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Technical Report

Measuring Mortality in the *Wisconsin County Health Rankings*

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Introduction: In an effort to improve the Wisconsin County Health Rankings, various mortality measures are discussed, and an argument is provided for the use of years of potential life lost before 75 years (YPLL75) in the Rankings.

Methods: The methods used to measure and report mortality differ in their strengths and limitations. The effect of using various cutoff ages and different measures is shown by illustrating how counties change in rank based on the measure used.

Results: Although various other measures have certain advantages over years of potential life lost, the decision to use $YPLL_{75}$ in the Rankings is based on two main points: First, its focus on premature and preventable mortality, and second, rather than using the number of deaths to summarize mortality, YPLL is a measure of the number of years of life lost prior to an age to which everyone can be expected to survive.

Conclusion: The mortality measure known as years of potential life lost (YPLL) is the best single measure of mortality in communities. While YPLL does have its shortcomings, we have decided to continue using YPLL as our primary means of quantifying mortality in Wisconsin counties.

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Introduction

The *Wisconsin County Health Rankings*[1] captures the current health of the population of Wisconsin counties with a summary measure of health outcomes. This health outcome measure is composed of two elements: a health-related quality of life index (self-reported health) which is used to quantify the average morbidity of a population, and a mortality index (years of potential life lost [YPLL][2]). As we prepare to compile our fourth annual version of the *Rankings*, we are revisiting each component of the *Rankings* to ensure that they are based on the best available measures. We recently reported on our review of health-related quality of life measures,[3] and in this report, we present our findings regarding alternative summary measures of mortality.

Mortality can be quantified in various ways, with each measure having a distinct conceptual base and emphasis. Each measure has its strengths and shortcomings, and differs in several ways. Because there is no one best measure that captures all aspects of mortality, a judgment must be made based on which dimension of mortality is most useful for a particular application. For example, one way in which mortality measures differ is in their ease of interpretation. Since the *Rankings* are meant to be understood by the general population, ease of explanation becomes a particularly important criterion for selection of measures for inclusion. However, it also important for the *Rankings* to be methodologically sound.

A previous *Issue Brief* [4] provided an overview of the years of potential life lost measure. In this *Brief Report*, we will review other measures of mortality commonly used and discuss our rationale for preferring years of potential life lost as the measure of mortality in the *Rankings*. In addition, we will describe the other decisions that must be made regarding further details within the choice of measure itself such as the cutoff age, which in the *Rankings* is the years of potential life lost prior to age 75. The reasons for and consequences of choosing a particular cutoff age are not widely discussed in the literature, and so we will also discuss these reasons and show the effects of using different cutoff ages.

Overview of the Measures

As mentioned above, there are various ways to report mortality, including the crude death rate, age-specific death rates, age-adjusted death rates, years of potential life lost, and others. Here we discuss what each measure entails and how it is calculated.

Crude Death Rates. The minimalist approach to measuring mortality is to simply count the number of deaths in a population, divide this number by the total population, and report this number as the crude death rate. As is the case with most epidemiologic rates, the rate is reported as per 1,000 or per 100,000 people. While this is probably one of the easiest mortality measures to understand, the main problem with this measure is that the rates cannot be compared between different populations because the age distributions in the two populations may be different, leading to confounding in the measure. A more detailed explanation of this problem can be found elsewhere.[5]

Cause-Specific Mortality. Although most of the mortality measures discussed here aggregate deaths due to all causes into one category, sometimes it is useful to know the cause-specific death rates to assess the burden of a particular disease. By knowing the cause-specific mortality rate for a particular disease, this may also illuminate the morbidity caused by the disease, as a high death rate may reflect high prevalence of the disease in the population.

Age-Specific Mortality. To avoid incorrectly comparing two populations with different age distributions, it is possible to instead compare age-specific death rates. This method allows one to directly compare two populations regardless of different age distribution by comparing subsets of the population stratified by age group. The age-specific death rates are calculated for each age group, and these rates can then be appropriately compared. A common categorization of age groups is in widespread use through the Centers of Disease Control and Prevention (CDC) WONDER database, broken into categories such as < 1 year, 1-4 years, 5-9 years, 10-14 years, and so on.[6] While age-specific death rates are reliable and comprehensive, and are relatively easy to explain to the lay person, this method of reporting mortality involves reporting many numbers for each population, making it difficult to report this data in a concise manner.

