

# **FINAL PERFORMANCE REPORT**

**Northern California Education and Research Center  
Center for Occupational and Environmental Health  
University of California  
School of Public Health  
Berkeley, CA 94720**

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**NIOSH Grant # T42 CCT 910427  
Years 16-20  
July 1, 1997 - June 30, 2002**

**October, 2002**

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**Years 16-20: 1997-98 through 2001-02**  
**Northern California Education and Research Center**

**TABLE OF CONTENTS**

<b>Table of Contents .....</b>	<b>2</b>
<b>Abstract .....</b>	<b>4</b>
<b>Administration.....</b>	<b>5</b>
Program Status .....	5
Highlights .....	6
Multidisciplinary Integration.....	6
Enrollment and Graduates .....	9
Funding.....	9
Supply and Demand .....	10
Future Prospects .....	10
 <b>Core Program Reports</b>	
 <b>Occupational Medicine - San Francisco</b>	
Major Accomplishments and Changes.....	11
Academic and Research Training Program.....	13
Supply and Demand for Graduates .....	16
Plans for the Future .....	16
Trainee Publications .....	17
 <b>Occupational Health Nursing</b>	
Major Accomplishments and Changes.....	35
Academic and Research Training Programs .....	37
Supply and Demand for Graduates .....	38
Future Plans.....	39
Trainee Publications 1997-2002.....	39
 <b>Industrial Hygiene</b>	
Major Accomplishments and Changes.....	41
Research Training Program.....	42
Supply and Demand for Graduates .....	42
Plans for the Future .....	43
Trainee Publications (doctoral) .....	43
 <b>Ergonomics</b>	
Major Accomplishments and Changes.....	45
Research Training Program.....	45

Supply and Demand for Graduates ..... 45  
Plans for the Future ..... 46  
Trainee Publications ..... 46

**Continuing Education/Outreach..... 48**

**Hazardous Substances Training ..... 50**

**Agriculture Health and Safety ..... 51**

**Pilot Project Research Program Reports**

Fadi A. Fathallah ..... 52  
Karen B. King ..... 54  
Colin Solomon..... 56

**Attachments**

**#1: List of Graduates ..... 61**

## ABSTRACT

The Northern California ERC was established in 1982. During the first twenty years of its existence it has provided professional and research training at the graduate and post-graduate levels in industrial hygiene, occupational medicine, occupational health nursing, and ergonomics. A clinic administered by the Occupational and Environmental Medicine Division at UCSF provides interdisciplinary training for the residents and the nursing, industrial hygiene, and ergonomics students. In addition to academic training, the ERC provides a wide spectrum of continuing education and outreach activities.

These programs are located on two campuses of the University of California (Berkeley and San Francisco). Located at Berkeley are industrial hygiene, the Labor Occupational Health Program, ergonomics (joint with UCSF) and the Continuing Education Program. An Occupational Medicine Residency Program and the Occupational Health Nursing Program are housed in the Schools of Medicine and Nursing, respectively, at San Francisco.

Robert C. Spear, PhD, has been the director of the ERC since its inception, and Suzanne Llewellyn, M.Ed., is the administrative officer, both of whom are from the Berkeley campus.

The ERC is complemented by the state-funded Center for Occupational and Environmental Health (COEH), directed by Professor Spear for the first three years of the ERC grant period, and by Professor John R. Balmes for the last two years. COEH comprises the same programs as the ERC at Berkeley and UCSF plus programs at UC Davis. It provides funding for the faculty and staff infrastructure that supports the teaching programs.

The University provides fully equipped teaching facilities at all of the ERC locations. They include classrooms, faculty and staff offices, laboratories, and clinical facilities. All of the campuses have an extensive library and are connected into the University's systemwide library. They also have essential computing resources.

## ADMINISTRATION

The Northern California ERC and COEH are guided by an Executive Committee:

**ERC & COEH Directors:** Robert C. Spear, PhD and John R. Balmes, MD  
**Administrative Officer:** Suzanne Llewellyn, MEd

**Program Directors of the ERC:**

**Occupational Medicine:** John Balmes, MD, (SF)  
**Occupational Health Nursing:** Julia Faucett, PhD  
**Industrial Hygiene:** Katharine Hammond, PhD (until 6/02)  
**Ergonomics:** David Rempel, MD  
**CE/Outreach Program:** Robin Baker, MPH  
**Continuing Education:** Barbara Plog, MPH  
**Agriculture CE/Outreach:** Barbara Plog, MPH and James Meyers, EdD  
**Pilot Research Training:** David Rempel, MD

The ERC has also been advised by an external statewide advisory committee composed of representatives from each of the occupational health disciplines and from industry, labor, government and academia. The chair of this committee during the period of this report was Donald M. Whorton, MD who is an occupational medicine physician in private practice. This committee is convened by the UC Vice President for Health Affairs and did not maintain a regular meeting schedule during the reporting period, so the COEH Director established a Northern California external advisory committee that can be convened more frequently.

Because the ERC has programs on two campuses of the University of California, we have made special efforts to integrate activities to create a whole that is greater than the sum of its parts. The Executive Committee has encouraged the development of interdisciplinary activities that cross program and campus lines, and some of these have become institutionalized. This team approach is also initiated by enterprising individuals who capitalize on the expertise of their colleagues and students from different programs.

Examples of integrative activities of the ERC include the clinic at UCSF which provides multidisciplinary training rotations for all disciplines, the MPH program at Berkeley which brings the medical residents into contact with the industrial hygiene students, special events and seminars sponsored by the ERC, service projects, faculty providing lectures in each others' classes, and research projects such as the NIEHS Superfund program project grant at Berkeley.

### Director's Overview

#### Program Status

In the five-year period covered by this report, the Northern California ERC has seen modest changes and significant strengthening. As detailed in the program reports the following has occurred:

- Leadership of the Industrial Hygiene program at Berkeley was transferred from Katharine Hammond to Mark Nicas at the end of this project period. The program did

not apply for ABET accreditation because of a need to provide customization of the curriculum to meet individual interests and needs. A new course on quantitative risk assessment was created.

- Julie Roberts was hired as a new clinical faculty member in the OEH nursing program, and the other OEHN faculty have developed successful research programs.
- The faculty of the Occupational Medicine Program at UCSF has been significantly expanded: Drs. Mark Eisner, Niklas Krause, and Craig Steinmaus provide more research opportunities, and Drs. Richard Fernandez, Leslie Israel, Lynda Lombardo, and Raymond Meister have expanded the clinical activities, including a major collaboration with the OEH nursing program that provides services to low wage immigrant workers and interdisciplinary clinical training for residents and nursing students.
- The Ergonomics Program added Karen King, a cell biologist, to its faculty to provide research training, and Fadi Fathallah, an ergonomist, was recruited to the faculty at UC Davis and contributes to the Ergonomics teaching program at Berkeley, along with Niklas Krause from the OM faculty.
- The Continuing Education Program significantly expanded the number of accreditations offered, including the difficult to obtain QME and CME accreditations.

### Highlights

Since its inception the Center for Occupational and Environmental Health has published a quarterly newsletter which covers the accomplishments of students and faculty associated with the ERC. These newsletters are archived on the COEH web site: <http://coeh.Berkeley.edu> and serve as an historical record of COEH and ERC activities.

### Multidisciplinary Integration

We believe that one of our great successes has been our continued progress toward substantive collaboration among the faculty and students of programs that are separated by distance and time schedules (semester versus quarter systems). Despite these barriers, we can point to extensive interaction across program and campus lines. The following table of courses shows enrollment of students from multiple programs and courses offered by faculty of one program for students in another program.

#### *Interdisciplinary Courses*

<i>Course Number and Title</i>	<i>Students</i>	<i>Faculty</i>
<i>M180 Industrial Toxicology</i>	<i>OEHN</i>	<i>Jewell (OM)</i>
<i>N271.06 Mgmt of Clinical Occ'l Hlth Problems</i>	<i>OM Residents, OEHN</i>	<i>Burgel (OEHN) &amp; Israel or Blanc (OM)</i>
<i>N273B Issues in Occupational Health</i>	<i>OEHN</i>	<i>Faucett &amp; practitioners from multiple disciplines</i>
<i>Joint UCSF/UCB: N274A and PH 268C Health &amp; Safety Hazards of the Workplace/Professional Practices</i>	<i>IH, OEHN participate in the field trips together</i>	<i>Gillen (OHN), Quinlan (IH), Plog (IH)</i>

<b>N274B</b> <i>Factors in Injury Control</i>	<i>Ergonomics, OEHN</i>	<i>Faucett (OEHN)</i>
<b>N274C / PH269B</b> <i>Occupational Safety</i>	<i>IH, OEHN, Ergonomics</i>	<i>Plog (IH)</i>
<b>N405</b> <i>OHN Practicum</i>	<i>OEHN: Internships with professional in all disciplines</i>	<i>Burgel, Gillen, Faucett (OHEN)</i>
<b>PH 204C</b> (offered every other year) <i>Occupational Health Education</i>	<i>IH, Health Education students</i>	<i>Baker (LOHP)</i>
<b>PH220C</b> <i>Risk Assessment, Policy &amp; Toxics Regulation</i>	<i>IH, Ergo, OM</i>	<i>Pease (EHS)</i>
<b>PH254A</b> <i>Occupational &amp; Environmental Epidemiology</i>	<i>IH, Ergonomics, OM</i>	<i>A. Smith (Epid)</i>
<b>PH 268A</b> <i>Physical Agents</i>	<i>IH, Ergonomics</i>	<i>Spear (IH) &amp; McKone (EHS)</i>
<b>PH 269C</b> <i>Ergonomics</i>	<i>Ergonomics, Engineering OEHN, IH, OM- interdisciplinary projects</i>	<i>Rempel (OM, Ergo)</i>
<b>PH 269D</b> <i>Occupational Biomechanics</i>	<i>Ergo, Engineering, OM</i>	<i>Rempel (OM, Ergo)</i>
<b>PH270A</b> <i>Exposure Assessment &amp; Control</i>	<i>IH, OM</i>	<i>Nicas and Spear (IH)</i>
<b>PH270B</b> <i>Environmental Toxicology</i>	<i>IH, OM, OEHN</i>	<i>M. Smith (Tox)</i>
<b>PH 297</b> <i>Field Study in Ergonomics</i>	<i>Ergo, IH</i>	<i>Rempel (Ergo)</i>
<b>PH 298</b> <i>Clinical Ergonomics</i>	<i>Ergonomics, OM</i>	<i>Rempel (Ergo) and physical therapists</i>
<b>Joint UCSF/UCB: PH 298 and N404</b> <i>Clinical rotations (SFGH, Mt. Zion, and AIWA clinics)</i>	<i>OEHN, OM, IH</i>	<i>Souza &amp; Burgel (OEHN) Quinlan (IH), Jewell, Israel Harrison, &amp; Lombardo (OM)</i>
<b>PH 298 Group Study</b> <i>Respiratory Health at an Automotive Manufacturing Facility</i>	<i>IH, OEHN, OM, Epidemiology</i>	<i>Hammond, Balmes, Baker, Gold, Quinlan</i>
<b>PH 298A</b> <i>Case Studies in Industrial Hygiene</i>	<i>OM, IH</i>	<i>Robinson (IH)</i>

The number of ERC faculty making major contributions to the other ERC disciplines is impressive and demonstrates the extent to which the programs have become integrated, and indeed, inter-dependent. Eleven of our core faculty contribute significantly to a program other than their home program, and faculty from all of the programs contribute to the ERC's Continuing Education Program.

