The Slow-Moving Crisis of Training in Occupational and Environmental Medicine

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Two years ago, the American College of Occupational and Environmental Medicine (ACOEM) published a Guidance Statement entitled *The Future of Occupational and Environmental Medicine* (OEM), which concluded that "Despite robust job opportunities, a shortage of formally trained OEM physicians remains and is expected to worsen given a declining number of training programs."[1] The authors identify funding as a major reason for this shortage: "Whereas for other US medical specialties the ability for residency positions to be filled is based on demand by graduating medical students, in OEM the issue is not primarily demand, but rather the inability of OEM training programs to fund positions for which they are accredited. Qualified applicants are turned away. The shrinking number of programs, as well as the inability to fund all accredited positions, is one of the factors affecting the pipeline for residency-trained, board-certified OEM physicians." They noted that 18 of 23 (78%) existing OEM training programs received funding from the National Institute for Occupational Safety and Health (NIOSH), which had been decreasing over time.

Although maintaining that qualified applicants were being turned away, they also cite "limited visibility of OEM among medical students, residents, and practicing physicians" as an additional reason for the OEM specialist shortage. In short, a paradox: The specialty is wonderful and much in demand, yet fewer and fewer are entering it and training programs are closing. If more candidates were made aware of OEM, and with greater funding to increase both the number of residency programs and funded positions, more specialists would be trained.

An in-depth examination of OEM training today, and of its history in this country over more than 50 years, points to an alternative explanation for the shortage of specialists. Furthermore, despite consistent assessments that training was failing to meet workforce needs from the very beginning, remarkably little has changed in the approach to OEM residency education, with one notable exception. Neither have the associated problems or the proposed solutions.

FORTY YEARS AGO

Dr. Douglas "Scutch" Scutchfield wrote in 1984: "It appears that the specialty of preventive medicine is declining as a viable specialty, with inadequate numbers of practitioners and with a declining number of physicians entering residency training programs."[2] At that time, there were four preventive medicine specialties, as public health (PH) and general preventive medicine (GPM) were separate and distinct board certifications and he addressed all four. For what was then called occupational medicine (OM), programs were "academic" or "in-plant." He reported a total of 23 such programs in 1974: four academic and 19 in-plant. By 1979, while the total remained the same, the number of academic programs had increased to 10, while in-plant training programs had been reduced to 13.

In the academic year 1978–79, 127 OM resident positions were available, 93 were funded, and 67 places filled. Seventy-six percent of the OM residencies were supported by federal funding. Notably, Scutchfield ignored the 26 funded-but-unfilled slots in OM. Instead, he focused on GPM and PH, where there were more filled than funded positions, which he attributed to "creative financing" on the part of the programs. He argued that, because there was excess capacity on the basis of the higher number of available slots in existing residencies, "…a limiting factor for their increase is availability of funding…." Two recommendations were made: "All medical students must be exposed to the excitement we all feel about preventive care. Our teaching programs in medical schools must be strengthened to assure that there is rigor in these programs and that the potential of preventive medicine is conveyed." Additional funding needed to be secured, and reimbursement from Medicaid and Medicare was suggested. The two recommendations of the ACOEM Guidance Statement of 2022 were made in 1984.

Thirty Years Ago

In 1994, in an article in this journal entitled "Too Many Residencies?", Dr. Howard Frumkin wrote:

"*These days, nobody would defend the presence of five computed tomography scanners in one small town. At a time of scarcity, it is difficult to justify over-capacity and underutilization of a costly resource. But occupational medicine residencies are exactly such a case. The nation now has 40 such residencies, 37 accredited and 3 "in the pipeline" for accreditation. This number has been expanding regularly; the 15 occupational medicine residencies in 1975 had increased to 26 by 1990, and no fewer than 14 new programs have been added in the ensuing 3 years (personal communication, Doris Stoll, PhD, October 1993). We now have too many.*"[3]

The NIOSH was supporting 28 of these residencies (70%), 14 through what were then called educational resource centers (ERCs) and nine through training project grants (TPGs). The "NIOSH's policy has been to support all programs that meet technical criteria." While acknowledging that the current production of specialists overall was "meager", Frumkin wrote "the proliferation of residencies has created its own problems – squandering faculty time and energy, ubiquitous underfunding, and pressure to accept less than top-notch applicants – that now need to be solved." "Running a residency is labor-intensive. There are Accreditation Council for Graduate Medical Education (ACGME) hoops to jump through, the NIOSH hoops to jump through, rotation agreements to nurture and maintain, and elaborate institutional requirements within each medical center."

He noted that the 31 programs operating long enough in 1991 to have graduates produced a total of 80 that year, for an average of 2.6 graduates per program. "There is probably no magic number that constitutes a critical mass for training, but it is hard to argue that programs producing zero, one, or even two graduates each year are large and active enough to provide an optimal learning environment for residents." He recommended that the best approach was "voluntary" closure of most of the current programs to reduce the total to 10–15.

OEM Training Today

Although the name changed from OM to OEM, the 3-year residency program accredited by the ACGME of 1984 with one clinical

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year, one academic year, and one "field" year remains the design of residencies today.[2,4] OEM shares this same fundamental structure for board certification with the other two Preventive Medicine residencies: Aerospace Medicine and the now unified public health and general preventive medicine, all of which are separate specialties certified by the American Board of Preventive Medicine (ABPM).[5] Indeed, there is substantial overlap in the eligibility for certification, with an identical clinical year and academic certification requirements.[6] There are several structural problems with the current model.

Unlike every other medical residency outside of preventive medicine, those who complete these three postgraduate years (PGYs) do so through a route disjointed by design. This situation arises because the broad-based initial clinical year of training (PGY-1) is supported federally through the Centers for Medicare & Medicaid Services based on Medicare and Medicaid funding, neither of which are relevant payers for OEM services. As a result, the first clinical year (PGY-1) is only offered by one OEM residency program in the country.[7] For every other program, individuals must first be admitted into another preliminary or categorical residency program and complete at least 1 year of clinical training. A second application is then required for acceptance into an OEM program. If admitted, the trainee is granted credit for the prior clinical training, starts the program at the PGY-2 level, and, from an ACGME perspective, is a transfer into the OEM residency. As a result, OEM residency programs have not participated in the National Resident Matching Program (NRMP) required for all PGY-1 positions, and the specialty is outside of the system in which all graduating medical students are deciding on their future careers.

