All The Same? On a Certain Pattern in Cross-National Death Risk

Arnold Barnett

ABSTRACT: This article considers whether a nation that fares relatively well (or badly) on a particular dimension of mortality risk tends also to do so on others. Working with 2016 data from the Global Burden of Disease (GBD) Study, we focus on six causes of premature death: transport accidents, other accidents, homicide, early-childhood diseases, and both communicable and noncommunicable diseases beyond early childhood. We consider data from all 26 nations that had populations of at least 50 million in 2016, as well as 15 clusters of smaller nations that are similar in longevity (e.g., Scandinavia). We use an analytic method that facilitates useful comparisons across nations, for it recognizes that some potential death risks can be underestimated because citizens die sooner from other causes. We estimate reductions in lifespan from each of the six causes relative to natural lifespan as defined by GBD. It emerges that, for all 15 pairings among the six causes, these reductions are positively correlated. We introduce metrics to summarize a nation’s overall “safety status,” and find that losses of longevity because of premature deaths are nearly three decades fewer in the safest countries than in the least safe ones. Turning to possible explanations for the cross-national differences, we find a strong association between a nation’s safety status and both its economic wherewithal as indicated by the 2016 GDP per capita (adjusted for purchasing power parity) and its income inequality as reflected by its Gini coefficient.

KEY WORDS: Cross-national comparisons; mortality risk; public health; public safety

1. INTRODUCTION

This article is motivated by the question: If a nation fares relatively well (or badly) on a particular dimension of mortality risk, does it also tend to do so on others? For example, are the countries with the lowest death risks from transport accidents largely the same as those with the lowest rates of early-childhood mortality? If so, then perhaps there is an underlying variable like “national safety” that indicates how a nation performs “across the board” in the various categories of death risk.

The analogy could be with the work of Charles Spearman in the domain of human intelligence. He offered empirical evidence that successes in a wide variety of intellectual activities were correlated, and might be viewed as manifestations of a “latent” variable that is commonly known as IQ. He devised the statistical technique of factor analysis to quantify this latent variable. Is it possible that a “safety quotient” exists that performs for individual nations the role that IQ (supposedly) performs for individual people?

To investigate the issue, we turn to an exceptional data source about mortality patterns in nations around the world, namely, the Global Burden of Disease Study that is performed by the Institute for Health Metrics and Evaluation and funded by the Bill and Melinda Gates Foundation. For 2016, the
study considered 195 countries on all six continents. Importantly, the study allows one to avoid a potential distortion in cross-national comparisons, under which a country’s observed rate of a disease that strikes the elderly could be low because few of its citizens reach old age. In consequence, the study allows one to compare all nations on a common basis in assessing their success in reducing premature death.

We focus on all 26 nations with 2016 populations of at least 50 million, as well as 55 smaller nations that we partition into homogeneous groupings (e.g., Scandinavia). Taken together, the countries we consider constitute about 90% of the world’s population living in nations outside conflict zones (a stipulation that excludes nations like Syria, Ukraine, and Afghanistan). We break mortality risks into six categories that, taken together, include virtually all sources of death risk.

As we will discuss, the losses of longevity tied to deaths in the six categories are all positively correlated in the 2016 cross-national analysis. Thus, it is defensible to summarize national mortality patterns with a single overall metric. While this finding is not totally surprising, we will argue that neither was it totally obvious. We do not dwell on the specific reasons that the safety metric differs across nations, but do consider the link between the metric and a nation’s overall economic strength and its internal distribution of wealth. The linkages we observe are sizable and statistically significant.

We start our work in Section 2, where we identify our six categories of death risk. Then we describe the GBD Study, and how we use its age-dependent death rates to estimate the effects of each source of premature death when considered in isolation (Section 3). Thereafter, we present our specific findings for 2016 for the 26 most populous nations and the 15 groupings of similar nations that together include 55 additional countries (Section 4). We offer two ways of assigning relative safety scores to the 41 entities we study (26 large nations + 15 groupings) that facilitate comparisons among them (Section 5). Then, we relate national safety scores to life-expectancy statistics (Section 6), to GDP per capita and to the Gini coefficient about income inequality (Section 7). We end with a discussion of the limitations of this analysis (Section 8) and with some concluding remarks (Section 9). Rather than offer a separate section about prior literature, we discuss previous research at the points in the narrative where it is most relevant.

2. SIX CAUSES OF PREMATURE DEATH

As we will discuss, a major concept in the Global Burden of Disease (hereafter GBD) study is the natural lifespan of an individual. This quantity is essentially how long a person will live if, having avoided all mortal hazards that shorten actual lifespan, she eventually dies of old age. We break the causes of premature death into six distinct categories and estimate the extent to which each one shortens lifespans from natural levels. Other than for accidents, however, we do not directly consider the reason the decedent suffered the fatal malady. For example, lung cancer could result from cigarette smoking, air pollution, the interaction of the two hazards, or something else entirely. Understanding the causes of a disease like lung cancer is obviously important, but it is outside the scope of the present investigation.

- **Transport Accidents**

  We treat transport accidents as a separate category because, in many countries, transport accidents cause more premature deaths than all other accidents combined. Transport accidents include plane crashes, derailments, auto wrecks, and mishaps involving pedestrians and cyclists.

- **Other Accidents**

  This category includes all accidents not involving transportation, examples of which are coal mine disasters, residential fires, and accidental drownings. However, it does not include deaths caused by medical errors in treatment.

- **Homicide**

  By homicide we mean the killing of one person by another not tied to war, terrorism, or police action. In other words, we consider criminal homicide as defined in the GBD Study.

- **Fatal Diseases before Age 5**

  Under-5 mortality caused by disease is widely viewed as an unambiguous proxy for a nation’s caliber of medical care (i.e., quality and availability). Very young children, after all, are not susceptible to causes of death like heart attacks caused by stress, diabetes caused by obesity, or the cumulative effect of air pollution. Of course, the caliber of medical care affects death statistics for all causes (e.g., it can determine whether the victim of a transport accident suffers death rather than injury). But its importance is most central among the very young.
• Communicable Diseases at Age 5 and Higher

These diseases include HIV/AIDS, typhoid fever, tuberculosis, malaria, meningitis, hepatitis, and intestinal infections.

