1

Table I). These data (representing approximately 139,000 operations) clearly justify the requirement for and stress the importance of interaction between industrial hygiene, hearing conservation (i.e., audiology), occupational vision (i.e., optometry), safety, ergonomics, and occupational medicine professionals. The occupational health program improves when the health care provider reviews the entire list of potential hazards associated with a surveyed operation, the corresponding exposure potential for each hazard, and the associated exposure levels (i.e., the actual sampling results) prior to determining appropriate medical surveillance.

Development Cycle

After the HHIM 2.2 Final software was implemented during June–November 1991,⁴ users worked together to identify enhancements to be included in the HHIM 3.0 product. Object-oriented analysis, design, and programming proved to be a beneficial approach to follow throughout the development cycle. Consistent use of object-oriented techniques leads directly to shorter system development life cycles, increased programmer productivity, increased code reusability, and reduced system maintenance costs. Users participated in Phase 1 software testing during June 1996, Phase 2 software testing during November 1996, and prebeta and beta software testing during November 1996 through April 1997. The HHIM 3.0 Final software was successfully implemented internationally during June 1997. The key to the project's success was that users were involved during all phases of development.

Current Features

The HHIM 2.2 software contained valuable industrial hygiene work site data pertaining to survey; organization; work site (i.e., location, operation); controls (i.e., engineering and personal protective clothing and equipment); hazards; personnel; samples (i.e., air, bulk, and noise); instrumentation; and calibration.⁴ The HHIM 3.0 software replaces the HHIM 2.2 functionality, plus incorporates numerous improvements. It can help users to plan and realize their goals with an array of sophisticated features. The HHIM 3.0 software:

- maximizes the data representation, entry, and retrieval benefits associated with the Microsoft Windows 95 operating environment
- enables system administrators (e.g., industrial hygiene program managers) to control user access (via security privileges) to 80 different system functions
- automatically downloads and converts historical data
- tracks record modification dates to facilitate data transfers
- accepts data transfers from the Army Civilian Personnel System
- contains a Report Wizard feature for standard reporting, and provides improved data access for customized reporting
- contains corporate and local cross reference files to preserve and protect data integrity
- provides increased flexibility when defining work sites



