Let's Make it the bio-psycho-social-ecological model of healthcare

Earth Day is this tomorrow. It's an important opportunity for us as researchers, educators of future healthcare professionals and those providing patient care to consider a change to the bio-psycho-social model. It was conceptualized in 1977 by physician George Engel. He wrote in the journal *Science*, "A biopsychosocial model is proposed that provides a blueprint for research, a framework for teaching, and a design for action in the real world of health care." (Engel, 1977).

Even as Engel was writing about the real world of healthcare, a massive problem was coming to light in a community near Niagara Falls, New York. More rain than usual had been coming down, trees were dying, and people didn't feel well. In 1978 the environmental disaster of the Love Canal was exposed. Toxic chemicals were surfacing in the community, many of which, like benzene were cancer causing. In the Love Canal neighborhood, a high number of miscarriages and birth defects also occurred. What the current residents didn't know was that since the 1920s, the canal had been used as a chemical dump site, and in 1953 the Hooker Chemical Company, which then owned the property decided to sell it. They covered the canal with soil and sold the property to the city for $1. New home sites went up and families moved in (Beck, 1979). With heavy rains, rusting and leaking containers of buried toxins resurfaced in different places in the neighborhood, like people's backyards. President Carter provided emergency financial aid to help families evacuate. This was the first time that such funds were approved for a catastrophe which wasn't a natural disaster (Beck, 1979).

The tragedy led to the development of Superfund sites, federally managed sites where the toxic residuals of industry are more closely managed and there's greater public knowledge of where they are and what the chemicals are. Currently there are 1333 such sites across the US which are on the National Priority List for clean-up (https://www.epa.gov/superfund/superfund-national-priorities-list-npl). Looking at the Toxic Substances Control Act's non-confidential list of chemicals used in US industry, there are 86,633 chemicals used in industry (https://www.epa.gov/tsca-inventory/how-access-tsca-inventory#download). We have some understanding of the biological and environmental impacts of some of these non-confidential chemicals, and many we don't. We also don't have a framework which includes the ecology we live in as a factor in health and disease. We certainly don't know about the effects of the list of substances on the confidential list.

Around the same time that the Hooker company was burying its waste in the area of Love Canal, Chisso, a chemical company in Japan was discharging methylmercury laden industrial wastewater into Minamata Bay. The way it ravaged human development and the nervous system gave these set of problems the name, Minamata disease. It's called that when the First Nation people living in Grassy Narrows, a community along the Wabigoon River in Ontario, Canada became ill from mercury waste too (Philibert, et al., 2020). In Japan, thousands were impacted, though the government only gave official recognition to only a small fraction of those cases (Harada, 1995 and https://hrcharitima.com/index.php/2021/11/01/minimata-disease/). The mercury, taken up by the aquatic life that's a staple food caused severe birth defects. To adults, a

spectrum of neurological problems emerged for which there was no cure. Below is the 1972 photo taken by W. Eugene Smith of a girl with Minamata disease, being bathed by her mother. It was part of a documentary photo series in a book called, *Warning to the World*.

Mother bathing her daughter, 1972, by Eugene W. Smith

In short, when the bio-psycho-social framework came into being in 1977 as a lens from which to see health and disease for the purposes of research, teaching and healthcare, it was already insufficient. In 2015, the world lost 9 million people to early deaths caused by pollution (Landrigan et al., 2018). It's clear that what happens outside our bodies makes inroads within it.

In 2011, an earthquake struck Fukushima, Japan. It triggered a tsunami which caused the meltdown of 3 nuclear reactors. This brought about a constant need to keep the reactors cool with water, and because the contaminated wastewater from this process has reached its storage capacity on land, it's scheduled to be slowly released into the Pacific (Nogrady, 2021). The ecological and health consequences of this no one knows. We will continue not to know unless we make a concerted effort to include ecology into our framework of health and illness.

Here's another issue with a global reach where ecology is writing its presence into the biology of billions. As the population of the world grows, so too do the needs for water, and in many places it's coming out of taps and wells with arsenic. In many areas of the world there's a naturally occurring arsenic substrate in the ground. As drilling needs to go deeper, once at the level of arsenic, it's contaminating the water for people around the world. In 1993 the biggest mass poisoning in the world began to come to light when it was discovered that a huge portion of Bangladesh's population were drinking from wells with high levels of arsenic contamination (Ahmed, Khan, Haque, 2018). While this problem profoundly impacts Bangladesh, it occurs in

other places too, such as in parts of the United States, Vietnam, China, Chile, Canada, Japan, Hungary, Poland, Finland, New Zealand, Italy and India (Jiang et al., 2013). It also impacts the Mekong Delta region between Vietnam and Cambodia (Buschmann et al, 2008). It's hurting the people in Iran (Alidadi, 2019) and West Africa as well (Bretzler et al., 2017). The cancers, cognitive changes and dermatological disease it causes are happening within social contexts like civil strife, or other environmental events like drought, heat waves or outbreaks of malaria. The arsenic is also taken up by agricultural crops such as rice, a food served to babies and a staple for many (Mawia et al., 2020). Surely ecology deserves to be part of how we learn about health, disease, wellness and prevention.

