3 Medicine and Health Care in the Anthropocene: Who Pays and Why?

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Introduction

The aim of this paper is to examine the nature of medicine and health care in the Anthropocene, in particular what exactly we mean by, and should aim to include in, the term "medicine," how this is shaped by the characteristics of the Anthropocene, and what implications this has for "medicine" as we move forward. It will consider how the provision of medicine may need to adapt to specific challenges such as the doubling of the average human lifespan since the Pleistocene, resulting in larger numbers of elderly, less economically active members of society against a socioeconomic context in which financial wealth is increasingly acknowledged as the main determinant of health across the life course. As these less contributory members need to be supported from within the existing resources and capital of their society, the paper will explore motivations for providing this support, both within populations and at an international level. The latter is particularly important as geopolitical tensions and conflict threaten to disrupt access to medicine and medical systems at a local level, leaving affected populations dependent on the international community for medical support. Last, by drawing on historical and archaeological evidence along with theories from evolutionary anthropology on the development of compassion, altruism, and cooperation, it will make a case for considering cross-disciplinary approaches to human behaviour in the Anthropocene.

Why Do We Need Medicine?

Before considering how medicine is delivered, it is worth taking a moment to reflect on what requires us to need medicine and health care and how this has changed over the course of Anthropocene history. In pre history, ill health was largely caused by a breakdown or failure of human biological processes in the face of equally biological challenges. From complications during birth, a

reflection of the relatively large heads of human infants resulting in a difficult passage through a relatively narrow birth canal (Macfarlane, 2018), through challenges in procuring sufficient nutrition for energy, growth, and maintenance of metabolic functions (Speth and Speilmann, 1983), to countering pathogens that overwhelm our immune system (Rifkin, 2017), our bodies fight a constant battle with nature from conception to death. While current thinking suggests that the upper limit of a natural human lifespan is approximately 120 years (Dong, 2016), in practice only one person in history is known to have lived until their thirteenth decade: the Frenchwoman Jeanne Calment, who died in 1997 at the age of 122. The rest of the human race is constantly picked off by the world around us throughout our lives.

Picture a theoretical cohort of one thousand babies. From the moment they are conceived, nature throws stones of ill health at the cohort. Some do not survive gestation; others die in childbirth; many fall in infancy and early childhood from infectious disease before their immune systems are fully developed, or in older age when it is failing. Others starve when harvests fail, or fall foul of severe cold, heat, or floods. Yet others – though in relatively small numbers – develop cancers, diabetes, and heart disease. The older they get, the more of them simply wear out. Eventually, none are left – long before any come close to 120 years of age.

But, over time, we have developed new tools to fight back against nature. Prehistorical burials with herbs known to have healing qualities, and which may represent early attempts at medicine, date back to the Neolithic (Lietava, 1992) as do early surgical procedures (Ackerknecht, 2016). As farmers and agriculturalists replaced hunter-gatherers to provide a more secure food supply and protection from starvation (Bar-Yosef, 2017), healers also emerged within stratifying human societies to provide protection from disease and sickness (Jùnior, 2018). Over the centuries, we have gradually developed more and more tools with which to ward off illness, just as fire allowed us to ward off cold and spears to ward off predators. The toolbox of the modern physician is vast: ultrasound scanners monitor the health of the unborn child, caesarean section sidetracks labour complications, and antibiotics protect the mother and infant from infection; vaccination protects against many diseases while others have been eradicated entirely (Hervé, 2000); cancer can be diagnosed, treated, and survived (Allemani, 2018), as can diabetes, HIV, and many other forms of ill health. When nature throws stones, we can reach for shields. There is an increasing number of researchers who believe that not only will more people survive until well past 100 years of age, but that artificial genetic modification will soon enable the natural ceiling of a 120-year lifespan to be extended (Ben-Haim et al., 2017).

Against this, however, the environmental damage we are inflicting on the Earth means that nature's arsenal is also growing (Cole, 2018). Crowded urban environments enable new diseases to emerge and old ones to spread more

quickly (McMichael, 2001; Weiss, 2004), and air pollution causes millions of deaths each year (Cohen, 2017), as does the modern preference for high-sugar, high-salt, and high-fat diets (Whalen, 2017). Nature is no longer the only stone-thrower: we throw stones at one another, too.