Listed below are the permanently established ways in which the ERC has become integrated. In addition to these, there are innumerable collaborations among the faculty and students resulting from their getting acquainted in the formalized settings. Evidence of research collaborations can be seen in the publication record. Faculty also provides lectures for each other's classes and serves on dissertation committees across programs and campuses.

- **Summer Institute on Continuing Education** - Annual, weeklong set of courses open to the professional community in which faculty and students from all programs participate.

- **Clinical Training** - Training sites for the residents, nurses, industrial hygiene, and ergonomics students. Required clinic rotations bring the trainees together to collaborate on the evaluation of patients and their workplaces.
- **Annual COEH Symposium** - in-depth discussion of topics of current interest to faculty, students, and government representatives.
- **COEH Student Award Program** - \$10,000 in funding from COEH and \$5,000, when possible, from NIOSH, for up to four student projects involving interdisciplinary teams conducting a research, teaching, or service project. A minimum of two students from different disciplines is required, and preference is given to teams from more than one campus. The projects conducted by recipients of the award are showcased each fall.
- The **COEH web page** links the web sites of the COEH-affiliated programs on all three campuses: <http://coeh.berkeley.edu>
- **Joint Grand Rounds, research seminars, journal club, workplace site visits, and case conferences** - the nursing students and residents participate in these activities. Indicative of the commitment to collaboration is that the Medicine Program moved the site to facilitate participation by the nurses even though it was less convenient for them.
- **Special Projects** - The program directors are committed to finding real world opportunities in which the students can work. Two recent projects were: (1) Assessing respiratory health problems among painters and welders at a local car manufacturing facility, NUMMI, Inc. (2) Providing health services and educating immigrant garment workers about H&S issues.
- **Interactions outside of the ERC** - Faculty who collaborate with colleagues across the campuses provide students with opportunities to broaden their perspectives. For example, ergonomics students have been involved in research projects with faculty from Hand Surgery, Bioengineering, and Orthopedics. Professors Spear, Rempel, and Koshland (all with engineering degrees) collaborate or have joint appointments in mechanical, biomedical, civil, and bioengineering as well as the Energy and Resources graduate degree Group
- **Distance Learning** - We continue to seek new ways to broaden our reach beyond the Bay Area. We have used distance teaching to successfully bridge the distance between our programs (Occupational Safety for IH and nursing students), and we have developed an online CE course for dental professionals.
- **Outreach to other disciplines** - the desire to recruit high quality applicants to the programs as well as to expose students from other disciplines to occupational health principles has resulted in formalized activities targeting non-ERC students. For example, medical students rotate through the occupational medicine clinics, as do residents in family practice and internal medicine. In nursing, occupational health curriculum has been added to all nurse practitioner programs, including family and women's health.

- **Joint Faculty Appointments** - Further evidence of the integration of our programs is seen in the institutional recognition of significant interdisciplinary collaboration in the teaching arena resulting in joint faculty appointments. Examples include: David Rempel and Karen King (UCSF-OM and UCB-Bioengineering); John Balmes (UCSF-OM and UCB-SPH); Patty Quinlan (UCSF OM and OEHN); Barbara Plog (UCB-SPH and UCSF-OEHN); Scott Robinson (UCB-SPH and UCSF-OM).
- **Research** – Major projects involving faculty and students (including residents) from at least two of the COEH collaborating campuses include:
  - Respiratory Problems Among Painters & Welders at NUMMI (17 students from UCSF, UCB, and UCD)—8 faculty (same campuses as students)
  - Fresno Asthmatic Children's Environment Study project (FACES) funded by California Air Resources Board (two students)—Tager (B), Balmes (SF) and Hammond (B);
  - Ergonomic Demonstration Projects in Agriculture funded by NIOSH (at least five MS and three PhD students)—Miles & Fathallah (D), Meyers (B, D), Faucett & Janowitz (SF);
  - State Prison Healthcare Workers, funded by ASPH/CDC —Harrison (SF-OM), Nicas (B), White & Goldmacher (SF-OEHN).
  - Exposure of auto repair workers to n-Hexane (two students)—Hammond (B) and Harrison (SF)

### **Enrollments and Graduates**

Attachment #1 provides a comprehensive listing of students and residents who completed their training in one of the ERC-funded programs during the five-year reporting period.

### **Funding**

For the most part, faculty and administrative staff in occupational health are supported by state funding provided by the University. COEH provides a significant portion of this support, including funding for most of the ERC program directors. These permanent positions provide stability to the teaching program.

NIOSH support of students and residents has been crucial to our success in developing a truly interdisciplinary program and in maintaining enrollments during difficult financial times. All of the programs depend heavily upon this support to recruit a qualified applicant pool for this career path and to attract particular students to their programs.

Each of our programs needs more NIOSH support than they are getting to match the increases in educational costs and to address the demand for occupational health specialists. While the UCSF residents have been exceptionally successful in competing nationally for the Occupational Physicians Scholarship Fund, they now anticipate having to turn qualified applicants away because of the lack of financial support. The nursing students, especially, are relying more heavily upon outside employment to support their schooling.

Federal training support for students is crucial to a career in occupational health to some extent because of the nature of students and residents who come to our programs. They are often older people who have work experience and discovered these fields after they have financial

responsibilities for families and homes. They return to the University with considerable motivation, but need financial assistance. The occupational health specialties are not visible to undergraduates and few of our students come through the traditional educational pipeline. Hence, support while in school is essential, both for the student and for making entry into these professions feasible for those who are committed and who understand the nature of work and the needs of working people.

### **Supply and Demand**

Demand for graduates of the Northern California ERC programs remains strong in all disciplines, in part because we are unable to graduate enough students to meet the ongoing demand. A combination of low application rates and funding constraints for training in industrial hygiene, occupational medicine, and ergonomics accounts for this. In occupational health nursing enrollment has been high despite funding constraints, but it is still insufficient to reduce the large gap between supply and demand. Graduates continue to find desirable employment and can stay in the Bay Area if they wish to do so. Numerous graduates have taken faculty positions in the past five years.

### **Future Prospects**

The ERC will continue emphasizing interdisciplinary activities and expanding educational opportunities as we work towards strengthening the Ergonomics Program and developing resources and expertise to evaluate the social and behavioral aspects of occupational health. The medicine program plans to offer new practicum and research opportunities with their expanded faculty. Consolidating clinical activities at Mt. Zion Hospital and the joint effort of the medicine and nursing program to support a community-based low-wage worker clinic will enable trainees to participate in all types of clinical cases. This should support the nursing program's efforts to further develop their clinical nurse specialist track by providing opportunities for students to develop their skills in case management, worker education, and program development.

Further investment will be made to improve our central web site as well as individual program web sites. A faculty-chaired advisory committee was formed to assess our web capabilities and will guide implementation of the committee's recommendations.

Extramural research is thriving, but a lack of adequate funding to support larger enrollments continues to hamper all of the teaching programs. The Medicine Program is exploring an alternative for supporting the residents' practicum year. Nursing students are finding it necessary to work more as their stipends fall. The IH program is reluctant to expand their recruitment efforts if they can't provide adequate support, and the ergonomics program continues to suffer from a level of funding that is half that of the other academic programs.

## Occupational Medicine UCSF

### Major Accomplishments and Changes

The Occupational Medicine (OM) Residency Program at the University of California, San Francisco (UCSF) continued to produce well-trained OM physicians who had no trouble obtaining good positions in industry, consulting firms, governmental agencies, or academia during the 5-year period from July 1, 1997 to June 30, 2002. The graduates of the UCSF OM Residency Program have been successful in positions in all of the practice settings listed above. The caliber of the OM residents trained at UCSF is evidenced by the fact that applicants from our program have received a high number of Occupational Physician Scholarship Fund (OPSF) awards. In 1998, the program was reviewed by the Accreditation Council for Graduate Medical Education (ACGME) Residency Review Committee for Preventive Medicine and received full accreditation for a period of 5 years.

The major accomplishments during this 5-year period include significant additions to the faculty and additional clinical activities resulting in increased training opportunities for residents. Faculty expertise in occupational epidemiology and research opportunities have dramatically increased with the addition of Drs. Mark Eisner, Niklas Krause, and Craig Steinmaus. Faculty recruited to expand clinical occupational and environmental medicine (OEM) activities include Drs. Richard Fernandez, Leslie Israel, Lynda Lombardo, and Raymond Meister.

The Occupational Medicine Clinic at the UCSF/Mount Zion Medical Center (MZ-OMC) provides employee health services for UCSF. In addition, complex occupational medicine patients are referred to this site by referring physicians and lawyers.

OEM faculty who work at the MZ-OMC (Drs. Leslie Israel and Robert Harrison) also operate the Asian Immigrant Women's Workers' Clinic (AIWWC). This project is supported by a grant from the Wellness Foundation. Volunteer faculty, residents, and occupational health nursing graduate students work together to provide health services to this under-served population. The project also resulted in the development of the *Healthy Worker* class (a course given to concerned workers), which includes education in proper ergonomic set up and physical therapy techniques for self-help. Additional personnel (certified industrial hygienists and ergonomics specialists) are provided by the California Department of Health Services' Occupational Health Branch. This pilot project has demonstrated the need for expansion of clinical services and the need for policy changes regarding low wage immigrant workers and work-related injuries. This is especially important since most of the garment workers are employed by small to medium-sized companies, a group with unmet needs in occupational and environmental medicine.

One area of particular concern involves motivating employers to modify work practices to prevent injury. The California Endowment (a large, non-profit health foundation) has provided \$200,000 in additional funds for the *Garment Industry Ergonomic Health Improvement Project* to evaluate ergonomic hazards in garment shops and to develop feasible and practical interventions to reduce the risk of repetitive strain injuries (RSIs). This is a collaborative project

between the UCSF School of Medicine, the UCSF School of Nursing and the California Department of Health Services (CDHS).

UCSF is now a site for a Pediatric Environmental Health Specialty Unit (PEHSU). The Northern California PEHSU is funded by the Agency for Toxic Substances and Disease Registry and the U.S. Environmental Protection Agency through a cooperative agreement with the Association of Occupational and Environmental Clinics (AOEC). Dr. John Balmes is the principal investigator. The primary function of PEHSU is education and outreach to community physicians. Our program in Northern California will provide consultative services, mostly by telephone, for pediatric environmental health problems with a focus on environmental triggers of asthma. PEHSU offers experience with environmental exposures and childhood illness to our residents.

The UCSF Medical Toxicology fellowship is now under the auspices of the ACGME. The program is formally affiliated with our OM residency program. This is expected to enhance cross training in occupational and environmental toxicology. A joint training program with Medical Toxicology is in development. It will include an extensive research project on a topic that involves both OEM and Medical Toxicology, which will satisfy both programs' requirements for research.

OEM faculty (Drs. Sarah Jewell, Stephen Born, Richard Fenandez, Lynda Lombado, and Raymond Meister) continue to provide medical services at an occupational injury urgent-care facility for employees of the City and County of San Francisco (CCSF). This urgent-care facility is located at San Francisco General Hospital (SFGH) in space adjacent to that which houses the Employee Health Service at SFGH and the pre-placement/medical surveillance unit for CCSF employees. The combined urgent-care, hospital employee health, and medical surveillance unit at SFGH is known as the Occupational Health Service (SFGH-OHS) and provides an in-depth placement for the OM residents. OM residents frequently work with CCSF health and safety personnel during their rotations at SFGH-OHS.

In addition to the new faculty in occupational and environmental epidemiology listed above, there have been several other OEM faculty recruitments. The first endowed chair in OEM at UCSF has been established and is currently held by Dr. Paul Blanc, the Chief of the Division of OEM at the Parnassus campus.

