Chapter

# Ethical Issues Which Have Prevented the U.S. from Maximizing Quality of Life Years

*Sage Arbor*

## Abstract

The cost of healthcare interventions varies greatly with age, with a significant fraction of cost being spent in the last two years of life. Treating a child can save orders of magnitude more life-years than an octogenarian treated for the same disease, such as cancer. While Quality-Adjusted Life Years (QALYs) can be used to plan a roadmap for how resources should be expended to maximize quality of life the execution of those plans often fail due to societal norms which trump the carefully measured QALYs, resulting in lowered average number and/or quality of years lived. The ethical issues concerning age, sex, lifestyle (smoking, drinking, obesity), cost transparency, and extreme examples (war, population explosion vs. collapse) will be discussed.

**Keywords:** Quality Adjusted Life Years (QALY), generation, elder care, disability-adjusted life year (DALY), fair innings, rule of rescue, standard gamble, cost transparency, organ donation, smoking, alcoholism, diabetes

## 1. Introduction

Quality Adjusted Life Years (QALYs) provide a quantified mechanism to alot limited healthcare resources to maximize desired years and quality of life. Both the numbers of years we live and the quality of health has increased more in the last 150 years than in any prior time in human history. It is interesting that QALYs were invented at the same time the variables that go into defining QALYs are changing so rapidly. The U.S. National Council on Disability (NCD) has found sufficient evidence that QALYs are discriminatory by design, and suggested Congress should pass legislation prohibiting the use of QALYs by Medicaid and Medicare [1]. What constitutes a disability and how much should it decrease QALYs? There have been deaf families that argue deafness is not a disability, it heightens other senses, and have chosen not to have cochlear implants. What QALY hit do paraplegics receive compared to quadriplegics? The very nature of QALYs cause users to assign some agreed upon weights to life abilities.

The average human lifespan has increased 80% over the last 120 years, with a clear increase in longevity starting at the end of the 19th century (around 1890). Those living in the United Kingdom, increased average lifespan from 45.2 to 81 years from 1890 to 2015. The United States had a similar increase, doing slightly less well recently with an average lifespan of 79 in 2015. The global average lifespan

started from a lower level with its significant increase delayed a decade (1900) but has paralleled the gains each year achieving even more impressive results, starting at 32 years in 1900 and rising to 71.7 years in 2015 [2] (**Figure 1**). Starting in the 20th Century infant mortality plummeted from 10% to under 1% currently, which significantly contributed to the average lifespan. However, if you look at mortality rates at later ages it is apparent that lifespan has increased after keeping infants alive [3]. There is significant scientific data now that, across the animal kingdom, caloric restriction extends life [4–9] which provided hope we could continue the trend increasing human longevity. In mice a 60% reduction in calories has been shown to increase lifespan by about a third, however in humans and primates it appears we may only be able to extend our lives 1–5 years [10, 11] though research is ongoing [12].

It has been estimated that while clinical care accounts for 15% of the quality of one's health, clinical care data only represents 0.1% of the data (0.4 terabytes) applicable to health outcomes over their lifetime (1,106 terabytes) [13]. Most of the data that affects one's health (1,100 terabytes) concerns one's social determinants of health and health behaviors which account for 40% and 20% of one's quality of health respectively. The last 25% of one's health is determined by "Nonmodifiable factors" such as genetics, but this data (6 terabytes) is still very actionable in that different actions (e.g. pharmaceuticals, diet, lifestyle interventions) can be taken based on one's genetics. While it is likely most easy to modify healthcare's actions in clinical care, because it only represents 15% of our health outcomes, in order to maximize QALYs we must invest in analyzing and modifying the other data realms that affect our lifetime biomedical health (social determinants of health, health behaviors, and nonmodifiable factors).

Medical spending has increased by an order of magnitude in the last 200 year as a proportion of GDP. The share of GDP used on healthcare in 1800, 1850, 1900, 1950, 200o was 2%, 2.1%, 2.5%, 4.5%, 13.5% respectively (**Figure 1**) [14]. There is a clear and historically long trend of healthcare accounting for larger percentages of GDP in the developing world. Despite concern that this increased expenditure is just going to fatten the profits of big pharma, the reality is more nuanced with significantly more people and services being funded. Concomitantly and unsurprisingly, in the U.S. rapid growth is projected in both health and STEM occupations

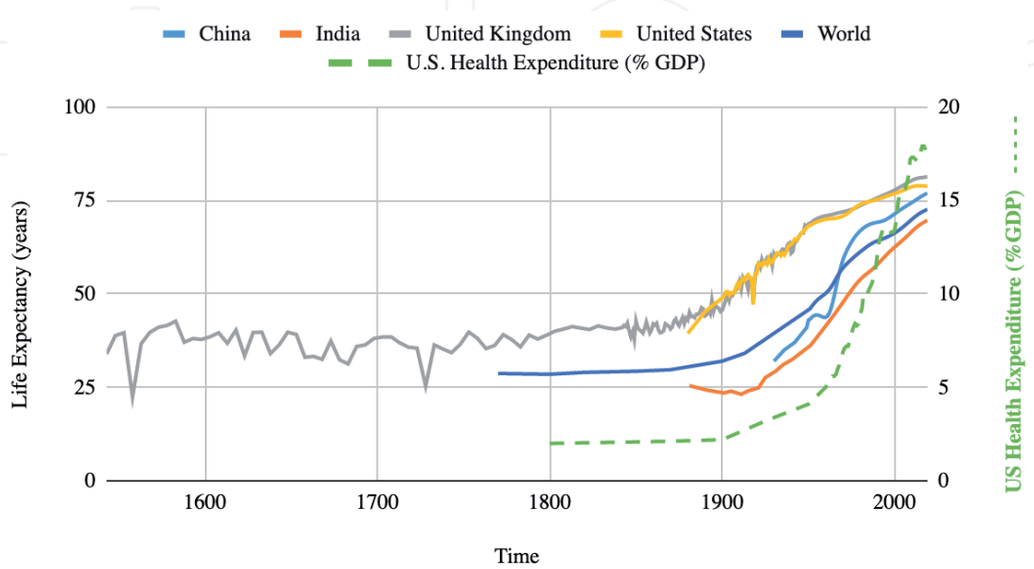


**Figure 1.**
*Life Expectancy and Expenditure on Healthcare increase over time. Source: Our World in Data. https://ourworldindata.org/life-expectancy.*

while office support, food service, and manufacturing production jobs will decline [1]. In order to maintain or lower the cost of healthcare, country's must either lower costs per treatment (increased efficiency) or reduce treatment provided (decreased expenditure). While everyone would like the former solution of getting the same treatment for cheaper, the continual rise in healthcare expenditures despite plateauing lifespan suggests cuts will be needed. There are large economic differences in healthcare expenditures between countries which do not translate to better care. Common examples are the United States spending 10-fold more per citizen than Cuba despite similar life expectancies. The counties of the E.U. also spend less than the United States while having the same or better life spans. The successes and failures of using QALYs to reduce healthcare costs will be discussed. Most of the QALY issues discussed apply globally. However, this chapter will focus on data and issues in the United States, which is unusual among industrialized countries because it does not have a single payer system, and therefore has uniquely heightened QALY misallocations.