Age-Adjusted Mortality. In order to allow comparisons across populations with different age distributions and summarize age-specific death rates succinctly, age-specific death rates can be summarized into an overall age-adjusted death rate. This is the traditional method used to account for confounding effects of differing age distributions in populations being compared. Age-adjusted mortality has the characteristic of capturing the broad distribution of age-specific mortality, so that all age groups are weighted according to the size of the age group in the standard population, making it possible to compare mortality

measures across different populations. The age-specific death rates, once adjusted to the standard population, can then be aggregated into an overall age-adjusted death rate. The resulting age-adjusted death rate is then interpreted as the death rate that would have occurred in a particular population if its age distribution was identical to that of the standard population. A common standard used in recent literature is the 2000 U.S. population, for example.

Years of Potential Life Lost (YPLL). The concept behind YPLL involves using the number of years of life (life-years) lost due to premature death defined by a standard cutoff age in a population to obtain a total sum of the life-years lost before 65, 75, or 85, for example. Calculating YPLL involves summing up the life-years lost based on this standard cutoff age. For example, if we define the cutoff age at 75 years ($YPLL_{75}$), a population with three deaths at ages 25, 40, and 70 would have a crude YPLL of

$(75-25) + (75 - 40) + (75 - 70) = 50 + 35 + 5 = 90$

or 90 years of potential life lost.

In its crude form, varying age distributions in different populations are not addressed explicitly in the basic calculation of YPLL. However, as with age-adjusted death rates, it is possible to calculate age-adjusted YPLL rates using a standard population to make the measure comparable between populations. This adjusted YPLL rate is sometimes called the rate of potential life lost (RPLL).[7,8] The *Wisconsin County Health Rankings* and others[9] do not distinguish between YPLL and RPLL and simply report YPLL as a rate based on a standard population. In order to compare rates between populations, it is necessary to age-adjust, unless the reason for comparing the rates is to determine the burden of mortality in a given population. In the *Rankings*, YPLL is an age-adjusted rate based on the direct method of standardization to the 2000 U.S. population.

Other Forms of YPLL. Although YPLL and age-adjusted death rates are the most commonly used measures, other measures have been proposed that take a different approach. The potential gains in life expectancy (PGLE) measure was created based on the idea that YPLL does not account for competing risks of death in a population by simply measuring the years of life lost corresponding to a specific age. The PGLE does take these competing risks into account, reflecting a more accurate measure of the actual risk of death in the population. This measure can be thought of as the "added years of life expectancy for the population if the deaths from that cause were removed or eliminated as a competing risk of death."[10]

An alternative YPLL measure that has been proposed is the cumulative rate of potential life lost (CRPLL).[6] This measure differs from YPLL in that instead of simply quantifying deaths that have already occurred, the CRPLL projects the rate of future mortality in a population. The CRPLL is essentially a marriage of traditional YPLL with the cumulative rate of death in a population, using the cumulative rate weighted to a standard population, and reporting the statistic as future years of potential life lost.

Life Expectancy. While all the other mortality measures discussed are ways of quantifying and presenting death rates in alternative ways, life expectancy can be thought of as an inverse measure of death, or a measure of how long a population is surviving on average. Measures of life expectancy are calculated based on historical data about deaths in a population and the ages at which these deaths occurred. Both the life expectancy at birth[11] and the active life expectancy, a measure of the expected years of life remaining at a particular age,[12] can be useful measures to compare between populations. Life expectancy at birth is not adjusted to account for differing age distributions in populations, but active life expectancy does allow one to determine the differences in subgroups of the underlying population. For example, a population with a very healthy elderly population will have a higher active life expectancy for that age group. Although one cannot determine the underlying causes of death from simply observing the life expectancy, the measure does present a broad, objective measure of population health.