Dr. Robert Goldberg, past president of the American College of Occupational and Environmental Medicine and current member of the American Board of Preventive Medicine, joined the SFGH Division of OEM to develop web-based distance learning programs in ergonomics and musculoskeletal injury management and prevention, in collaboration with Dr. David Rempel, who directs the UCSF/UCB Ergonomics Program. The target audience includes employers, both public and private, employees of small and medium sized businesses, health and safety professionals, graduate students, engineers and engineering students. Current projects include a CAL-OSHA sponsored web site for an ergonomics training program for dentists and dental hygienists and a course on the anatomy and medical evaluation of musculoskeletal disorders of the cervical spine and upper extremity (<http://www.me.berkeley.edu/ergo/>).

Dr. Karen King is a cell and molecular biologist with research interests in the mechanisms of tissue injury. Dr. King was recruited to expand Dr. Rempel's research program to include investigation of basic mechanisms of repetitive strain disorders. Dr. King was awarded a SERCA during this reporting period.

### **Academic and Research Training Program**

The UCSF OM program primarily seeks to train physicians who pursue academic medical careers in Occupational and Environmental Medicine. The program also trains physicians in clinical occupational medicine and actively seeks multidisciplinary training opportunities. The academic, practicum, and research experiences for trainees in the program have not changed dramatically because these have proven to be effective.

Briefly, the basic two-year program at the UCSF OM Residency includes the following: two months of summer didactics and site visits in both years; a nine-month program at the University of California at Berkeley (UCB) School of Public Health culminating in the award of a Masters in Public Health; a practicum year with four months of in-depth placements, three months of public health experiences, two months of electives, and two months of research. OM residents evaluate patients in the MZ-OMC throughout the 2 years of the program, as well as attend OEM Grand Rounds twice monthly and Case Conferences weekly. In addition, residents participate in monthly journal club and research seminars. Each resident is expected to present at OEM Grand Rounds and at the OEM Research Seminar before the end of their training program. Residents are required to take a ten-week UCSF course co-taught by OM and OHN faculty that is entitled "Clinical Management of Occupational Health Problems," and that is also required for Occupational Health Nursing Program students. There are additional courses the residents are required to attend as well as frequent supplemental didactic sessions. The program seeks continual enhancement of training opportunities through development of new practica and more effective didactics.

Coordination with UCB has increased since Dr. Balmes has become involved with the administration of the Northern California Center for Occupational and Environmental Health. He was named Acting Director of COEH in January 2000. The provision of 20% salary support for Dr. Balmes since that time has allowed him to physically spend one day per week at the Director's Office of COEH at UCB. This dedicated time has facilitated the interaction of the OM Program with the other core programs of the ERC. Dr. Balmes has ongoing collaborative research efforts with UCB faculty. In addition, this support has allowed Dr. Balmes to work on multidisciplinary projects such as the effort to study respiratory health problems among painters and welders at New United Motor Manufacturing Incorporated (NUMMI). He also organized the first two annual COEH scientific symposia on "Particulate Pollution: Research and Policy Issues" (2000) and "The Impact of the Environment on Asthma" (2001). These symposia were highly successful and brought together 130-150 faculty, staff, students, and government officials from all of the ERC disciplines.

Both basic science and clinical research opportunities are available for trainees. The research training activities of core UCSF faculty members are focused on four areas: occupational/environmental lung diseases, cumulative trauma disorders of the upper extremity, upper airway responses to irritants, and occupational/environmental epidemiology. Residents are

encouraged to seek an OEM faculty research mentor in their first year of training and begin to prepare for the mandatory two months of research during the practicum year.

In the beginning of the practicum year, residents take the Training in Clinical Research (TICR) course taught by the Department of Epidemiology and Biostatistics at UCSF. The class meets for seven weeks beginning in early August and helps residents develop individual study protocols to investigate a particular research problem. In this course, trainees are required to develop and present the design and protocol for a relevant research project. A feature of the course is peer review and faculty supervision of the trainee project under development. Residents are encouraged to develop a TICR project that may form the basis of their mentored research program.

Additional elective modules are offered to interested residents in other topics that include responsible conduct of research, getting funded, and meta-analysis. Continued training is provided throughout the year in the monthly Research Seminar and through Journal Club, which has a special emphasis on statistical methodology.

Principal faculty research mentors include Drs. Balmes, Blanc, Eisner, King, Krause, Rempel, Shusterman, and Steinmaus. However, in addition, there are a large number of other supporting and core faculty members who may sponsor resident research activities and regularly participate in the research-training program through Research Seminar and/or Journal Club. In addition to this basic research program, there is a strong commitment to the study of the epidemiology of occupational and environmental disease. Dr. Ira Tager, a Professor of Epidemiology at UCB and an experienced pulmonary and environmental epidemiologist, is also available to OM residents seeking more advanced training in epidemiological research. Drs. Tager and Balmes are currently collaborating on two projects, a study of the effects of chronic exposure to ozone on lung function and a study of the effect of air pollutants on the natural history of childhood asthma. Other opportunities for OEM resident training in research include the following:

- ◆ The NCI-funded Carotene and Retinol Efficacy Trial (CARET) which has a rich database regarding the effects of asbestos exposure (Dr. Balmes serves on the CARET steering committee).
- ◆ The Human Exposure Laboratory (HEL) at the UCSF Lung Biology Center. The HEL, directed by Dr. Balmes, currently has federal and California state funding to study the acute respiratory effects of inhaled zinc oxide, chlorine, rice straw smoke, carbon and ammonium nitrate particles, and ozone in normal and asthmatic subjects. During the reporting period, a new faculty investigator, Dr. Colin Solomon, was recruited to work in the HEL.
- ◆ The interdisciplinary COEH project at NUMMI, a local automobile manufacturing facility. The project is a collaborative effort led by Drs. Katharine Hammond (UCB IH), Julia Faucett (UCSF OHN), Ellen Gold (UCD Epidemiology), and Balmes that involves OM residents, OHN graduate students, UCB Health Education students, a UCD epidemiology student, and UCB IH students to investigate complaints of respiratory problems at the job site. The

project is funded by NUMMI in collaboration with the UAW. Analysis of data is ongoing, but preliminary results led to improved ventilation at the plant.

- ◆ Dr. Blanc's NIH- and NIOSH-funded research efforts, on the determinants of disability due to asthma, the contribution of occupational exposures to chronic obstructive pulmonary disease, and the effect of socioeconomic disparities on disability due to occupational injuries.
- ◆ Dr. Eisner's research on the health effects of environmental tobacco smoke and other indoor pollutants. Funding has been received for a study that will assess the effects of combined occupational and environmental exposures to tobacco smoke on asthma and COPD. The project is a collaboration involving Drs. Blanc, Balmes, and Hammond with interdisciplinary involvement of nurses and industrial hygienists.
- ◆ Medical surveillance of former Nevada Test Site workers, a project involving Drs. Harrison, Israel, and Meister. This project is funded by the Department of Energy in collaboration with Boston University, the University of Nevada School of Medicine, and the Southern Nevada Building & Trades Council. Residents are invited to participate in this project and many have toured the Nevada Test Site and helped with surveillance examinations.
- ◆ Surveillance for occupational asthma through the California Department of Health Services' Occupational Health Branch (Drs. Harrison, Balmes, and Blanc)
- ◆ Glove dermatitis/latex allergy (Dr. Shusterman)
- ◆ Occupational transmission of tuberculosis (Dr. Harrison)
- ◆ Dr. Shusterman's NIH-funded research program on upper airway effects of irritant and odorant inhalation at the Richmond Field Station Upper Airway Biology Laboratory. Over the course of the last several years, Dr. Shusterman has documented increased nasal irritant sensitivity in subjects with allergic rhinitis and has explored various potential mechanisms of irritant induced nasal congestion. This work may be relevant to explaining symptom reporting patterns in so called "problem buildings"
- ◆ Ergonomics of repetitive strain injuries (RSIs) of the hand and wrist due to work at computer work stations. Dr. Rempel has received NIOSH and industry funding to identify hand maneuvers associated with elevated pressure inside the carpal tunnel as well as multiple industry-funded research contracts aimed at understanding the biomechanical factors underlying computer keyboard and mouse use. This research has led to multiple projects and publications with residents and graduate students. He is collaborating with Dr. Karen King to develop animal models of cumulative trauma in order to investigate basic mechanisms of tissue injury.
- ◆ Drs. Rempel and Krause are collaborating on several NIOSH funded intervention trials to reduce RSIs at workplaces.

- ◆ Dr. Krause's NIOSH-funded research on the interactive effects of psychosocial and physical factors in determining disability due to low back injury. He has also applied for NIOSH funding to study the cardiovascular effects of prolonged standing at the workplace.

After selection of a research project, each research trainee works closely with his/her research preceptor. Other research opportunities are available through collaboration with COEH faculty at other campuses. Residents are referred to the COEH web-site to investigate possible research opportunities outside the core faculty (<http://coeh.berkeley.edu/Research/research.htm>). As noted above, research activities are extensively supported by extramural funds and residents may apply for COEH student trainee grants. State and federal agencies have supported occupational/environmental health research by our trainees. All research trainees of the OEM program are expected to play a major role in the preparation of research publications.

### **Supply and Demand for Graduates**

Despite the well documented shortage of OM residency-trained, board certified OM physicians in the United States that has been present for many years, the overall application rate of young physicians to OM residency programs remains low. In other words, the OM residency programs compete to recruit the best candidates. The UCSF program has continued to enjoy relative success in this endeavor over the past five years. As noted above, the high number of Occupational Physician Scholarship Fund (OPSF) awards received demonstrates the quality of the applicants to the UCSF OM Residency Program. All of the graduates of the program have been able to find desirable jobs without difficulty. These jobs have been in consulting firms, industry, governmental agencies, and academic institutions.

### **Plans for the Future**

We will continue to emphasize the development of interdisciplinary training as a direct result of both NIOSH and COEH funding. We will also continue to emphasize enhancement of resident training through development of new practicum experiences and a greater variety of research opportunities through the expansion of the core faculty. Dr. Karron Power graduated from the OEM residency in June 2002. She will continue to pursue a research project she started as a resident at UCSF on heart rate variability response to particulate matter (PM10 and PM 2.5) as a faculty member. She will also pursue funding for a research project on the effect of PM 10 and PM 2.5 in an occupational cohort of sand and gravel workers. Dr. Power will coordinate resident research projects and advise residents in the selection of projects and mentors. She will also assist residents in the selection and analysis of scientific method in articles submitted for Journal Club.

The Occupational Medicine Clinic at San Francisco General Hospital (SFGH-OMC) has been the primary clinical training site for OM residents. It is anticipated that the clinical functions of the MZ-OMC and SFGH-OMC will be combined in a faculty practice that joins faculty from both UCSF Divisions of OEM (Parnassus and SFGH campuses). This combined clinic will allow for future expansion of clinical services. This move is anticipated to provide a better setting for multidisciplinary training of OM residents, OHN graduate students, IH students and ergonomics students in patient assessment. Future plans for the combined clinics include the expansion of the AIWWC clinic. It will be renamed the Community Occupational Health Project (COHP). The patient population will include all low wage workers, both men and

women, who work in low wage jobs in restaurants, hotels, as casual day laborers and in the garment industry. Residents will rotate through this clinic as well as the MZ-OMC. Dr. Rempel currently provides clinical services for upper extremity repetitive stress injuries at Mount Zion so moving the multidisciplinary clinic to Mount Zion will also facilitate resident training in this important aspect of OM.

