The Pursuit of Longevity Fuels the Need for International Life Expectancy Standards

Standards Build Trust: The Use of Standards in Conformity Assessment of Life Expectancy

By

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Abstract

U.S. health outcomes have remained poorer than those of our high-income peer countries for the past several decades.[1] Currently, people in the U.S. have a shorter life expectancy than those in our peer countries. This difference in life expectancy has been growing for the past three decades, and the U.S. has now been labeled with a "health disadvantage." Additionally, the U.S. has for decades experienced the highest infant mortality rates among peer countries, and ranks poorly in other birth outcomes such as low birth weight. Surprising to some, U.S. children are less likely than those in peer countries to live to age five. For female life expectancy at birth, the U.S. ranked second to last.

Why the shorter life expectancy? Contemporary U.S. experts have unknowingly reached the same conclusion as their historical counterparts from over 100 years ago: that approximately half of all premature deaths are attributed to largely preventable behaviors and exposures such as tobacco use, poor diet, physical inactivity, and alcohol consumption. If efforts costing billions of dollars over the past several decades have been directed at increasing the public health and social services to the population, and this increase in services has not resulted in an improvement in population health outcomes, then how do we know if we are making progress?

This article seeks to explain humankind's ongoing pursuit of extending human life, the hype and misperception around extending longevity, and why a standard operational definition for life expectancy is necessary: to create international conformity on this definition, to calculate a standard definition of premature mortality, to benchmark within and across countries, and to identify if increasing human longevity is, in fact, occurring.

The Pursuit and the Hype

It is all too common to find articles in the lay press expressing our enthusiasm for, and assurance of, extending human life. Typically included in each article is the philosophical implication that humankind has control over its longevity, and is in a competitive race to win. For example, in 2016 Fortune Magazine states, "'If you ask me today, is it possible to live to be 500? The answer is yes,' Maris told Bloomberg Markets. Maris, 41, is the president and managing partner of Google Ventures and has used his position to make investments in companies that can slow aging, improve longevity, and possibly reverse disease."[2] As another example, ABC News states "Living Longer:

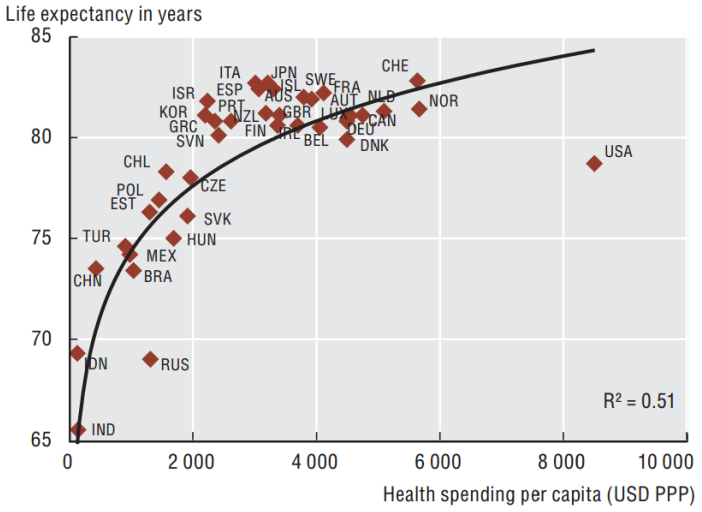
Increasing Lifespan May Be in Our Control." The article states **"**During most of recorded history any human who reached the mid thirties had beaten the system. Over the past century we gained a global average of 30 years, about 25 of which are attributed to improvements in public health, according to federal statistics."[3]

The United States is so invested in this idea that expensive federal programs monitor annual changes in the nation's life expectancy statistics so closely, that no matter how minute the change, it creates headlines. According to an NBC News article, "Life expectancy in the United States dropped in 2008, the first full year of a grueling recession that saw mixed effects, both good and bad, on the nation's health, according to new government data."[4] The article goes on to state "Overall life expectancy fell to 77.8 years, down slightly from 77.9 in 2007, the year that the recession began. In a country like the U.S., the drop is small but ominous, public health experts said…. The decline in life expectancy is a wake-up call...It is a call for action."