Instead of joining the NRMP, most of the civilian OEM residency programs have used an informal acceptance program roughly analogous to the pre-1952 methods of resident placement with a mutually agreed-upon timeline and detailed instructions to allow all programs a chance to reach candidates and make offers. Because available slots remain each year after the initial acceptance period in January (as discussed further below), the Association of Occupational and Environmental Clinics and, more recently, ACOEM, have provided a service to forward applications from candidates who did not receive offers or applied later in the year to programs with available positions. This arrangement exists precisely because the application environment described by Frumkin in 1994 persists. The pool of quality national candidates is smaller than the number of available positions each year; as a result, programs vie with each other to recruit the same applicants. There is broad dissatisfaction with this system among program directors, including allegations of programs breaking the agreement to make earlier offers, which has become a perennial discussion topic (and source of disagreement) at the annual meeting of the OEM program directors, with a recent vote to replace this informal and unenforceable system with participation in the NRMP. Notably, the public health and general preventive medicine program directors have already implemented use of the NRMP for the 2024–2025 application cycle.[8]

Even if these obstacles to program entry were overcome and a complete residency program could be offered to graduating medical students, there is ample evidence that it would not increase recruitment. When all graduating medical students in the US are asked the question "When thinking about your career, what is your intended area of practice?", the choice of "Preventive Medicine or subspecialty" was selected by 0.1% or less in each of the past 3 years.[9] Some have argued that the problem is "a lack of early awareness of OEM" and that one solution is "mandated representation of OEM in the medical school curriculum."[10] Such a recommendation is undermined by the authors' finding that 79% of the medical students surveyed reported having heard of OEM, although the extent of exposure may have been limited.

The paradox here of course is that, although OEM is among the least sought-after specialties, there is ample evidence that OEM physicians are pleased with their choice. The demand for graduates in a wide variety of settings is high,[1] while surveys of practitioners report relatively high resilience, low burnout,[11] and high job satisfaction.[12]

Perhaps these factors help explain why those who enter OEM do so later in specialty training or in midcareer. In 1995, a survey of residents in the 40 residency programs reported that only 11% of respondents chose to enter training before or while in medical school, 24% did so while in another internship or residency, and 62% entered sometime after beginning their professional working careers.[13] A more recent study of OEM practitioners found that only 17% were aware of OEM as medical students.[10] Over the years, several authors have observed that most who enter OEM do so after practicing in another specialty.[13,14,15] Leaving the active practice of medicine to return and complete a 2-year residency is an obvious obstacle for many interested in the field. As a result, many practice OEM without such training. The availability of certifications obtained through short courses for a variety of tasks performed by OEM physicians such as the review of drug test results, independent medical examinations, and commercial drivers' license medical examinations, make this a viable option for many. A 2007 random survey of 1500 ACOEM members reported that 40% were not board certified in OEM.[12]

A second structural challenge is that, unique among medical residencies, ACGME requirements for all three preventive medicine specialties, including OEM, state, "Residents must complete a Master of Public Health [MPH] or another equivalent degree program prior to completion of the residency program."[4] If, as is commonly the case, the incoming resident already has such a degree, the individual is still required to complete 2 years of residency training, meaning significant changes to the design of the program to replace the time spent completing a degree.

Although a minority of programs offer other master's degrees, most OEM residencies include an MPH, which must separately meet the accreditation requirements of the Council for Accreditation in Public Health (CEPH).[16] Simultaneous compliance with CEPH and ACGME standards pulls the OEM training program in opposite directions. As one example, CEPH requires at least 42 semester credits for an MPH, which must be accommodated within a total residency length of 2 years while also complying with all ACGME requirements, including "for a minimum of four months of direct patient care experience in an occupational setting during each year."[4,16] Arrangements must be made for the program to cover significant and rising tuition and fees. In practice, for the reasons discussed below, a partial or full tuition waiver is the only viable option, an institutional cost which can undermine the support of the host university for the program.

Finally, and unlike most other residency programs, the OEM training program is dependent upon a large number of diverse rotations at sites external to the institution for important experiences in government, corporate or union settings, workers' compensation insurers, and onsite OEM clinics. These are complex to maintain administratively and necessitate continuous outreach efforts on the part of the program. The OEM program director of 2024 is jumping through the same hoops of 1994.

Too Many Residencies?

On the other hand, reading Frumkin's paper 30 years after its publication, those familiar with the current state of OEM training might be surprised to learn that there was ever concern about "too many residencies." We are well on the way to following his recommendation for program closures. While precise numbers are difficult to obtain decades later, 40 was likely the peak number of civilian OEM residency programs in this country. The first residency to voluntarily close was at the University of Arizona in 1995: "Several reasons mentioned by Frumkin figured in this decision, including (a) lack of critical mass for training and (b) the labor intensiveness of running a program. We chose not to reapply for our noncompeting NIOSH training project grant (perhaps a first in professional memory)."[17] It is

important to emphasize that this program closed while receiving support from the NIOSH.

Since then, there has been a steady loss of programs, approaching a rate of one program per year (Table 1). Over at least the past 10 years, just as with the first closure, all of these programs closed while receiving NIOSH support, not due to the loss of an award.[18] As of July 1, 2025, there will be 19 civilian OEM programs accredited by the ACGME (Table 2). The majority of the residency programs active today were originally accredited in the 1970s and 80s. According to the ACGME, there has not been a newly accredited civilian OEM residency in 24 years. With this reduction, have the problems perceived by Frumkin to have arisen from having too many residencies been solved?

It is difficult to see any benefit to the academic institutions where residency programs closed from redirecting OEM faculty resources elsewhere. Indeed, inspecting the list of institutions in Table 1, for many, the closure of the OEM residency seems to have heralded a broader winding down of OEM activities at those universities, with a loss of most, if not all, clinical faculty.

Have the remaining programs benefitted from an increase in residents through a consolidation effect? The number of graduates can be inferred from the number taking the ABPM certification examination (Table 3), although these figures are a slight overestimate because a small number of candidates become eligible for certification through pathways other than residency training. For the past 10 years, apart from a modest upward bump from 2018–2021, the numbers are comparable to, or below, the figure of 80 provided by Frumkin for 1991. In 2023, 65 individuals took the examination, the lowest number over the past 10 years and lower than that for the period from 1997–2001 reported in an earlier publication.[19] Data from the ACGME indicating a current total of 116 OEM residents suggest that similar numbers can be predicted for 2024 and 2025 (Table 2). Assuming an even distribution in each of the 2 years of training and that all current residents successfully graduate, there will be approximately 58 residency pathway candidates for the certification examinations in 2024 and 2025. Eleven of the 21 civilian programs today will produce one to two graduates over the next 2 years based on a current enrollment of four or fewer residents (Table 2).