A major factor that has severely affected the UCSF OM Residency Program has been a UC-mandated increase in resident stipends. As a result, cutbacks have been necessary in Section A of the budget in order to meet requirements for all-inclusive resident salary support. Without additional support from NIOSH, it is becoming increasingly difficult to support our current number of trainees. Because of fiscal constraints, as well as the shortage of qualified clinical OM physicians, various solutions have been considered by the ACGME Preventive Medicine Residency Review Committee and the American Board of Preventive Medicine. The program is actively exploring the possibility for development of a separate practicum year track for qualified residents interested in pursuing a variable location program. This would allow residents to complete their practicum training over two years with the support of a sponsoring institution, without the need for additional residency training funds.

#### **Publications Co-authored by Trainees**

The following is a list of publications on which core faculty and students or residents are authors. The core faculty names are identified by an asterisk\* and the students' and residents' names are underlined.

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## **Occupational and Environmental Health Nursing Program San Francisco**

### **Major Accomplishments and Changes**

The major accomplishments for the OEHN Program over the last five years include maturation of OEHN faculty research and clinical programs, successful utilization of the Masters' Entry into Professional Nursing (MEPN) program as a pathway for non-nurses to enter OEH nursing, and the development of stronger community ties with practicing occupational health nurses and community groups.

Over the five-year grant period, 39 students have graduated from the MS program and two from the Ph.D. program. Since the beginning of the OEHN Program at UCSF, a total of 180 students affiliated with the OHN Program have graduated with MS degrees and 13 with PhD degrees. We have consistently attracted quality applicants, with approximately 8 new MS students and one new doctoral student who enroll each year. Our applicant pool is primarily from California, but we have always drawn a few students nationally and internationally. In 1999, for example, we admitted a doctoral student from Hong Kong and we will admit one from Korea in 2002. Likewise, our applicant pool has been consistently diverse. Since 1996 we have admitted 6 Hispanic American, 3 black African American, 13 Asian American and 1 American Indian.

Faculty of the program have been stable over the five-year period. In 2001, we added Julie Roberts to our clinical faculty. Dr. Roberts obtained her doctorate in September 2002. Dr. William Holzemer became chair of the Department of Community Health Systems (formerly the Department of Mental Health, Community and Administrative Nursing), which houses the OEHN Program, in 1995. He stepped down from this position in 2001 and the Department is currently searching for a national leader to take his place. The Department is currently led by Dr. Sandra Weiss.

Dr. Faucett has been director of OEHN Program since 1994. Dr. Faucett's research expertise focuses on pain and disability from work-related musculoskeletal disorders. Her research program has continued to develop over the last five years and has investigated agricultural, manufacturing, and office settings. In collaboration with investigators from UC Davis and UC Berkeley, she has been federally funded to study California's farmworker population in the fruit, vegetable and horticultural industries. Their work has led to strong ties with agricultural safety and health groups, providing unique opportunities for students in this important, but under-studied, California industry. Dr. Faucett has also been federally funded to study work disability resulting from carpal tunnel syndrome, and collaborated with Dr. John Frank on his investigation of the California Worker Compensation arena. She became a Fellow of the American Academy of Nursing in 2000 and was promoted to Professor in 2002.

In 1996, Dr. Marion Gillen joined the OEHN faculty as an assistant professor. Dr. Gillen has developed a program of research that focuses on injury control and prevention program development. She directs state and federally-funded studies that investigate bloodborne pathogen prevention programs, and safety cultures in the health care and construction industries.

In 2001, Dr. Julie Roberts joined the faculty as an assistant clinical professor. In 2002, she completed her dissertation research on occupational asthma and will pursue additional funding to continue her work. Drs. Gillen and Roberts work collaboratively with the State Dept. of Health's Occupational Health Branch, and this provides rich opportunities for students.

Ms. Burgel is co-investigator on several studies involving garment and other low wage workers, secondary to her collaboration in developing the Community Occupational Health Program (COHP). COHP is an expansion of the Asian Immigrant Women Workers' Clinic (AIWWC), a clinical enterprise developed by Ms. Burgel in conjunction with other COEH faculty in concert with the Asian Immigrant Workers' Association of Oakland, a community group which focuses on women in the garment industry. Starting in 2000, an increasing number of OEHN students participated in clinical training at AIWWC, and we expect the majority of them to receive training at COHP.

Drs. Katherine Lee, Erika Froehlicher, Mary White, and Susan Janson all participate in OEHN student seminars and provide research rotations and consultation on student research. These faculty add needed expertise on women's health, circadian rhythm and sleep research, exercise physiology, pulmonary and cardiovascular disease, infectious disease, epidemiology, and symptom management.

Strong ties to the Occupational Medicine faculty (Blanc, Rempel, Harrison, Balmes, Krause) have also enhanced the opportunities available to nursing students who wish to pursue research experiences in the areas of toxicology, pulmonary diseases, or ergonomics. All of the faculty listed above have funded research programs. In the coming year, Dr. Janice Humphreys will also participate in the OEHN Program, bringing with her expertise in research on violence and women's health.

In 1991, the School developed the MEPN Program, offering a pathway for non-nurses with BS degrees to enter the field of nursing, select specialty preparation, and graduate with a Master of Science degree in three years. Despite a one-year hiatus in 1996-97, the MEPN program has been quite successful in attracting students to nursing, and each year the OEHN Program has attracted MEPN applicants, many from previous jobs in human resources, safety, or occupational health research. Once graduated, these nurses have successfully obtained positions in occupational health nursing. In 2001-02, with additional State funding, the School was able to double enrollment in the MEPN Program to 60 students. The OEHN Program has benefited from this increase and will enroll 3 new MEPN students in the MS program in 2002-03.

We continue to place students in the community for practica and residencies in occupational health nursing and to utilize multiple corporate and industrial sites for walk-through inspection training. These activities serve to strengthen our ties with the community, in addition to the employers who work with us on research studies in the agricultural, construction, health care, and garment industries. We list 24 community occupational health nurses as faculty without salary who participate in students' clinical placements and offer practical and scholarly knowledge about occupational health nursing practice. They work at such sites as Chiron, Genentech, Hewlett Packard, Kaiser, Berkeley and Livermore Laboratories, and Roche Pharmaceutical. These faculty also assist COEH with continuing education programs; Loretta

Cochrane (from the Lawrence Livermore National Laboratory) directed our Worker Compensation CE course, and many graduates now participate in the Physical Assessment CE Course. Additionally, the development first of the AIWWC and now of the COHP has developed strong ties to the Asian and other immigrant workers' communities of the East Bay. We anticipate greater outreach to low wage workers in this region and greater collaboration with community organizations that serve them.

### **Academic and Research Training Programs**

The curriculum required of all OEHN students focuses on the OEHN role (N273A) and issues in occupational health (N273b), the assessment of safety, toxicological, ergonomic and other hazards (N274a, N274c, M180, PH269c), and intervention in the form of injury control, clinical management, and program planning, implementation, and evaluation (N274b, N271.06, N405). OEHN/NP students additionally take Adult Nurse Practitioner core coursework to prepare for clinical roles in the diagnosis and treatment of common illnesses and injuries that affect working adults. In addition to the OEHN core coursework, OEHN/CNS students take didactic and clinical courses to prepare them for the triage of injured or ill workers, prepare prevention programs including worker education and training programs, and perform disability case management. The Program ceased to enroll students in the Nursing Administration track in 2001-02. The OEHN students also participate with all MS students in the School in a series of six core courses focusing on nursing leadership development, nursing theory, research, and health care economics and policy. OEHN faculty present lectures in the School core courses, and their publications are part of the readings for these courses.

Doctoral students in the Research Training Program are prepared to contribute to knowledge development in the field of occupational and environmental health, and to assume leadership positions in the profession. The training includes an initial 2 years of core courses in nursing science (N229, N269), biostatistics (B187, B192), and quantitative and qualitative research design (N209a/b, N212a/b, N285a/b or N289a/b). Students also select one course about nursing theory (N290 or N202a, N202b), 2 cognate courses (didactic, non-nursing content related to the student's area of research interest) and 2 advanced nursing seminars that focus on key areas of nursing research interest (e.g. social support, symptom management). The OEHN doctoral seminar (N242) qualifies as an advanced nursing seminar. The seminar is required of NIOSH-funded OEHN students and, in fact, all OEHN students attend every quarter. Additional students from the School with a research interest in OEH topics may now attend during one quarter or more per year as well if their research interests are pertinent to worker health. Their inclusion facilitates our outreach about OEHN to other nurse scientists. Students also participate in two research rotations for practical skill development (N250.01). The research rotations require working with established researchers on funded projects in their field of study.

Students have been successful in obtaining additional funding to support their research. In the last 5 years, students have also successfully competed for the UC Regents' award (Cheung, Haiduven), the AAOHN Otis Clapp award (Haiduven), the AAOHN Foundation Research Award (Landry), and UCSF alumni awards (Haiduven, Owen). In 2001, Ms. Roberts won the Robert Legge American Industrial Hygiene Award and the Sigma Theta Tau Dissertation Award. She has also received training support from the National Institute for Nursing Research through the UCSF Symptom Management Center. Students are also

encouraged to apply for private foundation funding and one of the master's students was awarded a fellowship from the American Lung Association in 2000-01 (Legenza).

In 2000, Donna Haiduven graduated from the program and is now a research nurse at the Veteran's Administration in Tampa Bay. Julie Roberts graduated in 2002 and has joined the UCSF faculty. Lynette Landry is collecting data on her dissertation study of women's perceptions of risk and is expected to graduate in 2003. Kin Cheung continues her research study of home care workers in Hong Kong. Mori Costantino is on leave from the program. Denise Souza left the program for personal reasons. Three new Ph.D. students will enroll in Fall 2002, one from Korea, bringing our current student total to five (two will be NIOSH-funded).

### **Supply and Demand for Graduates**

Despite the considerable productivity of the OEHN program, the demand for OEHNs in California, especially those with formal educational preparation in the specialty, continues to outstrip the supply. A recent survey (1999) of the Program's graduates and advisory committee showed that the regional need for leaders in this field remains high. In fact, the Program receives well over 50 calls or notices per year from employers seeking graduate OEHNs.

The OEHN gap is further documented in the 2000 Institute of Medicine Report on occupational health specialty needs nationwide. Consider, for example, that there are currently over 7 million working age adults (16-64 years of age) in Northern California alone, with an estimated 53% who are Hispanic or non-White. Furthermore, construction is expected to grow by 26%, manufacturing by 15%, transportation and public utilities by 26%, and services by 39% in California before the year 2006, according to the State Employment Development Department.

The American Association of Occupational Health Nurses (AAOHN), however, reports that only 107 full time OHN members work in Northern California, out of 520 in the entire state. Over half of the 107 are prepared with a BSN degree or less, indicating that their formal educational preparation in occupational or environmental health is minimal. Furthermore, AAOHN reports that fewer than 2% of its national membership hold master's or doctoral degrees, as compared to over 6% for nursing as a whole.

From another perspective, Barnes and Sutherland reported that only 1% of California's nurses work in occupational health settings as compared to 64% in hospitals and an additional 21% in ambulatory, long term or other community care settings. Although these figures reflect only California and not the entire ERC region, they are strong indications that the gap between the number of workers who need OEH services and the supply of registered nurses adequately prepared to deliver these services remains very wide.