The Use of Mortality Measures in Public Health Practice

United Health releases an annual publication called the State Health Rankings, which ranks the health of the 50 States.[13] In addition to using age-adjusted mortality for all ages as a total mortality measure, the State Health Rankings report YPLL as a measure of premature death, using 75 years as a cutoff age ($YPLL_{75}$). In addition to these overall measures, cardiovascular deaths, cancer deaths, and infant mortality are reported for each state, providing a thorough assessment of the mortality in the population. By reporting several measures of mortality, the State Health Rankings may be providing a more comprehensive picture of mortality than reporting one measure exclusively. (United Health combines these multiple measures of mortality along with a non-mortality outcome measure and a series of measures of the determinants of health to create its overall ranking of states' health.)

The World Health Organization (WHO) also employs a more comprehensive measure than simply age-adjusted mortality or YPLL. The preferred measure of the WHO is health-adjusted life expectancy (HALE), which not only measures the underlying mortality of a population, but accounts for non-fatal health outcomes as well. The WHO defines the HALE as the "average number of years that a person can expect to live in full health by taking into account years lived in less than full health due to disease and/or injury."[14]

The Centers for Disease Control and Prevention (CDC) has compiled a health promotion agenda for the nation, continuing a trend began in 1979 with the Surgeon General's Report.[15] Although the first goal of Healthy People 2010 is "to help individuals of all ages increase life expectancy *and* improve their quality of life," evaluation of progress focuses on specific objectives such as physical activity and tobacco use. While significant efforts are underway at the CDC toward measuring the second overarching goal (eliminating health disparities), [16] there has been no formal adoption of specific measures for evaluating progress towards the first goal.

As mentioned previously, the *Wisconsin County Health Rankings* report age-adjusted YPLL rates as a measure of mortality across Wisconsin counties. The only cause-specific death rates included are deaths due to motor vehicle crashes, but these are reported as health determinants and are not included in the health outcomes measure. In contrast to the United Health State Rankings, the *Wisconsin County Health Rankings* reports only a single measure of mortality, $YPLL_{75}$. This measure of premature mortality is combined with a measure of morbidity to create an overall health outcomes score upon which counties are ranked.

Methodological Issues in Using YPLL

As previously noted, in addition to the number of measures of mortality from which one can choose, there are also several methodological issues to consider in terms of how to calculate any particular measure. These issues include age standardization, the choice of age cutoff, how deaths at different ages are valued, whether to convert measures from rates to ranks, and whether or not to report one or several measures.

Age standardization. Age standardization is used to compare rates between populations; however, age standardization can be performed in two different ways. One method is to use direct age-adjustment, in which the age distribution in a population is transformed to the standard age distribution. One way to directly age-adjust is to multiply the age-specific death rates in the population being measured by the standard population distribution. The resulting number of deaths is summed up and divided by the total standard population to give the age-adjusted death rate.

An alternative method of age-adjusting is indirect age-adjustment. This method is typically used when the age-specific death rates are not known, or to study occupational mortality.[3] Indirect age-adjustment uses known age-specific death rates from another population, usually a reference population, to calculate what the expected number of deaths would be in the population under consideration. Using the age-specific death rates from the reference population, the expected number of deaths in the study population can then be calculated and summed together to give a total number of expected deaths, which can be directly compared to the observed deaths in the study population to give a standardized mortality ratio (SMR). The SMR is simply the observed number of deaths divided by the expected number of deaths. One limitation of indirect age-adjustment is that rates are adjusted to different populations, and thus cannot be compared.

Choice of age cutoff. Another issue that is not widely discussed is that of choosing a cutoff age. When reporting age-adjusted mortality, an age cutoff is often not used. Because the age-adjustment accounts for differences in the distribution of age groups in a population, the adjusted mortality measure is used to directly compare populations. However, as an alternative to reporting age-adjusted death rates for the entire age range, they can also be reported only for the population below some cutoff age, or the population less than 75 years of age, for example. Although a cutoff is optional for reporting age-adjusted death rates, in order to construct the measure, YPLL requires a cutoff age from which the years of life lost can subsequently be calculated. Common age cutoffs used for calculating YPLL include 65, 70, 75, 85, or life expectancy.