This is particularly tragic when we consider that the tools to ward off ill health cost money. Not everyone can afford an equal array and some cannot afford any at all. Health is strongly correlated with the individual's ability to pay (Deaton, 2003). This in turn is correlated with the social environment in which they live (Marmot, 2005); pollution is worse in poorer environments (Landrigan, 2017) from anthropogenic chemicals and dirt and natural pathogens. The ill health we inflict on the Earth is batted towards those least able to deflect it. Wealth enables the rich to protect themselves from nature's stones and deflect humanity's onto others, creating gulfs of health between populations. Life expectancy at birth is more than eighty years in the world's richest economies, less than fifty in its poorest (Cole, 2018).

We need to keep this inequality in mind as we consider how the medical and health care systems of the Anthropocene are arranged and maintained, and for whom this arrangement is made. The history of human care and compassion that will be explored across this chapter is intertwined with the history of economic development, charity, state provision, and private enterprise. The human endeavour to bargain with nature over our health must acknowledge and accept that nature is no longer our only challenger: for many aspects of our ill health, we have only ourselves to blame. The future of our health will depend on our ability to maintain the health of the environments in which we live. While this chapter focuses on medicine and health care for our bodies, a better health care system for the planet is urgently needed.

How Do We Define "Medicine"?

The Oxford English Dictionary (OLD, 2018) defines medicine as: "The science or practice of the diagnosis, treatment, and prevention of disease (in technical use, often taken to exclude surgery)." Positioning medicine as a science or a practice embeds it firmly as a product of civilization, of the stratification of humanity within complex societies that is synonymous with the early Anthropocene model (Ruddiman, 2013). Practitioners of medicine are specialists of the kind that, like scholars, engineers, and lawyers, can only emerge within complex social systems.

In the *Etymology of Medicine* (Charen, 1951), Thelma Charen traces the word to a Latin root – medicina – meaning the healing art, a remedy. This has an implication of righting a wrong, of making something better. Further back is the ancient Indo-European root ma/mad/med, to think, to reflect or to consider. From this also comes meditate, an integral part of healing practice in many cultures, such as the Indian tradition of Ayurveda (Kraft, 2009). The

Indo-European root extends to diagnostic appraisal and clinical evaluation: the medical practitioner meditates on and weighs the illness, judges, and counsels, in addition to attending and treating the patient. This dual role of medicine – to contemplate the illness and its causes, as well as to treat – is more important to shaping our understanding of what the future of medicine should look like.

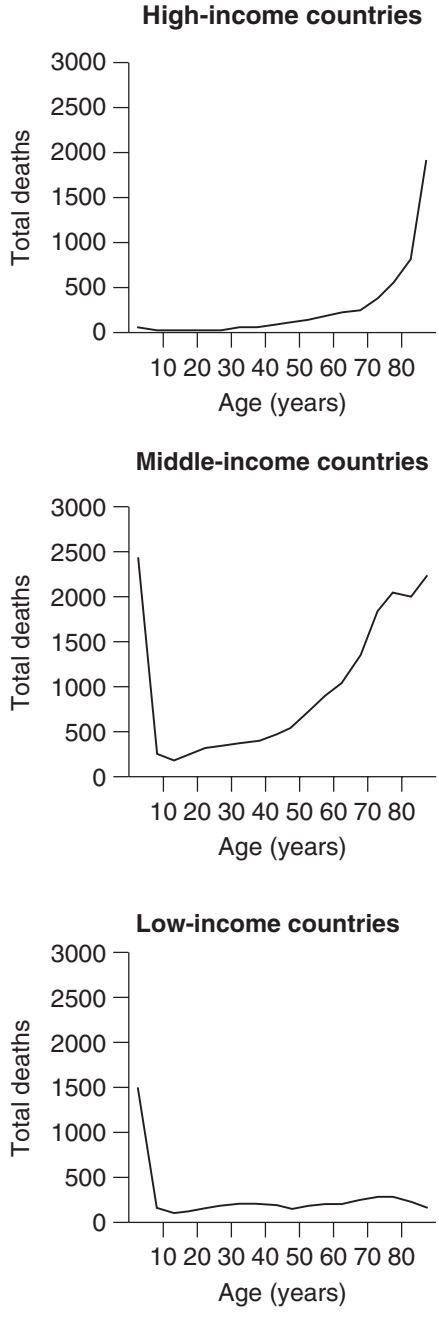
Humans today are living longer on average than at any other time in history. Average life expectancy remained reasonably constant, at around 30–40 years, from the Pleistocene (Hoggan, 2015) to the late nineteenth century but stands at more than 80 years in some parts of the world today (WHO, 2015). An average life expectancy of 40 does not mean that most people will die at around 40 years of age, however: the figure is reached by a large number of deaths in infancy, while other members of the population may reach old age. The average age increases as more infants and children survive to (late) adulthood: mortality of children under five has dropped from 50 per cent before the nineteenth century to a fraction of 1 per cent in most developed countries today.