• Noncommunicable Diseases at Age 5 and Higher

This is an omnibus category that includes several common causes of death, including cancer, heart disease, diabetes, drug-use disorders, and suicide. Yet the reasons people suffer these diseases include:

• Environmental hazards like air pollution (which can cause cancer and heart problems)
• Dietary and lifestyle patterns (which can cause cancer, heart disease, and diabetes)
• Psychological stresses (which contribute to suicide, drug overdoses, heart disease, liver disease, and certain cancers).

3. THE NATIONS CONSIDERED

We focus on the year 2016 and, at the outset, exclude nations that were at war that year or shortly before (e.g., Afghanistan, Syria, Ukraine, and Yemen). In such countries, it is unclear that even basic medical care is available to many citizens, so death statistics in several categories might be substantially worse than those in peacetime.

The population of the world in 2016 was 7.42 billion. This and other population statistics used here appear in the World Population Data Sheet for 2016 (Population Reference Bureau, 2016). We include in our analysis every nation in the world with a population at least 50 million in that year. A total of 26 countries satisfy that criterion:

Bangladesh Brazil China Egypt Ethiopia France Germany Iran India Indonesia Italy Japan Mexico Myanmar Nigeria Pakistan Philippines Russia South Africa South Korea Tanzania Thailand Turkey United Kingdom United States Vietnam

Taken together, these nations contained 73% of the world’s people in 2016.

We supplement this list by creating 15 clusters of similar smaller nations that in general are in close geographic proximity and also close in net life expectancy. One such cluster is Spain and Portugal, another is Denmark/Norway/Sweden/Finland (Scandinavia), and yet another is Singapore and Taiwan. The full list of these clusters appears in Table II. An indicator that these clusters are homogeneous is that, within all but one of the clusters, the variance of net life expectancies is far lower than worldwide variance in life expectancy. Table II shows the variance reduction for each cluster; in most instances, the reduction exceeds 90%.

The 26 large nations and the 15 clusters contain 91% of the world’s population outside of conflict zones. We will refer to these $26 + 15 = 41$ nations/groups of nations as entities. Many of the nations at peace not included among these entities are so small that much of their 2016 data are subject to sizable statistical fluctuations and thus unstable. For example, 10 of the nations—Andorra, Anguilla, Brunei, Iceland, Lichtenstein, Micronesia, Monserrat, Nauru, Palau, and Tonga—had homicide levels that oscillated between 0 and 2 in years near 2016.

4. THE GBD STUDY

4.1. The Available Data

As noted, the primary data set for the analyses we perform is the GBD Study, the results of which are available online at http://ghdx.healthdata.org/gbd-results-tool (Institute of Health Metrics and Evaluation (2016). This study breaks the age spectrum from birth to age 95 into 19 segments each five years long. For a particular category of deaths and the year 2016, it specifies for a particular country and particular age range:

• The number of deaths
• The death rate per 100,000 citizens

Importantly, the study also allows estimates of the drop in longevity attributable to a given cause, relative to the natural lifespan that would prevail in the absence of premature deaths. It does so via statistics about years of life lost (YLL), a widely used mortality metric that reflects the sense that a premature death at age 18 is distinct from (and more tragic than) such a death at age 72. This metric requires some benchmark age against which a particular loss of years can be measured. A benchmark of 75 years is common in YLL calculations. (e.g., see County Health Rankings and Roadmaps (2019), but 75 hardly seems satisfying as a de facto upper bound when citizens in many countries routinely live beyond that age. GBD instead uses the benchmark of 87.5 years as an estimate of when people will die of “old age” having avoided a premature death. However, GBD recognizes that, as people move beyond
Table I. Typical Years of Life Lost from Natural Lifespan because of Premature Death in Various Age Ranges, as Estimated in Global Burden of Disease Study

| Age Range | Years of Life Lost |
|-----------|-------------------|
| 0–4       | 85                |
| 5–9       | 79                |
| 10–14     | 74                |
| 15–19     | 69                |
| 20–24     | 64                |
| 25–29     | 59                |
| 30–34     | 54                |
| 35–39     | 50                |
| 40–44     | 45                |
| 45–49     | 40                |
| 50–54     | 35                |
| 55–59     | 30                |
| 60–64     | 26                |
| 65–69     | 21                |
| 70–74     | 17                |
| 75–79     | 13                |
| 80–84     | 10                |
| 85–89     | 7                 |
| 90–94     | 5                 |

Note: These typical losses of longevity by age range apply whatever the country and cause of death (e.g., years of life lost from transport accidents in Egypt in the age range 15–19 are essentially the same as those lost from homicides in Italy in that age range.) (Of course, the actual death rate per 100,000 citizens in a given age range can vary greatly by country and cause.) These are “typical” losses by age range; the GBD Study allows calculation of actual losses in an age range by country and cause, which differ slightly from the numbers in Table I.

Their 80th birthdays, their lifespans would typically extend beyond 87.5. Thus, in estimating YLL’s for people who die at (say) age 83 from a particular cause, BLL raises the benchmark age.

Table I presents typical YLL under GBD’s conventions, as a function of age at death. The loss in longevity does not depend on cause of death: no distinction is made between a death from a transport accident in Pakistan at age 22 and a death from drowning in Germany at that age. The YLL calculation based on age 87.5 is not tied to actual life expectancy in a given country. As we will discuss, that circumstance is a major advantage from the perspective of this study.

GBD reports, for example, that transport accidents in 2016 took the lives of approximately 305 French citizens in the age range 15–19, and that the victims lost a total of 21,418 years of life (relative to age 87.5) in such accidents. From these two statistics, we can work out YLL per transport-accident victim to be 70.23. GBD also records that the annual death rate from transport accidents for French people between 15 and 19 was 7.58 per 100,000 in 2016. We can therefore estimate a French citizen’s probability of a transport-related death in the age range 15–19, which entails on average a 70.23 years loss of life.

Not surprisingly, GBD has underpinned a large number of research papers. Some articles have focused on what GBD found about particular causes of death. Table II presents some clusters of similar middle-sized nations.