As in 1994, most OEM programs remain too small to offer an "optimal learning environment." The importance of residents as teachers of their peers is widely recognized in the medical education community.[20] For this reason, other programs accredited by the ACGME require a *minimum* number of residents. For example,

TABLE 1. Civilian OEM Residency Program Closures

Institution	Year of Closure
University of Arizona*	1995
Methodist Hospital/Indiana University	1996
Boston University	1997
University of California Davis (ERC)†	1997
University of Oklahoma	2000
University of Massachusetts Worcester	2000
Columbia University/Morristown Memorial Hospital	2001
Medical College of Wisconsin	2004
George Washington University	2004
University of Michigan (ERC)	2004
St. Louis University	2005
University of Alabama Birmingham (ERC)	2005
Emory University	2006
Wayne State University	2007
John H. Stroger Cook County Hospital Chicago (ERC)	2008
University of Pittsburgh	2009
University of California Los Angeles (ERC)	2011
University of Connecticut	2011
University of Texas Medical Branch	2011
University of Iowa (ERC)	2020
University of Kentucky (ERC)	2022
University of South Florida (ERC)	2024 (July 1)
West Virginia University	2025 (July 1)

Adapted from data collected by Katherine Kirkland, Association of Occupational and Environmental Clinics and Michael Gochfeld, Rutgers Biomedical & Health Sciences as well as citation 17. ERC, Education and Research Center.

* Although the University of Arizona was among the founding group of ERCs, it was a TPG at the time of program closure.[17]

TABLE 2. Current ACGME-Accredited OEM Residency Programs

Institution	Year of Original Accreditation by ACGME	Total Filled Resident Positions	NIOSH Support
University of Cincinnati	1957	4	ERC
Harvard University	1960	9	ERC
Mount Sinai School of Medicine	1976	3	ERC
University of California Irvine	1976	4	ERC
University of Texas at Houston	1976	5	ERC
University of Illinois at Chicago	1977	6	ERC
University of California San Francisco	1978	6	ERC
University of Minnesota	1978	5	ERC
University of Utah	1978	8	ERC
Johns Hopkins University	1979	4	ERC
Meharry Medical College	1979	3	TPG
Duke University	1981	1	ERC
University of Washington	1982	5	ERC
Rutgers University	1983	4	ERC
Uniformed Services University of the Health Sciences	1988	10	N/A
Yale University	1990	4	TPG
University of Colorado	1992	4	ERC
West Virginia University[1]	1992	2	TPG
University of South Florida[2]	1993	2	ERC
University of Texas at Tyler	1994	5	TPG
University of Pennsylvania	1999	8	TPG
Loma Linda University	2000	6	No external grant funding.
Department of Aviation Medicine (Fort Novosel)	2010	8	N/A
TOTAL - 23		**116**	**ERC: 15, TPG: 5, Military: 2**

Source: ACGME Accreditation Data System – Public, available at https://apps.acgme.org/ads/public/. Accessed April 2024.

ERC, Education and Research Center; TPG, Training Project Grant. ACGME Accreditation Council for Graduate Medical Education; NIOSH, National Institute for Occupational Safety and Health.

1. Closing effective July 1, 2025.

2. Closing effective July 1, 2024.

TABLE 3. Number of Candidates Taking the Initial Board Certification in OEM From the ABPM

Year	Number Taking Initial OEM Certification Examinations From ABPM
2014	78
2015	68
2016	70
2017	82
2018	102
2019	96
2020	99
2021	104
2022	84
2023	65

Source: https://www.theabpm.org/become-certified/exam-pass-rates/ and Chris Ondrula, American Board of Preventive Medicine, e-mail communication, April 2024; The American Board of Preventive Medicine, copyright 2024, all rights reserved.

internal medicine programs must have a complement of at least 9, with a stated rationale "that peer-to-peer interactions and learning are extremely important components of residency education."[21]

Without providing data, Frumkin's characterization that "...although occupational medicine offers many attractive career options, the fact remains that the national pool of applicants is small, and the pool of highly qualified applicants is even smaller" is an apt description of the situation today.[3] The ultimate proof is the consistent presence of funded, unfilled slots. The 2023 and 2024 surveys of OEM program directors reported a total of 26 and 8 unfilled, funded slots respectively after the uniform acceptance date in January of those years.[22] In both 2023 and 2024, nine positions were reported to have been filled outside of the uniform acceptance date. However, it is important to note that such offers are not equivalent to positions filling later in the application cycle. The two large military training programs, which make all offers through a separate military match, responded to this survey. Second, nine candidates in 2024 and 13 in 2023 were reported to have been admitted with advanced standing directly into the final year of training. Such offers can be made outside of the uniform acceptance date and are frequently made earlier as these are generally competitive applicants. In the 2024 survey, three programs reported having no junior year residents in their programs. Therefore, while it is possible some of the positions available after January are later filled, the evidence is clear that some unfilled, funded positions remain. This is at a time when the overall pool of potential applicants, graduating medical students, has been increasing since 2003 and is currently at record levels.[23] It seems that this may always have been the case in the United States, because unfilled, funded slots were also reported in 1984.[2] The situation is the same in Canada,[24] the United Kingdom,[25] France,[26] and Spain.[27]

Given the weak application pressure, it is not surprising that candidate quality is reported as a concern among the OEM program directors. In 2023, this was reported by nine programs as "the most important residency-related issue," tied with funding. In 2024, although most programs reported increases in both applicant quality and quantity, "resident pipeline/recruitment" was still reported as "the most important residency-related issue" by three programs, tied for second after funding. Furthermore, one program reported the most important to be "resident disciplinary issues" with another "new resident issues."

Frumkin's description of the challenges in OEM training remains just as accurate today, although his attribution of those problems as arising from the large number of residency programs was incorrect.

Funding

Publications on the state of OEM training consistently identify inadequate funding for residency programs as a limiting factor, with an appeal for more.[1,2,19] Another constant for more than 50 years has been the heavy reliance of training programs on external funding through NIOSH grants, the source of support for more than 70% of programs throughout this period.[1,2] This alone is problematic. On top of all other duties, the OEM program director must also be successful in the application for and administration of federal grants, a task not necessary for other residency directors to perform. Furthermore, just as Scutchfield observed, program directors must continue to be very "creative" in funding positions because the NIOSH provides only "partial funding support" in the words of the ACOEM Guidance Statement.[1]

The NIOSH funding comes nowhere close to covering actual training costs. The maximum award per year for an OEM TPG currently is $250,000.[29] Expenses include stipend and benefits for each resident, with a national median salary of $65,306 and $67,763 for PGY-2 and PGY-3 in 2023.[30] Assuming a 30% fringe rate, training one resident in each year of the program costs roughly $173,000. By contrast, Centers for Medicare & Medicaid Services Direct GME payments provide a capitation of approximately $150,000 per resident per year in all other specialties.[31] Additional expenses include a minimum 20% support for the faculty program director and 50% for a staff program coordinator to meet ACGME requirements.[4] None of these expenses are in any way discretionary, and they are completely beyond the control of the program. There are additional expenses such as travel costs and conference attendance. As a result, OEM programs must secure other funding sources as well as in-kind support, such as partial or full tuition waivers for the required master's degrees completed by residents. Not surprisingly, the OEM program directors' survey reported that only 43% of funded positions in 2023–24 were supported through NIOSH awards (Table 4).[22] The remainder were supported from no fewer than 11 different sources. The labor-intensive nature of OEM training, which includes a never-ending search for funding—a task unknown to our colleagues running medicine and surgery programs—and which led to the closure of the first residency, remains.