Deaths across the Life Course: Low-, Middle-, and High-Income Economies

Some of this increase is down to advances in medical science – including vaccination, antibiotics, and treatments for cancer, diabetes, and other non-communicable diseases – though medical science alone cannot take all the credit. Sanitation has also had an enormous impact on health and life expectancy, from the ancient cities of Mesopotamia (Mitchell, 2015) to the widespread introduction of piped, clean water and waste management systems in late nineteenth-century Europe (Geels, 2006). The developing world is yet to catch up, however: 18 per cent of childhood deaths in Africa are due to diarrhoea, which is linked to poor sanitation (Black et al., 2003; Kinney et al., 2010) and (excluding North Africa) the continent is estimated to be losing approximately 5 per cent of its annual GDP because of health problems linked to water and sanitation deficits (UN, 2008). Infrastructure can, clearly, be as important to health as cures and treatments.

In its 2008 report on the social determinants of health (WHO, 2008a), WHO set out five factors necessary for health care systems to function: a supply chain, simple management measures, training of staff, availability of frontline health workers, and financing. This emphasizes the importance of health as a collective endeavour. Humanity needs to make collective decisions on how to organize and provide the complex health care systems and infrastructure on which medical science depends.

The cost of this can be borne by individuals or society collectively, with figures suggesting that it is much more efficient and effective when borne collectively. At the national and international level, population-level approaches to health



3.1 The number of female deaths per thousand across the life course for low-, middle-, and high-income countries. While numbers differ slightly for males, the distribution pattern is similar for both genders (adapted from Harper, 2016).

cost on average five times less than individual interventions (Nurse et al., 2014). Interventions for specific diseases, such as measles and rubella, work best when combined with strengthening health care systems overall (Andrus et al., 2016). A country's average health outcomes show a linear relationship with increasing GDP per capita, but improve even more quickly with an increase in average health spending per capita (OECD, 2011), and countries with better-funded health provision tend to have healthier populations; however, these advances often come at the cost of increased pollution and greenhouse gas emissions and depletion of natural and mineral resources (Landrigan et al., 2017), creating a wicked dilemma. Furthermore, this damage is often displaced onto future generations (Guerry et al., 2015) and onto countries at an earlier stage of development. Governments of low-income, resource-poor countries may see themselves dependent on accepting polluting industries to grow their own economies (Atapattu, 2002), further complicating the issue. At an international level, some of the medical achievements we have already seen, such as smallpox eradication, and those we hope for in the future, such as polio eradication, can only be achieved through international cooperation (Cole, 2015). Scott Barrett (Barrett, 2007) in particular has put forward many arguments for (as well as identifying persistent barriers to) international cooperation on health as a global public good.

Challenges of Medical Advancement

Increased life expectancy presents a wicked problem, however, particularly when using pure accounting models of financing. Older members of society tend to be economically unproductive (or at least less productive), consuming more of the resources of the society in which they live than they generate: an 85-year-old male costs the United Kingdom's National Health Service (NHS) about seven times more on average than a male in his 30s, for example. Health spending per person in the UK is less than £2,000 per person on average – even for children under 5 – until around the age of 50 but rises steeply from the 60–4 age group onwards to an average of £7,000 a year for those over 85 (ONS, 2015). The survival of large numbers of people into old age may be an inevitable consequence of providing good health services through infancy, childhood, and adulthood, but it incurs a high financial cost to society. How to pay for it in the most cost-effective manner is a key consideration for the Anthropocene. So too is whether the "cost," and its attendant benefits, should only be considered in financial terms, or if there are other benefits that drive society's investment, such as the sense of well-being, and superiority to animals, we gain from engaging in acts of compassion (Spikins et al., 2010).