### 1.1 QALYs vs. DALYs

In 1976 Zeckhauser and Shepard first used the term Quality-Adjusted Life Years (QALYs) to describe measurements of health outcomes which were defined by both duration and quality of life measurements [15]. Pliskin detailed the three assumptions QALYs required to act as valid metrics to assign health resources [16], namely:

1. Independence between health status and life years

2. A constant proportional trade-off

3. Risk neutrality of life years

While these foundational assumptions of QALYs have been questioned [17], they have been globally accepted and used by most countries for making economic decisions [18–21].

Two decades after the description of a QALY, the Disability-Adjusted Life Years (DALYs) were developed in the 1990s measuring both duration as well as quality. DALYs by definition measure disease burden but are also often used like QALYs to maximize cost-effectiveness. QALYs have a health-related quality of life weighting (Q) that ranges from 0 to 1, with 1 representing a year of perfect health and 0 representing death. A Q measure of 0.5 has been expressed as bed ridden, and it should be noted that a state considered "worse" than death can have a negative Q rating. The quality of life each year can be added up to calculate one's quality-adjusted life expectancy (QALE). On the other hand DALYs are measured from 0 to 1 where 0 represents no disability. Therefore in QALYs the higher the weighting the better, but in DALYs the lower the weighting the better. Usually expert valuations are assigned to a universal set of weightings for DALYs, whereas QALYs use preference-based health-related measures gathered from groups of patients or the general population [22]. DALYs have an age-weighting function, and can therefore preferentially favor spending money on the young versus the old compared to QALYs.

- QALYs lived in one year = 1*Q (where $Q \leq 1$)

$$QALEt = \sum_{t}^{t+RLE} Qt$$

$Q_t$ = Health related quality of life weighting at year t.
QALE = quality-adjusted life expectancy at a given age.
RLE = Residual Life Expectancy at given age.
t = individual years within residual life expectancy range.

## 2. Equity - is each year of perfect life equal?

As QALYS are used to determine the allotment of financial resources, the age of the citizens receiving these resources can be a significant issue. The most common causes of death in the U.S. (stroke, cancer, Chronic Lower Respiratory Diseases (CLRD), Alzheimers, heart disease, and diabetes) debilitate patients for a broad duration, ranging from immediate death to 20 years (**Table 1**, **Figure 2**). Death can occur suddenly with almost no recourse for intervention or financial expenditure by society aimed to improve life, such as in an unforeseen and lethal suicide or stroke. However, disease care is becoming more often a case of extended managed care, such as with diabetes.

### 2.1 Old vs. Young

#### *2.1.1 Fair innings*

The philosophical framework termed "fair innings" posits that each human has an equal right to experience each phase (age) of life. Therefore if the same intervention could extend for one year the life of a 60-year-old or a 26-year-old, then the younger patient should preferentially get the intervention so they have their "fair-inning" at

| Disease | Total Deaths (million, U.S. 2017) | Deaths/100,000 (U.S. 2017) | Deaths/100,000 (U.S. 2007) | Change 2007–2017 (% change) | Average duration of disease |
|---|---|---|---|---|---|
| Heart disease | 647 | 165 | 190.9 | −13.6 | 7.3 yrs |
| Cancer | 599 | 152.5 | 178.4 | −14.5 | 2 yrs |
| Chronic lower respiratory diseases (CLRD) | 160 | 40.9 | 40.8 | 0 | 4 yrs |
| Stroke | 146 | 37.6 | 43.5 | −13.6 | 1 yr |
| Alzheimer disease | 121 | 31 | 22.7 | 36.6 | 6 yrs |
| Diabetes | 84 | 21.5 | 22.5 | −4.4 | 30 yrs |
| Influenza and pneumonia | 56 | 14 | 15.7 | −10.8 | 1.5 weeks |
| Kidney disease | 51 | 13 | 15.7 | −17.2 | 7 yrs |
| Suicide | 47 | 14 | 11.3 | 23.9 | 1 day |

*Data was retrieved from the National Vital Statistics Reports Final Death Reports. The color coding represents better values in green (low deaths, low disease duration, and decreased deaths over time) adn worse values in red.*
*https://pubmed.ncbi.nlm.nih.gov/25075874/*
*https://pubmed.ncbi.nlm.nih.gov/32501199/*