In Winter, 1997, COEH held a workshop of community specialists in occupational health to plan for the future of the Center. One major topic of concern was the need for our graduates by the community and the structure of the training they were receiving. Overwhelmingly, community OHNs and other OH specialists from corporate and government settings statewide reported that there is a continuing need for OHNPs and OHN specialists. They also indicated high levels of satisfaction with the current curriculum. The number of job announcements and

requests from “head-hunters” nationally received by the OEHN Program supports the belief that there is a continuing shortage of advanced practice OHNs who can act as leaders in this field.

### **Future Plans**

In the coming year, the OEHN Program intends to continue to develop the COHP and provide training for COEH students there in clinical care as well as community outreach programs. We also will continue to develop our Clinical Nurse Specialist track and especially opportunities for students to develop their skills in worker education and training, program development, and disability case management. We intend to further develop our rudimentary website to better serve our recruitment needs; deliver course materials to students; provide an interactive site for research collaborators, students and others across the world.

### **Publications Co-authored by Trainees**

The following is a list of publications on which core faculty and students or residents are authors. Student’s names have an asterisk\* and OEHN faculty are boldfaced.

### **Original Articles/Book Chapters/Abstracts**

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**Lee, K. A.**, & Zaffke, M. E.\* (1999). Longitudinal changes in fatigue and energy during pregnancy and the postpartum, *JOGNN*, 28, 183-191.

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**Lee, K.A.**, Zaffke, M.E\*., & Baratte-Beebe, K.R. (2001). Restless legs syndrome and sleep disturbance during pregnancy: The role of folate and iron. *J Women's Health & Gender-Based Medicine*, 10, 335- 341.

Lashuay, N., **Burgel, B.**, Harrison, R., Israel, L., Chan, J., Wong Lai, C. Cusac, C., Chao Pun, J\*., Fong, K., Shin, Y. (2002)“We Spend Our Days Working in Pain: The Occupational Health of Garment Workers.” Final Report for the California Wellness Foundation.

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## **Industrial Hygiene Program Berkeley**

### **Major Accomplishments and Changes**

The Industrial Hygiene Program at Berkeley has undergone several changes over the five-year reporting period. During the last year, the IH Program Director position transitioned from Professor Katharine Hammond, who had been the Program Director since fall 1994, to Dr. Mark Nicas, Adjunct Associate Professor. The transition has been seamless because Dr. Nicas has been part of the industrial hygiene faculty since 1993, and regularly communicates with Drs. Hammond and Spear.

The Program did not reapply for ABET accreditation of the MPH degree program, which had been granted in 1996. The reason involved deliberations by the industrial hygiene faculty to offer only the Master of Science degree, in lieu of the MPH degree, as a means of creating more time for pursuing course electives and research, and better tailoring the academic program to individual student interests and experience. Going through the laborious ABET reaccreditation process for a degree program which might be discontinued shortly thereafter was deemed an inefficient use of administrative resources. More importantly, the traditional rigidity of ABET concerning the academic substance of industrial hygiene training was deemed to be an obstacle to innovative restructuring of the curriculum.

Dr. Thomas McKone, Adjunct Professor of Environmental Health since 1996, assumed responsibility for the radiation portion of the Physical Agents course which was co-taught with Dr. Robert Spear and required for all IH students. Dr. McKone also created a course on Quantitative Risk Assessment, co-taught with Dr. Allan Smith, which was taken by about half of the industrial hygiene students. It is the only course on mathematical risk assessment taught in the School of Public Health. In Spring 2002, planning was initiated to require all industrial hygiene students to take a slightly modified version of Dr. McKone's course.

Dr. Hammond continued the Program's link with the semiconductor industry, a major employer in Northern California. Dr. Hammond taught an annual seminar on Occupational and Environmental Issues in the Semiconductor Industry, which was taken by nearly all the MPH industrial hygiene students. Via this seminar, students participated in the Semiconductor Safety Association (SSA) scholarship program. In 1999, seven MPH students received SSA grants to write papers on industrial hygiene topics related to the semiconductor industry, and one student (Michael Hogan) received the third-place prize for his project titled "Exposure Assessment for Controlled Pulse-Etching with Xenon Difluoride." The SSA grants are awarded nationally, and the Program's students captured one-third of all the awards for the 1999-2000 academic year.

MPH industrial hygiene students had the opportunity to pursue other academic research. In 2000, three MPH students (and two doctoral students) participated in a research project at the New United Motors Manufacturing Incorporated car/truck assembly plant in Fremont, CA. The project was an interdisciplinary effort to assess air contaminant exposures and respiratory symptoms among paint and bodyshop workers at the facility. Dr. Hammond directed the industrial hygiene component of the study. In 2001/2002, two MPH students received funding to pursue independent research projects. One concerned indoor air exposure to combustion-

generated aerosols and gases, and the other involved an exposure assessment for pentabromodiphenyl ethers.

Professor Martyn Smith's toxicology research program continued to develop in directions relevant to industrial hygiene training at Berkeley. In particular, Dr. Smith has worked in collaboration with NCI investigators on a large cohort exposed occupationally to benzene in China. Dr. Smith's work has focused on the identification of biomarkers of benzene exposure and of susceptibility to benzene-induced leukemia. This work has provided industrial hygiene students with insight into these new methods and their potential for utilization in epidemiology and risk assessment. For example, Dr. Nicas and Geoff Lomax, a DrPH student in Environmental Health Sciences, collaborated on analyzing the potential use (or misuse) of biomarkers of susceptibility to benzene toxicity in the context of genetic screening programs.

An area that remains unsatisfactory is laboratory instruction in industrial hygiene monitoring. Due to space reassignments and the small number of students, the Program lost its dedicated teaching and equipment storage space, which in turn required borrowing space to provide instruction. Further, most of the teaching equipment is outmoded, again because of higher priority being assigned to courses with larger enrollments. To continue offering state-of-the-art training, we arranged to provide instruction temporarily at the Cal/OSHA Calibration Laboratory, San Leandro, which is a 30-minute drive from the UC-Berkeley campus.

### **Research Training Program**

Due to Professor Spear's shift in research focus to schistosomiasis transmission, and to Professor Koshland's involvement in the Energy and Resources program at UC-Berkeley, traditional industrial hygiene research activity has primarily been under the direction of Dr. Hammond. Dr. Martyn Smith has directed toxicological research with an occupational component. Drs. Nicas and McKone have also advised students who pursued industrial hygiene-related topics.

Although research activity in exposure assessment as broadly defined has been extensive during the five-year period, a modest part has been in a traditional industrial hygiene context. In fact, exposure assessment methodologies developed in the industrial hygiene profession are now being widely applied in environmental health more generally. Further, an increasing number of students are doing advanced exposure assessment and control work, but often with a much broader set of applications than in the past. Professor Kirk Smith's work on the exposure of women and children to the products of biomass fuel combustion in homes in the developing world, Professor Hammond's work in assessing exposures to environmental tobacco smoke, and Professor Spear's work on controlling exposures to waterborne parasites in China are all examples of the broadening application of techniques originally developed for the occupational environment. Viewed from this perspective, the research activity at Berkeley continues to be vigorous.

### **Supply and Demand for Graduates**

Graduates from the master's and the doctoral programs in industrial hygiene have found jobs relatively easily. Most Master's graduates continue to remain in the Bay Area, where demand remains strong. Local employers are eager to work with students and graduates, as

evidenced by the demand for more summer interns than we can supply each year, the strong relationship with the Northern California section of the American Industrial Hygiene Association, which has an annual student night and presents awards to students, and the support of the semiconductor industry, who sponsor student seminars, scholarships, and attendance at their national meeting.

### **Plans for the Future**

The EHS faculty are defining a new curricular track in which industrial hygiene students will be included entitled, "Exposure Assessment and Control." A number of courses will be broadened to cover chemical, physical and biological agents using examples from both the community and occupational environments. Several new courses are proposed. Students may also focus on community air pollution by taking electives in engineering, or those interested in infectious agents can take appropriate courses in engineering and within the School. Material specific to the occupational environment will be provided in a coordinated series of special seminars, short courses, distance learning, and field placements being designed by Barbara Plog (our full-time CIH) and Hank McDermott (a long-standing member of our external advisory committee and CIH retiring this year from Chevron). Mr. McDermott has joined us on a part-time basis to work on this aspect of the curricular change. This will modify what has become an overly narrow, traditional industrial hygiene curriculum and enable us to tailor the educational program for each individual while at the same time providing detailed professional material needed by entry level industrial hygienists.

### **Publications Co-authored by Doctoral Students (underlined) and Faculty are boldfaced.**

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Klepeis NE, MA Apte, L Gundel, and **WW Nazaroff** (2002): Size-specific particle emissions for environmental tobacco smoke, submitted to *Aerosol Sci. Technol.*

Materna BL, D Harrington, P Scholz, SF Payne; HA Stubbs, K Hipkins, E Merideth, L Kirsch, G Lomax, P Coyle and C Uratsu (2002): Results of an intervention to improve lead safety among painting contractors and their employees, *Am. J. Ind. Med.* 41:119-130.

**Nicas M** and G Lomax (1999): A Cost Benefit Analysis of Genetic Screening for Susceptibility to Occupational Toxicants, *J. Occup. Environ. Med.* 41(7):535-544

Schulte PA, G Lomax, et al. (1999): Ethical issues in the use of genetic markers in occupational epidemiologic research. *J. Occup. Environ. Med.* 41:639-646.

Vork KL, **SK Hammond**, J Sparer and MR Cullen (2001): Prevention of lead poisoning in construction workers: a new public health approach, *Am. J. Ind. Med.* 39:243-253.

Wu JD, DK Milton, **SK Hammond**, and **RC Spear** (1999): Hierarchical cluster analysis applied to workers' exposures in fiberglass insulation manufacturing, *Ann. Occup. Hyg.* 43:43-55.

## **Ergonomics Program San Francisco and Berkeley**

### **Major Accomplishments and Changes**

The Ergonomics Graduate Training Program was added as a Special Program Area to the ERC in 1993 to meet a growing West Coast need for professionals and researchers with expertise in ergonomics. This need was driven by a demand from industry to control rising rates of work-related musculoskeletal disorders associated with repetitive work and for appropriately designed engineering interventions in the workplace. This need was further spurred by establishment in 1997 of an ergonomics standard by California OSHA. No other university on the West Coast offers a full graduate training program in ergonomics.

The professional aspects of the curricula have been provided by Ira Janowitz, CPE, Barbara Plog, CIH, and Don Morelli, CPE, and the academic content has been provided by Professor David Rempel. Recently, Karen King, Ph.D., a cell biologist, was added to the faculty to assist with research training.

The program is small, with one to four M.S. students and one to five Ph.D. students at any one time. In the last five years two post-doctoral fellows, three doctoral students, and five M.S. students have completed their training.

### **Research Training Program**

During these five years the core courses have been continually refined. The primary ergonomics course has been expanded to include lectures on spine injuries and biomechanics (Professors Fathallah and Krause) and human factors. In addition, all course materials have been placed on-line. The advanced ergonomics course has been restructured to provide more training in research methods and statistics. Practical experience is gained by field projects required in the introductory course and by a four to 12-week internship in industry under the direction of Ira Janowitz. In addition, Safety is taught by faculty at the School of Public Health and Psychosocial Aspects of Injury Control is taught by faculty at the School of Nursing.

The research training program requires weekly attendance at a research seminar enrolling two to five doctoral students at any time.

Given the multidisciplinary nature of this field, an important aspect of the training has been the exposure students receive to students and faculty from other disciplines. The ergonomics courses require the students to work on projects with occupational health nursing students, occupational medicine residents, industrial hygiene students and engineering students. Research trainees from bioengineering work side-by-side with those from public health. Faculty from engineering, public health, and medicine are available to students to assist them with their research project.