Table II. Some Clusters of Similar Middle-Sized Nations

| Cluster                                      | Similarity Score |
|----------------------------------------------|------------------|
| Asian “Tigers” (29 million):                 | [93.7%]          |
| Aust/Can/NZ (65):                           | [99.9%]          |
| Central America (45):                       | [85.1%]          |
| Eastern Africa (60):                        | [99.4%]          |
| Eastern Europe (92):                        | [94.5%]          |
| Former USSR/Asia (64):                      | [98.7%]          |
| Iberia (56):                                | [98.8%]          |
| Lower South America (64):                   | [86.6%]          |
| Middle East (58):                           | [91.2%]          |
| Northern Africa (85):                       | [99.8%]          |
| Scandinavia (27):                           | [98.8%]          |
| Southeast Asia (53):                        | [77.2%]          |
| Upper South America (80):                   | [88.7%]          |
| Western Africa (66):                        | [18.4%]          |
| West Central Europe (45):                   | [98.7%]          |

aNumber in parenthesis for a cluster is the total 2016 population of the nations that comprise it (to nearest million).

bNumber in brackets is similarity score, which is the percentage drop when the variance of net life expectancies among nations in the cluster is compared to the variance for all 41 entities (26 nations + 15 clusters). The only cluster with a low similarity score is Western Africa, where Cote d’Ivoire’s net life expectancy is about a decade below those of the other two nations. Even here, however, Cote d’Ivoire is closer to its fellow cluster member Ghana than to any of the 53 other nations in this table. (Net life expectancy statistics come from World Bank, 2016a.)
Cross-National Death Risk

mortality, such as malaria, hepatitis, HIV, tuberculosis, and dengue fever (e.g., Murray et al., 2014; Stanway et al., 2016). Other studies have combined GBD with other data sources to estimate how health outcomes vary with behavior (e.g., fruit and vegetable consumption, see Lock et al., 2005). Still other analyses have focused on nonfatal consequences of diseases, through such GBD variables as years lived with disability (e.g., Vos et al., 2016). However, none of these papers used GBD as we have done here. The papers most similar to this one divide the world into various regions and estimate or rank death risks from various causes (e.g., Lin et al., 2012; Murray & Lopez, 1997). Although insightful and comprehensive, these articles do not present results about individual nations, or offer calculations about premature death or cross-national correlations of the kind that appear in this article.

4.2. YLL by Cause

There are well-established methods for answering the question: if a certain disease did not exist, by how much would an individual’s life expectancy increase? (for example, see Beltran-Sanchez, Preston, & Canudas-Romo, 2008, concerning cause-deleted life tables). Here, we focus on the opposite question: if a certain mortal hazard were the only cause of premature death, by how many years on average would a citizen’s lifespan fall short of its natural length? This calculation thus excludes other causes of premature death and, because GBD defines natural lifespan the same way for all nations, it allows fair cross-national comparisons about the consequences of this particular cause of death. A deadly disease that strikes the elderly might be rare in a country with low life expectancy becomes few citizens reach old age. But the GBD data allow assessments of how successfully that nation copes with this disease among its residents who actually reach old age. Earlier deaths from other causes lose the opportunity to “camouflage” the mortality risk of the disease under consideration.

For a given country, the general formula for mean YLL for a given cause is

\[ E(L_i) = \sum_{k=1}^{19} S_{ik} q_{ik} (YLL_{ik}/N_{ik}), \]

where \( E(L_i) \) is mean YLL because of deaths from cause \( i \) (\( i = 1, \ldots, 6 \)); \( S_{ik} \) is probability of reaching age range \( k \) if the only reason for not doing so is a death from cause \( i \) at an earlier age (each age range is five years long); \( q_{ik} \) is probability that someone who reaches age range \( k \) suffers a death from cause \( i \) within that age range; \( YLL_{ik} \) is total YLL in 2016 because of deaths from cause \( i \) age range \( k \); and \( N_{ik} \) number of deaths from cause \( i \) in 2016 in age range \( k \).

Note that \( S_{ik} q_{ik} \) is the unconditional probability of suffering a death from cause \( i \) in age range \( k \), while \( YLL_{ik}/N_{ik} \) is the mean per capita loss of years of life because of such deaths.

The quantity \( S_{ik} \) is calculated under the probabilistic rule:

\[ S_{ik} = \prod_{j=1}^{k-1} (1 - q_{ij}), \]

while \( q_{ik} \)—which pertains to a five-year age range—is estimated by

\[ q_{ik} = 1 - (1 - \gamma_{lisk})^5, \]

where \( \gamma_{lisk} \) is per capita rate in 2016 of deaths from cause \( i \) in age range \( k \).

In summary, the formula for mean loss of lifespan \( L_i \) because of risk source \( i \) follows:

\[ E(L_i) = \sum_{k=1}^{19} q_{ik}(YLL_{ik}/N_{ik}) \prod_{j=1}^{k-1} (1 - q_{ij}). \]  

5. SOME FINDINGS

Tables III A and III B present YLL based applying Equation (1) to GBD data for 2016, for all 41 entities and all six causes of premature death. To summarize the entries of Table III, Table IV shows the total losses of life by entity from the six causes. It should be emphasized that these “noncamouflaged” totals exceed the actual losses of life from these six categories of risk because, in reality, deaths from causes that disproportionately strike the young reduce the toll from other causes that disproportionately strike the old. (We will say more about this issue in Section 7.) Tables III and IV make obvious that premature death takes a far greater toll in some entities than in others.

The raw data in these tables help answer the question: does a nation that performs well or badly on a particular dimension of mortality risk tend to perform similarly on other dimensions? If that is the case, one would anticipate that a nation’s losses in lifespan from different causes would be positively correlated (i.e., the worse on one dimension, the worse on others).
correlation matrix for losses of life for the six causes considered.

Every one of the 15 pairwise correlation coefficients in Table V involving the six causes of premature death is positive. While that circumstance does not mean that a nation that fared well on a given dimension definitely fared well on other dimensions, it does indicate a clear general tendency. Several of the lowest correlation coefficients involve homicide, which reflects the fact that some of the highest homicide rates in the world arise in Central and South America, in nations that are otherwise not especially high in premature-death risk.

Do these observed correlations differ significantly from zero? The familiar test for the hypothesis $H_0$ that a given correlation coefficient is zero (against the alternative that it is positive) uses as its test statistic the quantity $t$ defined by:

$$t = r \sqrt{\frac{n - 2}{1 - r^2}},$$

where $n$ is the number of pairings $(x_i, y_i)$ considered (which is 41 here), and $r$ is the observed coefficient of correlation.

If $H_0$ is true, then $t$ is assumed approximately to follow a $t$-distribution with $n - 2$ degrees of freedom. $H_0$ would traditionally be rejected in the one-sided test if the calculated value of $t$ exceeds the 95th percentile of the associated $t$-distribution.