Life Expectancy is Tied to U.S. Policy

Because of the U.S. "health disadvantage" and the U.S.' excessive health spending compared to other countries (Figure 1), the 2010 Patient Protection and Affordable Care Act (ACA) includes a number of provisions that attempt to address U.S. population health needs. Section 4001 of the ACA established the National Prevention, Health Promotion, and Public Health Council (NPC), chaired by the Surgeon General, and a provision that the NPC establish the nation's *first* National Prevention Strategy.[5] This is intended to be the key strategy and vision for managing U.S. population health. The "Strategy's" core values align with the idea that Americans live longer and healthier through an increased emphasis on, and investment in, prevention. The ACA's National Prevention Strategy includes Goal Key Indicators related to increasing life expectancy, as measured by an improvement in the infant mortality rate, and the proportion of Americans who live to certain age targets (ages 25, 65, and 85).[5]

Figure 1. Life expectancy at birth and health spending per capita, 2011 (or nearest year)



Source: OECD Health Statistics 2013, http://dx.doi.org/10.1787/health-data-en; World Bank for non-OECD countries.

StatLink http://dx.doi.org/10.1787/888932916040

To make informed policy decisions, whether it is for retirement calculations, social security, insurance, health care, city planning, or any number of areas, we would need accurate data on whether the U.S. population is living longer, what "living longer" means, and whether premature mortality is decreasing.

A Lack of Standards Results in U.S. History Repeating Itself

The underlying motivation of the Strategy indicators is driven by the idea that modifiable behaviors are responsible for millions of premature deaths, and is based on a few key papers. In 1993, McGinnis et al.[6] suggested that about *50% of all deaths in the U.S. could be attributed to behavioral factors*, such as tobacco use, poor diet and activity patterns, and alcohol use. Mokdad et al.[7] confirmed these findings a decade later.

While the ACA may have fostered the nation's first formal prevention strategy, in the U.S., medical and public health experts have been deliberating on the population's life expectancy and premature mortality from at least as far back as 1883.[8] Even more surprising, the historical experts had a resoundingly similar message as today's experts:

> "According to the census of 1880, 756,893 persons died during the census year. Estimating that one-half of these died from preventable diseases…"[9]

With the context focusing on a broad definition of preventable diseases, the same message was restated in another publication in 1884, that the number of deaths from preventable diseases in the U.S. in any year are regarded as:

> "one-half of the whole number of deaths in the same time."[10]

The seven 'priorities' of the U.S.'s 2011 national Strategy essentially mirror Dr. Henry S. Munro, MD's recommendation published in 1912:

> "One part of our [human] race is degenerating as the result of luxurious habits, such as lack of exercise, indiscretions in social life, eating, drinking and tobacco; while the modern industrial conditions have millions of working men, women and children 'in the mill'…"[11] …"we must teach the human animal how to live. Teach him (1) what to eat; (2) what to drink; (3) the kind of work and exercise adapted to his individual personality; (4) give him a sound philosophy of life, free from dogma, cant, or narrowness; (5) inform him concerning the value of the right kind of companionship and of self-education. These are the five life essentials, without which no life is complete—the absolute necessities of a life of health and happiness."[11]

Flourens penned a similar idea in Human Longevity, in 1855:[12]

> "A hundred years of life, is what Providence intended for man; it is true, few men reach this great term, but yet how few do what is necessary to attain it. With our customs, our passions, our miseries, man does not die—he kills himself."

