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Implications of Evolutionary Mismatch in the Field of Public Health

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Public Health can be defined in various ways, but a concise definition is, “the field that focuses on preventing disease and injury, prolonging life, and promoting human health in populations.” This discipline has a different focus than clinical medicine, emphasizing prevention, and it also differs in that its focus is at the population level rather than on individual patients.

Evolutionary mismatch is the phenomenon that occurs when a trait that evolved as beneficial in one environment becomes maladaptive in another [1]. Natural selection constantly sculpts species in response to environmental change, but when environmental change is too rapid or too extreme selection cannot keep up. Thus, traits can become maladaptive. This phenomenon has become exacerbated in the modern world because of the unprecedented rapidity and degree of anthropogenic environmental change, and our own species is facing increasingly novel environments, both physical and cultural [1].

Evolutionary mismatch has been subdivided into two types: genetic mismatch and cultural mismatch [1, 2]. The concept of genetic evolutionary mismatch in humans is well-known and much discussed, including aspects of modern diet and other examples of contemporary lifestyle, such as lack of exercise, reduced sun exposure, sleep deprivation, chronic stress, etc. (e.g., [1, 3, 4]). A few of the many specific examples directly relevant to Public Health include our innate attraction to sweet flavors, mismatched in the modern world with constant availability of sugar; our innate default to conserve energy, all too easy in a world with lounge chairs and TV remotes; the ease with which our neural reward systems can be hijacked by addictive substances or behaviors; and susceptibility to macular degeneration (ADM) upon exposure to the nutrient poor, seed oil rich modern diet [5].

Cultural mismatch, however, has been much less discussed, particularly in the context of Public Health. The concept of cultural mismatch is relatively new and lacks a well-defined definition. As a result, a “working” operational definition can be helpful: “a once advantageous culturally transmitted practice, custom, meme, idea, belief, or belief system that has become detrimental due to environmental change.” An example would be a religious or political belief system that was beneficial in the past [6], but under modern conditions would put the believers and their groups at a disadvantage. A specific case would be a religion that was able to expand in past centuries, but due to its continuing discrimination against women or failure to educate women finds itself at a disadvantage in the modern, globally competitive world where societies that maximize the innate potential of all their citizens are at an advantage. There are many other examples of cultural mismatch, and as described below, this idea can be particularly valuable as a way of “framing” a wide variety of Public Health problems including some with widespread implications.

In order to understand the concept of cultural mismatch, it may be helpful to first consider the idea of a cultural “match.” In our species, cultural evolution is very rapid, much faster than genetic change, and as a result can be a rapid process of adaptation. As such, cultural evolution can provide solutions to genetic mismatches. For example, in cold climates warm clothing provides a cultural adaptation, solution, or “match” to an environmental challenge [2]. Likewise, among the Inuit, Yupik, and similar Arctic peoples, the development of the kayak provided a major culturally based adaptive advantage [6]. Another example is seen in the widespread development by indigenous peoples all over the world of complex detoxification practices that render highly toxic plants edible.

Just as cultural matches solve problems, changes in either the physical or cultural environment can cause cultural adaptations to become detrimental and therefore result in cultural mismatches. Also, just as there can be detrimental genetic mutations that are maintained through linkage with

valuable genes [7], detrimental cultural traits can be maintained or even increase in populations through association with other adaptive cultural traits. For example, such cultural mismatches can result from situations where a detrimental practice is one part of a multifaceted cultural belief system that overall is beneficial and has been selected for. Also analogous to the genetic situation, cultural mismatches could be the result of pleiotropy, being beneficial in one context, such as signaling group identity and maintaining group cohesion, but detrimental in other ways.

Cultural mismatches can vary extremely widely in scope and importance ranging from some that are very narrow in effect to those that impact millions of people. A very small-scale example, limited both to the past and to a small region, that is nonetheless relevant is that of ritual funerary cannibalism. This cultural practice, which involved women and children ritually eating small amounts of brain tissue of deceased relatives as a sign of respect and mourning, was formerly practiced (until the 1960s) by the indigenous Fore people of the highlands of Papua New Guinea. It was presumably part of a complex religious/social belief system that overall was successful for the Fore people. However, with the inclusion of a disease agent (of unknown origin), the result is the transmission of Kuru, a horrifying, incurable neurodegenerative disorder transmitted by prions (in a manner similar to mad cow disease), and that belongs to a class of infectious diseases called transmissible spongiform encephalopathies [8].