**Table 1.**
*Duration of Disease vs. Population Effect.*

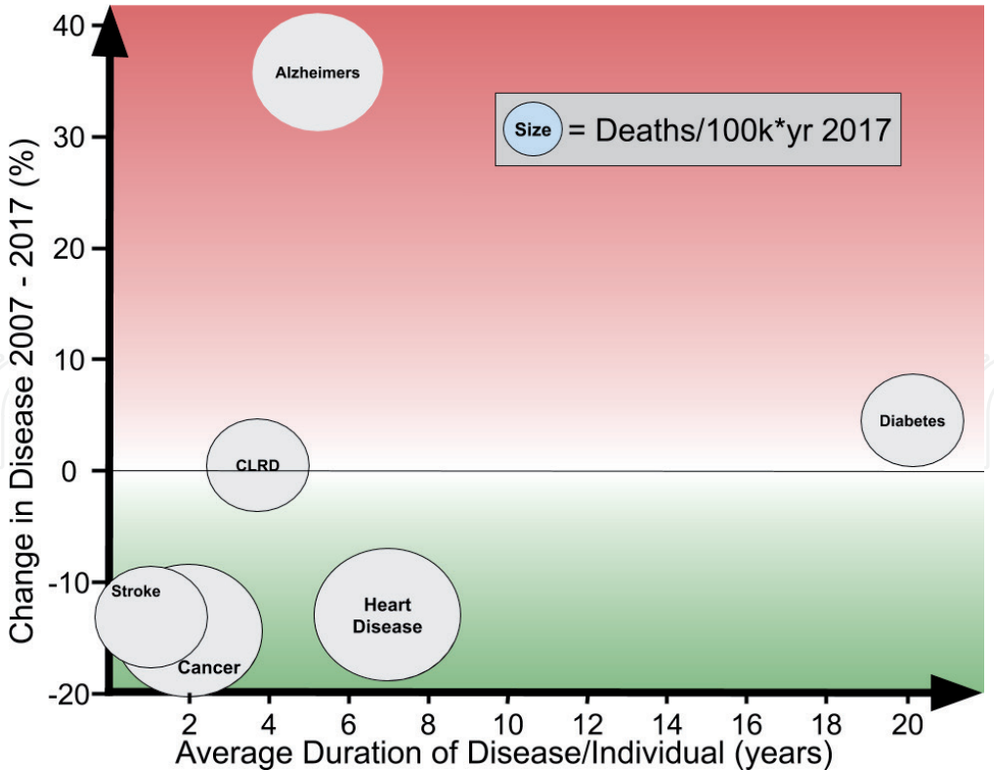


**Figure 2.**
*Length of Public Health Issues vs. Population Effect.*

living the age of 27. Human lifespan has roughly doubled in the last century, from roughly 40 to 80 years of life in the developed world. Does a child that is born into the world that now lives 10% longer than their parents have the scaled protection to get to the world's future average lifespan (10% older than their parents), or do fair innings apply as a static set of years based on the oldest generations having care rationed? If nations had been rationing care based on the "fair innings" philosophy they would have possibly undervalued young years of life if they were not taking into account the projected increase in lifespan for younger generations. Recently the lifespan in the United States decreased for the first time in decades due to a combination of macro health issues (obesity, opiod overdose, and suicide epidemics). While the current U.S. healthcare system does not ration care based on fair innings principles, if it had done so and taken into account the longstanding historical increases in lifespan younger generations would have received more resources than deemed fair in hindsight since their projected lifespan has dropped from historical trends. One of the most important aspects for implementing allotment of healthcare resources based on QALYs is for the electorate to have supreme confidence in its fairness. The use of fair innings is very transparent in taking from one group (older) to give to another group (younger), and any projection based on moving average lifespans could increase the publics distrust in QALY use for policy decisions.

### *2.1.2 Rule of Rescue*

In 1986 Albert Jonsen coined the term "Rule of Rescue" which described the medical community's unwillingness to allow patients to die, even when a high cost to save them made the QALY calculation suggest the resources would be better used elsewhere [23]. Jonsen described examples of sitting on various committees to decide the value of interventions (artificial heart, cardiac transplantation, amniocentesis, liver transplant, autologous bone marrow transplantation), and a recurring theme emerged in which the debate would go down a consistent path

detailing the high cost per QALY only to end abruptly with the group deciding the lives must be saved. These expensive transplant procedures are still covered in the United States despite continued poor QALY analysis. As genetic knowledge and biomedical technologies have continued to advance, the list of expensive procedures that deliver increased QALYs to patients, however the absolute cost and % of GDP spent on healthcare has also continued to rise. The incremental cost effectiveness ratio per QALY needs to be calculated for these high ticket items. For example, the recent chimeric antigen receptor T cell therapy (CAR-T therapy) [24] appears cost effective 95% of the time, assuming a willingness to pay $100,000 USD for each QALY gained, despite costing roughly half a million dollars USD in the United States (depending on the type of B-cell malignancy) [25]. The incremental cost-effectiveness ratio (ICER) for CAR-T was found to be somewhere between roughly $64,000/QALY and $175,000 depending on the study and assumptions for average 5-year progression-free survival (PFS) [25–27].

The Rule of Rescues inability to allow an overly expensive life to end has resoundingly caused a decrease in quality of life years. Attempts have been made over the last half century in the United States to limit excessive expenditures for care during the last two years of life, but almost all have failed. Some have argued the rule of rescue is defensible even from a utilitarian point of view in that the citizenry will have increased "well-being" because they desire living in a community that values life, and while that trend is likely true it cannot defend the rule of rescue without bounds [28]. Most see the rule of rescue as contradicting the utilitarian nature of QALY optimization for healthcare expenditures.

The Affordable Care Act (ACA, also known as Obamacare) was the greatest leap towards universal coverage in the United States in the last 50 years (since Medicaid was signed into law in 1965), but is not close to the single payer systems that Europe has long implemented. The ACA initially proposed paying physicians if they provided voluntary counseling to Medicare patients about end-of-life care options, advance directives, or living wills. During the 2009 presidential debate Sarah Palin famously termed these clauses "death panels" describing a future where doctors decided whose parents would die. These aspects of the bill were removed before final passage as result of public pressure.

#### *2.1.3 Standard gamble*

The standard gamble is a more patient specific measure of if a medical intervention should be done. **Figure 3** shows a simple standard gamble in which a health intervention could result in either a better or worse outcomes than no intervention (e.g. an organ transplant). The probability p of the best outcome (healthy), is changed until the patient has no preference over whether to get the medical intervention or not, at which point their personalized standard gamble has been calculated [22]. There are other standard gamble scenarios/diagrams when, for example, no outcome results in death, or any intervention outcome is higher than lack of intervention.

### 2.2 Women vs. Men

#### *2.2.1 Pregnancy*

Should a pregnant woman in need of care have QALYs counted for herself and her baby, just herself, just her baby, and how does the age of the fetus change that calculus? If one adheres to the "fair innings" paradigm (see above), then the early years of a newborn are more valuable than the mothers later years. It seems clear that if a female near term needed resources her QALY measurement should, at a minimum, be the