There are historical warnings that serve as a reminder to consider the complex interdependence between premature mortality and cause of death. The 1800's and early 1900's witnessed the decline in infectious disease mortality and a corresponding emergence in chronic disease mortality. Dr. Munro explained the emergence of chronic disease over 100 years ago, on September 7, 1911, "Chronic disease and degeneration of all sorts are increasing, and at a very rapid rate in recent times," with the prevalence of cancer increasing 500% in 60 years, mortality from

arteriosclerosis increasing 241% in 10 years, the mortality rate from diabetes increasing nearly 50% in ten years, and the mortality from heart disease increasing over 50% in ten years.[11] He stated:

> "Chronic disease kills half of the people who die in the United States, or about 750,000 annually. Half of these, that is 375,000, would not die if the average health were as good as thirty years ago. This enormous increase in mortality rate from chronic disease has escaped the attention of sanitarians because of the notable decrease in the general death rate, as the result of a decrease in deaths from acute disease so great as to more than equal the increase from chronic disease.[11] …This great improvement in the general death rate has increased the average length of life more than fifteen years in a century, and this fact has been accepted as satisfactory evidence that we are making rapid progress in [longevity] improvement. This is a grave error. It is important to recognize the radical difference between acute and chronic disease."[11]

Are We Living Longer?

In the February 2016 report from the National Vital Statistics System, the most recent data (from 2013) indicates U.S. life expectancy at birth was 78.8 years.[13] Psalm 90:10 states "The days of our lives are threescore years and ten; and if by reason of strength they be fourscore years…" (indicating a life expectancy of 70 and 80 years, respectively). Greek philosopher Sophocles is said to have lived to 90 years old, and Zeno to 98. Gorgias and Hippocrates, the latter deemed the "Father of Western Medicine," are said to have lived upwards of 100 years old. Plato lived to be 80.[14] In short, based on patterns in historical reports, the answer is no. Our current life expectancy has not extended past that of our predecessors. However, it is difficult to implement detailed monitoring and analysis at the population level given a lack of standardization and reporting.

The Need for World Standards

Why should we care about a standard definition of life expectancy? Without a standard definition, we cannot reliably compare one nation's longevity to another's, and we cannot compare our "progress" on life expectancy from one century to the next. Without a standard definition of life expectancy, and a definition that does not change over the centuries, we cannot reliably identify whether humans are in fact "living longer" in comparison to the past. Without a standard definition of life expectancy, we cannot create a standard definition of premature mortality. For

example, if the life expectancy standard is 100, we must then define *how much* lower than 100 is considered *premature* in order to define premature mortality. Is it 90? 85? 70? Likewise, if the life expectancy standard is 80, and dying at age 75 is within the "acceptable limits" then the premature mortality definition would be younger than age 75. Only after we define life expectancy and premature mortality, can we then begin to look at the effect of various interventions, behaviors, technologies, or risk factors to improve premature mortality, or extend the population-level life expectancy.