In addition, unlike many federal research grants, which include facilities and administrative (F&A) costs of 45% or more added on to the direct costs of the work, the F&A rate for training grants is fixed at 8%.[22] In effect, because the NIOSH only partially subsidizes the costs of training, the host institution incurs expenses from having an OEM program. As a result, the potential loss of a NIOSH award at the program level provides no security, hence the closure of programs while receiving support.

TABLE 4. Support Sources for Funded OEM Residency Positions 2023–24 Reported by Program Directors

Funding Source	Number of Positions (Stipend and Fringe Benefits)
NIOSH Education and Research Center	13
NIOSH Training Project Grant	6
Military	4
University	6
Health Resources Service Administration	1
Veterans' Administration	6
Hospital	6
Residency Department	2
Practicum Sites	1
Donations	1
Corporate	1
Foundation Support	2
Other	4

Each program ($N = 23$) may have multiple sources of funding.[22]

NIOSH and Training Support

The NIOSH was created in 1970 to perform the functions under Section 21 of the Occupational Safety and Health Act, which states that it "shall conduct, *directly* or by grants or contracts education programs to provide an adequate supply of qualified personnel to carry out the purposes of this Act" (italics added).[32] In the early years of its existence, the NIOSH was indeed very active in providing training directly. Unlike the CDC more broadly, which began to offer residency training in Preventive Medicine 1972,[33] the NIOSH's direct involvement in training consisted of continuing education. In fiscal year 1974, 50 courses were offered to 1100 professionals while for fiscal year 1982, "NIOSH will again offer a full schedule of short courses in industrial hygiene, occupational safety, industrial toxicology, occupational health nursing, and occupational medicine at the Cincinnati headquarters and in the field."[28] In addition, the NIOSH saw the need to provide financial support for training to be conducted outside the Institute. These awards are provided through two mechanisms: TPGs and what are now called ERCs.

Scutchfield did not specify the type of awards for the 76% of OM training programs receiving federal support in 1984, although he commented on the heavy reliance on NIOSH ERCs.[2] Frumkin reported that nine residencies were supported by TPGs and 14 by ERCs in 1993.[3] Based on the most recently available 2022 annual report from the NIOSH Office of Extramural Programs, which administers both the TPG and ERC awards, five OEM residencies were supported by TPGs and 14 by ERCs (Table 5).[34] As others have noted, while NIOSH funding for training has steadily declined over time,[1,19] a deeper examination reveals a more complex picture and important trends.

Training Project Grants

The year that TPGs started varies by the NIOSH source, one stating 1972[35] while another reporting that 21 TPGs were present in 1971.[36] A notice of awards with the conditions and procedures for eligibility issued by the NIOSH in 1972 describes three mechanisms for TPG awards.[37] *Long-term* TPGs were "to establish, strengthen, or expand graduate, undergraduate, or special training, of persons in the field of occupational safety and health. Such grants may include training in occupational medicine, industrial hygiene, industrial nursing and occupational safety engineering and the training of technicians and paraprofessionals in such areas." *Short-term* TPGs were "(1) To provide specialized instruction for occupational safety and health professional personnel which will increase their competence in an area in their respective fields. (2) To prepare or expand the capabilities of occupational safety and health professionals for leadership roles as administrators or supervisors, and (3) To prepare or expand the teaching capabilities of occupational safety and health professionals." Third, "A traineeship is an award of funds to an individual for his [*sic*] subsistence and other expenses during a period in which he is acquiring training (a) in the occupational safety and health professions, (b) for research relating to occupational safety and health, or (c) for teaching in occupational safety and health." These traineeships were up to 2 years in duration.

The number of TPG awards increased to 44 by 1976.[36] Over time and with the advent of ERCs, only the long-term and postbaccalaureate academic certificates remain at universities with TPG awards, although the NIOSH continues to support short-term, nonacademic training for workers in commercial fishing, emergency response, construction, and mining through this or similar awards. Twenty-five of the current 28 TPGs offer training in a single academic discipline. The eligible programs include both undergraduate and graduate level degrees in the same "core" disciplines identified by the NIOSH in 1972: Industrial Hygiene, Occupational Health Nursing, Occupational Medicine Residencies, and Occupational Safety, as well as "allied" disciplines.[28] Unlike the core programs, the NIOSH has never specified these allied disciplines, although later notices list examples. Current TPG awardees include allied programs in occupational health psychology and occupational epidemiology.

Education and Research Centers

In 1977, the NIOSH announced the availability of new funding to support training: "The objective of the educational resource center grants program is to provide a mechanism for combining and expanding existing activities and coordinating multidisciplinary and multilevel training and continuing education in occupational safety and health under a single grant for a geographic area."[38] Training in the same four core disciplines as the TPGs was required together with allied fields. The first nine ERC were awarded to Harvard University, the University of Cincinnati, Johns Hopkins University, the University of Texas Houston, the University of Minnesota, the University of North Carolina, the University of Washington, the University of Illinois at Chicago, and the University of Arizona.

The number of ERCs steadily grew, reaching 18 by 2012,[39] which remains the number today. The ERCs have been remarkably stable over time. The University of Arizona is the only institution ever to lose the status of an ERC, likely in 1985 based on a reported decline of one ERC that year,[19] although it continued as a TPG providing an OEM residency until 1994[17] and still offers master's level graduate training in industrial hygiene with NIOSH support.[40] These centers are required to go through a competitive renewal and peer review process every 5 years; the success rate for such renewal applications for ERCs overall has been 100% for almost 40 years.

Although not using the term ERC, the landmark Institute of Medicine (IOM) report *Addressing the Physician Shortage in Occupational and Environmental Medicine* of 1991 clearly regarded such centers as an essential component to increase the number of OEM

TABLE 5. NIOSH Funding by Award Types

Fiscal Year	Total TPG Funding	Total ERC Funding	Investigator-Initiated Research Grants (R01, R03, R21, R13, K01)
2012	$4,306,900	$24,268,033	$32,015,665
2013	$4,089,155	$23,005,303	$30,249,244
2014	$4,092,701	$26,925,999	$28,914,609
2015	$3,997,985	$26,949,959	$27,019,595
2016	$4,213,119	$27,956,791	$22,985,270
2017	$4,204,189	$28,351,166	$15,577,086
2018	$4,502,466	$28,400,861	$16,575,147
2019	$4,786,981	$28,380,942	$17,185,978
2020	$5,076,944	$29,333,381	$15,174,357
2021	$5,237,805	$29,280,156	$16,008,471
2022	$5,087,714	$30,345,061	$15,794,625

Source: NIOSH Office of Extramural Program Annual Reports available at https://www.cdc.gov/niosh/oep/annualreports/default.html. Accessed April 2024.

specialists.[41] One of the six recommended measures was that "a limited number of centers of excellence—10 to 15—that provide specialized training and research in occupational and environmental medicine should be established in the near future." Others cite the establishment of the ERCs in the 1970s as a rare time of promise and commitment to training by the NIOSH.[19] A closer inspection tempers this view.