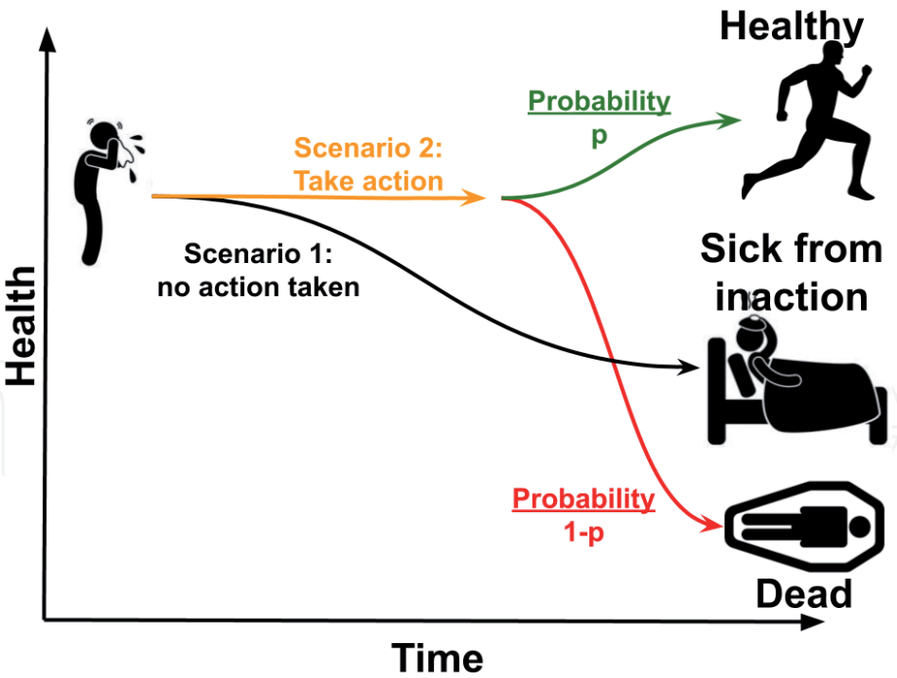


**Figure 3.**
*Standard Gamble.*

greater childs QALYs if fair innings were being taken into account. QALYs are often not scaled by age (no fair innings implementation) and the pregnant female would have resources assigned worth double a single person (with equal weight for her and her child). In reality there are often not even the attempted use of QALYs in such situations in the United States, because lethal pregnancy issues are handled like other Emergency Department critical patients following the rule of rescue (see above) in that any resources are used to save the lives at that moment. Costs of infertility treatment share many of these same QALY accounting issues, and have other societal/ethical issues in addition. For example, early this century the UK 's National Institute for Clinical Excellence (NICE) covered infertility costs but explicitly excluded "social infertility" which includes a woman being single or homosexual. Under that paradigm a woman 40 years of age that has fertility issues could qualify for in vitro fertilization (IVF) over a woman half her age that happens to be single and/or a lesbian [29]. Similarly to how the rule of rescue trumps all other QALY calculations, societal norms can have a trumping effect of completely removing groups from medical coverage. A common delimiter for excluding a group from medical coverage is if there is a nonmedical lifestyle action/intervention to effect the same increase in QALYs, such as finding a male spouse in the above example. To the authors' knowledge no country has seriously addressed this issue in any way other than looking at them on a case by case basis by a panel (e.g. by health experts, philosophers, politicians).

*2.2.2 Sex lifespan differences*

Women live longer than men across the globe (~8% or 6 years). Roughly $100,000 USD more is spent on women's health than men during their life ($375,000 $275,000). Since healthcare later in life is more expensive this translates to women costing society more as they live longer during an expensive healthcare phase. Roughly half (45%) of women's increased healthcare costs come just from this longer lifespan. However individual situations could have calculations suggesting women get more than parity in resources. For example, if 50-year-old male and a 51-year-old female needed the same resource (such as an organ transplant)

the longer female lifespan could suggest even a slightly older woman should take precedence over her junior male counterpart.

## 3. Organ Donor Waitlist

The transplant of organs could theoretically have extremely positive QALY returns per dollar spent, depending on the age. There are a plethora of ethical issues that arise from organ donations however, such as how important is the patient's age, their relation to the organ donor, the duration of organ viability after transplantation, or the degree to which their personal actions resulted in their need for an organ transplant.

If a young child in need of an organ could live a full life time with one transplant the QALY calculations would likely result in societies funding these transplants without any second guessing. Indeed curably treating young patients with a lethal disease is the best scenario to maximize QALYs gained, if comparing similarly priced interventions. However, organ transplants often do not alleviate a patient's disease for a normal lifespan. For example, cystic fibrosis (CF) patients most often die from lung failure due to thick mucus and biofilm accumulation leading to necrosis of the tissue. Lung transplants are done for CF patients but transplants usually only perform sufficiently for 5 years. CF patients can now live over 40 years, double the 20 year lifespan they had half a century ago. Therefore, contrary to other QALY based interventions, transplants are not recommended for the younger CF patients.

While most donated organs come from donors after they have died, there are also living organ donations. Directed living organ donation, the most common type as opposed to non-directed organ donation, allows the donor to choose the recipient (often a family member) [30]. Even the most rigorous ordering of donor recipients using rankings to maximize QALYs can suddenly be shortcut by directed living organ donors. This is an example where there is a limited supply (of organs) and the calculations to maximize QALYs changes because a family member is willing to increase that limited supply but only if used in the manner they want. Therefore there are times when a healthcare system can increase QALYs at the sacrifice of absolute ethical parity of all patients based on their need.

Smokers receiving lung transplants is another case example highlighting societies' concern about funding healthcare solutions for ailments which has been self-inflicted. More than a third of lung transplants in the U.S. are for former smokers (40%), but they often only qualify once they have proven they have quit smoking. This achieves two outcomes. Most quantifiably it increases QALYs in that a lung transplant given to someone who will never smoke again, will on average produce more QALYs than if the lung transplant were given to someone that immediately starts smoking multiple packs a day after surgery. It also addresses the moral issue, allowing the donor and society to feel like the gift of the organ is being valued by the recipient. However one study showed after smokers receive lung transplants 11% admitted they resumed smoking, with another 6% showing high levels of urinary cotinine (a metabolite of nicotine). These values are similar to heart and renal transplant recipients, who reported smoking after transplantation at a frequency of 21% and 25% respectively [31].

## 4. Self-inflicted medical issues

### 4.1 Smokers

There are many health issues for which the individual is primarily responsible. Smoking and alcoholism may be the best examples. A recent study showed that

cessation of smoking alone could save up to 12 years of life [32]. Should the population that lives a healthier lifestyle pay for the less healthy lifestyle chosen by other individuals? Even cases that seem extremely clear, such as smoking, are often more complicated. For example, those living in Beijing, China have the exposure equivalent to smoking 25 cigarettes per day, just from breathing in the high particulate air [33, 34]. It seems unfair to not cover the respiratory issues of a child born in Bejing, just because those same respiratory issues are self-induced by a heavy smoker in the countryside.

### 4.2 Alcoholism

For a decade scientific papers appeared to show low levels of alcohol could be beneficial, with people pointing to the resveratrol in wine as an epigenetic antiaging molecule, or the blue zones of the world that consumed red wine such as Italy. In reality their high fish, high vegetable, and low calorie diet are greater life prolonging life styles. It also turns out in many of these studies the alcohol "abstainer" groups had prior alcoholics included in them, who had previously changed their lifestyle to never consume alcohol. While the abstainer group had slightly poorer health than the one drink a day group, it is likely that could be due to prior damage the alcoholics had done to their body before becoming abstainers. Such scientific errors will cause resources to be misallocated if QALYs are used coarsely to allocate every dime of resource. Should alcoholics be required to quit drinking before receiving a liver transplant? Is one drink a day ok for them. One drink a day should be physically ok for the transplanted liver, but could cause the patient to slip and start drinking heavily again. Heavy alcohol consumption clearly causes cirrhosis of the liver, however contrary to the lay public's view this is the second leading cause of cirrhosis (while hepatitis C is the leading cause) [35]. Not publicly funding healthcare for self-induced ailments clearly could save significant percentages of healthcare expenditures. However, it could lead to patients lying about their health habits and is difficult to implement fairly given the multimodal hazards for multiple diseases.