As the global population over 65 has grown from 5 per cent in 1960 to 8.5 per cent in 2015, with the percentage of children (aged 0–14) dropping from 37 per cent in 1960 to 26 per cent in 2015, the economically active percentage of the population has shrunk. It is likely to shrink further as those moving from the 15–64 age group into the 65 and over demographic are not replaced

at the same rate, which may strain economies in future. A pure accounting model of health might advocate withholding state financing for medical care after retirement age, leaving health in old age dependent on the individual's ability to afford treatment (Lubitz et al., 2003), but welfare economics considers wider benefits and values that are harder to cost, such as the emotional value we place on family members (Daatland and Lowenstein, 2005) and the experience and advice older members of a society can contribute (Warburton and MacLoughlin, 2007). It is therefore important to reflect on how society's approach to health care and medical provision has developed over time, and what incentives, financial and otherwise, have been identified for a collective approach. This may help us to determine how health systems can adapt.

Health Care: A Collective Endeavour

One approach to reflecting on the provision of complex health care systems is to examine them through the lens of Collective Intelligence, a sociopolitical theory in which collaboration and collective decision-making create something greater than the sum of its parts. Collective Intelligence both influences and is influenced by society. In 1906, sociologist Lester F. Ward (Ward, 1906, p. 39) wrote, "The extent to which [society will benefit] will be based upon collective intelligence. This is to society what brainpower is to the individual." Ward believed that individual geniuses could do nothing without a social structure that enables them to emerge, supports them, and allows them to thrive. Only by working together through an enabling mechanism can individual members of a society help to improve that society. Collective Intelligence also enables the development of intelligently networked groups who share and pool knowledge so that others can draw from it (Lévy, 1997). Schools and professional societies that train and accredit doctors, as well as the pharmaceutical companies that develop new drugs and distribute them around the world, can be seen as manifestations of collectively intelligent systems.

A second approach is to consider the origins of cooperation and collaboration identified by the field of evolutionary biology: early humans began to pool their mental attitudes and skills once they realized they could not respond to increasing environmental pressure alone, overcoming individual limitations to construct artefacts that enabled knowledge to be shared across people, time, and space (Tomasello, 2009).

The Prehistory of Health Care

How a society approaches health care is one of the clearest and most visible expressions of its attitude to the value of life, particularly where saving a life incurs a cost to others. In such cases, a value has to be placed on the benefits to

the community – as well as to the individual – of the individual's life. Humans appear to have valued life for many thousands of years. Care for the ill and infirm is evidenced in the archaeological record through skeletons such as the Old Man of Shanidar (Solecki, 1957), a Neanderthal male who died aged approximately 40 years, circa 35–45,000 BCE. Injuries he had suffered early in his life had left him with a withered arm, a crippled leg, and a possibly sightless left eye (Trinkaus and Zimmerman, 1982) and it is unlikely he would have been able to survive without the support of his wider social group (though unusually worn teeth suggest he may not have been inactive, but simply given other work to do if he was unable to hunt or gather, such as chewing skins to soften them). This and other evidence of debilitating conditions in the Palaeolithic record – from dwarfism to palsy, toothlessness to arthritis – show that assistance to those with impairments, who would constitute an economic hazard to their social group (Winzer, 1993) has a very long history.

The Shanidar graves also contain remains of herbs that appear to have been intentionally buried. Some, such as *Ephedra altissima* (used to relieve wheezing and congestion) and *Senecio-types* (used to relieve pain and inflammation) have therapeutic qualities, leading to theories that this may be the reason they were chosen as grave offerings (Lietava, 1992). Seeds possibly used in herbalism have also been found in Bronze Age China (Mousume, 2017). As archaeology moves into history, written records of herbalism confirm the existence of early medical systems.

The History of Health Care Systems

The development of writing makes clear not only that herbs and plants were used as primitive medicines, but also that knowledge of which plants could be used, and how, had developed as part of a system that included the recording and sharing of knowledge and the specialization of some members of society into healing roles.

