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Drinking-Water Fluoridation as an Example of the Nurse + Engineer Fostering Informed Decisions and Actions

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While the public often associates engineers with driving trains or building things (National Academy of Engineering 2008), in fact, according to the Code of Ethics for Engineers, the first fundamental canon of engineering is to "hold paramount the safety, health, and welfare of the *public*" (National Society of Professional Engineers 2019; emphasis added). The practice of environmental engineering—including the design and deployment of technologies for drinking-water treatment (i.e., to meet the Surface Water Treatment Rule) and sewage treatment (i.e., to meet National Pollution Discharge Elimination System requirements for permits requiring effluent disinfection)—is widely recognized as a major contributor to one of the greatest public health achievements in the 20th century, namely, controlling infectious diseases (Centers for Disease Control and Prevention 2000).

Environmental engineering practice also contributed to another of the top 10 great public health achievements in the 20th century, namely, the design and deployment of technologies to achieve fluoridation of drinking water (Centers for Disease Control and Prevention 2000). In its most recent recommendation for fluoride concentration in drinking water for the prevention of dental caries, the US Public Health Service celebrated water fluoridation as "a major factor responsible for the decline in prevalence (occurrence) and severity of dental caries (tooth decay) during the second half of the 20th century" (US Department of Health and Human Services 2015). For example, as of December 31, 2012, nearly 200 million Americans were served by more than 12,000 community water systems that added fluoride (US Department of Health and Human Services 2015).

Yet despite the widespread practice of drinking-water fluoridation, there is increasing debate around the subject. For example, a recent narrative review [for a description of review types, see Page et al. (2021)] by Aoun et al. (2018) included a section entitled "Increasing Opposition to Fluoridation," which described acute fluoride toxicity in children and noted that natural levels of fluoride in drinking-water supplies are above safe levels in some locations. They also highlighted that variations in the consumption of fluoridated water as well as fluoride-containing toothpaste, fluoridated table salt, and fluoridated milk may create situations where individuals are unaware of a chronic overconsumption of fluoride. Beyond the concerns reported by Aoun et al., there are alarming reports of persistent disparities in dental caries, which increase as socioeconomic status decreases (i.e., the poor suffer from more tooth decay as compared to the wealthy) (Slade and Sanders 2017).

Heathy People 2030, a program of the US Department of Health and Human Services, includes the goal of increasing the proportion—from the 2016 baseline of 72.8% to the 2030 goal of 77.1%—of people whose water systems have the recommended amount of fluoride (US Department of Health and Human Services 2020). Currently, of the more than 54,000 community water systems [for definitions of public water systems, see USEPA (2022)] across the United States, fewer than 20,000 contain sufficient levels of fluoride to meet the US Public Health Service recommendation of 0.7 mg/L (US Department of Health and Human Services 2015). Therefore, to achieve the goal set in Healthy People 2030, there is an urgent need for the practice of environmental engineering to move beyond designing and deploying technological solutions such as large-scale community water systems and to find ways to engage with and empower individuals, families, and smaller communities (i.e., fewer than 15 service connections or serving fewer than 25 people for less than 60 days a year), often located in rural areas across the country.

Helping to achieve the goal of Healthy People 2030 aligns with the urgent need for the practice of environmental engineering to "foster informed decisions and actions," which has been identified as one of the five Grand Challenges of Environmental Engineering in the 21st Century (National Academy of Engineering 2019). Specifically, "addressing environmental challenges [i.e., dental caries] requires, in addition to effective solutions [i.e., fluoridation of drinking water], a pervasive recognition that implementing those solutions is in our [i.e., regulatory changes at the government level and behavioral changes at the community and individual level] best interest" (National Academy of Engineering 2019).