Traditionally, the age cutoff used for YPLL has been 65 years of age.[17] Because many people are now living longer lives, a cutoff at 65 may not capture all the relevant deaths occurring in a population. Given the current shift in age distribution with the aging baby boomer generation, this may become even more of a problem as more people are surviving into old age. Thus it is slowly becoming more common to report YPLL using a higher age limit, such as 70 or 75,[18] as is done in the *Wisconsin County Health Rankings*. In addition, while *upper* age limits can be used to focus on

premature mortality, *lower* age limits can also be used for specific purposes. For example, to report deaths for a specific cause such as breast cancer, it may be useful to set a lower age limit to limit those deaths to people who are at risk of developing the disease.

Although useful and perhaps less methodologically complex, using a set age cutoff is not the only option used in reporting YPLL. As previously discussed,[1] life expectancy at birth or the active life expectancy can be used as cutoff ages to calculate YPLL. While life expectancy at birth is similar to using a traditional age cutoff in that the cutoff is the same for all ages, using active life expectancy as an age cutoff takes into account the remaining years of life for a given individual. Table 1 shows the effect of cutoff age on YPLL.

Table 1. The Effect of Different Age Cutoffs on YPLL

	Age at Death	$YPLL_{65}$	$YPLL_{75}$	$YPLL_{LE}$*
Person A	25	40	50	53
Person B	50	15	25	33
Total		**65**	**75**	**86**

*$YPLL_{LE}$ represents the YPLL using the active life expectancy as an age cutoff. In the United States, the active life expectancy for a person aged 25 years is approximately 53 years of life remaining, and for a 50-year old, approximately 33 years of life.

Valuing life. The main difference between YPLL and age-adjusted death rates is that they represent different judgments on the value of life lost at a particular age. Conceptually, age-adjusted death rates treat each life lost equally, but using YPLL implies that lives lost at earlier age are valued more than lives lost at later ages. The inherent assumption that the lives of one age group are valued more than another may seem difficult to reconcile, but allows us to emphasize the significance of *premature* death in a single mortality measure.[7] Since most of the deaths in a population occur among the older age groups due to the natural aging process, having a measure emphasize premature deaths allows us to see past this "bias" in deaths occurring at older age.

Yet another alternative measure of YPLL is the valued years of potential life lost (VYPLL), which divides the life course into three different phases consisting of investment, production, and consumption.[9] This measure allows for different interpretations of mortality based on the life stage; for example, if infant mortality is emphasized by a health organization, one might focus on the investment segment of the measure, whereas an insurance company might want to focus more on the consumption segment to determine the relevant mortality for their purposes.

Single, multiple, or composite measures. As previously noted, some organizations choose to report multiple and sometimes overlapping measures of mortality, such as the State Health Rankings, while others, such as the *Wisconsin County Health Rankings*, report only one mortality measure. Still others, such as the WHO, choose to combine measures of mortality and health-related quality of life into a single summary measure. The *Wisconsin County Health Rankings* report on both mortality and health-related quality of life as separate measures but also combine them into a summary measure upon which counties are ranked. If and when measures are combined, an additional consideration is how to weight the various measures. In combining the two health outcomes measures in the *Wisconsin County Health Rankings*, each measure is given equal weight, whereas the State Health Rankings apply differential weights in combining measures.

Rates vs. Ranks. A final issue to consider in reporting mortality measures is whether or not to convert the rates into ranks. While both rates and ranks are reported in the *Wisconsin County Health Rankings*, clearly, the focus of the report is on how counties rank relative to each other. The decision to focus reporting on ranks is the subject of ongoing debate. Although we acknowledge that rankings are controversial, especially when there are limitations in the data, our experience has shown that ranking stimulates discussion and encourages action in public health stakeholders including policymakers and public health practitioners. While there are disadvantages to reporting ranks, in this case a strong advantage is that reporting ranks stimulates greater media interest. This increased interest offers a clear challenge to public health stakeholders and thus has the potential for a larger impact on the population health of Wisconsin.