The earliest written evidence of herbal remedies dates back more than five thousand years. The Sumerians compiled lists of plants with therapeutic qualities (Borchardt, 2002), and the Egyptians recorded their use of medicinal plants including cumin and aloe vera in the Ebers Papyrus, circa 1550 BCE (Aboelsoud, 2010). The fourth century BCE Greek *Historia Plantarum* (Preus, 1988) includes both beneficial and harmful properties of herbs along with information on how and when to harvest them. The Egyptian Imhotep, 2650–2600 BCE, often described as the first physician in history, is thought to be the original author of the medical text recorded on the Edwyn Smith papyrus (Brandt-Rauf and Brandt-Rauf, 1987), which details the diagnosis, prognosis, and treatment of forty-eight traumatic and accidental injuries, and the Indian surgeon Suśruta, circa 600 BCE, authored the *Suśruta-samhitā* (Veith, 1961),

a book describing over 300 surgical procedures and 120 surgical instruments. Hippocrates (circa 470–360 BCE) is credited with having made a systematic review of the medical knowledge available during his lifetime.

The fact that such detailed information was being written down reveals two key points about medical knowledge in the ancient world: first, that it was highly valued, as literacy was rare outside the very highest social strata, and second that there was already a system into which these authors fit. They were recording knowledge in order to contribute to a pool of knowledge from which others could draw, pointing to a collective body of medics who were doing more than simply practising healing: they were laying the foundations of complex medical systems.

Alongside this early codification of medical knowledge the institutionalization of medicine also appears. Hippocrates founded a medical school on the Greek island of Kos, and there is at least one known older Greek medical school, the Cnidian (Lonie, 1978). Suśruta also taught in a medical school, indicating that such institutions existed in India too, during his lifetime. Further evidence of the institutionalization of medicine is the establishment of hospitals. Romans built valetudinarii for the care of sick slaves, gladiators, and soldiers from around 100 BCE.

Following the adoption of Christianity, every cathedral town had a hospital, and some also maintained libraries and training programmes. Houses that dispensed medicines to the poor and sick existed in fifth century CE India (Liu, 2016), and an early hospital was established on Sri Lanka, as part of the Buddhist complex at Mihintale (Mueller-Dietz, 1996) in either the ninth or tenth century CE. Medieval Islamic hospitals or bīmāristāns ("asylum of the sick") such as the one established in Baghdad as early as 805 CE (Cope, 2016, p. 1286), were elaborate institutions that combined care homes for the aged and infirm with hospitals divided into separate areas for treating disease, ophthalmology, orthopaedics, and mental disease (Tschanz, 2017). They also tended to have lecture theatres and libraries, serving a dual purpose as hospital and medical school, set examinations for students, and issued diplomas.

Who Finances Health Care and Why?

Bīmāristānswere forbidden by law to turn away patients who couldn't pay, a reflection of the Islamic moral imperative to treat the ill regardless of financial status: their establishment also led to the emergence of charitable foundations called waqfs (Al Ansari, 2013), as well as contributions from state budgets – an early model for health care delivery. While it has been offered that "anyone who wishes to be considered humane has ample cause to consider what it means to be poor and sick in the era of globalization and scientific advancement" (Farmer, 2003), and also acknowledged that early public health systems were often public health policing to keep the infected poor away from the more

sanitary rich (Slack, 2012), the issue of who pays for health care, and the systems that deliver it, is a key Anthropocene challenge, particularly as the cost of medicines and health care individuals need (and expect) throughout their life increases with increasing life expectancy.

These costs can be borne by civil society, through philanthropic organizations, charitable donations, or private enterprise, or the state, mostly financed through taxation or private enterprise, with patients paying through health care insurance schemes or at the point of health care delivery. The favoured early model appears to be either the funding by the ruling elite as a service to their citizens, by religions orders as part of their moral duty, or by charitable organizations for the same reason. Early Ayurvedic establishments in Sri Lanka – Sivikasotthisala – were funded by the king from the fourth century BCE onwards (Gunawardana, 2010), and India, which had houses for dispensing charity and medicine as early as 400 CE (Legge, 1965) may have been one of the earliest civilizations to provide civic care to the ill (Wujastyk, 2003), but most early health care systems were provided and paid for by religious institutions.