### **Supply and Demand for Graduates**

The demand by industry for graduates exceeds their availability. All graduates are hired before or within weeks of completing their training or are accepted to Ph.D. programs for advanced training. Graduates have been hired by companies, consulting firms or are working for

government agencies (e.g., DOE, DOD). Three of the graduates have taken faculty positions in ergonomics at other universities.

### **Plans for the Future**

The plan is to recruit 3 to 6 new M.S. students to the program in the next 3 years. Undergraduates are informed of the Program by faculty lectures to classes at UC Berkeley. Others are informed by talks to health and safety professionals at regional and national conferences and by maintaining an informative web site.

The PH269C course will be modified by adding lectures on work physiology and training. A lecture on 'Universal Design' will also be added to the course. In addition, dynamics will be covered in the PH269D course.

Professors Goldberg and Rempel have been developing web-based training modules in ergonomics for health and safety professionals. Two courses are completed, one titled Dental Ergonomics and the second on the Medical Management of Musculoskeletal Disorders. Another course on Office Ergonomics is in preparation. The courses are used for CE training and for training of graduate students.

### **Publications and Presentations Co-authored by Trainees and Faculty are boldfaced.**

Students' names are followed by an asterisk

Dennerlein J\*, Miller J, Mote CD, **Rempel D**. A low profile human tendon force transducer: The influence of tendon thickness on calibration. *J Biomechanics* 1997, 30(4):395-397.

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Murthy G\*, Kahan NJ, Hargens AR, **Rempel DM**. Forearm muscle oxygenation decreases with low levels of voluntary contraction. *J Orthop Research* 1997, 15(4):507-511.

Keir PJ\*, Bach JM\*, **Rempel DM**. Fingertip loading and carpal tunnel pressure: Differences between a pinching and a pressing task. *J Orthop Research* 1998, 16(1):112-115.

Dennerlein JT\*, Mote Jr CD, **Rempel D**. Control strategies for finger movement during touch typing: The role of the extrinsic muscles during a keystroke. *Experimental Brain Research* 1998, 121:1-6.

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## CONTINUING EDUCATION

Of note in the past 5-year cycle is that the CE Program completed the complex and stringent applications to successfully become approved providers for the California Industrial Medical Council to offer continuing education for the state's Qualified Medical Evaluators (QMEs) and became an approved provider of Category I credit of the Accreditation Council for Continuing Medical Education (CMEs) of the California Medical Association for physicians. These accreditations are difficult to obtain and require a lengthy accrediting process, establishment of a Continuing Medical Education Advisory Committee that meets quarterly, and demonstration of a long history of providing quality continuing professional education in the region. In addition, this 5-year cycle has seen a significant leap in the number of other accreditations provided to occupational health professionals by the COEH CE Program. Just a few of those were: State Bar of California, Disability Management Specialists Commission, Committee on Rehabilitation Counselors, Commission for Case Manager Certification, California Department of Insurance Licensing Bureau, among others.

CE courses co-sponsored with other educational institutions, professional associations, community organizations, and/or government agencies have increased in number as well.

All of the ERC's academic programs continue to provide CE courses geared toward their specific constituents, as well as contributing to the development of the ERC-wide CE offerings. The ERC developed a written policy on CE courses in 1995-6 to respond to reduced budgets in the individual academic programs. Each academic program contributes one CE course per year and shares in the income generated from other courses co-sponsored with the central CE Program. The policy also provides free or greatly reduced fees for attendance in CE classes for students, faculty and others.

The CE Program's office space and main storage facilities were relocated in May 2001 to the same UC Berkeley building as LOHP's main office in order to be housed together again and optimize day-to-day operations. The new location is 2223 Fulton Street, Berkeley campus. A small amount of storage space is still used for COEH as a whole at the Richmond Field Station.

The CE Program presented successful Occupational Health and Safety Summer Institutes each year. These Summer Institutes provide the opportunity to offer a wider variety of new and timely, but sometimes financially riskier, courses to California occupational safety and health professionals as well as our regular classes, such as "Comprehensive Review of Industrial Hygiene," "Fundamentals of Workplace Safety," "Fundamentals of Industrial Hygiene," and "Workers' Compensation Overview Update." These other courses included "Occupational Medicine Practice Guidelines," "Hearing Conservation," "Reproductive Hazards in the Workplace" and "Health and Safety Communication."

The CE Program has offered two highly successful ergonomics classes annually during the five-year period. We co-sponsored a course with the University of Michigan and with our own ERC's Ergonomics Program at the Summer Institute. Together these classes attracted over 160 attendees each year.

During this period the CE Program continued a training relationship with the California Division of Occupational Safety and Health (Cal/OSHA), training their new and senior industrial hygienists and safety and compliance officers in ventilation, noise control, respiratory protection, and other health and safety topics.

The CE Program continued to offer the popular “Industrial Hygiene Forum Series” in collaboration with the Northern California Section of the AIHA. Three low-cost short sessions each year present topics of interest to local industrial hygienists and other health and safety professionals, and are particularly attractive to professionals with limited time and limited budgets. Some of the topics during the five-year period included “Occupational Medicine Issues for the IH,” “Communicating with Management,” and “Cal-OSHA Regulatory Update.”

## HAZARDOUS SUBSTANCE TRAINING PROGRAM

During the past grant cycle from 1997-2002, the basic 2-day "Pesticide Contaminated Hazardous Waste Sites" course has been offered five times in California and once in Carson City, Nevada. An entirely new course, an advanced version of the basic 2-day course called "Pesticides: Risk Evaluation and Site Mitigation," was developed and offered twice in California.

Professionals dealing with other types of pesticide contamination concerns have been identified through outreach to public agencies throughout region 9 and have been trained. For example, through contact with the EPA Region 9 pesticide coordinator, the Hawaii Medical Association Environmental Committee and the Hawaii Department of Agriculture, the HST Program identified the need for specific pesticide training in Hawaii. As a result, two very successful courses were designed and offered in Hawaii in April 2000: "Pesticides and Medicine in Hawaii" and "Pesticide Emergency Response." Further specific regional needs were identified through the Advisory Committee and through local participating agencies for training in pesticides and medical concerns such as emergency treatment for pesticide exposures and pesticide injury prevention. As a result, "Agricultural Pesticides and Health" (given in the central valley of California), "Pesticide Illnesses and Injuries" (given twice in the central valley), "Pesticides and Health in the Southwest" (given in southern Nevada), and "Prevention and Treatment of Pesticide Illnesses" (given for the Navaho Nation EPA in New Mexico) were all developed and presented.

Another course developed for public sector professionals in collaboration with the California Integrated Waste Management Board was "Pesticide Hazards at Solid Waste Sites." The class was designed and pilot-tested in Sacramento. For the second year, the class was redesigned based upon evaluations and further needs assessment, and offered twice in California.

The one-day "Pesticide Emergency Response" class has been offered a total of nine times in the last five years: in Hawaii, Arizona, and a special version given every year in Sacramento in conjunction with "The Continuing Challenge, Hazardous Materials Workshop."

Since the 1994-95, a new one-day course has been presented jointly by the HST Program and the NIEHS California-Arizona consortium. The "Pesticide Hazardous Waste Refresher" combined the Consortium's standard Hazardous Waste curriculum with additional basic information on pesticides. The course offers partial or full scholarships for pesticide-related training to a growing group of public sector professionals with responsibilities at waste sites and storage facilities where pesticides are present. The course meets the need for recertification and for specific training on pesticides. Because the course is offered with full or partial scholarships provided by the HST Program, we believe that it will be a successful way to reach our targeted public sector professional audience in a time of constrained training budgets.

**AGRICULTURE HEALTH & SAFETY**  
**(A supplement to the Northern California's ERC Training Grant)**

The ERC's Agricultural Safety and Health Program has again seen its funding eliminated at the recommendation of an external review team. While this will not end the ERC's successful program of external training for farm safety coordinators across the state, it will end NIOSH's participation. Unfortunately, the rejection of the ERC's proposal to evaluate the impact of the training program developed with NIOSH ERC funding on injury and illness frequency cannot now be undertaken. Thus, just as important impact evaluation data becomes available, it cannot be collected and utilized.

As planned, the curriculum has been completed and translated into Spanish. Minor modifications in the format and curriculum materials are being made, and a statewide campaign is being planned for the beginning of 2003. There is evidence of growing interest and demand for the training. With new support from the University's Division of Agriculture and Natural Resources (DANR) a briefer version of the curriculum has been developed for use in cooperation with the California Farm Bureau for outreach to small farmers.

The original program plan supported by NIOSH in two sequential supplemental grants is now fully complete and proving successful in the field. As originally planned, the curriculum consists of a series of 5 half-day (4-hour) courses along the following outline:

1. Introduction to Safety Laws and Regulations
2. Foundations for Occupational Health & Safety
3. Ag Workplace Injury and Illness Prevention
4. Effective Health and Safety Training
5. Ag Health & Safety Practicum

Work in the past two years focused on translation and field trial of the Spanish language curriculum. As noted earlier, DANR provided a full-time Training Coordinator for this program in recognition of its growing importance and effective outreach. Based on current cooperative ERC and AgSafe efforts, we anticipate reaching at minimum between 200-300 trainees per year over the next two years.

## Pilot Research Training Program Final Reports

**Award #1:**

**Title:** *Accuracy and Feasibility of the BackTalk to Estimate Long Term Exposure to Extreme Trunk Postures in Agricultural Work*

**Principal Investigator:** Fadi A. Fathallah

**Institution:** University of California, Davis

**Objectives:**

The first two years' objectives of this pilot study were to assess the validity and feasibility of a newly developed technology to capture extreme trunk postural data in agricultural settings. To achieve these objectives, four original specific aims were set. The following discussion will outline the progress made with regard to reach of these specific aims.

**Specific Aim 1: Using a calibration apparatus, conduct a laboratory experiment to validate the accuracy of the BackTalk device in recording flexion angles.**

An experiment was successfully completed to address this specific aim. The findings of this experiment were presented at a national conference and were published in the conference proceedings (Fathallah and Kato, 2001). The results of this accuracy evaluation of the BackTalk device indicate that, for large sagittal flexion angles, the device consistently recorded the surpassing of these angles. However, the device performed poorly when attempting to record small sagittal flexion angles (i.e., 15 °) at fast speeds (around 20 deg/s), especially under the symmetric conditions. Also, under the symmetric fast conditions for the 30 ° of sagittal flexion, the devices missed about 20% of the trials. Therefore, if the device is to be used in highly dynamic situations that do not involve extreme sagittal postures, the device may have a high rate of missed recordings (about 50%).

**Specific Aim 2: Compare the accuracy of the BackTalk to the accuracy of a commercially available spinal electrogoniometer (Lumbar Motion Monitor, LMM).**

Again, this was accomplished through the experiment discussed above. The results showed that for gross trunk flexion "windows," both devices performed equally. One of the shortcomings of the BackTalk device was its inability to record the flexion duration.

**Specific Aim 3: Conduct a pilot field study to assess the concordance between the BackTalk and the LMM in capturing the percent of time an agricultural worker spends in extreme trunk postures.**

The device was placed on twelve agricultural workers simultaneously with the LMM. This study showed the feasibility of using the device in actual field work. Both devices were equally effective in recording the surpassing of pre-selected sagittal flexion angles. The device was also used to compare the effect of two grape picking tubs on workers' postures.