Early on, the NIOSH decided to outsource its involvement in education, akin to extramural research. "The number of trainees trained directly by the NIOSH steadily increased until 1977 when mechanisms were developed with outside organization to provide "indirect" training to meet ever-increasing demand. The Educational Resource Center Grant Program contributed a large part to the indirect training efforts."[25,28] In other words, the ERCs were created in part to shift educational activities outside of the NIOSH. This trend was to continue. Today, the NIOSH involvement in physician training, with a few, small-scale exceptions such as residency rotations at facilities in Cincinnati and Morgantown as well as participation in the Epidemic Intelligence Service, is almost entirely confined to the award of grants to external institutions.

While pulling back from education, the NIOSH placed greater emphasis on research. The National Occupational Research Agenda was launched in 1996.[42] In 1998, the NIOSH announced that the ERC were to be renamed education and research centers.[43] From 1980 to 2000, the share of NIOSH's total budget for training had declined from 38% to 6.6% with an absolute decrease of 40% when corrected for inflation.[19] On the other hand, by 2012, the NIOSH funding for external investigator-initiated research grants exceeded the combined total for TPG and ERC awards that year by more than $3 million, although it has since declined by about 50% (Table 5).

While ERCs overall have been remarkably stable over time, the same cannot be said for their component training programs. Eight OEM residency programs within ERCs have closed since 1997, including three of the most recent closures (Table 1). Before 2004, all ERCs offered a residency, as of July 2024, only 13 of 18 will.

Over time, NIOSH's training requirements for ERC eligibility have also progressively become more lax. From the original notice of 1977: "There shall be full-time students in each of these [four] core disciplines, with a goal of a minimum total of 30 full-time students."[38] By 1994, an ERC was required to offer three of the four core programs.[44] There was to be a minimum of five full-time students in each of the core programs, with a goal of a minimum of 30 full-time students in all of the core programs together. Currently, NIOSH ERCs are required to have a minimum of two core academic programs, the third program can either be in a core or an allied discipline.[45] Allied academic disciplines supported at ERCs at present are even more diverse than those at TPGs and include degree programs in biomonitoring,[46] health physics,[47] occupational health at the human-animal interface,[48] and athletic training.[49] Many allied academic programs are PhD or other doctoral degrees, meaning the support is effectively for research. There are no longer any requirements for a minimum number of trainees, either for any academic program or in total.[45] As of July 2024, only three ERCs will offer all four of the core academic disciplines.

In addition to funding for up to 10 academic programs, ERCs can also receive support for a growing list of additional "center-wide" administrative activities, which include an evaluation and planning core for central administration, as well as programs entitled Emerging Issues (discretionary funds, added by 2022), continuing education, outreach, pilot project research training (added by 2000), and targeted research training (added by 2015) for a total of up to $1.8 million per year.[45] Because ERCs have an established administrative infrastructure in place for training and research, they are also well positioned to secure additional closely related awards from the NIOSH, further expanding the level of external support. Seven of the 11 NIOSH Centers for Agricultural Safety and Health[50] are at institutions with ERCs. Because this was previously a program within ERCs, this separation to a distinct award mechanism represents an effective significant increase in funding. Eight of the 10 more recent Centers of Excellence for Total Worker Health[51] and two of the 20 NIOSH-sponsored State Occupational Safety & Health Surveillance Programs[52] are at institutions that are also ERCs. Only two TPGs have any of these additional centers or programs.

A final important difference is that ERC funding, unlike TPG support, is a separate line item within CDC's budget for the NIOSH and therefore periodically receives targeted increases, such as $1 million through the 2023 Omnibus Appropriations spending bill.[53] As a result, ERC funding has been much more stable year-to-year compared with TPGs (Table 5). Furthermore, TPGs have declined from 44 in 1976 to 28 at present. In each of 2018, 2020, and 2022, the NIOSH announced that "[e]nough funds to support applications for new NIOSH TPGs or new programs within TPGs are not expected to be available."[54]

In 2022, NIOSH funding for the 18 ERCs totaled $30,345,061 while for the 28 TPGs the total was $5,087,714.[34] This six-fold difference in overall level of funding and three-fold difference in the number of OEM programs at ERCs compared with TPGs does not correspond to proportionate differences in the number of graduates from this or programs overall. For all NIOSH-supported graduates, 44% in OEM and 45% overall were from TPGs (Table 6).

The Way Forward

For more than 50 years, we have lamented the decline of our field.[1,2,19] Despite these consistently dire assessments, there has been very little change in the approach to training apart from an expansion in the number of residency programs in the early 1990s. From 1984 to today, the same remedies have been proposed to increase the supply of OEM practitioners: increased funding for residency programs and efforts to make the specialty more appealing to candidates.[1,2,41] These two solutions have never been implemented on a wide scale, demonstrating that neither are workable.

The history of OEM training reveals several harsh realities. The model we have now is one that we inherited and not one that anybody would design today. The training is incomplete and circuitous, forced into both application and accreditation systems that are ill-suited for our purposes. Funding must be cobbled together from multiple sources. Despite all this additional effort on the part of the training programs, it has always been a struggle to recruit high-quality candidates and the number of residents in all but a few programs is small. The end result is an extraordinarily labor intensive, inefficient training environment.

The uncomfortable truth of our field that we have ignored for too long is that OEM has simply never been a popular career choice among candidates for traditional residency training. This is not to say that OEM is unpopular among *all* potential candidates, as it clearly becomes attractive to physicians after they train or practice in other specialties, but it is among the medical students applying to residency

TABLE 6. NIOSH Supported Occupational Safety and Health Graduates, 2021–2022

	ERC	TPG	Total
Occupational Safety	56	83	139
Industrial Hygiene	112	78	190
Occupational Medicine	28	22	50
Occupational Health Nursing	34	0	34
Allied Occupational Safety and Health	84	76	160
Total	314	259	573

Source: NIOSH Office of Extramural Programs 2022 Annual Report available at: https://www.cdc.gov/niosh/oep/annualreports/2022.html. Accessed April 2024.

programs. Given the multitude of challenges, it is not surprising that OEM residency programs have closed. They can be predicted to continue to close without fundamental change.

The lack of appeal of OEM among the pool of applicants to ACGME residency programs must further be acknowledged as the *rate limiting factor* in the current training pipeline overall. Stating that funding for existing residency training is a current limitation is simply not defensible in the consistent presence of funded-yet-unfilled slots. Dispensing with this assertion is critical if we are to move forward. Even if more funding could be secured, used to continue to train in the way we have always trained, it can be predicted to have no effect. The situation was the same when there were 40 residency programs: there was neither an increase in the total number of graduates nationally nor in the number of trainees per program. This does not mean that select OEM residency programs at the most prestigious universities would not grow if they could fund more positions. However, they would do so by pulling in more candidates from the same, small, and fixed national pool, leading to more unfilled positions in other programs and no net increase in the total number of graduates.