Fortunately, environmental engineers have a natural ally in meeting this urgent need. The Code of Ethics for Nurses is unique among healthcare professionals because nursing practice spans clinical care of individual patients as well as care for and education of the public. For example, the Code of Ethics for Nurses notes that nurses' "primary commitment is to the patient, whether an individual, family, group, community, or *population*" (American Nurses Association 2015; emphasis added). In contrast to the Code of Ethics for Nurses, the Code of Ethics for Physicians (American Medical Association 2023), which guides the practice of physicians who hold degrees such as medical doctor (MD), and the Code of Ethics for Dentists (American Dental Association 2023), which guides the practice of dentists who hold degrees such as doctor of dental medicine (DDM), emphasize the relationship between the healthcare provider and the patient—as an *individual*. Thus, while physicians and dentists may work in public health, nursing is unique among these healthcare professions in that the training and responsibility of registered nurses (RNs) includes *both* clinical care of individual patients as well as care for and education of the public.

Because of this unique aspect of the practice of nursing (i.e., clinical care for every individual patient as well as care for and education of the public), it shares a similar commitment with the practice of engineering to prioritize the health, safety, and welfare of the public. But the practice of nursing offers a unique approach that is beneficial to improving the practice of environmental engineering. Specifically, "the nurse practices with compassion and

respect for the inherent dignity, worth, and unique attributes of every *person*" (American Nurses Association 2015; emphasis added). Thus, while engineers may practice design and deployment of technology for the benefit of the public, the nurse centers the value of every person, which has the value of "leaving no one behind" (Oerther and Oerther 2022). As environmental engineers work to expand our current technological solutions for drinking-water fluoridation, nurses are a natural ally when we foster informed action including behavioral change at the level of individuals, families, communities, and populations.

This natural partnership between the profession of nursing and the profession of environmental engineering has been highlighted previously in a series of editorials focused on the public health response to the COVID-19 pandemic (Oerther and Watson 2020; Oerther and Shattell 2020; Oerther and McCormack 2021; Oerther and Klopper 2021). Environmental engineering has been shown to be a caring profession—a trait that is commonly associated with nursing (Oerther et al. 2022). And interprofessional collaboration among nurses and other healthcare professionals—including engineers—has been described as a type of bridge between the current parallel professions and the future V-shaped profession of nurse + engineer, where two disciplines practice convergence research to solve a shared societal problem contributing to a better future for everyone (Oerther and Oerther 2021; Oerther and Glasglow 2022).

An example of the type of collaboration envisioned between environmental engineers and nurses includes successful work overseas as part of joint trips of Engineers Without Borders (EWB) and Nurses Without Borders (NWB) (Dossey et al. 2017; Oerther 2017). Engineers and nurses, working side by side in a role best described as community health workers (e.g., Perry et al. 2014), can listen to, educate, and empower individuals, families, communities, and populations to access clean drinking water, safe sanitation, proper nutrition, as well as antenatal care (i.e., care for pregnant women) and care for infants, and other services. The attraction for engineering students and professionals to participate in programs such as EWB includes a desire for "engineers to make a world of difference" as well as a recognition that "engineering is essential to our health, happiness, and safety" (National Academy of Engineering 2008).

Despite the desire among environmental engineers to engage in community-based projects to empower individuals and families, there are substantial hurdles that need to be overcome in terms of defining research among faculty and identifying sources of funding to support the work of professionals (Montoya et al. 2021). In support of the benefit of the nurse + engineer collaborating as community health workers, a recent systematic review [for a description of review types, see Page et al. (2021)] by Berini et al. (2022) noted that "community health workers can improve access to care in rural settings and may represent a cost-effective investment for the healthcare system." As part of this review, one study was identified where education was delivered by community health workers resulting in improved dental health (Riedy et al. 2015). The results of this study point toward the type of intervention that should be undertaken by the nurse + engineer to achieve the goal of fluoridation of drinking water described in Healthy People 2030.

As environmental engineers continue to tackle the other Grand Challenges of Environmental Engineering—including sustainably supplying food, water, and energy; curbing and adapting to climate change; eliminating waste; and creating better cities—there is both an urgent need as well as a window of opportunity to explore the interface with other caring professions—including nursing—to ensure that the technological solutions of engineers support and empower the behavioral choices of individuals, families, communities, and populations. The history of drinking-water fluoridation at the end of the 20th century and the success we achieve—or fail to achieve—toward the goals of Healthy People 2030 will have profound implications when the practice of environmental engineering is once again evaluated in the context of a future list of the great public health achievements.

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