

• HISTORY LESSON •



Collaboration among Professionals: The Role of Civil Engineers in Public Health

THE 19TH CENTURY has been called the “great sanitary awakening,” an era during which cities became more aware of the importance of sanitation and hygiene in combating the transmission of diseases such as cholera.

In particular, the so-called Great Stink of 1858 helped drive the development of environmental engineering. That summer, London—the largest city in the world at the time—reached an environmental tipping point at which “large quantities of sewage combined with a particularly hot summer created a perfect storm of rubbish, stink, and death,” wrote Steven C. Chapra, Ph.D., F.AEESP, F.ASCE, a professor emeritus and the Louis Berger Chair of the Civil and Environmental Engineering Department at Tufts University in Medford, Massachusetts (“Rubbish, Stink, and Death: The Historical Evolution, Present State, and Future Direction of Water-Quality Management and Modeling,” *Environmental Engineering Research*, September 2011). This rubbish included dead animals floating in the River Thames, emitting a dreadful stench.

Eventually a government committee was formed to solve the problem, led by Joseph Bazalgette, a civil engineer who served as the chief engineer of London’s Metropolitan Board of Works. Bazalgette—who was knighted in 1875 and elected president of the Institution of Civil Engineers in 1883—over-

Modern sanitation engineering began in London, as engineers developed new sewer lines to contend with the Great Stink of 1858, when human waste and effluent flooded the River Thames during a hot summer.

saw the design and construction of six intercepting sewers and a pumping station to “carry most of London’s wastewater to a discharge point well downstream of the city,” Chapra wrote. “This huge and expensive sewer project can be considered the birth of modern environmental engineering.”

According to an article exploring the history of engineering and public health by Chapra, Richard J. Gelting, Paul E. Nevin, David E. Harvey, and David M. Gute, Ph.D., fellow at the American College of Epidemiology, public health and engineering were “closely aligned” for decades, and “engineering was integral in the emergence of public health as a distinct discipline from clinical medicine” (“‘Back to the Future’: Time for a Renaissance of Public Health Engineering,” *International Journal of Environmental Research and Public Health*, February 2019).

But there was a gradual bifurcation during the 20th century—a split between public health and engineering that over the decades has obscured the crucial role engineers played in the development of public health as a field and that has current implications with the emergence of COVID-19. We are reminded that solutions to major health crises—now and in the future—will require more holistic approaches.

The United States Public Health Service (USPHS), the country’s oldest public health agency, traces its roots to the

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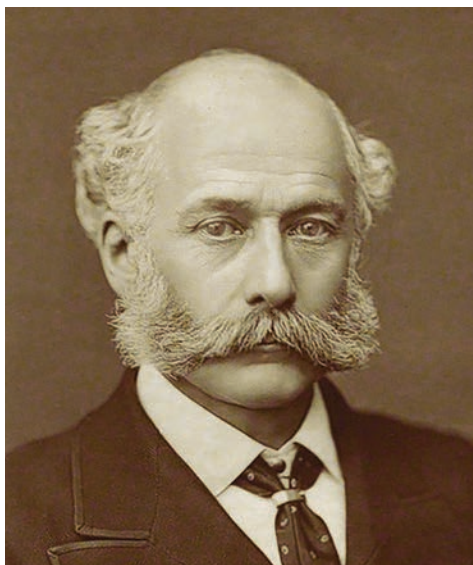
establishment of marine hospitals authorized by John Adams to treat sick sailors. According to Sven E. Rodenbeck, Ph.D., P.E., M.ASCE, who authored a paper on the subject in 2013, when he was a rear admiral in the service, the USPHS hired its first sanitary engineers in 1913 to solve “technical problems associated with contaminated water” (“USPHS: 100 Years of Engineering Service,” *The Military Engineer*, Vol. 105, No. 683, May-June 2013, pages 73–75). Six of those engineers, working out of the agency’s Ohio River Investigation Station (Harry R. Crohursts, Leslie C. Frank, Harry B. Hommon, John K. Hoskins, Harold W. Streeter, and Ralph E. Tarbett), formed the leadership nucleus that “led to the expansion of the USPHS mission to address environmental public health concerns over the next century,” Rodenbeck wrote. “Initially hired as civilians, some later obtained their commissions in the USPHS Commissioned Corps.” Hoskins became the first USPHS chief engineer in 1943.

Rodenbeck, who is now a senior service fellow at the Agency for Toxic Substances and Disease Registry, in Atlanta, added that USPHS engineers developed drinking water standards in 1914, the nation’s first such standards. The standards have been revised several times over subsequent decades, and the U.S. Environmental Protection Agency (EPA) eventually assumed responsibility for their enforcement. But “to this day, the nitrate drinking water standard remains the same as proposed by USPHS,” Rodenbeck wrote.