Contemporary Definitions

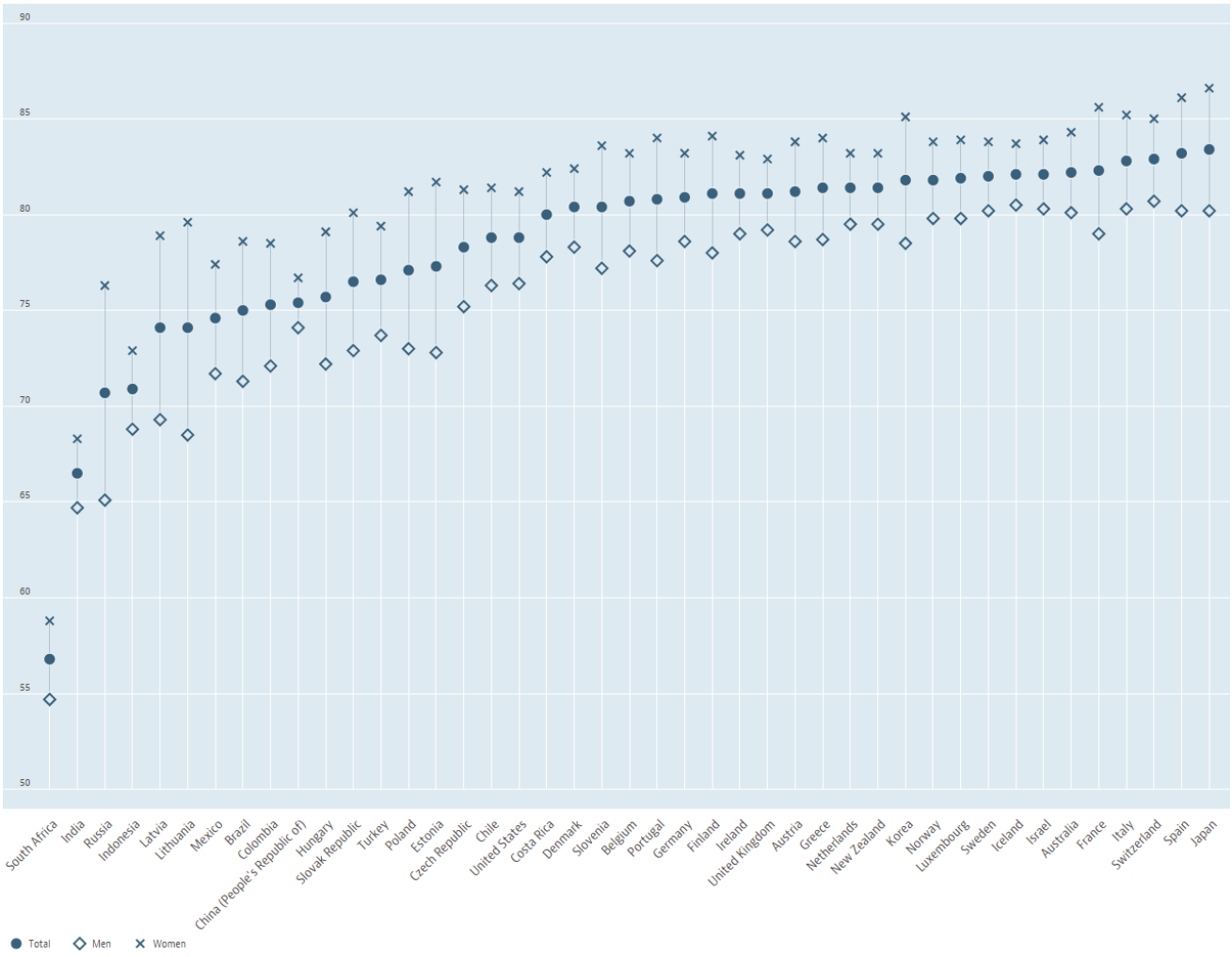
The World Health Organization (WHO) defines life expectancy as the "average number of years that a newborn is expected to live if current mortality rates continue to apply."[15] WHO uses the following life expectancy indicators:[16] life expectancy at birth, by sex; and life expectancy at age 60, by sex. WHO calculated the life expectancy at birth in 2000 and 2012 as 66.2 and 70.3, respectively.[16] WHO has a more complex method of calculating years of life lost from mortality (YLL), being that the "number of deaths are from the WHO Global Health Estimates, and the standard loss function is based on the frontier national life expectancy projected for the year 2050 by the World Population Prospects 2012 (UN Population Division, 2013), with a life expectancy at birth of 92 years."[17]

The Organisation for Economic Co-operation and Development (OECD) says life expectancy:

> "…is defined as the average number of years that a person could expect to live if he or she experienced the age-specific mortality rates prevalent in a given country in a particular year. It does not include the effect of any future decline in age-specific mortality rates. Each country calculates its life expectancy according to somewhat varying methodologies. These methodological differences can affect the exact comparability of reported estimates, as different methods can change a country's measure of life expectancy slightly."[18]
>
> "Life expectancy at birth for the total population is calculated by the OECD Secretariat for all countries, using the unweighted average of life expectancy of men and women."[19]

OECD calculates life expectancy at birth, and at age 65,[20] and defines premature mortality using potential years of life lost (PYLL) with an age 70 cut-off.[21] OECD's most recent (2013) country comparison of life expectancy at birth is shown in Figure 2.