It could be argued that the development of grain cultivation techniques and methods of turning them into edible flours, etc. has become an example of a cultural mismatch in the modern context. Early agricultural societies benefited from the increased food supplies these adaptations provided and were able to increase in population size and thus successfully outcompete and displace surrounding hunter-gatherer societies. However, in the modern context, grain production and processing ensure unlimited access to flour-based grain products year-round. It is now widely believed in the Ancestral Health community and increasingly in the medical community at large that large amounts of these nutrient poor, high glycemic foods, to which humans are not well-adapted, contribute to the alarming rise in obesity, diabetes, and other chronic diseases seen in modern societies [9-11].

I hypothesize that the current anti-vaccination movement is in part a cultural mismatch with broad implications. While some of the resistance to vaccines may simply be the result of genetic mismatch (e.g., due to innate human cognitive biases such as discounting temporally distant benefits and the tendency to respond most strongly to immediate threats or clear and present danger), cultural mismatch is also a contributor. Ironically, anti-vaccination beliefs may have been beneficial at the beginning of vaccine development centuries ago when there was no understanding of how or why they worked and the potential for harm was real. Even in the modern world, vaccines, like any potentially life-saving medical intervention (e.g., antibiotics, surgery), can have side effects and cause problems including reactions to certain vaccine components and allergic reactions including anaphylaxis. Vaccines are known to rarely cause injury and in extreme cases even death [12]. Likewise, vaccines vary a great deal in their efficacy. For example, the effectiveness of influenza vaccines in the time period 2004-2018 varied from 10 to 60 percent. Nonetheless, even in those years where they were least effective, huge numbers of illnesses and deaths were prevented [13]. Even considering such imperfections, given the tremendous overall benefits of vaccines, as discussed below, current anti-vaccination beliefs appear to be detrimental.

Vaccines are widely agreed to have been one of the most effective Public Health interventions of all time and have saved untold millions of lives with only clean water more effectively reducing the burden of infectious disease [14]. Smallpox, for example, devastated humankind for centuries and had huge impacts on the development of Western civilization and the course of world history

[15]. The disease was common in the U.S. in the 19th century and persisted there until the mid 20th century, but was eradicated worldwide by the 1970s thanks in large part to vaccines. Because of the resulting tremendous decrease in suffering, blindness, scarring, and death, the development of smallpox vaccines is sometimes said to rank among the greatest achievements in human history [16].

Likewise, polio (Poliomyelitis) was a greatly feared and often devastating acute paralytic viral disease. Anyone alive today in their 60s or older can remember the widespread fear of polio, the resulting paralysis, and the psychological shadow of the iron lung, the large chambers (negative pressure mechanical respirators) required to sustain the lives of those so severely affected that even their respiratory muscles were paralyzed. The development of polio vaccines in the 1950s was widely hailed in the press, was recognized as a tremendous breakthrough by large portions of the population, and the discoverers, Salk and Sabin [17], were essentially cultural heroes.

When assessed based on the best scientific evidence available, modern vaccines have been shown to be among the safest medical interventions [18]. Despite the tremendous benefits of vaccines and the scientific evidence of their much greater benefits than costs, there has been and continues to be a vigorous anti-vaccine movement. In fact, "...concern over vaccination began shortly after the introduction of smallpox vaccination and has continued unabated ever since" [19]. The anti-vaccine movement is a good example of cultural mismatch—it is a cultural belief/meme that on average harms its participants, an example of harm being the recent outbreaks of measles primarily among the unvaccinated [20]. While based largely on pseudoscience and misunderstanding, once such a belief system gains traction or becomes part of widespread religious or political belief/identity systems, it can spread culturally whether or not it is based on evidence and whether it harms or benefits those involved.