### 4.3 Diabetes

Diabetes and Alzheimer disease are two of the most serious medical conditions the developed world must grapple with. Both diseases are increasing rapidly in the population, while patients are able to live with the conditions for over a decade. Alzheimer's will not be discussed as there are excellent reviews of the issues [36–38], but in short it poses a problem in that there is no treatment on the horizon. Diabetes (type II) on the other hand is extremely targetable, with reduced caloric consumption and exercise literally at the patients finger tips. However, both of these solutions have some socioeconomic interacting factors. Wealthier people can afford the time for leisure exercise, and can buy more expensive but healthier food that is less calorically dense (e.g. fresh vegetables). Some of these caveats are not as pernicious as they sound. While some fresh vegetables can be expensive and perishable, frozen vegetables, potatoes, and legumes are all healthy and cheap with a long shelf life. In addition, while difficult, anyone can choose to "just eat less" which actually has a negative cost. The true social cost to reduced calorie intervention is in building and supporting structures to increase the success rate obese individuals have in transitioning from an unhealthy to healthy lifestyle.

Are genetic predispositions a disability? Generally any inherited disorder is more likely to have healthcare solutions funded for it than self-imposed maladies. Historically these inherited disabilities have been very binary, e.g. an extreme life threatening autosomal recessively inherited disease in which a child had the poor

misfortune, 25% chance, of getting both deleterious alleles from their mom and dad. However we are now getting genetic knowledge that a person is only predisposed to ailments, which often have environmental causes as well. For example obese grandparents can pass on epigenetic modifications to their grandchildren that makes them 4-fold more likely to be diabetic. Is that a self-induced ailment? The grandparents might have caused their metabolic disorder by overeating, but the grandchildren clearly started birth with a biological handicap.

Hemodialysis, the most common form of dialysis, performs the kidneys function by taking a patient's blood through a filter outside of their body (cleaning it), and then returning it to their body. Dialysis is a one of the most common, expensive, and recurring treatments in developed countries, with diabetics greatly predisposed to need treatment [39]. Diabetics, by definition, cannot control their blood glucose levels and their kidneys are therefore working overtime to continually secrete excess sugar from the blood, often ending in organ failure. Early type II diabetics (<5 years of disease) do not cost society a lot in healthcare, with depression being the costliest comorbidity (64–82% increase). However, the later nonfatal complications have much larger increases in healthcare costs: end-stage renal disease with dialysis (201–599%), hemorrhagic/ischemic stroke (37–376%), and amputation of upper/lower-extremities (13–279%). Fatal complications had even larger cost increases with cardiovascular death being the most expensive (1,784–2,001%), but "other-cause deaths" being costly as well (1,285–1,584%) [40]. The rule of rescue makes these later expensive interventions covered, while spending that money on prevention earlier would save more QALYs/$.

## 5. Extreme examples affecting QALYs

When assigning QALYs gained by a medical intervention both the duration of extra time lived and the quality of that time need to be measured, with the former being a much easier/reproducible value to calculate. There are many extreme health scenarios (e.g. wars, population changes, climate change, paradigm shifts creating seemingly unlimited resources) that are useful examples to walk through when considering how QALYs should be measured and used to alot resources.

### 5.1 War

Warfare represents an extreme environment in which both the broad and mortal health need can bring clarity to how we perform our healthcare resource allocation decisions. During war the local healthcare capability can change quickly as resources are stressed both geographically and temporally. Medical triage during war is needed to use the limited medical personal and resources for those most likely to benefit from that care. In extreme examples this can include neglecting dying patients who could be saved during less strenuous times.

Medics are viewed as more important because they can in the immediate future save more lives. The future potential of one to increase QALYs of others is a thorny topic. How far in the future can you predict this and how certain do you need to be? The argument has been made that richer people that own companies could have more highly weighted QALYs because they employ others, raise the Gross Domestic Product (GDP), which causes a greater tax base to contribute more taxes towards the healthcare infrastructure therefore increasing the resources to improve QALYs. Such an argument clarifies a known tradeoff when measuring and using QALYs: there are times when a known method to increase QALYs is openly not desired or acted on because of the consensus that it would not be fair. Therefore, while QALYs

are usually presented in a completely utilitarian view, their implementation openly breaks this at will when there is a consensus that the increased utility would come at the cost of equality for the program's participants. This favoring of fairness over utility may be because the equality or lack thereof is apparent immediately at each decision point, whereas the utility gain is often deferred temporally (sometimes as long as decades into the future).

### 5.2 Population explosion vs. collapse

The value assigned to a new human life can change during an individual's life or as a society evolves. Early in life people may not be ready to care for a child and choose to terminate pregnancies, saving their resources for the average 1–3 children they want to have later in their life. As nations become more wealthy their population chooses to have less children, investing more resources in the quality of each life. In the last two centuries human population has grown exponentially. If the total sum of QALYs were measured over that time, the last 200 years, they would clearly also follow a similar, and likely steeper, exponential increase. Not only has lifespan increased but quality of life has increased. While people are unaware of how much life has improved [41], poverty and related health issues have decreased outside the first world nations during the last 50 years [42].

#### *5.2.1 Climate catastrophe*

With the rising global population and use of fossil fuels, there has been a causal rise in the global warming gas carbon dioxide ($CO_2$). Earth $CO_2$ atmospheric levels are now at 418 parts per million (ppm), a third higher than they were after world war II. Deleterious climate effects have already occurred [43] (e.g. acidification of the ocean, bleaching of coral reefs, sea level rise submerging island nations, increased hurricane activity, droughts, crop loss, famine). In 2006 Patz and Olson estimated that climate change had already caused 5,000,000 DALYs in a 30 year timeframe, which was mostly burdened by the developing countries [44]. Scientists are even more concerned about future tipping points which the earth would be unlikely to recover from for many decades. Recently Schneider et al. showed a level of 1,200 ppm $CO_2$ could cause the disappearance of climate cooling clouds covering the ocean and result in 8°C (14F) rise in global temperature [45]. Such a dramatic change would melt all of Greenland and much (if not all) of Antarctica's glaciers, raising sea level and flooding all coastal cities globally, in which roughly 20% of the world's population lives.

