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Time Trends in the Prevalence of Cancer and Non-Cancer Diseases among older U.S. adults: Medicare-based analysis

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Abstract

Longer lifespan is accompanied by a larger number of chronic diseases among older adults. Because of a growing proportion of older adults in the U.S., this brings the problem of age-related morbidity to the forefront as a major contributor to rising medical expenditures. We evaluated 15-year time trends (from 1998 to 2013) in the prevalence of 48 acute and chronic non-cancer diseases and cancers in older U.S. adults aged 65+ and estimated the annual percentage changes of these prevalence trends using SEER-Medicare and HRS-Medicare data. We found that age-adjusted prevalence of cancers of kidney, pancreas, and melanoma, as well as diabetes, renal disease, limb fracture, depression, anemia, weight deficiency, dementia/Alzheimer's disease, drug/medications abuse and several other diseases/conditions increased over time. Conversely, prevalence of myocardial infarction, heart failure, cardiomyopathy, pneumonia/influenza, peptic ulcer, and gastrointestinal bleeding, among others, decreased over time. There are also diseases whose prevalence did not change substantially over time, e.g., a group of fast progressing cancers and rheumatoid arthritis. Analysis of trends of multiple diseases performed simultaneously within one study design with focus on the same time interval and the same population for all diseases allowed us to provide insight into the epidemiology of these conditions and identify the most alarming and/or unexpected trends and trade-offs. The obtained results can be used for health expenditures planning for growing sector of older adults in the U.S.

Keywords

Disease Prevalence; Time Trends; Medicare; Annual Percent Change; Epidemiology; Age-adjusted Rate

Introduction

During the recent decades a persistent increase in the length of life of successive birth-cohorts has been observed in the U.S. However, a longer life span is also associated with increased risk of contracting cancer as well as other chronic diseases associated with the aging process. This makes the ability to accurately estimate and model the changes in nationally representative age-specific prevalence proportions critically important for public health specialists and policy makers. To understand the patterns of the changes and use them in future projections and forecasts, information on disease incidence, mortality, and prevalence need to be analyzed. Extensive work has already been done on incidence and mortality patterns¹⁻⁸, but studies focusing on diseases prevalence are relatively rare and often focus on diabetes, hypertension, obesity, and kidney disease⁹⁻¹². Furthermore, even when multiple disease are considered, these studies usually focus on mortality (e.g., the analysis of trends of leading causes of death¹³) and/or study a group of diseases that are related to a single risk factor (e.g., smoking related mortality¹⁴).

At the population level disease onset, progression, and patient survival interact to form disease prevalence. In turn, their trends are impacted by the time-trends of other assorted factors such as socioeconomic characteristics, the demographic structure of the population, behavioral factors (i.e., smoking, physical activity, diet), as well as changes in prevention, diagnostic, and treatment strategies. For example, decreasing smoking prevalence in the U.S. is associated with a reduction in the rates of certain cancers (e.g., squamous cell carcinoma of lung, cancer of oral cavity, cancer of urinary bladder) as well as lower rates of chronic obstructive pulmonary disease and cardiovascular diseases¹⁵⁻¹⁸. Due to increasing rates of multi-morbidity, or the presence of multiple life threatening chronic diseases in a single patient, a single change in any of the above factors can have a synergistic effect on individual health. Furthermore, improvements in early diagnosis of cancer and the consequent increased efficacy of treatment increase patient survival of patients making it, for some cancers, compatible to survival for cardio- and cerebrovascular diseases (e.g., 5-year relative survival rate is 73-89% for breast cancer and 50-99% for prostate cancer vs. 50% for stroke and 62% for heart failure¹⁹). However, better cancer-specific survival does not imply better total survival. In fact, the mortality of cancer patients age 65+ from non-cancer causes substantially affects the total mortality trends as well as cancer prevalence. For example, during the past two decades the overall all-age cancer-specific mortality rate in the U.S. has declined by 30%-40% for common cancers such as cancers of the colorectum, female breast, male lung, and male prostate²⁰. However, these improvements did not extend to patients age 65 and older²¹⁻²³. One of the explanations for this observation could be that a substantial proportion of cancer patients die of other co-existing chronic diseases^{24,25}. The close relationship between these two categories of chronic diseases suggests that the study of any individual disease in isolation from its co-morbidities is likely to paint a biased picture of the *status quo*.

