# Before or after Diagnosis? Comparing Improvements in Disease Incidence and Disease Survival across Major Diseases in Sweden

Anna-Kathleen Piereth (PhD Student)[1,2], Katharina Schmidt-Mende[3,4], Karin Modig[2], Marcus Ebeling[1,2,5]

1 Max Planck Institute for Demographic Research, Rostock, Germany

2 Karolinska Institutet, Unit of Epidemiology, Stockholm, Sweden

3 Academic Primary Health Care Centre, Stockholm, Sweden

4 Division of Family Medicine and Primary Care, Department of Neurobiology, Care Sciences and Society, Karolinska Institutet, Huddinge, Sweden

5 Max Planck – University of Helsinki Center for Social Inequalities in Population Health (MaxHel Center)

## Abstract

Medical progress is currently one of the most important drivers of population change. Primary prevention prevents the onset of diseases, resulting in fewer diseases (declining incidence rates). Secondary and tertiary prevention reduce the impact of diseases, increasing life years with the disease (improved disease survival). It is unclear which of these two forces experienced greater improvements and how this has shaped the population composition. This is the first study to investigate the dynamics of incidence and survival across several major diseases, and to examine whether their interplay leads to rising or falling disease prevalence. Drawing on Swedish register data including 57 birth cohorts of the total population, we traced disease events of myocardial infarction, stroke, hip fracture, and cancer over the last three decades for the ages 60 to 90. We analysed incidence rates, one- and five-year survival and compared their changes across cohorts.

Preliminary results show that the decreases in incidence were larger than the increases in survival, except for cancer, where only survival improved and incidences rose. The prevalence of myocardial infarction, stroke and hip fracture declined, whereas the prevalence of cancer increased over time. The decreasing prevalences of acute conditions stand in contrast to the rise in multimorbidity. The results raise questions about how disease burden is increasingly characterised by an accumulation of milder conditions. Despite Sweden's relatively exemplary performance in managing modifiable risk factors, cancer has emerged as an important condition shaping the disease panorama in a low-mortality population, highlighting the disease-specific patterns of medical progress.

## Introduction

Medical progress is currently one of the most important drivers of population change, drastically fuelling the opportunities for disease prevention. Disease prevention has advanced in all areas, spanning from interventions that stop illnesses before they start (primary prevention) to strategies aiming at the early detection of diseases (secondary prevention) or adequate treatment (tertiary prevention) of existing conditions. Preventive efforts change not only the health characteristics and demographics of the subpopulation of patients, but also those of the general population.[1] While effective primary prevention results in declining incidence, effective secondary and tertiary disease prevention lead to longer survival with the disease. Comparing changes in incidence and survival across different diseases offers important insights into the dynamics of population health and life expectancy improvements, beyond causes of death. In an era of multimorbidity rising worldwide[2,3], surprisingly little is known about how the observed prevalences are shaped by dynamics in incidence and survival. This applies especially to higher age groups, where large proportions of individuals already have two or more coexisting conditions and are likely to accumulate even more diseases over their remaining lifespan.[4,5]

This is the first study to investigate incidence-survival dynamics and their impact on prevalence across several major diseases. We analysed disease events of different aetiologies (myocardial infarction, stroke, hip fracture, and cancer) occurring at ages 60 to 90, drawing on a linkage of Swedish register data which covers the entire Swedish population. We followed 57 adjacent birth cohorts over the last three decades to derive incidence rates, one- and five-year survival for the considered diseases. Furthermore, we compare the changes in incidence and survival across birth cohorts at every age at diagnosis. Similar to the other Nordic countries, Sweden has been an early and systematic adopter of preventive innovations, making it a relevant case study.[6] By taking a multi-disease approach, we aim at providing deeper insights into the changes in disease burden at the population level.

## Data and Methods

Information was gained from a linkage of several Swedish registers: The population was identified from the Total Population Register and the date and causes of death were retrieved from the Cause of Death Register (CDR). Disease diagnoses were obtained from the National Patient Register (NPR) and the National Cancer Register.[7,8] Cases of MI, stroke and hip fracture were identified by using either the primary diagnosis code in the NPR or the underlying or contributing cause of death code in the CDR (MI: 410 (ICD-

9), I21-22 (ICD-10); stroke: 430-434, 436 (ICD-9), I60-I64 (ICD-10); hip fracture: 820 (ICD-9), S72.0-S72.2 (ICD-10)). Malignant cancer cases were identified by combining the cancer diagnosis from the Cancer Register with hospital admissions due to a malignant cancer diagnosis according to the NPR and the causes of death (underlying or contributing) from the CDR (any malignant cancer: 140–209 (ICD-7), 140–209 (ICD-9), C00-C95 (ICD-10)). All data was available up to 31 December 2022, except for the Cancer Register data, which was available up to 31 December 2021. This data covers all women and men that lived in Sweden at any point in time between 1987 and 2021 or rather 2022. Our analysis includes the cohorts born in 1904 to 1960 which allowed us to cover the ages (at diagnosis) 60 to 90.