Figure 2. Life expectancy at birth, OECD 2013 data[22]



The Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics reports life expectancy at birth, at age 65, and at age 75.[23] CDC's Healthy People defines premature mortality using years of potential life lost as follows:

> "Years of Potential Life Lost (With International Comparison)

YPLL is a summary measure of premature mortality (early death). It represents the total number of years not lived by people who die before reaching a given age. Deaths among younger persons contribute more to the YPLL measure than deaths among older persons.

YPLL is based on the number of deaths at each age up to some limit. For example, in the United States, the age limit is often placed at 75."[24]

Table 1. Summary of Life Expectancy and Premature Mortality Definitions

Organization	Age Used for Life Expectancy Calculations	Age Used for Years of Life Lost (YLL) or Premature Mortality
WHO	Birth, 60	92
OECD	Birth, 65	70
CDC's National Center for Health Statistics	Birth, 65, 75	
CDC's Healthy People		75
ACA's National Prevention Strategy	Birth, 25, 65, 85	

The Need for Standards in Reporting: The Enduring Omission of the Word "Average"

When contemporary reports fail to use the word "average" in regards to life expectancy, we forget that a high mortality rate at earlier stages of life will skew the average, even if the potential of human longevity has remained surprisingly stagnant over time. The average age of those in ancient Rome and Greece is thought to be only about 35 years old. However, Ancient Romans and Greeks had high childhood mortality rates, high rates of women dying in child birth, and high rates of death from military service, which greatly reduce the average. We should not confuse the *average* life expectancy with the human capacity for longevity. As stated earlier, many ancient Romans and Greeks lived upwards of 100 years.

The BioMeter Table for the State of Maryland in 1906 provides a nice illustration of this point. Table 2 reflects the percentage of the population in each age category, ranging from ages 0.5 to 75.8. This indicates that human longevity in 1906 spanned roughly the same length as today (based on the U.S. life expectancy of 78.8 years).

However, from the second column, we see the percentages in each age category reflect that only a fraction of the population lived to reach the older age groups. Therefore, the population-based average life expectancy would be much lower than the recorded human longevity at the time.

Table 2. Maryland Biometer Table, 1906[25]

Ages	Per Cent.	Estimated Population	Deaths	Mortality per 1000 Annual	Mortality per 1000 Age Period	Deaths in Age Period	Survivors of 10000 Born 1906	A. D.
0. 5	11.36	145976	6127	41.97	209.65	2099	7901	1911
5.10	11.21	144048	501	3.48	17.40	130	7771	1916
10.15	10.66	136981	384	2.83	14.15	110	7661	1921
15.20	10.13	130171	615	4.73	23.64	181	7480	1926
20.25	9.06	116421	—	—	—	—	—	—
25.30	8.58	110253	1677	7.39	73.90	553	6927	1936
30.35	7.17	92135	—	—	—	—	—	—
35.40	6.68	85838	1594	8.96	89.60	621	6306	1946
40.45	5.80	74530	—	—	—	—	—	—
45.50	4.73	64521	1780	19.99	199.90	1261	5045	1956
50.55	4.07	52300	—	—	—	—	—	—
55.60	3.09	39707	1870	20.33	203.30	1026	4019	1966
60.65	2.57	33035	—	—	—	—	—	—
65.70	1.80	23130	2172	38.67	386.70	1554	2465	1976
70.75	1.23	15806	—	—	—	—	—	—
75.80	0.79	10152	2158	83.13	831.30	2049	416	1986

Therefore, standard definitions, as well as standard calculations and standard reporting, are required.