Those early USPHS engineers also launched major campaigns to eliminate standing water in and around populated areas. The subsequent reduction in mosquito populations and corresponding decrease in malaria cases heralded the single greatest decline in morbidity and mortality in U.S. history.

A 1959 editorial in the *American Journal of Public Health* (“Engineering for Health,” Vol. 49, No. 3) laid out other areas in which engineers contributed to the medical field in the first half of the 20th century, including the design of precise measuring devices

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Joseph Bazalgette, top, served as the chief engineer of London’s Metropolitan Board of Works and oversaw the construction of sewers and a pump station to resolve the city’s Great Stink in 1858. Abel Wolman, a pioneering sanitation engineer, above, never wavered in his belief in the importance of keeping engineering and public health closely allied.

for medical use, such as the electron microscope, sonar, the cytoanalyzer, and a gadget called a telecor, which provided anesthesiologists with an electrocardiogram, body-temperature reading, and heart sounds during surgery. Also included was hospital design. “The entire hospital environment, including air-conditioning, waste handling, and a host of new and refined pre- and postoperative facilities, is the result in significant part of the thought and skills of the engineer,” the editorial notes. The opinion piece also points out the work accomplished, presumably in the late 1950s, at the USPHS’s Robert A. Taft Sanitary Engineering Center, where engineers worked in concert with biologists, chemists, bacteriologists, physicists, and other specialists. (It should also be noted that the USPHS oversaw, for 40 years, the notorious Tuskegee Study of Untreated Syphilis in the African American Male, in which black men with syphilis were studied but never treated.)

Yet despite the work of engineers in the public health space, the concept of public health gradually shifted, and engineers found themselves increasingly moving away from public health. “Engineers were really in the leadership roles in public health in the late 1800s [and] early 1900s, and that changed when physicians became more prominent within public health,” says Cdr. Richard J. Gelting, Ph.D., P.E., a program director with the Division of Global Health Protection at the U.S. Centers for Disease Control and Prevention (CDC). He argues that physicians initially weren’t that interested in public health because it wasn’t considered a prestigious career choice, and it remained that way through much of the first half of the 20th century.

Gute, a civil and environmental engineering professor at Tufts University, contends that the bifurcation between engineering and public health was brought on in part by a “larger sense of professionalism and the specialization of science and engineering.” He notes that from 1913 to 1922, the Harvard–Massachusetts Institute of Technology (MIT) School for Health Officers trained engineers in the “basic,

rudimentary knowledge of biology and the spread of infectious diseases along with dynamics and all the other challenging courses that engineers receive. But then the Harvard School of Public Health was founded [in a split with MIT], and essentially the emphasis on biology and health went across the Charles River.”

After the influenza pandemic swept across the world in 1918—infecting 500 million and killing at least 50 million, according to the CDC—the mission of public health began to expand beyond its roots in sanitation. Journalist Laura Spinney, writing in *Smithsonian* magazine, noted that epidemiology—“the study of patterns, causes, and effects in disease”—is now the cornerstone of public health (“How the 1918 Flu Pandemic Revolutionized Public Health,” *smithsonianmag.com*, September 27, 2017). By 1925, states across the country “were participating in a national disease reporting system, and the early warning apparatus that had been so lamentably lacking in 1918 began to take shape.” A decade after that, Americans participated in the country’s first national health survey, “reflecting the authorities’ new interest in the population’s ‘baseline’ health.”

Articles published in the *American Journal of Public Health* in the middle decades of last century reveal the gradual widening between engineers working in the field of sanitation systems and medical researchers working in the field of public health. Earle B. Phelps, a professor of sanitary science at the College of Physicians and Surgeons at Columbia University, in discussing a paper read by MIT professor Samuel Cate Prescott during a 1931 American Public Health Association meeting, noted a bifurcation between the sanitary engineer—described as a designer or builder, “a civil and hydraulic engineer ... confined for the most part to works relating to municipal water supply and sewerage”—and the public health engineer, whose job was to know “why sewers are necessary and what results may be anticipated from the discharge of their contents without treatment into a body of water” (“Training for the Public Health Engineer,” Vol. 21, No. 11, November 1, 1931). It was the work of this latter group that gradually became the purview of public health experts with expertise in health or medicine but not in engineering.

Today, the nation’s chief public health agency is the CDC. The agency emerged out of a program called Malaria Control in War Areas established during World War II. Gelting says, “One of the reasons why that was such a big push was [that] during World War II, they had very large basic training bases in Georgia, and something like a quarter of the recruits were coming down with malaria. So they had to deal

with this issue, and public health became a force-protection issue at that point.”