In early history medicine and mysticism were closely linked. Priests often had a dual role as healers: in ancient Greece, temples dedicated to the healer god Asclepius, known as Asclepieia, functioned as centres of medical advice, prognosis, and healing. In medieval Europe, hospitals were largely run by monks and nuns as part of religious communities, particularly following the fall of the Roman Empire, though funding also came from "pious laypeople," professional and municipal associations (Brodman, 2009).

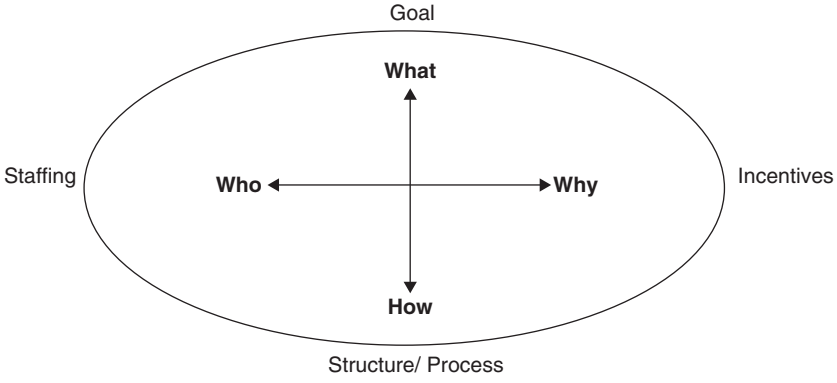
The church remained the main supporter of hospitals across Europe for the next millennium, ending in the UK only with the dissolution of the monasteries in 1540 by Henry VIII. Afterwards, the crown directly endowed some hospitals, such as St Bartholomews (Bart's), St Thomas's and St Mary's of Bethlehem (Bedlam) in London following a petition from the populous, who by now expected hospitals and medical care to be provided. In Catholic countries such as France, hospitals remained linked to religious institutions until the Enlightenment. Later, in the eighteenth and nineteenth centuries, hospitals were often funded by civil philanthropists – such as Guy's by wealthy merchant Thomas Guy in the UK. US charitable hospitals such as Pennsylvania, New York, and Massachusetts General also worked to this model. Protestant churches and Methodist churches re-entered the health field in the mid nineteenth century as part of a growing interest in social work (Washburn, 1931). An important part of European colonial expansion, particularly during the nineteenth century, was the provision of health care services by missionaries, though whether the main purpose of this was to improve the health of local populations or to prevent the spread of tropical diseases to the colonisers is debatable (Manji and O'Coill, 2002). More than a century later, 25–50 per cent of African health care was still provided by voluntary faith-based organizations (Good, 1991).

As nations have developed, the funding of medical systems has increasingly come to be seen as a public service, at least organized, regulated, and overseen by the state and in most cases at least partly funded by it. Most OECD nations provide health care to their citizens through the state to some degree. In 2000, average EU spending on health care (public and private) was 8.5 per cent of GDP (The King's Fund, 2016) increasing to 9 per cent by 2014, due largely to aging populations (OECD, 2014). More recently, a slowing down of increasing life expectancy (and in some cases reduction) in Europe has been blamed on the difficulties of financing health care following the economic crisis (Hiam, 2018).

Incentives to Fund Health Systems

The rewards for investment in health care systems may not be as straightforward for the state as they are for individuals, however, particularly as the benefits of investment in health may not be returned within the current generation, let alone within a single term of political office. For an individual, investment – through private insurance or tax and national insurance – ensures complex health care will be there when needed. But at state level, an increase in health care investment, which helps to increase average population life expectancy, may not lead to a corresponding increase in GDP, and certainly not an immediate one (Acemoglu and Johnson, 2006). GDP can initially drop and may not recover for 30–60 years, as the overall resources generated by economically active members of society need to be shared with an increasingly large economically inactive population. Income per person can be lower initially than if life expectancy had not improved (Ashraf et al., 2008). It may, however, be economically more beneficial for state medical systems to focus on treating diseases that do not necessarily kill, but affect productivity – for example, reducing hookworm and malaria can lead to a fitter and more productive workforce, with fewer days on which individuals could otherwise be economically active lost to sickness (Bleakley, 2010), while better health in earlier life may reduce the age at which the elderly begin to require extensive health spending (Lubitz et al., 2003). It may also be the case that slower growth in GDP avoids too fast a move towards a more polluting, natural-resource depleted society, however, which may have co-benefits for health. It is interesting to note that many of the countries that come closest to having achieved all the Sustainable Development Goals while living within Planetary Boundaries (O'Neill et al., 2018), are middle-income countries such as Vietnam and Costa Rica.