On this basis, $H_0$ would be rejected all the pairwise correlations in Table V except for homicide and nontransport accidents (0.17), homicide and noncommunicable diseases (0.19), and homicide and early-childhood diseases (0.26). Those three correlations are at, respectively, the 85th, 87th, and 94th percentiles of the $t$-distribution with 39 degrees of freedom. But while these outcomes are consistent at the 5% significance level with the possibility of no correlation, they are even more so with at least

---

**Table IIIA. Mean Adjusted Years of Life Lost for Each of Six Causes of Premature Death in Nations with over 50 Million Inhabitants in 2016, Based on 2016 Mortality Data**

| Nation          | TA   | OA   | H    | U5   | CD   | NCD  |
|-----------------|------|------|------|------|------|------|
| Bangladesh      | 0.65 | 1.04 | 0.10 | 2.68 | 3.99 | 14.93|
| Brazil          | 0.89 | 0.90 | 1.02 | 1.34 | 2.54 | 13.44|
| China           | 0.79 | 0.94 | 0.05 | 0.83 | 0.84 | 14.10|
| Egypt           | 1.28 | 0.48 | 0.03 | 1.58 | 1.37 | 16.73|
| Ethiopia        | 0.84 | 2.04 | 0.43 | 3.39 | 11.01| 16.61|
| France          | 0.26 | 0.75 | 0.03 | 0.30 | 0.81 | 12.96|
| Germany         | 0.20 | 0.46 | 0.03 | 0.30 | 0.68 | 11.71|
| India           | 0.89 | 2.05 | 0.14 | 3.17 | 7.56 | 16.41|
| Indonesia       | 0.76 | 0.89 | 0.04 | 2.02 | 6.14 | 15.72|
| Iran            | 1.21 | 0.64 | 0.12 | 1.34 | 1.05 | 13.69|
| Italy           | 0.33 | 0.40 | 0.03 | 0.26 | 0.48 | 10.67|
| Japan           | 0.17 | 0.42 | 0.02 | 0.19 | 1.09 | 9.54 |
| Mexico          | 0.65 | 0.72 | 0.60 | 1.19 | 1.44 | 13.51|
| Myanmar         | 1.10 | 1.38 | 0.08 | 2.30 | 3.05 | 17.09|
| Nigeria         | 0.56 | 1.40 | 0.39 | 10.09| 11.07| 12.16|
| Pakistan        | 0.94 | 0.91 | 0.19 | 4.60 | 4.89 | 17.32|
| Philippines     | 0.47 | 0.79 | 0.55 | 2.03 | 6.94 | 16.74|
| Russia          | 0.74 | 1.37 | 0.54 | 0.63 | 1.40 | 18.16|
| S. Africa       | 1.54 | 0.86 | 1.30 | 3.84 | 13.74| 14.70|
| S. Korea        | 0.63 | 0.55 | 0.05 | 0.25 | 1.12 | 11.80|
| Tanzania        | 0.77 | 2.06 | 0.34 | 4.92 | 12.41| 15.34|
| Thailand        | 1.02 | 0.76 | 0.24 | 0.45 | 3.09 | 12.23|
| Turkey          | 0.45 | 0.46 | 0.08 | 1.24 | 0.55 | 12.18|
| UK              | 0.16 | 0.41 | 0.03 | 0.38 | 1.38 | 11.68|
| US              | 0.51 | 0.60 | 0.22 | 0.53 | 0.99 | 12.84|
| Vietnam         | 1.00 | 1.53 | 0.07 | 1.00 | 2.26 | 14.64|

**Table IIIB. Mean Adjusted Years of Life Lost for Each of Six Causes of Premature Death In 16 Groups of Similar Nations, Based on 2016 Mortality Data**

| Group          | TA   | OA   | H    | U5   | CD   | NCD  |
|----------------|------|------|------|------|------|------|
| Asian Tigers   | 0.47 | 0.50 | 0.05 | 0.30 | 1.87 | 11.66|
| Aust/CAN/NZ    | 0.30 | 0.52 | 0.05 | 0.38 | 0.87 | 10.96|
| Central America| 0.66 | 0.98 | 1.12 | 1.59 | 3.14 | 13.27|
| E. Africa      | 0.66 | 2.15 | 0.38 | 4.11 | 16.27| 13.86|
| E. Europe      | 0.38 | 0.76 | 0.06 | 0.46 | 0.87 | 14.23|
| Iberia         | 0.21 | 0.45 | 0.03 | 0.25 | 0.92 | 10.43|
| Middle East    | 1.23 | 0.73 | 0.05 | 0.65 | 1.82 | 12.97|
| N. Africa      | 0.92 | 0.60 | 0.04 | 1.48 | 2.23 | 13.10|
| N. So. America | 0.76 | 0.91 | 0.68 | 1.48 | 2.82 | 12.33|
| NW Europe      | 0.21 | 0.72 | 0.03 | 0.31 | 1.15 | 11.05|
| Scandinavia    | 0.17 | 0.73 | 0.04 | 0.23 | 1.11 | 11.13|
| SE Asia        | 0.98 | 1.21 | 0.09 | 1.70 | 5.55 | 15.48|
| S. So. America | 0.53 | 0.74 | 0.22 | 0.85 | 2.95 | 13.21|
| Former USSR Asia| 0.55 | 0.82 | 0.20 | 1.91 | 1.24 | 17.45|
| W. Africa      | 0.81 | 2.40 | 0.11 | 5.72 | 12.31| 16.69|

Note: TA = transport accident; OA = Other Accident; H = Homicide; U5 = Under 5 Disease; CD = Communicable Disease beyond Age 5; NCD = Noncommunicable Disease beyond Age 5.

Loss of life listed for each mortal hazard are estimated as if it were the sole cause of premature death, relative to natural lifespan as defined by the Global Burden of Disease Study. Under this convention, results for a given hazard are directly comparable across nations.