When millions, or billions, of humans are affected by such a foreseeable super event the weightings of actionable paths forward often have large ranges of uncertainty. What is the likelihood of such an event happening and of suggested interventions preventing the negative effects? What will be the health consequences of such a large portion of the earth having to relocate. The situation becomes more dire the faster the migration of people has to happen. While sea level rise is universally understandable and viewable, a faster and perhaps more pernicious effect will likely be rising air temperature. While humans are amazingly adaptable to different temperature zones we do have an upper temperature limit, the wet-bulb temperature (TW) of 35°C (95°F). Above this temperature humans cannot shed heat, and if a region attained this temperature for extended periods it would be impossible for humans to live there without air conditioning. In a business-as-usual emission model, Representative Concentration Pathway (RCP) 8.5, parts of the Middle East and South Asia could regularly exceed this 35°C threshold in the near future [46–48]. Deaths have not historically been cataloged at or above this 35°C limit

because lethal issues can occur before that temperature limit is reached. In 2020 Raymond et al. reviewed weather stations globally and found many TW around 31°C and two stations above the human limit of 35°C [49]. Most of these temperatures occurred for short periods, 1–2 hours, but a fearsome spike in TW was found to occur in some coastal locations where an afternoon breeze could bring in humidity from the water spiking the wet bulb temperature. Dubai is already planning a city that will be enclosed in a dome, called "Mall of the World" and cover 48 million square feet while taking 10 years to complete. This domed city would protect the citizenry from inhospitable heat, while acting in a second fashion as a place to study a closed ecosystem with an eye towards building cities on the moon or mars.

#### *5.2.2 Small populations*

The value societies assign to growing their population can vary for a myriad of reasons, such as predominant religious doctrine. There has been recent excitement about human travel to the moon and mars, with permanent settlement on the latter. If there were a mars base with less than 10,000 people the QALY analysis to save a newborn compared to a 80 year old would likely be different than the same question on earth. In this thought experiment the fair innings would likely trump the rule of rescue on Mars when assigning health resources to young vs. old.

#### *5.2.3 Unlimited resources*

In the next 50–100 years humanity may have nearly unlimited resources: energy (e.g. solar panels, fusion) and robotics/machines to perform the necessary tasks for humans to thrive (e.g. farming food, building shelter, developing and raising children). Under such a paradigm the younger generation is not an imposition on older generations so there would not be as much of a downside to increasing birth rates. Humanity has historically seemed insatiable in its use of resources so such a paradigm may never arise, but if it did for even a few generations (somewhat like fossil fuels did for energy use at times) then QALYs would have to be fought over less as the world would be less of a zero sum game.

These extreme examples point out that QALYs between groups are useful to view how resources are assigned in different situations, highlighting societal norms that can override QALY analysis. It is fairly easy to determine the Life Years (LY) saved when measuring a QALY, harder to measure the Quality (Q), and perhaps hardest to incorporate the QALY to limit resource use in one area compared to another when confronted by societal norms that push against this.

## 6. Cost transparency

### 6.1 Insurance deductions

A common modern occurrence in the United States is for an insured patient to receive a medical bill in which over 90% of the cost has been deducted through agreements between the insurance company and the medical supplier. The remaining bill is paid by the insurance company and the patients copay, or by the patient if they haven't met their deductible limit. With people's healthcare plan changing annually in the U.S. for multiple reasons (e.g. loss of job, changing job, moving to a different state, employer change in plan options, change in medical conditioning warranting upgrading or downgrading coverage), patients realistically rarely know the cost of medically covered procedures prior to obtaining care.

### 6.2 Care across health systems

In the United States the lack of universal healthcare or a single payer system makes it harder to collect data on where and what healthcare dollars are being spent on. Large hospital systems are much better at measuring costs and expenditures within their network, than cities are at measuring the same across multiple networks. As an example between 2002 and 2016 patients with Heart Failure (HF) had a decrease in mortality (6.8% to 4.9%) and length of stay in a hospital (8.6 to 6.5 days) respectively. However they had an increase in cost per stay ($14,301 to $17,925) due to more extensive complications and procedures during the stay. At the same time their post-hospital expenses went up from 2002 to 2016 including discharge to long-term care (20.8% to 25.6%) [50]. Hospitals can save money by getting patients out the door quickly, but the society and patients are worse off if they leave the hospital only to encounter greater expenses and long-term discharge times.

### 6.3 Balanced budgets

The United States has held a privileged position in the world (militarily, financially, and societally) since the end of the second world war. Financially the U.S. has been able to borrow money both domestically and through foreign funds as the US dollar has been held as the global reserve currency. At times, such as during the Clinton presidency (1993–2001) there was economic prosperity and balanced budgets, at which time you see a leveling off of healthcare expenditure by %GDP (**Figure 1**). However, the vast majority of years the U.S. Congress has not been able to pass a balanced budget. This has allowed the U.S. to spend more on healthcare then there is money for, putting this debt on future generations. Perhaps the electorate would demand more of their elected officials if when economic successes were conveyed in the media they were scaled by how much debt was taken on to achieve them. For example, if healthcare coverage was increased by spending $X more for services, but that was during a year where the deficit (or borrowed money) was 20% higher than revenues, then the reported success should only be in funding a 80% * $X increase in healthcare support. The U.S. Revenue has been around 17% of GDP for the past 30 years, while spending has averaged about 20%. While congress has historically worried about deficits in the capital-B range (Billions) of US dollars, during the covid-19 pandemic both the Trump and succeeding Biden administration had relief packages in the capital-T (Trillion) dollar range. The fact that states generally keep balanced budgets, since they don't have the legal means to print money like the fed, has kept future medical debt from being much worse.

### 6.4 Surgical decisions

Hospital administration, physicians, and patients can choose a very expensive procedure/surgery based on a perceived outcome which does not match the scientific outcome data. This misalignment can occur when a decision needs to be made quickly, the intervention has a positive short term outcome compared to longer term issue (such as reducing immediate pain), or for financial reasons if the hospital stands to benefit from a procedure covered by insurance. An example is the increase in the United States of C-section deliveries, compared to vaginal births, which rose from ~20% in the late 1990s to over 30% 15 years later [51]. In 2010 cesarean deliveries were 40% more expensive than vaginal deliveries, $9,905 versus $7,089 respectively [52]. Cesarean deliveries can reduce the incidence of pelvic floor disorders

(PFD), namely stress urinary incontinence (SUI) and pelvic organ prolapse (POP), but the future savings do not offset the larger increase in delivery costs. The rate of SUI and POP after a vaginal birth are 13% and 14% respectively, but drop to 7% and 5% respectively after a cesarean birth. While the cost of surgeries for POP and SUI are expensive ($6,878 and $10,600 respectively) the relatively rare occurrence causes the average savings ($344 and $742 respectively) to be dwarfed by the higher delivery cost ($2,816) [52].