Just as the disaster of Love Canal was a surprise, it was surprise to many that there are a group of thousands of synthetic chemicals now known as "forever chemicals" and that they had been making inroads into our fields, crops, rivers, oceans, tap water and our bodies, and had been doing so for 70 years (Kurwadkar et al., 2022). Called "forever chemicals" because they may not breakdown in the environment, they have even shown up in glacier melt from Mr. Everest (Miner et al., 2021). They are perfluoroalkyl and polyfluoroalkyls (PFAS) and perfluorooctanesulfonic acid (PFOS) which are used widely in the manufacture of everyday items from non-stick coatings to firefighting foams. They are used to make fabric stain-resistant but they may be leaving their mark on us, just how is not fully known. A scoping review of the existing literature indicates that these chemicals are associated with altered immune and thyroid function, insulin dysregulation, cancers, reproductive and developmental harms, (Fenton, et al., 2021). Once again, the research came to the starting line after the chemicals had had a 70 year advantage. Letting them continually have this advantage is another issue, but not including ecology into the model of health and disease to facilitate this only maintains this inequality further.

There's a need to research, teach and care for people within a model which names one of the biggest sculpting forces of human health and well-being, it's a bio-psycho-social-ecological model. It was proposed by physician Steve Moffic in 2019, and in the three years which have elapsed, climate instability has increased while the words climate *change* have seemingly solidified. Playing down our reality in language and action isn't what's needed now. In every example, healthcare professionals were behind the curve of an evolving health disaster, but we have to give ourselves a chance to be protective and proactive. We can catch up when we care to. Physician Peter Densen wrote in 2011, "It is estimated that the doubling time of medical knowledge in 1950 was 50 years; in 1980, 7 years; and in 2010, 3.5 years. In 2020 it is projected to be 0.2 years — just 73 days." (Densen, 2011). We may not be at the starting line, but we're fast when we need to be.

If the bio-psycho-social model doesn't come to include ecology, it obliquely lays blame for illness and debility on individuals through omission. We know profoundly that we have an obligation to do what we can to get more people into routine care and close gaps in healthcare outcomes. Not engaging in environmental issues only worsens the issues.

Across the lifespan we are intimately connected to the health of the environment around us. In meta-analysis of which looked at 32,798, 152 births in the United States, researchers found that heat, level of ozone and air pollution comprised of fine particulate matter (PM2.5) were risk

factors for stillbirths, having a baby with a low birth weight, and premature delivery (Bekkar, et al., 2020). In infancy and childhood there is an increased autism risk from prenatal and infant exposure to pesticides, (von Ehrenstein, 2019), and for childhood asthma from air pollution (Khreis, et al., 2017). Research shows an increased risk for weight gain and obesity from hormone mimicking synthetic chemicals (Philippa Darbre, 2017) which will raise the risk of other conditions associated with obesity. Air pollution has also been associated to self-harm among young people (Liu et al., 2018) as well as suicide mortality, (Ng, et al. 2016). In our middle years there's an increased risk for breast cancer from many environmental toxins (Koual, et al., 2020) and from air pollution specifically (Li, Lin, Wei, Yeh, 2021). Our proximity to oil refineries also increases our risk of cancer (Williams et al., 2020). In our older years there is increased risk for cardiovascular disease and early mortality due to air pollution (Bourdrel et al., 2017), and an increased risk for dementia from exposure to PM2.5 air pollution (Ru, Brauer, Lamarque, Shindell, 2021). This is the kind of small particle air pollution which is small enough to cause neuroinflammation (Thiankhaw, Chattipakorn, Chattipakorn, 2022). Over the course of life, these risks which began prenatally or in childhood cross paths and can interweave with each other as we move forward in our lives. The child with mild asthma can become the adult who has more severe respiratory disease (Savran and Ulrik, 2018), and perhaps other conditions as well.

Without changing the framework to include ecology, how do we develop interventions as researchers, or begin conversations with patients so that healthcare can best protect people's health in the face of challenges of this magnitude? There are many people who are hesitant to get care or who drop out of treatment. Some part of this may be because the bio-psycho-social model is one where when things go wrong, it's your biology, your mind, or the social forces you've surrounded yourself with which are holding a kind of blame or responsibility.

Without this change we also cannot adequately address new issues for which there are very likely health effects, but we aren't sure what they might be. For example, for the first-time, research has discovered microplastics in human blood (Leslie et al., 2021), and it's likely that our rate of ingestion is faster than our rate of excretion. So, what impacts will this have? A framework which includes ecology makes sure that our healthcare is not divorced from the ecological context we live in.

Those in healthcare have a role in communicating risks, promoting habits of health, and deciphering the complexities of research science to the people they care for and sometimes the broader society. It's foolhardy to enter an era of increased climate destabilization and ecological destruction without this ability. There was once a mind-body split in the West, another split to overcome is the full recognition that the ecology outside of us *does* shapes the ecology within us. These problems will soon look us in the eyes more directly, and we should be prepared for that.

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