Source: Global Burden of Disease Study, 2016 age-specific data as described in text.
Cross-National Death Risk

Table IV. Total Years of Life Lost to Premature Deaths for 41 National Entities, Based on 2016 Mortality Data

| Nation          | Mean Total Loss | Mean Total Loss |
|-----------------|-----------------|-----------------|
| Bangladesh      | 23.38 (years)   | 14.84           |
| Brazil          | 20.13           | 13.08           |
| China           | 17.54           | 20.76           |
| Egypt           | 21.46           | 37.43           |
| Ethiopia        | 34.32           | 16.76           |
| France          | 12.96           | 12.30           |
| Germany         | 13.37           | 17.44           |
| India           | 30.22           | 18.37           |
| Indonesia       | 25.64           | 18.98           |
| Iran            | 18.04           | 13.48           |
| Italy           | 12.05           | 13.40           |
| Japan           | 11.43           | 25.01           |
| Mexico          | 18.12           | 18.49           |
| Myanmar         | 25.00           | 22.17           |
| Nigeria         | 35.68           | 38.03           |
| Pakistan        | 28.84           |                 |
| Philippines     | 27.52           |                 |
| Russia          | 22.84           |                 |
| S. Africa       | 35.98           |                 |
| S. Korea        | 14.39           |                 |
| Tanzania        | 36.26           |                 |
| Thailand        | 17.78           |                 |
| Turkey          | 14.96           |                 |
| UK              | 14.24           |                 |
| US              | 15.69           |                 |
| Vietnam         | 20.50           |                 |

Note: The sum of six “noncamouflaged” losses in Tables III A and III B.

Table V. Correlations among the Six Mortality Variables for 41 Nations/National Groupings in 2016

|       | T    | OA   | H    | U5   | CD   | NCD  |
|-------|------|------|------|------|------|------|
| T     | 1    | 0.33 | 0.32 | 0.31 | 0.35 | 0.41 |
| OA    | 1    | 0.17 | 0.65 | 0.67 | 0.77 | 0.57 |
| H     | 1    | 0.26 | 0.39 | 0.39 | 0.77 | 0.19 |
| U5    | 1    | 0.79 | 0.41 |      |      |      |
| CD    | 1    | 0.41 |      |      |      |      |
| NCD   | 1    |      |      |      |      |      |

Note: T = Transport Accidents; OA = Other Accidents; U5 = Under-5 Diseases; H = Homicide; CD = Communicable Diseases; NCD = Noncommunicable Diseases.

6. TWO OVERALL SAFETY METRICS

Given the correlations among the six loss-of-life variables, there is a basis for constructing a “latent” safety factor that summarizes a nation’s status. Factor analysis would seek the linear combination of the six variables that best fits the data in a particular sense. However, it seems more natural to consider two intuitively-accessible linear combinations that process the variables in distinct ways. One is simply the sum of the six loss variables, which is reported in Table IV. This sum gives greater emphasis to the larger sources of YLL. The other is a normalized sum that weights the six variables equally. For given entity $i$ and given cause $j$, the normalized outcome $X_{ij}$ follows:

$$X_{ij} = \frac{(L_{ij} - \mu_j)}{\sigma_j},$$

where $L_{ij}$ is mean loss of life in entity $i$ attributable to cause $j$, $\mu_j$ is (simple) average of losses of life attributable to cause $j$ among the 41 entities, and $\sigma_j$
is standard deviation of losses attributable to cause $j$ among the 41 entities.

Entity $i$'s normalized sum $S_i$ would follow:

$$S_i = \sum_{j=1}^{6} X_{ij}.$$ 

Because the loss-of-life variables are correlated, one would anticipate that the two summation metrics are themselves correlated. For ease of exposition, Table VI creates a 0-to-100 scale for each of the metrics so they can be compared for each entity. The score of 100 is assigned to the entity that performed best and 0 is assigned to the weakest performer. Intermediate scores are linear interpolations between the highest and lowest raw outcomes. For example, the lowest total loss of life was 11.43 years for Japan (score 100) while the highest was 38.03 years for Western Africa (score 0). Entity $i$'s score $T_i$ on this metric would follow:

$$T_i = 100 \times (38.03 - L_i)/(38.03 - 11.43),$$

where $L_i$ is entity $i$'s total loss of life, presented in Table IV.

As a glance at Table VI suggests, the two scores for a particular entity are highly similar. The correlation coefficient for the two scores is 0.963. The largest deviations between scores on the two metrics occur for Central America and for Brazil. This happens because the exceptionally high homicide rates in those entities are far more influential in the normalized calculations that weigh all six death causes equally than in the unweighted calculations in which noncommunicable diseases are dominant.

In subsequent sections, we will use the simple average of the two scores in Table VI as the overall safety score for a given entity. Table VI makes apparent that taking some weighted average of the two scores would not yield very different results from taking the simple average.

7. SAFETY SCORES AND LIFE EXPECTANCY

How do the safety scores just discussed compare with life expectancies in various countries, meaning the average lifespans of newborns given current age-specific mortality rates? An immediate comparison is not available because the safety scores reflect YLL, while life expectancy concerns years-of-life gained after birth. However, a commonality can be established using the fact that Japan fares best among the 41 entities on both criteria, with both the longest life expectancy and minimum loss of longevity from premature death. For entity $i$, we can define two quantities:

$$x_i = \text{excess in mean years of life in entity } i \text{ lost compared to that in Japan}$$

$$z_i = \text{reduction in life expectancy in entity } i \text{ beyond that in Japan}.$$

We would expect that $x_i$ and $z_i$ would be positively correlated, and would also expect that $x_i$ would generally exceed $z_i$. This last expectation arises because we constructed YLL so as to capture the full effect of each disease, without any diminution tied to deaths from other diseases. Yet such diminution is an integral part of the calculation of life expectancy. To approximate the relationship between the two variables, we can perform the ordinary least squares linear regression analysis:

$$z_i = \beta x_i + \varepsilon_i,$$

where $\varepsilon_i$ is a zero-mean “noise” term independent of $x_i$.

Both $z_i$ and $x_i$ are based on 2016 data, but the life-expectancy statistics (which appear in World Bank, 2019) are not necessarily based on the same information as the GBD-based safety scores. Given that $x_i$ should exceed $z_i$, we anticipate that the $\beta$ - estimate should fall below one.