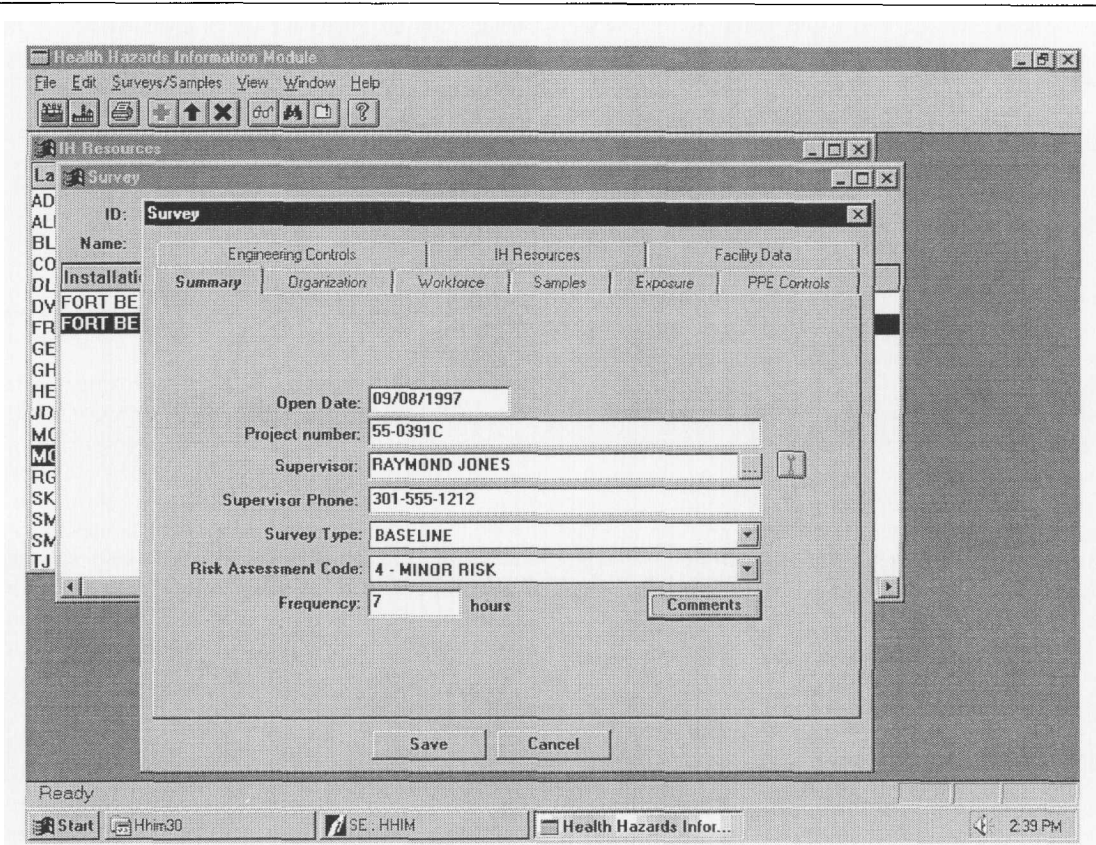


FIGURE 1. The OHMIS HHIM 3.0 graphical user interface incorporates features indicative of software products designed to operate in Microsoft Windows environments: menu bar, tool bar, status bar, windows, dialog boxes, tabs, buttons, and tool tips. Note that multiple windows are open simultaneously, and information in the Survey window is displayed in tab format.

- enables users to track industrial hygiene personnel, the certifications they may hold, the training they have completed, the surveys they have participated in, and the samples they have collected
- enables users to build an organization tree that may be defined with as many levels as the user deems appropriate
- enables users to add, update, or delete surveys
- enables users to review existing survey data (including samples) for a selected work site and assign them to the current survey and/or enter new survey data
- enables users to document an open date, close date, and survey type (i.e., walk through, baseline, periodic, complaint, environmental) for each survey
- enables users to prescribe appropriate administrative controls (e.g., employee rotation)
- contains user-defined notification timers, where the software notifies the user when one or more of the following conditions are met: a survey has been opened for an extended period of time, an analytical laboratory has not returned an air or bulk sample, an instrument is due for manufacturer calibration, and a certification has expired
- contains easy-to-use tools (e.g., Global Maintenance) for maintaining accurate data

Browse the OHMIS web site (<http://chppm-www.apgea.army.mil/DOHRS/>) to review the HHIM 3.0 software data dictionary.

Graphical User Interface

The graphical user interface (Figure 1) incorporates features indicative of software products designed to operate in Microsoft Windows environments: menu bar, tool bar, status bar, windows, dialog boxes, tabs, buttons, and tool tips. Users access the Report Wizard function from the File menu or from the Toolbar button that resembles a printer. When users select desired reports, the Report Wizard guides them through the steps for generating the report. The final step enables the user to preview the report on screen, print a hard copy report, or save the report to an electronic file. In the example in Figure 2, the HHIM High Noise Worksites Report was selected to assist a local hearing conservation program because it reveals operations where noise sampling data indicate that the steady-state (or continuous) noise level is greater than or equal to 85 dB and/or the impulse noise level is greater than or equal to 140 dB. These operations represent exposed workers who need audiometric testing and who are required to wear hearing protection.

Task Group

In 1993, during the international Conference on Occupational Exposure Databases, the OHMIS HHIM functional manager presented the Army's position on corporate occupational health software standardization and provided an in-depth description that extensively detailed the HHIM software data elements.⁽⁴⁾ Furthermore, the functional manager participated in the workshop chartered with determining the core data needs for a quantitative