The Need for Standards in Recording

Beyond standards for definitions and reporting, we also need to be aware of the role of recording standards, within and across countries, on life expectancy calculations. For example, to identify successes (or failures) in life expectancy progress among subgroups is greatly limited, due to restricted reporting across subpopulations. In the U.S., life table functions were not calculated separately for the black population prior to 1970;[26] these had to be estimated from the total nonwhite population. Additionally, over time, improvements in age reporting (completeness and accuracy) have been shown to influence calculated values more so than changes in actual mortality,[27] which may artificially appear to be an improvement (or decrement) in average life expectancy, rather than in the quality of data or change in reporting. For example, with the U.S. National Center for Health Statistics, the methods for life expectancy at birth changed in 1997.[28] Consequently, an artificial increase in life expectancy is reflected in 1997, and impacts the ability to compare pre-1997 to post-1997 (Table 3).

Table 3. Life Expectancy at Birth for Selected Years 1900-2005, National Center for Health Statistics[28]

Specified age and year at birth	All races, both sexes
1900	47.3
1950	68.2
1960	69.7
1970	70.8
1980	73.7
1990	75.4
1995	75.8
1997	76.5
1998	76.7
1999	76.7
2000	77.0
2001	77.2
2002	77.3
2003	77.4
2004	77.8
2005	77.8

Pliny the Elder "professes to derive from the census of Vespasian, the instances of longevity in the region between the Appenines and the Po—fifty four persons of the age of 100 years, fourteen of 110 years, two of 125, four of 130, four of 135 to 137, and three of 140…Haller [a writer of the 1870's] got together 1,000 instances of individuals between the ages of 100 and 150, and Bailey has made a catalogue of from 3,000 to 4,000 cases of longevity, reaching nearly to 100 years."[14] In 1876, The Sanitary Record reported the following:[14]

> "Another curious illustration is the case of Mary Billinge, of Liverpool, who was reported to have died at the age of 112. The proof seemed to be satisfactory. It was included in the report of the Registrar-General, and has become a familiar instance in the citations by writers on longevity. But, nevertheless, it has been proved to be a mistake, the certificate of baptism relied upon having been in fact that of another person of the same name. She died at the age of ninety-one instead of 112."

These suggestions of an extended life emphasize the need for additional standards—those around the quality and accuracy of birth certificate reporting.

Differences in life expectancy across countries, even today, in part reflect differences in reporting, completeness of the data, and recording of birth and death records. Contemporaries Manton and Stallard suggest that the maximum life span limits have not yet been actualized,[29] and that humans may have a maximum longevity potential of approximately 130 years. Manton and Stallard recognize the need for standards, and state "…Standard methods overestimate current life expectancy and potential gains in life expectancy from health and safety interventions,

while underestimating rates of individual aging, past progress in reducing mortality, and mortality differentials between pairs of populations. Calculations based on Swedish mortality data suggest that these errors may be important, especially in old age."[30]

The Impact of Societal Efforts

The lack of a standard definition of life expectancy and premature mortality affects a multitude of industries globally, including population health; health care; medicine; economics; insurance; consumer products of aging, beauty, and health; national resource allocation; etc. If humankind has had the same potential longevity and life expectancy for the past several thousand years, with approximately the same rate of premature mortality (about 50% is preventable), then our efforts have been futile. This would be important information to know!

Conversely, if education averts more premature mortality than medical advances,[31] then the impact of societal efforts on understanding whether we can extend human longevity, whether our efforts have been effective, and if so whether we *should* extend human longevity, either at the individual or population level, is important to know!

Without the ability to measure and answer these questions, what good has been, at the population level, the countless dollars we have spent on programs, treatments, care, technology, etc, except our own amusement and pursuit of extending human longevity?

Summary

In summary, at the population level we have increased the *proportion* of humans living longer, but not the potential length of human life. Standard definitions for life expectancy are required so that we might design an idealized, purposeful system around tracking and monitoring human longevity to measure progress within countries, across countries, and across centuries.

> "Teach us to number our days, that we may gain a heart of wisdom." (Psalm 90:12).

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