In the regression, the least squares estimate of $\beta$ is 0.962, and the 95% confidence interval for $\beta$ extends from 0.908 to 1.016. (Ratios greater than one cannot arise for the GBD data alone, but could occur against life expectancy calculations using slightly different data.) The correlation coefficient between the $x_i$'s and the $z_i$'s is 0.983. It seems surprising that reductions of life expectancy are estimated as fully 96% as large as those against total YLL in our “non-camouflaged” calculations. Early-childhood mortality, after all, yields a larger loss of longevity against age 87.5 than against the life expectancies around 65 that arise in some entities. But in all countries, deaths before age 5 befall only a small fraction of newborns (well below 10% nearly everywhere), so the effect of childhood deaths on overall longevity is modest. Diseases that strike the old have a limited influence against a benchmark of age 87.5 and on life expectancy and, so their effects on $x$ and $z$ need not differ appreciably.
Table VI. Safety Scores on a 0–100 Scale for 41 National Entities, Based on 2016 Mortality Data

| Nation       | Total Loss a | Normalized Loss b | National Grouping | Total Loss a | Normalized Loss b |
|--------------|--------------|-------------------|-------------------|--------------|-------------------|
| Bangladesh   | 55           | 56                | Asian Tigers      | 87           | 86                |
| Brazil       | 67           | 45                | Aust/Can/NZ       | 94           | 92                |
| China        | 77           | 68                | Central America   | 65           | 45                |
| Egypt        | 62           | 55                | E. Africa         | 2            | 15                |
| Ethiopia     | 14           | 17                | E. Europe         | 80           | 78                |
| France       | 94           | 91                | Iberia            | 97           | 96                |
| Germany      | 93           | 93                | Middle East       | 77           | 65                |
| India        | 29           | 28                | N. Africa         | 74           | 68                |
| Indonesia    | 47           | 52                | N. So. America    | 72           | 56                |
| Iran         | 75           | 62                | NW Europe         | 92           | 91                |
| Italy        | 98           | 95                | Scandinavia       | 93           | 92                |
| Japan        | 100          | 100               | SE Asia           | 49           | 47                |
| Mexico       | 75           | 62                | S. So. America    | 74           | 71                |
| Myanmar      | 49           | 41                | Former USSR       | 60           | 58                |
| Nigeria      | 9            | 21                | Asia              | 0            | 10                |
| Pakistan     | 35           | 36                |                   |              |                   |
| Philippines  | 40           | 46                |                   |              |                   |
| Russia       | 57           | 43                |                   |              |                   |
| S. Africa    | 8            | 0                 |                   |              |                   |
| S. Korea     | 89           | 83                |                   |              |                   |
| Tanzania     | 7            | 14                |                   |              |                   |
| Thailand     | 76           | 65                |                   |              |                   |
| Turkey       | 84           | 88                |                   |              |                   |
| UK           | 89           | 89                |                   |              |                   |
| US           | 84           | 78                |                   |              |                   |
| Vietnam      | 66           | 53                |                   |              |                   |

Note: 100 = lowest loss; 0 = highest loss. Other scores based on where the entity’s loss fell linearly on the spectrum from lowest to highest; see main text. 

a based on mean total years lost as presented in Table IV

b based on normalized loss which gives equal weight to all six causes of premature death.

The coefficient of correlation of the two rankings is 0.963.

8. ECONOMICS AND NATIONAL SAFETY

This article is concerned with documenting a pattern in the mortality-risk data, rather than explaining why that pattern arose. But one might suspect that relatively-wealthy countries have greater resources to devote to reducing premature deaths of various kinds, and thus that economic differences might underlie the disparities that we have seen in YLL. At the same time, one might speculate that sharp divergences in a country’s distribution of wealth mean that many of its citizens are systematically less safe than their more affluent counterparts. Because great wealth might improve safety less than great poverty might diminish it, huge disparities in incomes could act to depress a nation’s safety score relative to those in equally wealthy countries where income is more equally distributed. It is of interest to explore the consistency of such conjectures with the safety scores we have amassed.

Regression analysis allows an approximation of the relationship between safety scores and economic phenomena. We work with GDP per capita as a measure of economic strength (World Bank, 2016b) and the widely used Gini coefficient (U. S. Central Intelligence Agency [2017]) for measuring inequality of income, and use the familiar mathematical formulation:

$$S_i = \gamma (GDP_i)^\alpha (Gini_i)^\beta \varepsilon_i,$$

where $S_i$ is entity $i$’s average safety score in Table VI ($i = 1, \ldots, 41$); $GDP_i$ is entity $i$’s GDP per capita in 2016 in Purchasing Parity Dollars, $Gini_i$ is entity $i$’s Gini coefficient for 2016; and $\varepsilon_i$ is a lognormal factor.
allowing for “random” variations around the trend curve.

Using ordinary least squares linear regression analysis on the logarithms of the \( S \)'s, we reach the following parameter estimates and confidence intervals for \( \alpha \) and \( \beta \):

\[
\alpha = 0.549 \quad 95\% \text{Confidence Interval} : (0.365, 0.733) \\
\beta = -1.258 \quad 95\% \text{Confidence Interval} : (-2.163, -0.353)
\]

The value of \( \alpha \) (0.549) suggests that safety approximately varies with the square root of GDP per capita. With such a concave function, fixed dollar increases in GDP per capita accompany larger increases in safety scores when the baseline value is lower than when it is higher. The negative value of \( \beta \) is harder to interpret, because the Gini coefficient itself is a bit abstract. However, it indicates that, holding GDP per capita constant, greater income inequality in an entity is associated with greater loss of longevity.

To make more transparent the findings in the regression analysis, Table VII divides the 41 entities into quadrants. A cross-quadrant comparison shows how GDP per capita relates to loss of lifespan: the overall effect is large and, as GDP per capita grows, the associated rise in longevity per $1,000 growth in GDP declines steadily (as befits a concave relationship). In every one of the quadrants, the correlation between Gini coefficient and safety scores is large and negative. We are not asserting a simple causal relationship, but documenting a high degree of statistical association.

This analysis is not the first investigation of the relationship between Economics and longevity. Several studies have explored the link between GDP per capita and life expectancy. Many of their results have been summarized by the Preston curve, which depicts life expectancy as a concave function of per capita GDP (see Bloom & Canning, 2007; Preston, 1975; Shkolnikov, Andreev, & Leon, 2019). This specific curve has been changing over the years though it remains concave, with the poorest countries making disproportionate gains over time. At the same time, there have been studies that relate life expectancy in a country to its income inequality, as measured by the Gini coefficient (e.g., De Vogli et al., 2005 Messias, 2003; Moore, 2006). These studies generally support the position that, other factors equal, lesser inequality is associated with higher life expectancy.