To understand what other incentives may drive collectively intelligent systems, we can turn to the Collective Intelligence Genome (GIC) (Malone et al., 2009), which conceptualizes the components of a system and the motivations behind its use. The GIC has four basic building blocks: what, who, why, and how. Each of these has variations that can be combined and recombined in



3.2 The collective intelligence genome (Malone et al, 2009)

different ways. The why – the incentives – has the variants money (reward), love (altruism), and glory (power).

If, as has been shown above, "money" or financial reward in terms of increased GDP is not necessarily an (immediate) outcome of state investment in medicine, what else might be?

Though there is at least some evidence of "glory" in the high-status medical practitioners have enjoyed throughout history, "love" – in the form of altruism and compassion – is a stronger candidate. Compassion has very ancient evolutionary roots (De Waal, 2008), and compassion that requires planning and rational thought emerged around 1.8 million–300,000 years ago (Walker and Shipman, 1997).

Compassion is associated with love, commitment to others, willing self-sacrifice – characteristics that make us "human" and separate us from other animals (Spikins et al., 2010). In this sense, we could also see the payoff as "glory," a sense that we are better and more advanced than others who do not demonstrate similar compassion. Even apparently altruistic acts confer some rewards, however. Undertaking a compassionate act that is not an obligation and has no selfish gain releases the hormone oxytocin, creating a sense of well-being and happiness (Shen, 2015) that may motivate the actor to do the same thing again in similar circumstances.

Compassion is observed in several animals, including dolphins and elephants, but seems particularly important in higher primates with complex social structures; it may help to develop long-term relationships, and has been described as "the glue that holds society together" (Baron-Cohen and Wheelwright, 2004). This suggests a particularly valuable role in the Anthropocene's larger, more complex societies than in the Pleistocene's more immediate family group structure.

If the main motivation for providing state-level cooperation in health systems is compassion, the issue then becomes, how far is this compassion likely to extend? It has, so far throughout history, moved from being provided by the immediate family group, to the city state, to the state. In larger and more complex social units, it is activated by patterns of mutual identification (Elias, 1994), a sense of community now and in the future (Anderson, 2010), and/or a shared high culture (Gellner, 2008), all of which create a function of compassion for those who share membership of the group with which they identify. There is no global health provider, but there is a strong argument for the richer regions of the world subsidising the health of the poorer regions, and this may be possible to incentivize through stronger emphasis on human beings as a single race, in which all members have obligations to all others. Among other benefits, such global investment in ideas of citizenship as well as medical equipment and services would help to ensure that health challenges such as disease outbreaks like the 2014–15 Ebola epidemic are better controlled and do not suffer because of a sense of detachment in more developed countries from a distant and unrelated Africa (Honigsbaum, 2014; Schuklenk, 2014).

Breakdown of Health Care Systems in Times of Conflict

From a selfish perspective, there is a strong incentive to shore up other states' failed systems in order to protect ourselves, as it is more efficient to treat health problems at source. The two most recent Public Health Emergencies of International Concern (PHEICs) (WHO, 2008b) – the 2014–15 West Africa Ebola crisis and the polio outbreak that began in Syria in 2014 – illustrate this point.

In West Africa, Ebola emerged in a region where health care facilities were extremely basic (Cole, 2014). For example, prior to the outbreak in 2012, Sierra Leone spent just US$96 per capita on health care and had 0.02 doctors per 1,000 people: in the UK per capita spending stood at US$3,468 (WHO, 2012) and there were 2.7 doctors per 1,000 members of the population. Such a basic medical system hampered early detection, early infection control, and early containment of the outbreak, enabling it to spread rapidly. No vaccine existed because there had been insufficient incentive for pharmaceutical companies to meet the cost of developing treatments for a disease that affected only small numbers of people in very poorest countries. Fast-tracking vaccine development in the wake of the outbreak meant that we will be better protected in future, but international cooperation to provide decent health care in poorer regions of the world beforehand might have proved a more efficient and effective way of producing the same end result (Rull et al., 2015).

