How have disease prevalence and mortality after diagnosis contributed to changes in life expectancy at the national level?

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Abstract

For many diseases, survival has improved at a faster pace than the improvement in incidence. This led to increasing prevalence proportions, and a changing population composition. It is unclear how improved survival and prevalence proportions contributed to life expectancy change at the national level. Using Swedish register data, we decompose the change in remaining life expectancy at age 60 between 1994 and 2016 into the contributions of changing mortality after diagnosis and changing disease prevalence. We perform separate decompositions for myocardial infarction, stroke, hip fractures as well as colon and breast cancer, distinguishing also between recent patients and long-term survivors. Improved survival after diagnosis contributed to life expectancy increase for all diseases analyzed, and most strongly for stroke and myocardial infarction. However, combined evidence across the analyzed disease suggests that the overall compositional change slowed the increase of life expectancy. This dynamic might be considered "cost" of saving lives.

Introduction

A key factor for mortality improvements at older ages are the advancements in disease prevention. In the past, survival after diagnosis improved at a faster pace than disease incidence. The imbalance has led to growing prevalence proportions of many diseases ,and consequently, a changing composition of the total population.[1] Moreover, although the prognosis for patients of various disease has improved, excess mortality if compared to the disease-free group often remains as a persistent consequence.

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Both increasing prevalence proportion and excess mortality of individuals with disease history have direct consequences for life expectancy change at the national level. The reduction of excess mortality of individuals with disease history contributes directly to increasing life expectancy, while an increasing prevalence proportion can counteract these improvements because of an increasing importance of their mortality levels for total population mortality. It could be speculate if this mechanism may already be partially responsible for the recently observed slowdown in life expectancy increases in many low mortality countries.[2] Even if this is not the case, ongoing population aging will likely generate higher prevalence proportions in the future, making the interplay of mortality after diagnosis and the prevalence proportions even more relevant for life expectancy changes at the national level. This study aims to unravel these dynamics by asking *how has improved survival for different diseases contributed to gains in general life expectancy, and have these gains been counteracted by increasing prevalence proportions of the respective disease?*

Methods

This study is based on data from several Swedish population registers, incorporating all men and women over the age of 60 residing in Sweden at any point during 1994 and 2016. We choose to study myocardial infarction, stroke, hip fracture as well as colon and breast cancer (only females). These diseases are among the most common at older ages, and they cover a "broad disease panorama", meaning that the diseases have different risk factors, affect different kinds of people and have different prognoses.

To capture the difference between the acute phase and the long-term consequences of the disease , we stratified the total population for each disease separately into three subpopulations. These were the recent and distant cases as well as the disease-free population. For myocardial infarction, hip fracture and stroke, all diagnosis that occurred in the last three years prior to the calendar year are defined as recent cases. For breast and colon cancer, recent cases include all individuals diagnosed within the last five years prior to the calendar year. Distant cases are encompassing all cases that are further past. We conduct this split for each disease separately, and therefore, do not account for multi-morbidity.

Subpopulations with a disease history are linked by two factors to the mortality of the total population: the subpopulation-specific mortality (I) and the share of the subpopulation in the total population (II). By stratifying the total population by individual disease history, subpopulation-specific mortality can be interpreted as mortality after diagnosis, whereas the proportion of the subpopulation can be understood as age-specific prevalence proportion. Using a general decomposition algorithm,[3] this allows us to estimate the contributions

of changing mortality after diagnosis and changing prevalence proportion to the change in life expectancy between 1994 and 2016. We preformed this decomposition for each disease separately.

Preliminary results

During the observation period, remaining life expectancy at age 60 for females increased by around 1·93 years. The top panel of Figure 1 shows the total contribution of the different subpopulations with disease history to this improvement in life expectancy. The middle panel depicts the decomposition results at one more level of stratification by separating additionally into the contributions of recent (orange) and distant (blue) cases. The lower panel shows the results for further stratifying also into the contributions of changing mortality and changing prevalence proportion. Note the contribution of the disease-free populations is included in the appendix. The y-axis depicts the contribution in years.