The findings here are consistent with these studies focused on life expectancy. The square-root relationship we found between safety and GDP per capita takes the general form of a Preston curve. And, as with life expectancy, income inequality in its own right emerged as significantly associated with safety score. That the relationships are so similar with a safety metric different from life expectancy suggests the robustness of the findings that correlate economics with longevity. At the same time, the high correlation discussed in Section 7 between safety scores and life expectancy make it unsurprising that the results under one metric also arise under the other.

### 9. CAVEATS

There are limitations to the analysis presented here. First of all, it presents cross-sectional comparisons for the single year 2016. It is conceivable that the results would differ if based on similar data for another year, though one would not expect large shifts in short periods. Less certain is whether the findings would be sustained in longitudinal analyses within individual countries. In a given nation, have improvements over time on some dimensions of mortality risk typically been accompanied by improvements on others? That pattern is suggested by the analysis here, but it would be desirable to test this pattern against nation-specific time-series data.

Second, we have explored differences across nations, but have only considered indirectly (via the Gini coefficient) the variation of mortality risks

| GDP/Capita Quadrant | Mean GDP/Capita | Mean Loss of Lifespan (Years) | Gini/Safety Correlationb |
|---------------------|----------------|------------------------------|--------------------------|
| Highest             | $44,120        | 13.99                        | -0.664                   |
| Second Highest      | $25,310        | 17.34                        | -0.599                   |
| Second Lowest       | $11,590        | 22.86                        | -0.657                   |
| Lowest              | $4,500         | 30.97                        | -0.572                   |

Note: Because 41 is not divisible by four, the four quadrants could not have equal numbers of data points. Here the second highest quadrant contains the median entity and has 11 entries while the other three quadrants have 10 apiece.

These are correlations within the quadrants between Gini scores for economic inequality and average safety scores in Table VI. The variation by GDP per capita is relatively modest among the entities in each quadrant, so economic strength among them is roughly the same.

\[ 95\% \text{Confidence Interval} : (0.365, 0.733) \]

\[ 95\% \text{Confidence Interval} : (-2.163, -0.353) \]
within individual countries. This variation can be substantial: it has been estimated that those who live on the northern segment of a Chicago subway line on average live 30 years longer than residents along the southern segment. (WTTW, 2019). It could be valuable to replicate the analysis here in a particular country. For example, are the subgroups of Americans at the greatest risk of homicide also at the greatest risk of early-childhood mortality or deaths in accidents?

Third, as noted, we have concentrated on the cause of death as listed on a death certificate, which often leaves unclear which environmental hazards and/or aspect of personal behavior led to the death. We have, in other words, worked with aggregate variables that reflect the total effects of various phenomena rather than their individual effects. Yet understanding the contributors to specific death risks is obviously important; that it is not the subject of this article is not to suggest otherwise.

There have been empirical studies that focus less on the medical cause of death than on the underlying reasons those medical conditions arose. An extensive literature concerns why people suffer heart attacks, cancer, and diabetes, often at the level of individual nations. Calazzo, Ashok, Waitz, Yin, and Barrett (2013) estimated the extent to which air pollution in the United States causes premature deaths, while Guo et al. (2013) did so for Beijing, China. Ng, Freeman, and Fleming (2014) estimated the prevalence of smoking and cigarette consumption in 187 countries, though not the health consequences of such smoking. That task was undertaken by Siegel et al. (2015), who approximated the death toll from cigarette usage in the United States from 12 smoking-related cancers. Leon and Shkolnikow (1998) estimated the extent to which stress caused premature death in Russia, while Matthews and Gump (2011) approximated increases in mortality tied to chronic job stress and marital dissolution in the United States. Yoon, Chen, Yi, and Moss (2011) estimated how many premature deaths in the United States were tied to the combination of alcohol and drug-use disorders. Martinez-Gonzalez et al. (2012) described the association in Spain between adherence to a Mediterranean diet and reduction of premature deaths. Keeney (2008) concluded that “personal decisions” in the United States were the leading cause of premature deaths, and that these deaths could have been avoided if “readily available alternative choices were made.” Moreover, Makary and Daniel (2016) estimated that medical errors in treating patients in the United States cause over 250,000 premature deaths per year. Because practically all of these early deaths arose from noncommunicable diseases, the calculations in this article about such diseases reflect the cumulative effect of these contributors to mortality within an entity. But they do not partition this effect among its various causes, whether acting singly or in combination.

10. FINAL REMARKS

The kinds of cross-national correlations that we have found for mortality risks (and that previously arose for forms of personal intelligence) might also exist in other settings. If a region has a high rate of a particular type of crime, is it likely also to have high rates of other crime types? Do countries known to be creative in some fields of art or science tend to be creative in a wide variety of them? If a city’s team excels in one sport, are the city’s other teams also likely to be superior? (Those of us who live in Boston might suspect the answer is yes). While there have been some explorations along these lines (e.g., Savage, 2013 showed that death rates have been dropping in tandem among transport modes in the United States), many more such investigations could be worthwhile.

This article has discussed correlations, and we reiterate that correlations do not establish causal relationships. Yet one can imagine a model of national safety that is consistent with the findings here. The results raise the possibility that, as nations advance economically, simultaneous improvements might occur on most if not all of the six dimensions considered in this article. For that reason, the indirect benefits of economic progress might overshadow the direct ones: greater longevity could be more consequential than the greater availability of material goods. Moreover, if several death risks are declining at once, the speed at which economic advances raise lifespans might be unexpectedly high. At the same time, lesser inequality of wealth might yield sizable longevity benefits in itself, presumably because the poorest citizens see their death risks diminish.

Perhaps we should end by referring yet again to the analogy between national safety scores and individual intelligence scores. If a person has a high IQ, the tendency is to expect more of her in tasks with high intellectual content. Perhaps one should have a similar expectation for the countries with high safety scores. Among the future threats to mortality
are terrorism, nuclear proliferation, climate change, and outbreaks of deadly diseases like Ebola. Might the countries that have done especially well with existing sources of death risk be especially likely to contribute to reducing the threats that are materializing now? The answer is not automatically “yes,” but the question is worth pondering.

ACKNOWLEDGMENTS

This article is far better because of many thoughtful comments and suggestions by Richard Larson, Amedeo Odoni, and Lee Ullman of MIT, Kenneth Huang of Singapore National University, and three anonymous referees. I am very grateful to all of them.

REFERENCES

Beltran-Sanchez, H., Preston, S. H., & Canudas-Romo, V. (2008). An integrated approach to cause-of-death analysis, cause-deleted life tables and decompositions of life expectancy. *Demographic Research*, 19(35), 1323–1350.

