Morbidity dispersion and compression

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Abstract

The common measure of morbidity compression is insensitive to a variety of shape-related aspects of late-life morbidity prevalence. We offer a simple dispersion measure to account for how much a given morbidity condition is concentrated in at the very end of life. We estimate morbidity compression and dispersion for a set of cohorts in the US Health and Retirement Study and the English Longitudinal Study of Ageing. We argue that all else equal, it is preferable for morbidity to be concentrated rather than dispersed, and this is why the measure is worth calculating alongside compression when data permits.

The concept of morbidity compression is typically instrumentalized by taking a ratio of expected years lived in poor health, e^U to total expected years lived, e^T. It is therefore a proportion derived from two means, and it is usually conditioned on survival to some age. If after some time this proportion decreases, then morbidity is said to have compressed. This is intuitive because on average a smaller proportion of life is spent in poor health, and therefore morbidity has been squeezed into a relatively smaller fraction of life.

Various changes in morbidity patterns and longevity distributions can produce a change in compression, but this single measure cannot separate them. Specifically, and for the case of late-life morbidity, the measure of morbidity compression does not indicate to what extent morbidity prevalence is concentrated in the final years of life. All else equal, we suppose that individual wellbeing and equality are both maximized for a given level of morbidity and longevity if morbidity prevalence is concentrated in a narrow set of years at the very end of life. We therefore propose a direct measure of late-life morbidity dispersion that is both intuitive and clear to interpret: how close to the moment of death a given morbidity is concentrated, calculated as the prevalence-weighted average time-to-death, or dispersion, $\mathbb{D}$.

Definitions

Compression, $\mathbb{C}$, is here defined as:

$$\mathbb{C}(a) = 1 - \frac{e^U(a)}{e^T(a)} \quad , \tag{1}$$

where

$$e^T(a) = \frac{1}{\ell(a)} \int_a^\omega \ell(x)\, \mathrm{d}x \tag{2}$$

$$e^U(a) = \frac{1}{\ell(a)} \int_a^\omega \ell(x)\pi(x)\, \mathrm{d}x \quad . \tag{3}$$

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Here, $\mathbb{C}$ is conditional on survival to age a, because we are interested in old-age morbidity, so we typically choose a to be something like 65 or 70. $l(a)$ is lifetable survivorship, and $\pi(a)$ is the age-specific prevalence of morbidity. We take the complement of the ratio so that *more* compressed corresponds to a higher value in $\mathbb{C}$.

$\mathbb{D}$, on the other hand measures the spread of morbidity at the end of life. Assuming for a moment perfect equality of longevity, it can be defined as:

$$\mathbb{D}(a) = \frac{\int_a^\omega (\omega - x)\pi(x)\,\mathrm{d}x}{\int_a^\omega \pi(x)\,\mathrm{d}x} \qquad . \tag{4}$$

Slightly more realistically, since lives are of different lengths, we can still keep things simple by letting longevity vary, but assuming the same time-to-death trajectory of morbidity, $\pi^\star(y)$, where y denotes years left to live:

$$\mathbb{D}(a) = \frac{\int_0^{\omega-a} y\pi^\star(y)\,\mathrm{d}y}{\int_0^{\omega-a} \pi^\star(y)\,\mathrm{d}y} \tag{5}$$

If we want to allow both lifespans and the time-to-death trajectories to vary by lifespan, then define a morbidity prevalence function that varies by both age and time-to-death, $\pi^\star(a, y)$ such as the cohort patterns described by Riffe, T. et al. (2016). In this case prevalence is weighted by the deaths distribution, usually the lifetable deaths distribution, $f(a)$, preferably but not necessarily from the cohort perspective.

Morbidity and longevity scenarios

Several morbidity and longevity scenarios can produce a given change in dispersion. For example, morbidity may change its level, onset may postpone, or lengthening life may stretch morbidity into ever higher ages. These aspects of morbidity are all illustrated in the morbidity diagrams of James Fries (e.g., Fries 2003), but such patterns are not directly detectable or separable using the measure of morbidity compression. Another simple scenario is that the morbidity prevalence leading up to each age at death remains the same, but the lifespan distribution simply changes (van Raalte and Riffe 2016). Such aspects characterize late-life morbidity more completely, and provide better answers to the question of whether there is a survival-morbidity tradeoff.