To state that funding is not the limiting factor currently is not to state that funding is adequate. In this regard, the history of NIOSH support for training is an illustrative exercise in contrasts. Funding for ERCs may be among the most stable of any competitive federal grant award. With average awards of close to $1.7 million per year plus positioning for additional grants for closely related activities, these centers will of course be valued by the host universities. High levels of stable funding have resulted in ERCs that have been exceptionally durable as centers for over 40 years. Of course, stability is essential to educational programs, which make multiyear commitments to trainees admitted on a continuous basis. On the other hand, woefully inadequate funding at the academic program level has added to the multitude of threats facing OEM residencies and, as a result, many at ERCs have closed.

Beyond external funding for training, additional fundamental questions also need to be asked about the role of the NIOSH. If one accepts that they constitute "qualified personnel" to carry out the OSH Act, then Congress clearly placed the responsibility for training OEM physicians with the NIOSH. For whatever reason, the NIOSH transitioned out of direct involvement in training early on and created ERCs to achieve this goal. There is recent evidence of this phenomenon more broadly at the DC. In a mystifying and troubling decision in light of the COVID-19 pandemic, the closure of the Preventive Medicine Residency and Fellowship Program after 52 years was announced effective July 1, 2024.[55] The problem with outsourcing training is that the trend of deemphasizing education in the core disciplines in favor of related programs and research has rippled out from the NIOSH into the ERCs it supports. Whether successively looser NIOSH training requirements for these awards were a factor behind this shift or the ERCs were already struggling to meet them (or both) is important to ascertain. Either way, the "centers of excellence" model to address the shortage of OEM physicians envisioned by the IOM has never materialized. Currently, TPGs are much more efficient than ERCs in producing core program graduates, including OEM physicians (Table 6).

Now is the time for the NIOSH to lead a major reform of the current training model. Because more funding is likely not forthcoming, how and what is funded by the NIOSH must be re-examined. Of course, NIOSH and the ERCs are currently performing much highly valuable work. Research and allied disciplines are important. However, can we continue with the current priorities while in a slow-moving crisis which, based on the most recent OEM residency graduation numbers, may now be accelerating? It is worth noting that three of the current ERC directors and both the director and deputy director of the NIOSH are OEM physicians. Where will these future leaders come from if we continue to lose the core programs? Where will future OEM program directors come from?

It is time to move beyond calling for increased funding that will not help if it is spent on the current training model. The evidence from decades of experience is clear that this model has never worked well. It never will. What is indisputable is what will happen without fundamental reform in how we train physicians in the field of OEM. As the late Dr. Joe LaDou observed of these same trends in 2002, "it appears that the specialty of occupational medicine is returning to its former obscurity."[19] Novel approaches are needed which should be informed through an examination of successful and failed experiences both within and outside of the United States.

Should the predominant training pathway be an ACGME residency of at least 3 years like all other medical specialties? The IOM proposed three levels physicians in OEM: "OEM Specialist" certified by the ABPM, "OEM clinician" certified in another specialty with an added qualification in OEM, and primary care physicians with some core OEM training within their residency.[41] Canada has a similar model with both residency-trained specialists through the Royal College of Physicians and Surgeons and a numerically much larger group of physicians from other disciplines who practice in the field certified by the Canadian Board of Occupational Medicine.[56] Canada has also recently demonstrated that OEM as a subspecialty of internal medicine or public health and preventive medicine is not viable.[57]

It is clear that to reach large numbers, any new training model in OEM must be attractive and feasible for entry by physicians who are already in practice. The "Train-in-Place" program at the University of Pennsylvania which reaches practicing physicians has been among the most productive OEM residencies in the country for more than 25 years.[58] The ABPM acknowledges such a need through the complementary pathway which "is designed to accommodate physicians who wish to make a midcareer shift into the practice of Occupational and Environmental Medicine."[59] Under this pathway, "physicians must complete two or more years of training in a clinical residency program. They must also complete one year with an ACGME-accredited Occupational and Environmental Medicine residency program."[59] Crucially (and somewhat confusingly), complementary pathway trainees are not regarded as residents by the ACGME.[60] As a result, there is much greater flexibility, trainees can remain employed and received compensation through their current positions and ACGME requirements do not apply to such individuals. In addition, the NIOSH support can be used for complementary pathway trainees. However, to date the number of candidates following this pathway has been small, with only one individual admitted in 2024 according to the Program Directors' Survey.[22] One factor cited is the significant administrative effort necessary to ensure requirements are met.[61] In addition, this pathway still requires training offered by an ACGME-accredited OEM residency, which may become an increasing constraint as the number of programs decline.

The approach to training needs to be greatly streamlined to become more efficient and sustainable. Funding must be provided from a single source at a level to cover actual costs, stable, and without the burden of applying and administering federal grants awarded every 5 years. If OEM programs have never closed due to the loss of a NIOSH award, the requirements for an ERC have been progressively loosened, and with a 100% success rate of competitive renewals, Frumkin's observation that the NIOSH supports all programs meeting technical criteria continues to ring true. While no doubt well-intentioned, this does beg the question of why funding is allocated using a competitive external peer review process designed for research grants. In addition, why are there two distinct NIOSH award mechanisms for the same academic training programs, especially when TPGs are far more efficient than ERCs in producing graduates? Could TPGs become components of the ERCs which serve their region? If other obstacles are addressed, would reinstating the NIOSH requirement that ERCs offer an OEM residency as envisioned by the IOM increase the number of graduates? Serious consideration also needs to be given to the benefits versus the costs of incorporating programs within OEM training that require accreditation by ACGME and CEPH, especially contemporaneously. While such accreditation confers a valuable

element of credibility among those external to the field, neither system was designed for OEM physician training and compliance is both burdensome and highly constraining.

Lastly, as in 1994, we continue to squander scarce resources by having each program individually teach much of the same material to small numbers of residents. Are more efficient, centralized approaches to the delivery of training possible, especially with advances in technology for distance education? All three Canadian OEM residency programs collaborate to offer a common didactic curriculum through two-hour didactic sessions delivered via videoconferencing each week over a 2-year schedule, with faculty associated with each program contributing sessions. Is there a role for NIOSH to return to providing some of this centralized training directly? The CDC 2-year Epidemic Intelligence Service Fellowship program begins with a one-month course for all new fellows in Atlanta before field placements.[62] In Finland, OEM is the second most popular medical specialty and the Finnish Institute of Occupational Health is directly involved in providing a common curriculum in partnerships with universities.[63]

The NIOSH has sponsored systematic workforce assessments in 1977, 1985, 2000, and 2011.[64] These have included extensive surveys of employers as well as training programs, and all four have found shortages in the number of OEM physicians. The 2000 assessment, issued by the IOM, went further in both presenting successful models and making several specific recommendations for training, such as for a new pathway for board certification by the ABPM similar to the complementary pathway and greater use of distance learning to reach practicing physicians.[65] An updated workforce assessment therefore represents a timely opportunity for the NIOSH to demonstrate renewed leadership on workforce training. The longstanding barriers to training and the growing shortage of OEM physicians have been well characterized in the previous assessments, what is urgently needed now is a new approach to address this ever-worsening crisis. The future of our field depends upon it.