## 7. Conclusions

Human lifespan has doubled over the last 150 years, with the quality of those extra years also rising. However, the % of GDP spent on healthcare has more than doubled at a rate that is unsustainable to continue for the next 150 years. The concept of using QALYs to maximize quality with limited resources has gained acceptance in countries throughout the world. The country's (e.g. in the E.U) with single payer systems are better situated to measure QALYs and use them to maximize quality of care compared to the United States. Societal norms, such as Rule of Rescue, prevent the maximum use of QALYs. The lack of transparency to prices and the ease with which the U.S. can borrow money has both made the use of QALYs difficult. As the costs, outcomes, and options of clinical interventions are made more clear and accessible to society writ large, the cost of healthcare can be lowered and average quality increased at a national level.

## Conflict of interest

The authors declare no conflict of interest.

## Appendices and nomenclature

| | |
|---|---|
| ACA | Affordable Care Act (also known as Obamacare) |
| CAR-T | Chimeric Antigen Receptor T-cell therapy |
| CLRD | Chronic Lower Respiratory Disease |
| DALY | Disability Adjusted Life Year |
| IVF | In Vitro Fertilization |
| NCD | National Council on Disability |
| NICE | UK's National Institute for Clinical Excellence |
| GDP | Gross Domestic Product |
| HF | Heart Failure |
| PFD | Pelvic Floor Disorder |
| POP | Pelvic Organ Prolapse |
| ppm | Parts Per Million |
| QALE | Quality Adjusted Life Expectancy |
| QALY | Quality Adjusted Life Year |
| RCP | Representative Concentration Pathway |
| SUI | Stress Urinary Incontinence |
| USD | United States Dollar |

IntechOpen

## Author details

Sage Arbor
Marian University College of Medicine, Indianapolis, IN, USA

*Address all correspondence to: sagearbor@gmail.com

## References

[1] Romano N, Ogunyipe B, Altom B, Belt R, Brett J, Gade D, et al. Quality-Adjusted Life Years and the Devaluation of Life with a Disability [Internet]. National Council on Disability (NCD); 2019 Nov [cited 2020 Nov 16]. (Bioethics and Disability Series.). Available from: http://www.bioethics.net/2019/11/quality-adjusted-life-years-and-the-devaluation-of-life-with-a-disability-2/

[2] Roser M, Ortiz-Ospina E, Ritchie H. Life Expectancy. Our World in Data [Internet]. 2013 May 23 [cited 2020 Nov 16]; Available from: https://ourworldindata.org/life-expectancy

[3] Bongaarts J, Feeney G. How Long Do We Live? Population and Development Review. 2002;28(1):13-29.

[4] López-Lluch G, Navas P. Calorie restriction as an intervention in ageing. J Physiol. 2016 Apr 15;594(8):2043-2060.

[5] Mercken EM, Crosby SD, Lamming DW, JeBailey L, Krzysik-Walker S, Villareal D, et al. Calorie restriction in humans inhibits the PI3K/AKT pathway and induces a younger transcription profile. Aging Cell. 2013 Aug;12(4):645-651.

[6] Redman LM, Smith SR, Burton JH, Martin CK, Il'yasova D, Ravussin E. Metabolic Slowing and Reduced Oxidative Damage with Sustained Caloric Restriction Support the Rate of Living and Oxidative Damage Theories of Aging. Cell Metabolism. 2018 Apr 3;27(4):805-815.e4.

[7] Arbor S. Where and How in the mTOR Pathway Inhibitors Fight Aging: Rapamycin, Resveratrol, and Metformin. Resveratrol - Adding Life to Years, Not Adding Years to Life [Internet]. 2018 Nov 5 [cited 2019 Feb 6]; Available from: https://www.intechopen.com/books/resveratrol-adding-life-to-years-not-adding-years-to-life/where-and-how-in-the-mtor-pathway-inhibitors-fight-aging-rapamycin-resveratrol-and-metformin

[8] Arbor S. Targeting amyloid precursor protein shuttling and processing - long before amyloid beta formation. Neural Regen Res. 2017 Mar 7;12(2):207-209.

[9] Mirzaei H, Raynes R, Longo VD. The conserved role of protein restriction in aging and disease: Current Opinion in Clinical Nutrition and Metabolic Care. 2016 Jan;19(1):74-79.

[10] Flanagan EW, Most J, Mey JT, Redman LM. Calorie Restriction and Aging in Humans. Annu Rev Nutr. 2020 Sep 23;40(1):105-133.

[11] O'Flanagan CH, Smith LA, McDonell SB, Hursting SD. When less may be more: calorie restriction and response to cancer therapy. BMC Med [Internet]. 2017 May 24 [cited 2018 Aug 23];15. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5442682/

[12] Longo VD, Antebi A, Bartke A, Barzilai N, Brown-Borg HM, Caruso C, et al. Interventions to Slow Aging in Humans: Are We Ready? Aging Cell. 2015 Aug;14(4):497-510.

[13] Singhal S, Rosen E, Newman E, Autran L, Sam K, Rao N, et al. McKinsey on Healthcare: Best of 2019 [Internet]. McKinsey & Company; 2019 [cited 2020 Nov 16]. Available from: https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/mckinsey-on-healthcare-best-of-2019

[14] Catillon M, Cutler DM, Getzen TE. Two hundred years of health and medical care [Internet]. VoxEU.org. 2019 [cited 2020 Nov 24]. Available from: https://voxeu.org/article/

two-hundred-years-health-and-medical-care

[15] Zeckhauser R, Shepard D. Where Now for Saving Lives? Law and Contemporary Problems. 1976 Oct 1;40(4):5-45.

[16] Pliskin JS, Shepard DS, Weinstein MC. Utility Functions for Life Years and Health Status. Operations Research. 1980;28(1):206-224.

[17] Bleichrodt H, Johannesson M. The validity of QALYs: an experimental test of constant proportional tradeoff and utility independence. Med Decis Making. 1997 Mar;17(1):21-32.

[18] Gerard K. Cost-utility in practice: a policy maker's guide to the state of the art. Health Policy. 1992 Jul;21(3): 249-279.

[19] Shepard DS. Cost-effectiveness in Health and Medicine. By M.R. Gold, J.E Siegel, L.B. Russell, and M.C. Weinstein (eds). New York: Oxford University Press, 1996. The Journal of Mental Health Policy and Economics. 1999;2(2): 91-92.

[20] Russell LB, Gold MR, Siegel JE, Daniels N, Weinstein MC. The role of cost-effectiveness analysis in health and medicine. Panel on Cost-Effectiveness in Health and Medicine. JAMA. 1996 Oct 9;276(14):1172-1177.

[21] Adamiak G. Methods for the economic evaluation of health care programmes, 3rd ed. J Epidemiol Community Health. 2006 Sep;60(9): 822-823.

[22] Torrance GW. Measurement of health state utilities for economic appraisal. J Health Econ. 1986 Mar;5(1):1-30.

[23] Jonsen AR. Bentham in a box: technology assessment and health care allocation. Law Med Health Care. 1986 Sep;14(3-4):172-174.