During its early years, the agency was staffed mostly by entomologists and engineers; of the CDC’s original 369 employees, only seven were physicians. And the CDC’s first leader when it became a permanent U.S. government agency, Mark Hollis, was an engineer.

By the time malaria was vanquished in the United States in 1951, the CDC had shifted its focus to studying and tracking disease outbreaks. “Indeed, since 1953, all CDC directors have been physicians,” the “Back to the Future” authors wrote.

At the same time, the very definition of “sanitation” changed. The article noted, “The term ‘Sanitarian’ was used in the early part of the 20th century as a general descriptor for all public health professionals, including sanitary engineers and physicians working in public health. Later, it was sometimes used to describe those working in the field of public health engineering, but without specific engineering education or experience. By the middle of the 20th century, use of the designation had evolved to describe those engaged in more specific environmental health tasks, especially related to ensuring safe food, water, and sanitation.”

The authors trace one more development, the rising environmental movement that was launched by Rachel Carson’s book *Silent Spring* (Houghton Mifflin, 1962), which led to the creation of the EPA in 1970. According to the authors, many engineers who were working in the USPHS moved to the EPA, and engineers working at the state level followed suit, moving to state environmental departments.

According to Capt. David E. Harvey, P.E., the deputy director of the Division of Sanitation Facility Construction at the Indian Health Service within the USPHS Commissioned Corps, in Rockville, Maryland, this split has become so ingrained that even at the USPHS Commissioned Corps there are now only 380 engineers on a staff of more than 6,500.

Chapra says that the first generation of engineers working in public health probably did not think the separation was a good idea, but as that “generation faded away, retired, [and/or] died off,” subsequent generations grew up understanding their profession as strictly environmental in focus and “didn’t consider public health as part of their core mission.”

The authors argued there were several consequences to this split. Gelting sees the water crisis in Flint, Michigan, as an example. “The decisions about Flint were seemingly made more for financial and maybe political reasons, but it was a pretty simple water-quality problem at some level,” he says. What was needed was “the expertise to say, ‘No, you shouldn’t take a

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different source of water and run it through the same system without at least considering the effects it would have on the piping and other infrastructure elements.’ That was never even raised.

“And it’s not that complicated,” he adds. “I’m not trying to belittle the problem at all, but I think that if there was an engineering perspective more involved in that decision-making, there would at least be someone saying, ‘Wait a minute, let’s think about this.’ And that just simply did not happen.”

Chapra and others are calling for the reintegration of engineering and public health. Gute, for instance, is working on strategies to prevent kids in sub-Saharan Africa from contracting the parasitic disease Schistosomiasis by improving water infrastructure rather than by mass drug administration. And, of course, civil engineers have played an important role in devising strategies and technologies to cope with the current COVID-19 pandemic. (See *Civil Engineering’s* special coverage: news.asce.org/civil-engineering-special-coverage-covid-19.)

“Because engineering and public health have become partially separated as professions and in practice, there is no longer a standardized program of training for public health engineers in the U.S.,” the authors of “Back to the Future” wrote. “Few engineers set out initially to work in public health, but that needs to change if we are to effectively address many public health challenges. Engineers working in public health often graduate from ‘typical’ engineering programs, and then gravitate toward public health engineering work either through personal interest or because of unique opportunities.” Chapra and Gute are exploring ways to integrate public health content within the civil and environmental engineering curriculum at Tufts University.

The influenza pandemic of 1918 killed at least 50 million people and accelerated the transition of public health away from its roots in sanitation. Patients were treated across the United States, including at Walter Reed General Hospital in Washington, D.C.

What good might that do? During the COVID-19 pandemic, for example, public health officials have stressed the importance of handwashing. “But the public health community also needs to go beyond that messaging in countries [that are] not like the U.S., where people do not have the means to wash their hands. What can we do about that?” Gelting asks.

Those are the kinds of problems that civil engineers are well equipped to tackle. A new generation might take a page from the legendary career of Abel Wolman, the former Johns Hopkins engineering professor who never wavered in his insistence on the importance of keeping engineering and public health closely allied. “What the public health engineer does is increasingly correlated with the activities of the physician, the laboratory worker, the industrialist, and the agriculturist,” Wolman wrote in in 1937 (“Recent Trends in Public Health Engineering Practice,” *American Journal of Public Health*, Vol. 27, No. 1). “The field of action of the engineer has truly become the land, the water, and the air.”

Wolman also noted the following: “When the American Public Health Association recognizes what the Health Section of the League of Nations has already recognized, namely, that public health activity requires an additional group of new indices for housing, nutrition, physical education, etc., the practices in engineering herein discussed may gain new force and perhaps even new budgets.” This may yet prove to be the case.—T.R. WITCHER



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