Methodological Choices in the *Wisconsin County Health Rankings*

We now present results based on the consequences of using the particular age cutoff and the choice of measure for reporting mortality data in the *Wisconsin County Health Rankings*. In examining the impact of these choices, we focus our analysis on the effect on ranks rather than rates since, as

[1] See section on "Life Expectancy" in the "Overview of the Measures" section.

shown in Table 2, there is a very high correlation between the different rates.

Table 2. Pearson Correlations Between Alternative Measures of Mortality Rates for Wisconsin Counties, 1999-2002

	YPLL-65	YPLL-75	YPLL-85	AAM-75	OAAM
YPLL-65	1.000	0.999	0.990	0.918	0.807
YPLL-75	**0.999**	1.000	**0.995**	**0.933**	**0.825**
YPLL-85			1.000	0.962	0.865
AAM-75				1.000	0.924
OAMM					1.000

***** YPLL= Years of potential life lost, AAM = Age-Adjusted Mortality, OAAM = Overall Age-Adjusted Mortality

Cutoff age of 75 years. 75 years of age is used as the cutoff for calculating YPLL in the *Wisconsin County Health Rankings*. The impact of choosing 75 years as a cutoff, rather than 65 or 85 as is commonly done, is summarized in Table 3 and shows that increasing the age cutoff to 85 for the calculation of YPLL or decreasing it to 65 would have only a minimal impact on the ranks, with the counties changing only 2.0 or 2.0 ranks on average, respectively. In changing the age cutoff from 75 to 85, only seven counties would change more than five places in rank, while changing the age cutoff from 75 to 65 would also cause only seven counties to change more than five places in rank.

Table 3: Impact of Change in YPLL Age Cutoff

	$YPLL_{75}$ ↓ $YPLL_{85}$	$YPLL_{75}$ ↓ $YPLL_{65}$	$YPLL_{75}$ ↓ AAM_{75}	$YPLL_{75}$ ↓ OAAM
Counties With No Change in Rank	18	15	8	4
Average County Change in Rank	2.0	2.2	7.3	11.1

***** YPLL= Years of potential life lost, AAM = Age-Adjusted Mortality, OAAM = Overall Age-Adjusted Mortality

YPLL vs. Age-Adjusted Mortality. Table 3 also presents the results of our analysis of the impact of a change from reporting ranks based on $YPLL_{75}$ to ranks based on age-adjusted mortality less than 75 years. We also show the impact of a change to ranks based on overall age-adjusted mortality rates. Clearly, a change in methodology from ranking based on YPLL to age-adjusted mortality rates would lead to some significant changes in counties' ranks. On average, each county's rank would change by 11 places using the overall age-adjusted mortality approach. In fact, one county's rank would improve its rank 53 places (from 67 to 14) with a change from YPLL to age-adjusted mortality rate due to this county having particularly high mortality among the younger age groups and low mortality among the elderly relative to other counties. Overall, 46 counties would change more than five places in rank.

The impact of a change from YPLL to age-adjusted mortality rates would be lessened if the mortality rates were limited to mortality for those under age 75 years. However, each county's rank would, on average, change seven places even with the age cutoff. The single largest change in rank would be 30 places (from 8 to 38). Overall, 34 counties would change more than five places in rank.

Comment

Due to the provocative nature of ranking, it is important that the measure used to rank counties be well-justified so that our audience understands why some counties rank worse than others. The United Health Foundation uses multiple measures of mortality in its ranking of states. These measures, that include overall age-adjusted mortality, YPLL, infant mortality, and cause-specific mortality, are all

publicly available. United Health combines these multiple measures of mortality with a single measure of health-related quality of life to rank states by health outcome, effectively weighting mortality more heavily than health-related quality of life. In contrast, the *Wisconsin County Health Rankings* uses a single measure of mortality, $YPLL_{75}$, combined with a single measure of health-related quality of life to create its health outcomes rankings, implying that mortality and morbidity have equal weighting.