Table 1 illustrates a set of Fries-like scenarios that is instructive to walk through. Assume that for a given scenario it is either the case that all lives are of the same length, or that lives of different lengths all have the same average end-of-life morbidity prevlence pattern. The length of the lifeline in each scenario is proportional to (conditional) remaining lifespan, while the area shaded in grey is the average morbidity prevalence pattern. Scenarios A through E all have a length of life equal to the baseline scenario, while F through H have longer lives. Scenarios A, B, F, and H have morbidity triangles of equal area to the baseline (equal e^U). Scenarios E and G have morbidity triangles that are larger than baseline (higher e^U). Scenarios C and D have morbidity triangles drawn smaller than baseline (lower e^U). Scenarios A, D, F, and H have postponed morbidity onset.

Scenarios A through H combine in different ways to produce different outcomes for $\mathbb{C}$ and $\mathbb{D}$, and in many cases these two measures do not change in the same direction. Clearly the best scenario here is for baseline to change to H, while the worst scenarios are either E or G (higher morbidity prevalence with no increase in lifespan, or else increases in both). We now discuss the scenarios in order.

Scenario A yields the same morbidity compression, but lower diserpersion. Morbidity amounts to the same total, but is more concetrated at the end of life. Scenario B is the opposite: compression does not change, but morbidity extends into lower ages and ultimately *may* affect fewer individuals. In scenario C each value of $\pi(a)$ is halved, increasing $\mathbb{C}$. However, the underlying shape does not change, and $\mathbb{D}$ therefore stays the same. In scenario D morbidity onset is later, but the ultimate prevalence at death is the same. The volume decreases, and $\mathbb{C}$ therefore increases, but the shape also becomes more compact, which decreases $\mathbb{D}$. In scenario E $\pi(a)$ is doubled, thereby decreasing $\mathbb{C}$. Since the underlying shape does not change, $\mathbb{D}$ remains unchanged. In scenerio F morbidity is exactly the same, but onset is postponed, and life extended an equal amount. This acts to decrease $\mathbb{C}$, but it does not

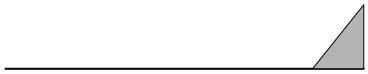
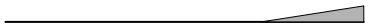
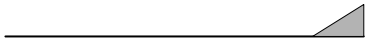
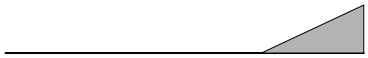
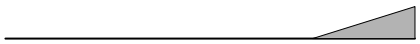
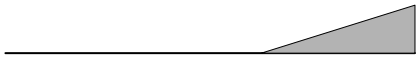
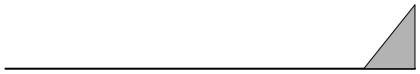
Scenario		e^U	e^T	$\mathbb{C}$	$\mathbb{D}$
Base					
A		=	=	=	↓
B		=	=	=	↑
C		↓	=	↓	=
D		↓	=	↓	↓
E		↑	=	↑	=
F		=	↑	↓	=
G		↑	↑	↑	↑
H		=	↑	↓	↓

Table 1: A variety of morbidity and longevity scenarios that illustrate how compression differs from concentration. Arrows and equalities are all with respect to the baseline scenario.

affect $\mathbb{D}$. In scenario G life extends, and the prevalence pattern keeps increasing at the same pace from the baseline scenario (Fries' stretching scenario), thereby increasing both $\mathbb{C}$ and $\mathbb{D}$. H is the golden scenario where increasing longevity is matched with a more compact but equally voluminous morbidity pattern, which acts to decrease both $\mathbb{C}$ and $\mathbb{D}$.

We have provided scenarios in which compression and dispersion respond in the same way or differently to various longevity and morbidity scenarios. We have not shown how these different scenarios would produce different responses in $\mathbb{C}$ and $\mathbb{D}$ under changes in the shape or location of the lifespan distribution, nor more involved interaction scenarios. These things may be discussed in the final paper, or we might just make some assumptions to keep it simple.

Data and methods

We will do some empirical demonstrations to compare these two indicators for a small set of health conditions that is to be decided. The health conditions will be selected based on both substantive and illustrative criteria. Data will come from the RAND version of the US Health and Retirement Study (HRS 2013) and the English Longitudinal Study of Ageing (Steptoe et al. 2012). Data processing will be set up similarly to Riffe, T. et al. (2016), and smoothed prevalences by age and time-to-death will be derived using natural splines over age, time-to-death, and birth cohort, in a general additive

framework. We will then report trends in compression versus dispersion for England and the US, and further explain why dispersion is a good measure to complement compression.

References

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