**Specific Aim 4: Assess the capability/feasibility of the BackTalk in capturing extreme trunk postures data throughout the entire period of working hours and throughout non-working hours.**

The device was shown to be feasible for the collection of postural load from workers throughout their working shifts. However, the issue of trying to use the device in non-working environments was not pursued due to technical, logistical and other difficulties.

### **Objectives-Year 3**

The objective of the project continuation year was to develop a device that takes into consideration the findings learned during the first two years of this training project. To achieve this objective, the following two specific aims were generated.

#### **Specific Aim C1: Develop a device that calculates the duration spent beyond prescribed sagittal flexion angles.**

The capability of capturing the magnitude and duration of trunk flexion was explored using two dual-axis accelerometers (Analog Devices ADXL202). The accelerometers (inclinometers) were individually calibrated and showed acceptable angle determination accuracy under slow to moderate speeds. One inclinometer was placed on the hip area and another on the upper back region (around T-9 level). The trunk flexion angle is the difference between the two angle readings. The data were collected with an A/D system for further analysis. This portion of the study showed that this approach could be a viable approach to capture trunk flexion magnitude, frequency, and duration; however under moderate to low speeds. We also, have acquired a device (Virtual Corset) that may be capable of capturing trunk flexion in a similar manner to the BackTalk, but which may be capable of capturing duration trunk flexion angles at higher speeds. Unfortunately, the company just delivered the device to us after several months of waiting for it. Despite the fact this project is officially concluded, we will pursue the testing of this new device.

#### **Specific Aim C2: *Develop the device in a manner to accurately record postural data under higher trunk velocities.***

As mentioned above the approach taken with the inclinometers did not result in a device that would be accurate under high-speed motion. Various options were considered; however, due to time constraints this specific aim was not accomplished by the project end-date. Nevertheless, we are currently discussing the issue with a company that is currently working on a device that is capable to accomplish this feature, as well as explore the option of building such a device in-house.

#### **Publication/Presentation:**

Fathallah, F.A., and Kato, A.E. (2001). Accuracy of a portable inclinometer for recording frequency of trunk sagittal flexion. In Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting. Santa Monica, CA: Human Factors and Ergonomics Society.

**Award #2:**

**Title:** *A Model for Occupational Joint Disease of the Hand*  
**Principal Investigator:** Karen B. King, Ph.D  
**Institution:** University of California, UCSF Ergonomics

**Overview**

The long-term goal of this pilot research training project was to adapt an *in vivo* animal model for investigating the pathophysiologic mechanisms and exposure-response relationships of repetitive finger loading and degenerative joint disease (DJD) of the hand. The specific aims of the first two years were:

- 1) to develop a rabbit repetitive finger flexor-loading model as an experimental model for occupational joint disease of the hand, and
- 2) to validate the loading model by comparing the resulting histological changes in articular cartilage and bone to those observed in arthritis of the human hand and other articulating joints.
- 3) In the third year, a unique third aim was added. This aim was to develop tools for measuring the degenerative changes of the articulating cartilage surfaces.

**Year 3 Progress Report**

The originally proposed method to be used for the 10-month Year 3 project was ultra-structural examination of the rabbit metacarpal phalangeal (MCP) joint surfaces using environmental electron microscopy. However, due to the addition of new equipment to the Center for Tissue Bioengineering we were able to take advantage of more sensitive techniques. Recently acquired is the Hysitron Nanoindenter. This equipment is typically used to measure the stiffness and uniformity of smooth surfaces such as metals. The laboratory of Professor Lisa Pruitt, UCB, has recently measured the material properties of biological tissues such as arterial wall at the nanoscale level. In this project we adapted these methods to measure the elastic modulus of the articular cartilage of the finger joint surfaces. Our hypothesis is that areas of repeated loading will be stiffer than non- or less-loaded areas. In other words, the cartilage surface of the finger joint is heterogeneous. The traditional method of measuring compressive characteristics is to excise or core a cartilage plug from the joint and then to load it in confined or unconfined compression of between platens. The two advantages of using a nanoindenter over traditional methods are 1) that very small regions of interest can be measured using the very small 200  $\mu\text{m}$  diameter probe, and 2) the experiment is more like natural compression than confined or unconfined compression using platens because the joint surface is in a nearly native state.

To test this hypothesis we obtained the MCP joint of three fingers (D2, D3, and D4) from the right hands of 3 subjects (New Zealand White Rabbits, 4.1 to 4.5 kg, sacrificed for other experiments). The first 3 tests were of joints that had been previously frozen. The last 6 tests ( $n = 2$  rabbits) were of fresh joints dissected within 2 hours of sacrifice. Seven sites on the cartilage surfaces were tested. The 3 sites on the proximal side were centered in the convex shaped areas. These areas resemble the condyle structures found in the human knee. The 4 remaining sites were in the slightly concave shaped areas of the distal side. These areas resemble the plateau structures in the human knee. We find that the load-displacement curves from our nanoindentation resemble the behavior of articular cartilage measured by (macro)indentation methods. From these curves we calculate the modulus value of the material. The modulus is a measure of the cartilage stiffness.

The higher the value the more stiff or brittle the material, the lower the value, the more deformable the material. The table below reports the modulus for the 3 samples (4 plateau points averaged and 3 condyle points averaged) and the average of the three samples.

Reduced modulus values of MCP joint cartilage. All values are in Mpa. Standard deviation in parentheses.

	<b>Distal "Plateaus"</b>	<b>Proximal "Condyles"</b>	<b>All Positions</b>	<b>Treatment</b>
<b>Sample 1</b>	83.3 (63.6)	91.8 (65.0)	86.9 (62.7)	Fresh
<b>Sample 2</b>	42.4 (26.0)	57.9 (30.4)	49.1 (28.3)	Fresh
<b>Sample 3</b>	90.6 (30.5)	152.0 (108.0)	117.0 (78.5)	Frozen
<b>Average 1-3</b>	72.1 (47.3)	100.0 (82.2)	84.3 (65.6)	Both

### Summary of Progress Years 1-3:

The first two years of this pilot project provided the means to develop the method for examining the finger joints using the *in vivo* rabbit model. These methods led to the successful grant application to the Arthritis Foundation to pursue this model for hand OA through statistical validation. The Arthritis Foundation feasibility project is currently generating data that will be used in a large-scale project (R01) application to the CDC/NIOSH this fall. A first-year graduate student (UCSF/UCB Bioengineering) has been recruited to conduct this study as a rotation or thesis project.

The third year project is still in the early phase. Yet to be accomplished are a statistical study of the data generated comparing the difference between the different surface zones and between frozen and fresh tissue. Our plans are to begin a similar study using human cadaver joints. We will initially use frozen tissue, as it is more readily available. Therefore, measurement of the difference, if any, between fresh and once-frozen cartilage mechanical properties will be useful in evaluating data from once-frozen human specimens. A first-year graduate student (UCSF/UCB Bioengineering) has been recruited to assist in this study as a rotation project. We will continue our collaboration with Dr. Pruitt.

**Award #3:**

**Title:** *Pulmonary Toxicity of Repeated Zinc-Oxide Exposure in Non-Asthmatic and Asthmatic Individuals*

**Principal Investigator:** Colin Solomon, Assistant Adjunct Professor

**Institution:** Department of Medicine, University of California, San Francisco

**Period:** July 1999 - June 2002.

**Introduction**

Zinc is an essential biological element important in neuromuscular activity, activation of multiple enzymes including phosphatase, and catalyzation of reactions involving adenosine triphosphate. However, exogenous zinc can be toxic to humans. Work processes generating zinc fume include foundry operations, galvanizing, and welding of galvanized materials. NIOSH has estimated that 50,000 workers per year in the U.S.A. are potentially exposed to zinc-oxide (ZnO) (1). The current OSHA standard for ZnO fume exposure is a Permissible Exposure Limit of  $5\text{mg}/\text{m}^3$  (8-h average) (2).

Zinc-oxide exposures are associated with Metal Fume Fever (MFF), an acute, self-limiting syndrome, clinically characterized by fever, myalgia and malaise, the exposures being typically inhalation of ZnO particulate suspended in air. Ingestion or parenteral administration of ZnO does not induce fever or leukocytosis (3-6). Therefore, the systemic effects of ZnO exposure are most logically mediated through the pulmonary system. Single controlled ZnO exposure in healthy individuals results in a time-related and dose-dependent, increase of neutrophils in bronchoalveolar lavage (BAL), and IL-6 in peripheral blood (7-12). Also, ZnO inhalation is significantly co-related to BAL concentrations of TNF $\alpha$ , IL-6 and IL-8 (7-10). Similarly, a single exposure to ZnO ( $20\text{mg}/\text{m}^3$ ; 60 min), results in a significant increase in the total cell count, neutrophil percent, TNF $\alpha$ , IL-1 $\beta$ , IL-6, and IL-8, as measured in sputum, collected using sputum-induction (S-I), in healthy individuals (13-14).

The acute airway inflammatory response to ZnO exposure is attenuated following repeated exposures. A decrease in symptoms was found following the second of two sequential-day occupational zinc exposures (15). In a controlled exposure experiment, 3 sequential-day ZnO exposures ( $5\text{mg}/\text{m}^3$ ; 2 h), attenuated the increase in neutrophils, and IL-6, induced by a single exposure (12). The exposure conditions (dose; concentration x duration), and format (number and timing of exposures), that induce MFF, and airway inflammation, are unknown. Also, the time dynamics of the inflammatory response are unknown. Further, the mechanisms of both the ZnO-induced acute inflammatory response, and the attenuation of the response, are unknown.

In occupational environments, both normal healthy individuals, and those with already compromised pulmonary function, such as individuals with asthma, are exposed to airborne ZnO. Asthmatic individuals could be at higher risk for health effects from airborne ZnO, as compared to non-asthmatic individuals, due to underlying airway inflammation and/or non-specific hyper-responsiveness.

Sputum induction was used in this project for the collection of airway cells and fluid. Sputum induction has been shown to be a valid, accurate, and reliable method for sampling cellular and biochemical indices of inflammation in the pulmonary tract in both unstimulated and

post-inhalation exposure conditions (13, 14,16-19). Changes in differential leukocyte cell counts (specifically increased neutrophils, and macrophages), and activation in S-I have been used as the primary measure of airway inflammation following air pollutant exposures (13, 14). Specific proteins measured in the fluid phase of S-I are indicative of respiratory tract inflammation, inflammatory cell degranulation, and airway injury and permeability. Total protein is a marker of epithelial permeability. Tumor necrosis factor-alpha is a pro-inflammatory cytokine, which can induce the production of IL-8, and the regulation of IL-6. Interleukin-8 sources include neutrophils, activated T and B cells and NK cells and it is a potent neutrophil chemoattractant and activator.

This study was designed to investigate the airway inflammatory response to single and repeated ZnO exposure in healthy and asthmatic individuals. It was hypothesized that:

- 1) both non-asthmatic and asthmatic individuals would exhibit airway inflammation (increased neutrophils, cytokine proteins) following one ZnO exposure compared to filtered-air;
- 2) both non-asthmatic and asthmatic individuals would exhibit decreased airway inflammation following two ZnO exposures compared to one ZnO exposure;
- 3) asthmatic individuals would have a higher level of inflammation in response to the ZnO exposure in both the one ZnO exposure and two ZnO exposure conditions.
- 4) that cytokine gene expression would indicate up-regulation of pro-inflammatory cytokine genes, as a function of ZnO-induced, and asthma-induced, airway inflammation.