The selection of YPLL as the single measure of mortality is not without controversy. It is possible that use of the overall age-adjusted mortality rate might present a more representative and valid measure of all mortality in counties. However, the decision to report a measure of *premature*, rather than overall mortality underlies the intent of the *Wisconsin County Health Rankings* to focus attention on the type of mortality that could have potentially been prevented. As noted earlier, including all mortality and not just premature mortality in the *Wisconsin County Health Rankings* would have a significant impact on counties' ranks and might draw attention to areas with higher mortality rates among the oldest segment of the population, where there may be little that can be done to change chronic health problems that have been developing over many years.

YPLL is a reliable measure of premature mortality, but the decision to exclude other measures of mortality from the *Wisconsin County Health Rankings* implies that when combined with the measure of health-related quality of life, $YPLL_{75}$ is an accurate enough measure to comprehensively assess the health outcomes of all Wisconsin counties. In contrast, the State Health Rankings includes measures such as infant mortality and mortality by causes of death such as cancer, cardiovascular disease, or injury. It could be argued that public health practitioners might find these rates easier to change, allowing them to focus in on reducing specific types of mortality, for example, rather than trying to reduce mortality as a whole. However, the *Wisconsin County Health Rankings* are intended to draw attention to the *current* overall health of entire counties (via the health outcomes ranks) and then specifically to challenge practitioners to examine the determinants of health to identify specific areas where improvements could be made to improve *future* health. The determinants of health provide the opportunity for more focused attention in specific areas, such as injury prevention or improvements in individual health behaviors.

The final decision that was made in the selection of $YPLL_{75}$ as the sole measure of mortality in the *Rankings* was to calculate years of potential life lost prior to age 75 – rather than age 65 or age 85 as is sometimes reported. As noted earlier, the first uses of the YPLL indicator did apply an age cutoff of 65. Perhaps not coincidentally, some who report YPLL refer to the measure as years of "productive" life lost rather than years of "potential" life lost. If the intent was purely to focus on loss of productive years, then the appropriate age cutoffs might include a lower and an upper end, for example 18 and 65. However, in the *Wisconsin County Health Rankings*, we are striving to measure loss of "potential" years of life. In this instance, then, the age cutoff of 75 serves as a proxy for life expectancy. Since the current life expectancy in Wisconsin for men is 76.4, 81.5 for women, and overall is 79.0, [19] $YPLL_{75}$ is a better cutoff than $YPLL_{85}$ as a measure of *premature* mortality, since any deaths prior to 75 have occurred prior to the life expectancy for both men and women; Thus, a cutoff at 75 ensures that we are counting deaths that are truly premature. In addition, because we want to capture *all* the deaths occurring prematurely, no lower age limit is used.

As noted earlier, YPLL can actually be calculated using active life expectancy as the cutoff; the years of potential life lost are calculated as the difference between the age at death and the years of remaining life expectancy at the age of death. Although this approach using active life expectancy may seem more intuitive and accurate, the argument here is based on a fundamental criterion for selection of measures for public reporting – the measure should not only be reliable but it should also be easily understandable. The concept of years of potential life lost is not particularly intuitive itself, and adding the continuously increasing target of life expectancy as the basis for the age cutoff complicates its interpretation even further.

Finally, although we have presented arguments in support of the use of a sole measure of premature mortality as one of the two components of our measure of health outcomes at the county level, it is important to make explicit the underlying value judgment that is implied by our selection of $YPLL_{75}$ as our measure of premature mortality. We could instead have based the *Wisconsin County Health Rankings* on the age-adjusted mortality rate for those under age 75 since this too represents a measure of premature mortality, or the deaths prior to the attainment of life expectancy. The age-adjusted mortality rate with an age cutoff is very similar to YPLL except for the fact that each *death* prior to the age cutoff is counted equally, whereas in calculating YPLL, each *year of life lost* is counted equally. Alternatively stated, this means that age-adjusted mortality rates give less weight to a year of life lost whereas YPLL gives less weight to a single

death, or the choice of either measure involves a valuation of years lost versus deaths. We will continue to report health outcomes based on YPLL, recognizing that we are weighting each year of potential life lost with equal importance. We recognize that it is difficult to select one mortality measure, and while all mortality measures have their strengths and limitations, YPLL has the best balance of characteristics for our purposes in the *Wisconsin County Health Rankings*.

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