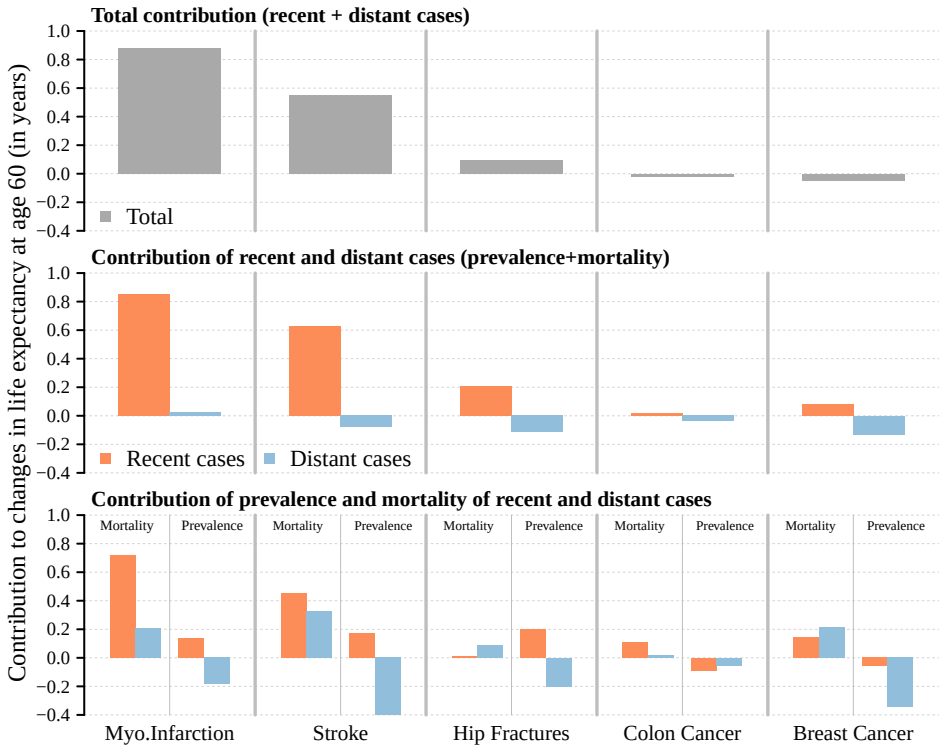

Figure 1: Decomposition of life expectancy at age 60 between 1994 and 2016 by several subpopulations with history of diseases, Sweden, females. *Life expectancy at age 60 is defined as the average person-years lived between ages 60 to 104. The respective contributions are the sum across the respective age-specific contributions. Data: Swedish National Patient Register and Swedish National Cancer Register. Own calculations.*

In the most coarse-grained setting neither stratifying for timing of diagnosis nor for

prevalence or mortality after diagnosis, one could conclude that progress has been made for myocardial infarction, stroke and on a much lower scale also for hip fractures, while non to even slightly receding progress could be attested for breast and colon cancer. This finding may appear contradictory to existing evidence about improved cancer survival.[4] However, stratifying for time since diagnose proposed already first explanations for the overall contributions. The decomposition showed that the slightly negative contributions of both types of cancer to the overall life expectancy change result from counteracting dynamics of the recently diagnosed and the long-term survivors. These patterns suggest that their has been indeed progress for both cancer types and also for the other diseases but only for patients with a recent diagnosis. In opposite, for long-term survivors of both cancer types but also of stroke and hip fractures, these pattern would suggest deteriorating progress over time, while the progress of myocardial infarction cases stalled. From a public health perspective, does this mean that medical advancements ensured only improvements for short-term survival?

Stratifying additionally for the contribution of changes in the prevalence proportion and mortality after diagnosis clearly denies this. Survival after diagnosis has improved for all diseases analyzed and for both recent and distant cases. As a consequence, the negative to virtually non-existent contributions observed at more coarse levels of stratification come from changes in the prevalence proportion. More specifically, particularly rising prevalence proportions of distant cases are responsible for the negative impact.