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REFERENCES

1. Green-McKenzie J, Khan A, Redlich CA, Margarin AR, McKinney ZJ. The future of occupational and environmental medicine. *J Occup Environ Med* 2022;64:e857–e863.
2. Scutchfield FD. Postgraduate preventive medicine: where do we stand today. *J Community Health* 1984 Spring;9:240–250.
3. Frumkin H. Too many residencies? *J Occup Med* 1994;36:675–676.
4. ACGME. Program requirements for graduate medical education in occupational and environmental medicine. 2022. Available at: https://www.acgme.org/globalassets/pfassets/programrequirements/382_occupationalenvironmentalmedicine_2023.pdf. Accessed April 15, 2024.
5. The American Board of Preventive Medicine. Accreditation Council for Graduate Medical Education approves designation of three separate preventive medicine specialties. Press release. 2022. Available at: https://www.theabpm.org/2022/02/08/accreditation-council-for-graduate-medical-education-approves-designation-of-three-separate-preventive-medicine-specialties/. Accessed: June 22, 2024.
6. American Board of Preventive Medicine. Requirements for certification. Available at: https://www.theabpm.org/become-certified/. Accessed April 18, 2024.
7. Loma Linda University Health. Occupational & environmental residency. Available at: https://lluh.org/health-professionals/gme/resident-fellow/occupational-environmental-medicine-residency. Accessed April 18, 2024.
8. American College of Preventive Medicine Update. Preventive medicine residency program directors vote to join the NRMP. 2024. Available at: https://www.acpm.org/news/2024/preventive-medicine-residency-program-directors-vo/. Accessed April 19, 2024.
9. Association of American Medical Colleges. Graduation Questionnaire. Washington, D.C. Available at: https://www.aamc.org/data-reports/students-residents/report/graduation-questionnaire-gq. Accessed April 18, 2024.
10. Green-McKenzie J, Savanoor U, Duran H, et al. Outcomes of a survey-based approach to determine factors contributing to the shortage of occupational medicine physicians in the United States. *J Public Health Manag Pract* 2021;27(Suppl 3):S200–S205.
11. West CP, Dyrbye LN, Sinsky C, et al. Resilience and burnout among physicians and the general US working population. *JAMA Netw Open* 2020;3:e209385.
12. Baker BA, Dodd K, Greaves IA, Zheng CJ, Brosseau L, Guidotti T. Occupational medicine physicians in the United States: demographics and core competencies. *J Occup Environ Med* 2007;49:388–400.
13. Schwartz BS, Pransky G, Lashley D. Recruiting the occupational and environmental medicine physicians of the future: results of a survey of current residents. *J Occup Environ Med* 1995;37:739–743.
14. Harber P, Ducatman A. Training pathways for occupational medicine. *J Occup Environ Med* 2006;48:366–375.
15. Guidotti TL. Training in occupational and environmental medicine: the US should look to international models. *Arch Environ Occup Health* 2009;64:215–216.
16. Council on Education for Public Health. Accreditation criteria: schools of public health & public health programs. 2024. Available at: https://media.ceph.org/documents/2024.Criteria.pdf. Accessed April 20, 2024.
17. Cordes DH, Rea DF. Residency closed. *J Occup Environ Med* 1995;37:416.
18. Elizabeth Maples, PhD, CIH, Scientific Program Official, NIOSH Office of Extramural Programs, personal communication, April 29, 2024.
19. LaDou J. The rise and fall of occupational medicine in the United States. *Am J Prev Med* 2002;22:285–295.
20. McKeon BA, Ricciotti HA, Sandora TJ, et al. A consensus guideline to support resident-as-teacher programs and enhance the culture of teaching and learning. *J Grad Med Educ* 2019;11:313–318.
21. ACGME Program Requirements for Graduate Medical Education in Internal Medicine. Available at: https://www.acgme.org/globalassets/pfassets/programrequirements/140_internalmedicine_2023.pdf. Accessed June 21, 2024.
22. OEM Program Directors' Annual Survey. Presented May 18, 2024, Orlando, FL and April 15, 2023 Philadelphia, PA.
23. National Resident Matching Program. 2024 Main residency match data and reports. Available at: https://www.nrmp.org/match-data-analytics/residency-data-reports/. Accessed April 21, 2024.
24. Canadian Resident Matching Service. Medicine subspecialty match 2023 report. Available at: https://www.carms.ca/data-reports/msm-data-reports/. Accessed April 18, 2024.
25. Zhou AY, Aston I, Agius RM. What factors influenced trainees to choose occupational medicine? *Occup Med (Lond)* 2017.
26. Épreuves Classantes Nationales. Statistiques: Médecine et santé au travail, 2023. Available at: https://www.medshake.net/medecine/ECN/statistiques/medecine-et-sante-au-travail/. Accessed May 14, 2024.
27. Atresmedia. Nueva convocatoria de plazas MIR 2024: Sanidad hace un segundo llamamiento tras quedar 473 vacantes. Available at: https://ampondaceroes/noticias/salud/nueva-convocatoria-plazas-mir-2024-sanidad-hace-segundo-llamamiento-quedar-473-vacantes_202404196622af978e6602000171576d5html. April 19, 2024. Accessed May 20, 2024.
28. Program of the National Institute for Occupational Safety and Health. 1981. DHHS (NIOSH) Publication Number 82-108. Available at: https://wwwcdcgov/niosh/docs/82-108/pdfs/82-108pdf?id=1026616/NIOSHPUB82108. Accessed May 9, 2024.
29. Centers for Disease Control and Prevention. NIOSH RFA-OH-22-003: Occupational Safety and Health Training Project Grants. Available at: https://grants.nih.gov/grants/guide/rfa-files/RFA-OH-22-003.html. Accessed May 5, 2024.
30. Association of American Medical Colleges (AAMC). 2023 AAMC survey of resident/fellow stipends and benefits. Available at: https://www.aamc.org/data-reports/students-residents/report/aamc-survey-resident/fellow-stipends-and-benefits. Accessed May 10, 2024.
31. United States Government Accountability Office. Physician workforce: HHS needs better information to comprehensively evaluate graduate medical education funding. 2018. Available at: https://www.gao.gov/assets/gao-18-240.pdf. Accessed May 5, 2024.
32. U.S. Department of Labor. OSH Act of 1970. Available at: https://www.osha.gov/laws-regs/oshact/completeoshact. Accessed May 16, 2024.
33. Centers for Disease Control and Prevention. Our 50th Anniversary. Available at: https://archive.cdc.gov/#/details?q=PMR/F&start=0&rows=10&url=https://www.cdc.gov/prevmed/50th-anniversary/index.html. Accessed May 5, 2024.
34. NIOSH Extramural Research and Training. Fiscal year 2022 annual report. Available at: https://wwwcdcgov/niosh/extramural-programs/php/data-research/2022-annual-reporthtml?CDC_AAref_Val=https://wwwcdcgov/niosh/oep/annualreports/2022html. Accessed May 30, 2024.