It is also important to consider how the international community should respond to countries whose previously functioning health care systems are disrupted by conflict and disaster. While Ebola was spreading in West Africa,

crisis-torn Syria was experiencing a re-emergence of polio, a previously eradicated disease (Soghaier et al., 2015). At the time the crisis began, Syria was a medically advanced country: there were 1.5 doctors per 1,000 people, near universal vaccination (an estimated 95 per cent of the population was vaccinated against polio), and sound surveillance and monitoring systems. As the crisis unravelled, however, the Syrian health care system was severely damaged.

By 2012, just a year after the crisis began, vaccination coverage had dropped to barely 50 per cent of the children eligible that year, sparking fears that unvaccinated children were at risk of contracting polio from environmental reservoirs. These fears were realized in July 2013, and by the end of January 2014 36 cases had been recorded in Syria, putting seven neighbouring countries at risk. Though the outbreak was quickly contained through a concerted effort by the WHO and neighbouring countries, the episode highlighted the fragility of the medical system.

The conditions that led to these PHEICs show that health needs to be approached from directions other than purely medical science: economic and cultural challenges can be just as great. The more cross-disciplinary the approach, the more likely solutions are to succeed, particularly in societies and situations where the barriers to the implementation of medical solutions are high. Episodes of diphtheria were common after the break-up of the former Soviet Union due to lack of vaccine supply (Vitek and Wharton, 1998) and outbreaks of malaria affected up to 100,000 people per year in Iraq in the period following the First Gulf War (WHO, 2003). The increasing dynamic mobility of people across the world, whether refugees fleeing war and civil unrest, victims of disasters and climate change, or simply economic migrants following the best opportunities, may require a more coordinated international approach to health systems than we have seen in the past (Stein, 2015).

Conclusions

Medicine works best when it is a collective endeavour: a medical system that is accessible to all. Knowledge needs to be recorded, pooled, shared, and distributed equitably. Centralization and institutionalization of medicine provide economies of scale and encourage specialization, enabling medicine as a field to grow. Complex systems require financing, however. How we finance medicine is partly influenced by the cost-benefit analysis to individuals and to society as a whole and partly influenced by evolutionary drivers of human behaviour. Compassion and care for the infirm has been part of humanity since the Palaeolithic, but the challenge today is that due to demographic changes, a higher percentage of the population are infirm, for longer, than has been the case in the past. This is, at its heart, a difference between a purely accounting model of financing health care, which looks only at the money spent, and an welfare

economics model that considers wider benefits, such as family ties, the experience and wisdom the elderly can offer the young, individuals' own desire to grow old, and adhering to moral norms (Theixos, 2013). The welfare economist would argue that not all rewards and incentives are financial, and evolutionary biology would appear to favour this approach. This does not mean that we cannot measure the benefits of health care through financial instruments, however, particularly in a world where resources are finite and competition for them may increase. In fact, the very act of doing so may help us to reconsider how, as we navigate the Anthropocene, we refinance medical systems to support good health throughout life and preventative care for everyone, so that longer life does not automatically place a financial burden on the very health systems that have enabled it and exclude those individuals and populations who are less able to pay. Authors such as Scott Barrett (2016) and Ramanan Laxminarayan (2016) have analysed economic incentives for the provision of public goods; others have considered the role of social norms as solutions (Nyborg et al., 2016) or commented on the value of international investment in the health care systems of low-income countries to protect against future health emergencies (Dzau, 2016). Looking to the history of medicine and the anthropological/evolutionary roots of cooperation and altruism for inspiration offers an additional approach. The best insights will no doubt be gained by combining and drawing on all these fields, enabling us to build a framework for medical provision and its incentives that will help us move through the Anthropocene's demographic changes and challenges towards a future where medicine might be provided by global systems that are less vulnerable to local disruptions, more equitably distributed, and more capable of acting at source.

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