One particular aspect of the anti-vaccine movement that warrants closer attention is the controversy surrounding the vaccine against human papillomavirus (HPV). This vaccine was approved by the FDA in 2006 [21] and since that time, in addition to the general anti-vaccination criticism, there has been opposition to vaccination against HPV by some religious groups and politicians because of the fear of increased promiscuity. Once religion and politics become involved many people easily fall into the trap of additional cognitive biases including the "in-group" versus "out-group" or "us versus them" bias. Further, once a political party or religion or other group "decides" what is "correct," there are psychological and social consequences of non-conformity including ostracism, expulsion from the group, and loss of reputation. These can lead to individuals making choices that ultimately cause harm to themselves and others. Thus, affiliation with a religion or political party that advocates such ideas harmful to group members becomes an example of cultural mismatch. This is especially tragic in the case of HPV where the vaccine is now known to reduce cervical cancer risk, as well as the risk of throat and mouth cancer in both males and females, and those not taking the vaccine have a greater risk of unnecessary suffering and death.

Another cultural mismatch with Public Health implications is the now widespread meme of what is sometimes called the one disease, one pill/drug approach (e.g., Brett Smith, [22] and pers. comm.) impacting much of modern medicine. Because of the obvious success of some very efficacious drugs, particularly antibiotics, much of the focus of modern medicine and the expectations of the public revolve around the cure or treatment of almost all health problems with a pill or drug. While this belief may have been advantageous with antibiotics and some other very successful drugs, the limitation of this approach is all too evident given the continued increase in incidence of a large number of chronic conditions including diabetes, obesity, non-alcoholic fatty

liver, and a variety of autoimmune diseases. This cultural mismatch is now preventing both effective research on such problems and the use of other more efficacious treatments.

A final example of an evolutionary mismatch involving Public Health is global climate change denial despite overwhelming evidence. This example includes aspects of both genetic and cultural mismatch. Margaret Chan, former Director-General of the World Health Organization, considers climate change to be the greatest threat to global health in the 21st century [23]. This is because of the large number of downstream health consequences associated with a changing climate such as heat stress, food insecurity, impacts on air quality, water insecurity, increased likelihood of natural disasters and associated health impacts, climate refugees, effects on disease vectors and disease distribution, etc. As I have discussed before [24], from the genetic mismatch standpoint climate change is an almost uniquely difficult challenge for humans to deal with (e.g., [25-30]). This is because our brains include evolved cognitive biases to ensure we focus most strongly on certain things including: 1) immediate problems and threats, particularly where there is clear danger (versus something long-term); 2) objects or events that appear suddenly or grow rapidly (versus those that are slow-moving or gradual); and 3) choices that don't require short-term sacrifice or loss in exchange for long-term benefit, and thus don't trigger our loss aversion bias. Climate change may also trigger our "out-group" bias because of the possibility of other countries cheating on agreed upon controls. In other words, climate change is either not sending effective alarm messages or is sending signals that run counter to our innate biases.

While climate change denial was never a beneficial cultural idea, there are still aspects of cultural mismatch in its current manifestation. In recent years it has become an integral part of widespread religious and political belief/identity systems. As in the case with the anti-vaccination movement, once climate change denial becomes incorporated into culturally accepted religious or political identities, the "us versus them" cognitive bias and associated social and psychological pressures make its rapid spread culturally almost inevitable. Indeed, when taken from the long-term global perspective, climate change denial may be the most damaging aspect of these belief systems.

What can be done about these and many other harmful genetic and cultural mismatches? This is a crucial question since so many of the problems facing us in the modern world are complicated in part by such mismatches. That question is largely beyond the scope of this article, but one of the most important starting points is to educate others about the concepts of genetic and cultural mismatches so that there is a broader understanding of why we are susceptible. Simply understanding the concepts in a sense provides an intellectual "vaccination." But more importantly, understanding what is going on will allow us to develop strategies and solutions that are effective since they are based on a real understanding of the biological and cultural susceptibilities faced by our species.

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