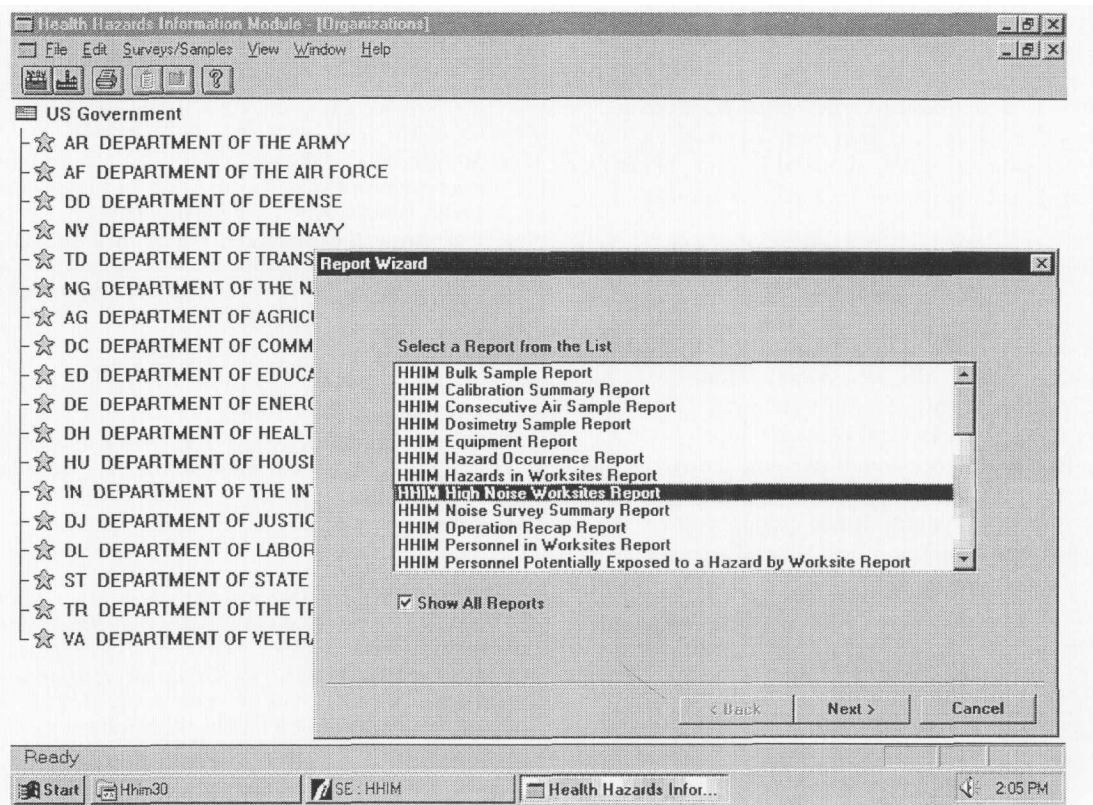


FIGURE 2. The OHMIS HHIM 3.0 Report Wizard feature assists users in the development and creation of on-screen, hard copy, and electronic file reports.

occupational exposure database.^(8,9) In 1996 the Joint American Conference of Governmental Industrial Hygienists-American Industrial Hygiene Association (ACGIH-AIHA) Task Group on Occupational Exposure Databases published its report⁽¹⁰⁾ outlining guidelines and recommendations for occupational exposure databases for airborne hazards and noise, and the authors are certainly grateful to the task group for including some of the Army's thoughts provided during the workshop.

Upon completing a review of the suggested data elements, similarities are evident between the HHIM software and the task group's suggestions. The Army always focused on the needs of the Army user community, and it was never the intention to develop a product that met the task group's recommendations. However, the HHIM satisfies two-thirds of the 134 recommended data elements within the 13 data groups, and 70% of the 83 essential or key data elements. The HHIM software incorporates appropriate information and represents an excellent template worth examining during the ongoing international effort to standardize occupational exposure data.

CONCLUSIONS

The HHIM software and corporate mainframe computer database contribute significantly to the field of occupational and environmental hygiene by stressing the importance of documenting industrial hygiene survey data (e.g., exposures) electronically. The computer application incorporates enhancements identified

by users, serves as an adaptable database product, and facilitates the electronic documentation of qualitative and quantitative industrial hygiene survey data. The corporate mainframe contains possibly the largest exposure database in the world and its probable use in understanding epidemiology and exposure assessment strategies must be explored.

Software development is a continuous improvement process. The proposed HHIM 3.x software will add the following features in an incremental, phased development approach:

- Laboratory Information Management System interface
- statistical analysis
- ergonomics program
- exposure assessment (e.g., occupational exposure values; automatic notification when a referenced standard has been exceeded)
- homogeneous exposure group (also known as similar exposure group)
- required regulatory training programs (e.g., confined spaces, ergonomics, hazard communication, respiratory protection)
- scheduling (e.g., surveys and resources)
- deficiency tracking and hazard abatement (i.e., facility management)
- accounting (e.g., cost and chargeback)
- references (e.g., CD-ROM, World Wide Web)

Planned refinements include distributing the software to other DoD agencies, and making it commercially available for a nominal fee through the National Technical Information Service in the near future.

The Defense Occupational Health Readiness System Program is using a collaborative approach to combine the Army OHMIS and the identified Air Force and Navy systems into a single software product.⁽¹¹⁾ Tri-service (i.e., Departments of the Army, Navy, and Air Force) integration is most productive when all of the players are willing to work together for the common cause of providing a useful tool for DoD occupational health, industrial hygiene, bio-environmental engineering, and hearing conservation professionals.

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