### **Method:**

**Design:** This project consisted of two controlled human exposure experiments. Each of the experiments utilized a repeated measures design, with each subject completing each condition within the experiment. The experiments were conducted single-blind, the subjects being unaware of the exposure conditions. The order of the experimental conditions was counter-balanced within each experiment. A Control condition of exposure to filtered air (FA) was used in both experiments. A minimum of three weeks separated the conditions within each experiment. All exposures were of 30 min duration. For each condition, each subject performed S-I 65 h pre-exposure and 6 h post-(final) exposure.

**Independent Variables:** The conditions of both experiments were: 1) Filtered-air (FA; Control) exposure; 2) one ZnO exposure (ZnO-1); 3) two (sequential-day) ZnO (ZnO-2) exposures. The subject groups were: Experiment One; healthy individuals, and Experiment Two; individuals with asthma.

**Dependent Variables:** Pulmonary toxicity was assessed using: 1) cell distribution ; 2) cytokine and protein levels; 3) gene expression 4) pulmonary function.

### **Subjects:**

The subject group for each of Experiment One and Experiment Two, consisted of 12 volunteers. For Experiment One subjects were healthy individuals, and for Experiment Two subjects were individuals with asthma. Asthma status was determined using the guidelines of the National Asthma Education Program (20). Subjects were characterized by physical characteristics, spirometric pulmonary function, and non-specific airway responsiveness (Table 1. and Table 2.). All subjects completed a medical history questionnaire, were not pregnant, denied a history of

pulmonary or cardiac dysfunction, were current non-smokers (life-time non-smokers, or <10 pack-years), and had no respiratory-tract illness in the three weeks preceding any session. Subjects abstained from caffeine for 4 h prior to each session. Subjects in Experiment Two (Asthma), abstained from inhaled steroids for two weeks, long-acting bronchodilators for 2-days, and short-acting bronchodilators for 8 h, prior to each session. Each subject was informed of the procedures of the experiment and provided informed consent prior to participation. The procedures for this experiment were approved by the University of California, San Francisco Committee on Human Research.

## Discussion

The results of this study indicate that both single and repeated exposures to inhaled ZnO induce airway inflammation, as indicated by increases in the TLC, neutrophil percent, cytokine proteins, and gene expression, measured from S-I. There were no variables that supported the hypothesis that repeated exposure would decrease the changes induced by the single exposure. However, there were several variables that were increased in the single exposure, but unchanged in the repeated exposures. Similarly, there were no differences between the healthy and asthma subject groups in the response to ZnO. Nevertheless, the pattern of cell, protein, and gene expression responses appeared not to be identical in the two groups.

Although there is the potential for S-I to produce cell count, protein, and RNA level data that is more variable than that from BAL, the results of this study indicate that S-I provides useable and reasonable data, for each of these variables for the assessment of inhaled toxin-induced airway inflammation in healthy individuals and individuals with asthma. This study also indicates that gene expression in cells collected using S-I can be used to measure toxin-induced changes in both healthy individuals, and individuals with asthma.

One of the major indices of toxin-induced inflammation in the airway is the number of neutrophils. The absence of a decrease in neutrophils in S-I as a function of the repeated ZnO exposure in this study could be due to the dose of ZnO in the first, of the two, exposures being too low to induce an inflammatory response that would subsequently initiate the anti-inflammatory processes. The ZnO dose was 25% (30 min vs. 60 min; 10 mg/m<sup>3</sup> vs. 20 mg/m<sup>3</sup>), of that which produced larger increases in neutrophils and TNF $\alpha$ , IL-1 $\beta$ , IL-6, and IL-8 compared to the exposure used in this study (13, 14).

In investigating the mechanisms for both the acute, and attenuation responses to ZnO, the finding of a decrease in NF $\kappa$ B following the repeated ZnO exposure is of interest. This transcription factor controls the production of multiple pro-inflammatory cytokines being controlled through MAPK pathways. Also, the increase in IL-13 gene expression in the single exposure condition, but not in the repeated exposure condition in both subject groups, could indicate that this cytokine has a role in mediating response to ZnO, potentially through effecting leukocyte recruitment. Similarly, in the healthy subject group the increased change in IL-10 in both exposure conditions compared to FA, could indicate initiation of an anti-inflammatory process. This change in IL-10 was not present in the asthma subject group.

The variables measured in this study do not indicate a difference in the response to single versus repeated inhaled ZnO exposure, or in individuals with asthma, compared to healthy

individuals. Obviously, there are a multitude of indices that need to be investigated in determining the mechanisms of both the acute inflammatory response to ZnO, and the phenomenon of attenuation of this response. Determination of these factors will aid in the formulation of guidelines for the control of ZnO exposure in occupational environments.

### **Publications and Presentations**

Reintjes K., Witten A., Arjomandi M., Balmes J., Blanc P., Solomon C. (2002) The effects of single and serial zinc oxide exposures on airway inflammation in healthy humans. *Am. J. Respir. Crit. Care Med.* 165 (8).

### **Funding Applications:**

Data from this project formed the basis of a K01 Award application to NIOSH (October 2002).

### **References:**

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Attachment I

**CORE PROGRAM GRADUATES**

*Years 16-20 July 1, 1997 –  
June 30, 2002*

**OCCUPATIONAL MEDICINE RESIDENTS –  
SAN FRANCISCO**

**Rajiv Bhatia '97**  
Director, Occup. & Environ. Health  
SF Dept of Health  
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**Matthew R. Brodie '00**  
Consulting OM Physician  
Evergreen, CO 80439

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**David Ross Field '01**  
Consulting OM Physician  
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**Lisa M. Key '99**  
OM Physician Kaiser SSF  
San Bruno, CA 94066

**Perna Mona Khanna '98**  
Director, Employee Health  
Riverside County, CA

**Janice L. Kirsch '00**  
Consulting OEM Physician/ Oncologist  
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**Patrick R. Laraby '00**  
Dir, Occ. & Env. Health  
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**Mark Francis Luppino '97**  
OM Physician, US Air Force  
Andrews AFB, MD 10762

**Raymond Kibbe Meister '98**  
Staff Physician UCSF Div. Of OEM  
San Francisco, CA 94110

**William Ngai '98**  
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**Jessica Nutik-Zitter '00**  
Assistant Professor of Medicine,  
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**Robert J. Pandya '01**  
OM Physician  
Kaiser Southern California  
Los Angeles, CA 90020

**Joni Rochelle Parker '02**  
OM Physician  
Kaiser Southern California  
Chula Vista, CA 91910

**Karron LeGarie Power '02**  
UCSF-Asst Adj Instructor  
San Rafael, CA 94901

**Craig Murray Steinmaus '99**  
Assistant Professor of Medicine  
UCSF Div. Of OEM/UCB EHS  
Berkeley, CA 94720-7360

***OCCUPATIONAL HEALTH NURSING GRADUATES  
SAN FRANCISCO***

**Barger James, MS/CNS '02**

**Edith Barnica, MS '02  
University of California  
San Francisco, CA**

**Diantha Fullmer, MS '02  
Department of Public Health  
San Francisco, CA**

**Kelly Gelenter, MS'02  
(on maternity leave from UCSF)**

**Jason Libby, MS'02  
UC Davis- Neuro-Surgery ICU  
Sacramento, CA**

**Mary Owen, MS '02  
(Currently looking for placement)**

**Be Thi Phan, MS '02  
(Currently looking for placement)**

**Julie Roberts, Ph.D. '02  
UCSF-School of Nursing  
San Francisco, CA**

**Kathleen Ruel, MS '02  
Alameda County Medical Center  
Oakland, CA**

**Rossana Segovia-Bain, MS '02  
UC Davis Med. Surveillance  
& Preventive Medicine**

**Janheen Pascual (Trias), MS '02  
(Currently looking for placement)**

**Andrew Fernandez, MS '2001  
Alvarado Hospital Med. Cent  
San Diego, CA**

**Pamela Greene-Foreman, MS '01  
Owens Corning  
Napa, CA**

**Judy Ann Herriman, MS '01**

**Sharon Ann Legenza, MS '01  
UCSF Medical Center  
San Francisco, CA**

**Jane Shih-Chin Pun, MS '01  
El Camino Hospital-Emp. Hlth Serv  
Mountain View, CA**

**Heather West, MS '01  
Ob-Gyn Specialists  
Walnut Creek, CA**

**Sandra Buckley, MS '00  
Kaiser  
Valejo, CA**

**Dorothy Christian, MS '00**

**John Deex, MS '00  
El Camino Hospital  
Mountain View, CA**

**Jeanette Landucci, MS '00  
Kaiser/East Bay Region**

**Donna Haiduven, Ph.D. '00  
James Haley VA Hospital  
Tampa, Fl**

**Candy (Haymaker) Hanratty, MS '99**  
**Chiron**  
**Emeryville, CA**

**Deborah Sohr, MS '99**  
**Kaiser Permanente-San Francisco**  
**City College of San Francisco**  
**University Health Center-Berkeley**

**Gwendolyn Cashman, MS '99**

**Keith Sheirich, MS '99**  
**Lawrence Livermore National lab**  
**Livermore, CA**

**Mary Gould, RN, NP, MS '99**  
**Integrated Pain Management, Inc.**  
**Concord, CA**

**Susan Price, MS '99**

**Victoria Becker, MS '99**

**Weeraporn Seugthaworn, MS '99**  
**Doctoral Student**  
**Johns Hopkins, MD**

**Jane West, MS '98**  
**Chiron**  
**Emeryville, CA**

**Diane Fuller, MS/Admin '98**  
**Genetech, Inc.**  
**South San Francisco, CA**

**Allison Wong-Hanson, MS '98 Kaiser**  
**Permanente Med. Center**  
**Walnut Creek, CA**

**Brenda Stengele, ANP, MS '98**  
**Orthosurgery, University of California**  
**San Francisco, CA**

**Erin Andersen, MS/OHNP '98**  
**Employee Health Services**  
**University of California**  
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**Karen Truong, MS '98**  
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*Industrial Hygiene Graduates – UC Berkeley*

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**Esther Ho, MPH '00**  
The Cohen Group  
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**Michael Hogan, MPH '00**

**Mark Minto, MPH '00**

**Aimee Tucker, MPH, '00**  
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**Colleen Yeh, MPH '00**  
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*Ergonomics Graduates-Berkeley/UCSF*

**Joel Bach, PhD '95**  
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**Melissa Jacobson, MS '97**  
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Pleasanton, CA

**Gita Murthy, PhD '99**  
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**Gary Au, MS '01**  
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Doctoral Student  
University of Southern California  
Los Angeles, CA

**Evan Scott Collier, MS '99**  
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DEPARTMENT OF HEALTH & HUMAN SERVICES

Memorandum

Date August 4, 2003  
From Principal Engineer, OEP, NIOSH  
Subject Final Progress Report for entry into NIOSHTIC2/NTIS for  
NIOSH Training Grant No. T42 CCT 910427  
To Vern P. Anderson, Chief, IRB, EID (C-18)

The enclosed report has been received from the Center Director to document work performed during the specified grant project period. The following information applies to the designated Education and Research Center (ERC):

Title: Northern California Education and Research Center

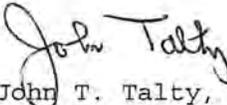
Center Director: Robert C. Spear, Ph.D.  
School of Public Health  
University of California  
Berkeley, CA 94720

Grant No.: T42 CCT 910427

Project Period: 7/1/97 - 6/30/2002

Please place the report in DIDS and I also recommend it for entry into NIOSHTIC2 and submission to NTIS.

Thanks for your assistance.

  
John T. Talty, P.E., DEE

Enclosure

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