Bloom, D., & Canning, D. (2007). Commentary: The Preston curve 30 years on: Still sparking fires. *International Journal of Epidemiology*, 36(3), 498–499. Retrieved from https://academic.oup.com/ije/article/36/3/498/655864

Calazzo, F., Ashok, A., Waitz, I., Yin, S., & Barrett, S. (2013). Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005. *Atmospheric Environment*, 79, 198–208.

Chabris, C. (2007). Cognitive and neurobiological mechanisms of the law of general intelligence. In M. J. Roberts (Ed.), *Integrating the mind: Domain general versus domain specific processes in higher cognition* (pp. 449–491). Hove, UK: Psychology Press.

County Health Rankings and Roadmaps. (2019). Premature Death (YPDLL). Retrieved from https://www.countyhealthrankings.org/explore-health-rankings/measures-data-sources/county-health-rankings-model/health-outcomes/length-of-life/premature-death-ypdll

De Vogli, R., Mistry, R., Gnesotto, R., & Cornia, G. (2005). Has the relation between income inequality and life expectancy disappeared? Evidence from Italy and other top industrialised countries. *Journal of Epidemiological Community Health*, 59(2), 158–162.

Guo, Y., Li, S., Tian, Z., Pan, K., Zhang, J., & Williams, G. (2013). The burden of air pollution on years of life lost in Beijing, China, 2004–08: Retrospective regression analysis of daily deaths. *BMJ*, 347, f1739. Retrieved from https://www.bmj.com/content/347/bmj.f1739

Institute for Health Metrics and Evaluation. (2016). *Global Burden of Disease Study 2016 (GBD 2016)*. Retrieved from http://ghdx.healthdata.org/gbd-results-tool

Keceny, R. (2008). Personal decisions are the leading cause of death. *Operations Research*, 56(8), 1335–1347.

Leon, D., & Shkolnikov, V. (1998). Social stress and the Russian mortality crisis. *JAMA*, 279(10), 790–791.

Lin, S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., … Ezzati, M. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380(9859), 2224–2260.

Lock, K., Pomerleau, J., Causer, L., Altmann, D., & McKee, M. (2005). The global burden of disease attributable to low consumption of fruit and vegetables: Implications for the global strategy on diet. *Bulletin of the World Health Organization*, 83(2), 100–108.

Makary, M., & Daniel, M. (2016). Medical error—The third leading cause of death in the US. *BMJ*, 353, i2139. Retrieved from https://www.bmj.com/content/353/bmj.i2139.full

Martinez-Gonzalez, M., Gea, A., & Ruiz-Canela, M. (2019). The mediterranean diet and cardiovascular health. *Circulation Research*, 124(5), 779–788.

Matthews, K., & Gump, B. (2011). Chronic work stress and marital dissolution increase risk of posttrial mortality in men from the multiple risk factor intervention trial. *JAMA Internal Medicine*, 309–315.

Messias, E. (2003). Income inequality, illiteracy rate, and life expectancy in Brazil. *American Journal of Public Health*, 93(8), 1294–1296.

Moore, S. (2006). Peripherality, income inequality, and life expectancy: Revisiting the income inequality hypothesis. *International Journal of Epidemiology*, 35(3), 623–632.

Murray, C. J. L., & Lopez, A. D. (1997). Mortality by cause for eight regions of the world: Global burden of disease study. *Lancet*, 349(9061), 1269–1276.

Murray, C. J. L., Ortblad, K. F., Guinovart, C., Lim, S. S., Wolock, T. M., Roberts, D. A., … Vos, T. (2014). Global, regional, and national incidence and mortality for HIV, Tuberculosis, and Malaria during 1990–2013: A systematic analysis for the global burden of disease study 2013. *Lancet*, 384(9947), 1005–1070.

Ng, M., Freeman, M., & Fleming, T. (2014). Smoking prevalence and cigarette consumption in 187 countries, 1980–2012. *JAMA*, 311(2), 183–192.

Population Reference Bureau. (2016). *2016 World Population Data Sheet*. Retrieved from https://www.prb.org/wp-content/uploads/2016/08/prb-wpds2016-web-2016.pdf

Preston, S. (1975). The changing relation between mortality and level of economic development. *International Journal of Epidemiology*, 29, 231–248.

Savage, I. (2013). Comparing the fatality risk in United States transportation across modes and over time. *Research in Transportation Economics*, 43(1), 9–22.

Shkolnikov, V., Andreev, E., & Leon, D. (2019). Patterns in the relationship between life expectancy and gross domestic product in Russia in 2005–15: A cross-sectional analysis. *Lancet Public Health*, 4(4), e181–e188. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6506569/

Siegel, R., Jacobs, E., Newton, C., Feshkanich, D., Freedman, N., Prentice, R. & Jemal, A. (2015). Deaths due to cigarette smoking for 12 smoking-related cancers in the United States. *JAMA Internal Medicine*, 175(9), 1574–1576.

Stanislaw, J., Shepard, D. S., Undurraga, E. A., Halasa, Y. A., Coffeng, L. E., Brady, O. J., … Murray, C. J. L. (2016). The global burden of dengue: An analysis from the global burden of disease study 2013. *Lancet Infectious Diseases*, 16(6), 712–723.

U. S. Central Intelligence Agency. (2017). Country comparison: Distribution of family income—Gini Index. *The World Factbook*. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/rankorder/2172rank.html

Vos, T. et al. (2016). Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: A systematic analysis for the Global Burden of Disease Study 2015. *Lancet*, 388(10053), 1545–1602.

Yoon, Y., Chen, C., Yi, H., & Moss, H. (2011). Effect of comorbid alcohol and drug use disorders on premature death among unipolar and bipolar disorder decedents in the United States, 1999 to 2006. *Comprehensive Psychiatry*, 52(5), 453–464.
World Bank. (2016a). Life expectancy at birth, total (Years). Retrieved from https://data.worldbank.org/indicator/SP.DYN.LE00.IN.
World Bank. (2016b). GDP per capita, PPP. Retrieved from https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD

WTTW News. (2019). Chicago life expectancy gap driven by race, segregation, says researcher. Retrieved from https://news.wttw.com/2019/07/22/chicago-life-expectancy-gap-driven-race-segregation-says-researcher (This news story includes a chart of life expectancy by neighborhood.)