[24] Commissioner O of the. FDA Approves First Cell-Based Gene Therapy For Adult Patients with Relapsed or Refractory MCL [Internet]. FDA. FDA; 2020 [cited 2020 Dec 10]. Available from: https://www.fda.gov/news-events/press-announcements/fda-approves-first-cell-based-gene-therapy-adult-patients-relapsed-or-refractory-mcl

[25] Sarkar RR, Gloude NJ, Schiff D, Murphy JD. Cost-Effectiveness of Chimeric Antigen Receptor T-Cell Therapy in Pediatric Relapsed/Refractory B-Cell Acute Lymphoblastic Leukemia. J Natl Cancer Inst. 2019 01;111(7):719-26.

[26] Lin JK, Muffly LS, Spinner MA, Barnes JI, Owens DK, Goldhaber-Fiebert JD. Cost Effectiveness of Chimeric Antigen Receptor T-Cell Therapy in Multiply Relapsed or Refractory Adult Large B-Cell Lymphoma. J Clin Oncol. 2019 20;37(24):2105-19.

[27] Silbert S, Yanik GA, Shuman AG. How Should We Determine the Value of CAR T-Cell Therapy? AMA Journal of Ethics. 2019 Oct 1;21(10):844-851.

[28] McKie J, Richardson J. The rule of rescue. Soc Sci Med. 2003 Jun;56(12): 2407-2419.

[29] Ashcroft RE. Quality of Life as the Basis of Health Care Resource Allocation: A Philosopher's Perspective on QALYs. AMA Journal of Ethics. 2005 Feb 1;7(2):195-199.

[30] How Organ Donation Works | Organ Donor [Internet]. 2018 [cited 2020 Dec 13]. Available from: https://www.organdonor.gov/about/process.html

[31] Vos R, Vusser KD, Schaevers V, Schoonis A, Lemaigre V, Dobbels F, et al.

Smoking resumption after lung transplantation: a sobering truth. European Respiratory Journal. 2010 Jun 1;35(6):1411-1413.

[32] Li Y, Pan A, Wang DD, Liu X, Dhana K, Franco OH, et al. Impact of Healthy Lifestyle Factors on Life Expectancies in the US Population. Circulation. 2018 Apr 30; CIRCULATIONAHA.117.032047.

[33] Muller RA, Muller EA. Air Pollution and Cigarette Equivalence [Internet]. Berkeley Earth. [cited 2020 Dec 13]. Available from: http://berkeleyearth.org/archive/air-pollution-and-cigarette-equivalence/

[34] Rohde RA, Muller RA. Air Pollution in China: Mapping of Concentrations and Sources. PLOS ONE. 2015 Aug 20;10(8):e0135749.

[35] Tsochatzis E, Bosch J, Burroughs A. Liver cirrhosis - The Lancet. 2014 May 17;383(9930):1749-1761.

[36] Cummings J, Lee G, Ritter A, Sabbagh M, Zhong K. Alzheimer's disease drug development pipeline: 2020. Alzheimers Dement (N Y). 2020;6(1):e12050.

[37] Reitz C, Brayne C, Mayeux R. Epidemiology of Alzheimer disease. Nat Rev Neurol. 2011 Mar;7(3):137-152.

[38] Bauzon J, Lee G, Cummings J. Repurposed agents in the Alzheimer's disease drug development pipeline. Alzheimers Res Ther. 2020 Aug 17;12(1):98.

[39] Chen Z, McCulloch CE, Powe NR, Heung M, Saran R, Pavkov ME, et al. Exploring reasons for state-level variation in incidence of dialysis-requiring acute kidney injury (AKI-D) in the United States. BMC Nephrol. 2020 Aug 10;21(1):336.

[40] Chen H-Y, Kuo S, Su P-F, Wu J-S, Ou H-T. Health Care Costs Associated With Macrovascular, Microvascular, and Metabolic Complications of Type 2 Diabetes Across Time: Estimates From a Population-Based Cohort of More Than 0.8 Million Individuals With Up to 15 Years of Follow-up. Diabetes Care. 2020 Aug 1;43(8):1732-1740.

[41] The Worldview Upgrader – Gapminder launches a groundbreaking new service to fight misconceptions [Internet]. [cited 2020 Dec 14]. Available from: https://www.gapminder.org/news/the-worldview-upgrader-gapminder-launches-a-groundbreaking-new-service-to-fight-misconceptions/

[42] Rosling H, Zhang Z. Health advocacy with Gapminder animated statistics. J Epidemiol Glob Health. 2011 Dec;1(1):11-14.

[43] Lenton TM, Held H, Kriegler E, Hall JW, Lucht W, Rahmstorf S, et al. Tipping elements in the Earth's climate system. Proc Natl Acad Sci U S A. 2008 Feb 12;105(6):1786-1793.

[44] Patz JA, Olson SH. Climate change and health: global to local influences on disease risk. Ann Trop Med Parasitol. 2006 Sep;100(5-6):535-549.

[45] Schneider T, Kaul CM, Pressel KG. Possible climate transitions from breakup of stratocumulus decks under greenhouse warming. Nature Geoscience. 2019 Mar;12(3):163-167.

[46] Pal JS, Eltahir EAB. Future temperature in southwest Asia projected to exceed a threshold for human adaptability. Nature Climate Change. 2016 Feb;6(2):197-200.

[47] Im E-S, Pal JS, Eltahir EAB. Deadly heat waves projected in the densely populated agricultural regions of South Asia. Science Advances. 2017 Aug 1;3(8):e1603322.

[48] Coffel ED, Horton RM, Sherbinin A de. Temperature and humidity based projections of a rapid rise in global heat stress exposure during the 21st century. Environ Res Lett. 2017 Dec;13(1): 014001.

[49] Raymond C, Matthews T, Horton RM. The emergence of heat and humidity too severe for human tolerance. Science Advances. 2020 May 1;6(19):eaaw1838.

[50] Khan SU, Khan MZ, Alkhouli M. Trends of Clinical Outcomes and Health Care Resource Use in Heart Failure in the United States. J Am Heart Assoc. 2020 Jul 21;9(14):e016782.

[51] Osterman M, Martin J. Trends in low-risk cesarean delivery in the United States, 1990-2013 [Internet]. National Center for Health Statistics; 2014 p. 16. Available from: https://www.cdc.gov/nchs/data/nvsr/nvsr63/nvsr63_06.pdf

[52] Kuhlmann PK, Patel DN, Chen A, Houman J, Weinberger J, Wood Thum LN, et al. Economic evaluation of elective cesarean versus vaginal delivery on cost of future pelvic floor disorders in the United States. Neurourol Urodyn. 2020 Nov 24;