To identify incident cases of MI, stroke and hip fracture, we applied a seven year wash out period at start of the NPR in 1987 and then used a continuous 7-year wash out over the follow-up period.[9,10] For cancer, we used a five-year wash out period. Information on incident cases could be derived from 1994 (MI, stroke, hip fracture) or rather from 1992 (cancer) onwards. Sex-, age-at-diagnosis-, and birth-cohort-specific incidence rates of first events of MI, stroke, hip fracture and malignant cancer were calculated as the number of incident cases at each age and birth cohort divided by the person-years at risk. We further calculated the one- and five-year survival for incident cases with a sufficiently long follow-up period at every age and sex by birth cohort as the proportion of MI, stroke, hip fracture or rather cancer cases that were alive one year or rather five years after the event date.[11]

## Preliminary results

Figure 1 shows the incidence rate, one-, and five-year survival proportion for MI, stroke, hip fracture, and cancer at diagnosis ages of 60 to 90 in men, for the birth cohorts of 1910, 1920, 1930, 1940, and 1950. It is evident that incidence rates typically increased with age at diagnosis, whereas survival proportions declined with age at diagnosis.

According to the upper panel, the age-specific incidence rates for MI improved considerably across birth cohorts. That is, younger birth cohorts showed lower incidence rates at the same ages. For example, the incidence rate at age 75 decreased from 22 cases per 1,000 person-years (PY) in cohort 1920 to 10 cases per 1,000 PY in cohort 1940, which implies more than a halving in incidence during a 20-year period. There were also remarkable decreases in stroke incidence rates over time. However, relative improvements between cohorts were slightly smaller compared to MI. Unlike with MI and stroke, there were only minimal, if any, improvements in hip fracture incidence across cohorts. Men between the ages of 60 and

70 were found to have particularly stagnant incidence rates. Notably, rates of cancer incidence were the only ones that showed slight increases over time. For instance, at age 65, cancer incidence in men rose from 13 cases per 1,000 PY in cohort 1930 to 18 cases per 1,000 PY in cohort 1950 (+38%). Among the diseases investigated, cancer had the highest incidence rates at every age.

When it comes to survival dynamics, there were remarkable improvements across birth cohorts in the one-year survival proportions of men who experienced an MI, as illustrated in the middle panel. In other words, younger cohorts exhibited higher survival proportions at the same ages. For example, 80% of men born in 1950 who had an MI at age 70 survived for at least one year after experiencing the event. This implies an improvement in one-year survival by 16 percentage points, or rather 25%, compared to the 1930 birth cohort, of which only 64% survived for at least one year after having the MI at age 70. Compared to MI, the one-year survival proportions of individuals experiencing a stroke or hip fracture increased to a much smaller extent over time. However, in the age range of 60 to 70, there seemed to be even a stagnation (stroke) or decline (hip fracture) in one-year survival. With regard to cancer, there were considerable improvements in one-year survival across cohorts, which were especially pronounced at the ages 60 to 80.

The patterns of five-year survival proportions in men, as shown in the bottom panel, were mainly similar to those described for one-year survival proportions. The five-year survival for any disease was typically lower than the one-year survival. However, improvements in five-year survival across cohorts were greater than those observed for one-year survival. For instance, while the five-year survival for men diagnosed with cancer at age 70 increased by 9 percentage points between the 1930 and 1940 cohorts, the improvement in one-year survival was only 3 percentage points.

Women exhibited incidence and survival trends that were largely similar to those observed in men (not shown here for the sake of space). However, age-specific incidence rates for women were usually lower than for men, except for hip fractures, where the incidence rates were higher for women. In contrast, women experienced greater improvements in hip fracture incidence and larger increases in cancer incidence over time. In terms of survival, women generally had a slightly better survival prognosis after disease diagnosis than men. For hip fracture, one- and five-year survival was even remarkably higher but improved less across cohorts. Sensitivity analyses reveal that the survival proportions of both women and men who had experienced an MI, stroke, hip fracture or cancer at any age were significantly lower than those observed in the general Swedish population.