35. National Institute for Occupational Safety and Health (NIOSH). Notable milestones in NIOSH history. Available at: https://www.cdc.gov/niosh/about/timeline.html?CDC_AAref_Val=https://www.cdc.gov/niosh/timeline.html. Accessed May 30, 2024.
36. Felknor SA. NIOSH OSH workforce training past – present – future. Presentation to NIOSH Board of Scientific Counselors. 2018. Available at: https://www.cdc.gov/niosh/docket/archive/pdfs/niosh-278/felknorbscpresentationmay2018v2.pdf. Accessed May 7, 2024.
37. Federal Register. 37:225 (Tuesday, November 21, 1972).
38. Federal Register. 42:190 (Friday, September 30, 1977).
39. University of Kentucky College of Agriculture, Food, and Environment. Available at: https://www.uky.edu/erc/about. Accessed May 18, 2024.
40. The University of Arizona Mel & Enid College of Public Health. Available at: https://publichealth.arizona.edu/academics/masters/mph/eoh/ih. Accessed May 17, 2024.
41. Institute of Medicine (US) Subcommittee on Physician Shortage. *Addressing the Physician Shortage in Occupational and Environmental Medicine: Report of a Study*. Washington, DC: National Academies Press (US); 1991.
42. National Institute for Occupational Safety and Health. National Occupational Research Agenda (NORA). Available at: https://www.cdc.gov/nora/default.html. Accessed May 5, 2024.
43. National Institute for Occupational Safety and Health Update. January 22, 1998. Available at: https://archive.cdc.gov/www_cdc_gov/niosh/updates/ercna.html. Accessed May 5, 2024.
44. Federal Register. 1994;59:81. Available at: https://www.govinfo.gov/content/pkg/FR-1994-04-28/html/94-10112.htm. Accessed May 8, 2024.
45. Centers for Disease Control and Prevention. Occupational Safety and Health Education and Research Centers (T42). Funding Opportunity Announcement (FOA) Number RFA-OH-23-003. 2022. Available at: https://grants.nih.gov/grants/guide/rfa-files/RFA-OH-23-003.html. Accessed May 5, 2024.
46. University of Cincinnati, College of Medicine. Available at: https://med.uc.edu/depart/eh/centers/erc/programs. Accessed May 6, 2024.
47. University of Colorado, School of Public Health. Available at: https://coloradosph.cuanschutz.edu/research-and-practice/centers-programs/chwe/map-erc-programs/health-physics. Accessed May 5, 2024.
48. University of Washington Department of Environmental & Occupational Health Sciences. Available at: https://deohs.washington.edu/nwcohs/training-programs. Accessed May 5, 2024.
49. Central Appalachian Regional Education and Research Center. Available at: https://www.kyerc.com/programs. Accessed May 5, 2024.
50. NIOSH Update. 2022. Available at: https://www.cdc.gov/niosh/updates/upd-09-06-22.html. Accessed May 30, 2024.
51. NIOSH Extramural Research and Training. Centers of Excellence for Total Worker Health®. Available at: https://www.cdc.gov/niosh/extramural-programs/php/about/twh_centers.html?CDC_AAref_Val=https://www.cdc.gov/niosh/oep/twhcenters.html. Accessed May 30, 2024.
52. NIOSH Extramural Research and Training. State Occupational Safety and Health Surveillance Program. Available at: https://www.cdc.gov/niosh/extramural-programs/php/about/state-surveillance.html?CDC_AAref_Val=https://www.cdc.gov/niosh/oep/statesurv.html. Accessed May 30, 2024.
53. National Institute for Occupational Safety and Health (NIOSH) Board of Scientific Counselors Update. April 2023 Available at: https://www.cdc.gov/niosh/media/pdfs/2_directorstalkingpointsapril2023_508.pdf?CDC_AAref_Val=. Accessed May 30, 2024.
54. NIOSH. Notice regarding TPG revision applications and new applications for RFA-OH-22-003: "Occupational Safety and Health Training Project Grants (T03)". 2022. Available at: https://grants.nih.gov/grants/guide/notice-files/NOT-OH-22-006.html. Accessed May 5, 2024.
55. Centers for Disease Control and Prevention. About the preventive medicine residency and fellowship. May 8, 2024. Available at: https://www.cdc.gov/prevmed/index.html. Accessed May 6, 2024.
56. Canadian Board of Occupational Medicine. Available at: https://cbom.ca/. Accessed May 3, 2024.
57. Royal College of Physicians and Surgeons of Canada. National consultation: occupational medicine. January 2024. Available at: https://www.royalcollege.ca/en/specialty-discipline-recognition/specialty-applications-and-national-consultations.html. Accessed May 13, 2024.
58. Green-McKenzie J, Emmett EA. Characteristics and outcomes of an innovative Train-in-Place residency program. *J Grad Med Educ* 2017;9:634–639.
59. American Board of Preventive Medicine. Available at: https://www.theabpm.org/become-certified/specialties/occupational-medicine/. Accessed May 5, 2024.
60. ACGME Review Committee for Preventive Medicine. Frequently asked questions: occupational and environmental medicine (effective July 1, 2023). Available at: https://www.acgme.org/globalassets/pdfs/faq/382_occupationalenvironmentalmedicine_faqs.pdf. Accessed May 2, 2024.
61. ACOEM. Complementary pathway for achieving board certification in OEM. Live Webinar Date: Thursday, April 18, 2024. Available at: https://connect.acoem.org/CPBase__item?id=a13Uu000005mOMyIAM. Accessed June 22, 2024.
62. Centers for Disease Control and Prevention. Applying to EIS. Available at: https://www.cdc.gov/eis/application/index.html. Accessed May 14, 2024.
63. Eva Helaskoski MD, Director, Chief Physician Occupational Health Unit, at the Finnish Institute of Occupational Health – Työterveyslaitos, personal communication, April 24, 2024.
64. McAdams MT, Kerwin JJ, Olivo V, & Goksel HA. (2011). National Assessment of the Occupational Safety (WESTAT Report). 200–2000-08017, Task Order 18.
65. Institute of Medicine. *Safe Work in the 21st Century: Education and Training Needs for the Next Decade's Occupational Safety and Health Personnel*. Washington, DC: The National Academies Press; 2000.