Table 1 summarizes the total contributions of the respective components on the change of remaining life expectancy. The percentage given in brackets depicts the relative impact on the total change between 1994 and 2016. As already visible in the bar charts, improved mortality after being diagnosed with particularly stroke, myocardial infarction and breast cancer have played an important role for the increase in the remaining life years. For instance, almost half of the total change for males and females can be attributed to improved survival after being diagnosed with a myocardial infarction.

To gather the impact of changes in the population composition on the total change of life expectancy, the subpopulation-specific contributions must be interpreted in conjunction to each other due to their interrelation. If this number is positive the composition has changed in favor of life expectancy increase, while a negative value suggest that changes in the composition prevented even stronger increases in life expectancy.

The effect of the changing population composition varies across disease. By stratifying for myocardial infarction, the compositional changes contributed around 1% for females and 5% for males to the total increase of life expectancy between 1994 and 2016. In op-

Table 1: Component- and disease-specific contributions to the change in remaining life expectancy at age 60 in years, males and females, 1994 and 2016, Sweden. *Life expectancy at age 60 is defined as the average person-years lived between ages 60 to 104. Data: Swedish National Patient Register and Swedish National Cancer Register. Own calculations.*

		Changing mortality		Changing
Disease	Sex	after diagnosis	disease-free pop.	population composition
Myo. infarction	F	0.93 [48.05%]	0.97 [50.51%]	0.03 [1.44%]
	M	1.61 [48.5%]	1.56 [46.93%]	0.15 [4.58%]
Stroke	F	0.78 [39.94%]	1.27 [65.42%]	-0.1 [-5.36%]
	M	0.96 [28.42%]	2.54 [75.47%]	-0.13 [-3.89%]
Hip fracture	F	0.09 [4.76%]	1.82 [93.56%]	0.03 [1.68%]
	M	0.15 [4.43%]	3.26 [96.33%]	-0.03 [-0.76%]
Colon cancer	F	0.13 [6.55%]	1.88 [97.41%]	-0.08 [-3.96%]
	M	0.13 [3.96%]	3.32 [98.29%]	-0.08 [-2.25%]
Brest cancer	F	0.36 [18.43%]	1.72 [89.32%]	-0.15 [-7.75%]

posite, compositional changes after stratifying for stroke, breast or colon cancer prevented further life expectancy increases, and thus, potentially slowed the overall the increase of the average remaining life years at age 60.

Preliminary conclusion

Although patients of the different diseases still reveal excess mortality, our study confirms the positive development of mortality after diagnosis. This underpins the central importance of survival after diagnosis as driver of life expectancy increase at the national level. However, the improved prospects after diagnosis does not always pay-off. With increasing disease prevalence, excess mortality of subpopulations with a disease history gain more impact on total population mortality. This diminishes, as in the case of stroke, or completely off-sets, as in the case of breast cancer, the achieved mortality improvements. Although only assessed for Sweden, the dynamics are largely applicable for populations, whose disease-spectrum is dominated by non-communicable and chronic diseases. With population aging going forward, this topic will become even more important in the future.

This analysis is among the first that highlights the composition and mortality dynamics within the total population that come into action if successful disease prevention is taking place. Previous research most often used causes-of-death or changes in age-specific mortal-

ity to grasp the effect of health dynamics on longevity change.[5,6] Instead, we use diagnosis to capture such dynamics, which actually refers to the disease progression during lifetime, and thus, to the process which may or may not generate longer individual lifespans over time.

The paradoxical relationship between prevalence and longevity increases on the national level points also to a potential "failure of success". Although a consequence of successful medical interventions, the increasing share of individuals with a disease history could be regarded as failure for extending average longevity. It could also be argued that this development is the cost of saving lives.

The paradoxical relationship between prevalence and longevity change motivate also a critical review of life expectancy as measure for evaluating health policies. This or similar measures will overlook the progress that has been made by the various subpopulations with disease history. Alternatives should rely on approaches that are less sensitive to population composition, or should at least acknowledge potential opposing dynamics.

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