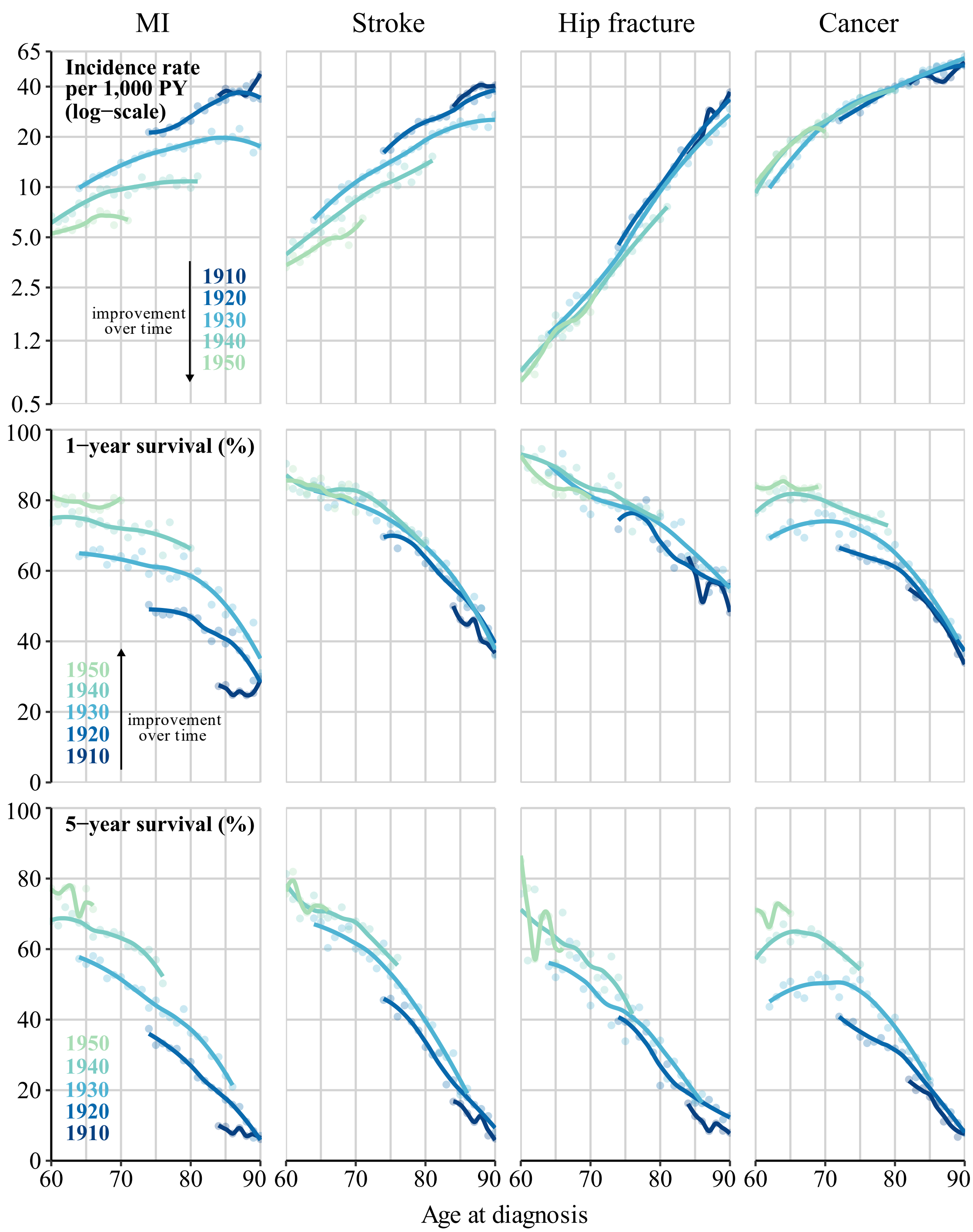


**Figure 1**: Age-specific incidence rates, one- and five-year survival proportions of myocardial infarction, stroke, hip fracture, and cancer at diagnosis ages of 60 to 90 in men born in 1910, 1920, 1930, 1940, and 1950, Sweden. Note: solid lines represent the smoothed trends (locally estimated scatterplot smoothing (LOESS) with a span of 0.75), while points show the observed values.

## Outlook

In further analysis, we will derive and compare relative changes in incidence and survival across birth cohorts by computing age-specific rates of change. Moreover, we will determine the prevalence of MI, stroke, hip fracture and cancer by sex and birth cohort for the ages 70, 80, and 90. The prevalence calculations will be based on the incident cases that a cohort experienced within 10-year age ranges (60-69, 70-79, 80-89) and survived until the end of this age range (69, 79, 89). To adjust for influences of general survival improvements across cohorts, we plan to additionally standardize the prevalence proportions by taking the life table of the youngest observed cohort as the standard.

Preliminary results following this analysis strategy show that the average relative cohort-to-cohort improvements in incidence were consistently larger than those in one- and five-year survival for MI, stroke and hip fracture, both in women and men. However, the magnitude of changes varied across the diseases, with incidence and survival improvements in MI being greater than in stroke and hip fracture. With regard to cancer, a different pattern was observed. Both one- and five-year survival improved more than incidence rates which were increasing at all ages across birth cohorts. As a consequence, the age-specific prevalences of MI, stroke and hip fracture declined with younger birth cohorts, whereas the age-specific prevalences of cancer increased with younger birth cohorts.

Our results reveal that the success in the areas of disease prevention differed between major diseases in Sweden. For MI, stroke, and hip fracture, all types of prevention turned out to be effective, with successes in primary prevention being the strongest force. For cancer, achievements were mainly made in the area of tertiary prevention (i.e., treatment of cancer patients), which enabled a longer survival with the disease. However, the increasing incidence rates of cancer might be explained, on the one hand, by enhanced secondary preventive measures (screening), resulting in a more complete detection of cancer cases. On the other hand, less effective primary prevention associated with emerging risk factors, for example, may also drive increasing cancer incidences. While it is analytically difficult to determine the impact of primary and secondary preventive efforts on rising cancer incidences, the declining incidences of MI, stroke, and hip fracture will be further explored by investigating the incidence-survival dynamics of underlying conditions.

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