The above concerns make the analysis and modeling of these complex processes with sufficient external validity a complicated task that requires large nationally representative medical data-sets that are not easily available. One way to overcome this difficulty is to use individual-level administrative health insurance claim records such as those provided by the

Medicare social insurance system. Medicare is nationally representative of the U.S. population at ages 65+ and is the primary payer for institutional and professional health services for the U.S. elderly. Although not initially designed for research purposes, use of Medicare Administrative claims data has been validated for use in the analyses of incidence, survival, and prevalence of cancer, diabetes, cardio- and cerebrovascular diseases, diseases of renal and endocrine systems as well as other diseases^{26–31}.

In this study, we identified the time-trends in the prevalence and age patterns of several major cancers and common age-related non-cancer diseases among older U.S. adults. The list of cancers includes several site-specific cancers as well as groups of solid cancers characterized by slow and fast progression, cancers with metastasis, and non-solid malignancies. Non-cancer diseases are represented by a spectrum of cardio- and cerebrovascular, respiratory, mental, endocrine, digestive, renal, and blood system diseases, as well as infections and injuries. Rather than being preselected *a priori*, the disease list and has been selected using a newly developed algorithm that takes into account the impact of each disease on mortality among older U.S. adults.

Data

Two complementary Medicare datasets are used: the Health and Retirement Study (HRS-Medicare) linked to administrative claims data from the Medicare program, and the Medicare-linked Surveillance, Epidemiology and End Results (SEER-Medicare) data-set. The HRS-Medicare is an ongoing, nationally representative study of individuals reaching age 50+ in the U.S. while SEER-Medicare is the largest and most detailed registry of cancer cases in the U.S. and. Mortality data from Medicare sources were supplemented with data on cause-specific mortality (not available in Medicare) drawn from the Multiple Cause of Death (MCD) dataset (1996-1998).

We evaluated the month-specific prevalence probabilities in the 1998-2013 period for both datasets. All individuals were longitudinally tracked for Medicare Part A and Part B service use. Records were available for institutional (inpatient, outpatient, skilled nursing facility, hospice, or home health agency) and non-institutional (physician and durable medical equipment) providers claim types. MCD data was used as part of the algorithm used for disease selection.

Methods

The disease groups of interest for this study were identified based on the analysis of their impacts on mortality in older U.S. adults. Specifically, we evaluated i) disease rank as a leading cause of death in MCD data; ii) the strength of the association between the prevalence of a disease and mortality observed in SEER-Medicare and HRS-Medicare; and iii) the frequencies as secondary cause of death in patients who died from diseases selected in the first two steps.

Age-specific and age-adjusted disease prevalence were evaluated from Medicare administrative claims data using individual disease presence. An individual was considered to have a disease at any time t of his/her follow-up if there existed a primary or secondary

record with a disease-specific ICD-9 code during the optimal disease-specific look-back period. This period was defined as the length of time before time t used to search for the presence of disease-specific code(s) in individual claim records. In this study, we use four base sources of Medicare data (physician, inpatient, outpatient and skilled nursing facility) and 12-month look-back period.

Estimates for the prevalence of acute conditions (e.g., myocardial infarction, limb fractures, gastrointestinal bleeding, and others) were obtained on a month-by-month basis. We estimated the prevalence of these conditions the same way we estimated the prevalence of chronic conditions. This approach provided us with opportunity to compare the results for both types of diseases as they were obtained from the same data using the same approach.

For both Medicare datasets, the empirical time- and age-specific prevalence, $p_a(t)$, were calculated as a fraction of individuals with disease presence at time t and age a . The age-adjusted rates (or directly standardized incidence rates) were calculated for the population age 66+ as $p(t) = \sum_{a=66}^{105} p_a(t) P_a^{2000} / \left(\sum_{a'=66}^{105} P_{a'}^{2000} \right)^{-1}$, where P_a^{2000} are age-specific counts of US 2000 standard population. The standard error (SE) for the age-adjusted rate was estimated using the approach based on the approximation suggested by Keyfitz³²: $SE = \lambda(t) / \sqrt{n_0}$, where n_0 is the sum of the cases.

Among many measures appropriate for the analysis of time trends we chose the average annual percentage change (APC) in prevalence proportions estimated using log-linear model in the form $\log(p(t)) = a + bt + \varepsilon_t$ or $p(t) = p_{2000} \exp(b(t - 2000))$, where t is calendar time, and ε_t is the error term of the regression. The estimate of the average APC is given by $100b$ and expressed in percent³³. The estimate of the prevalence at 2000 is given by p_{2000} . The model estimation is based on weighted least squares where the weights are the reciprocal of the variance estimated for each annual rate. This approach is preferable to the simple averaging of empirically estimated annual percentage changes because it: i) accounts for the standard errors of the prevalence proportion resulting in more precise estimates of APC, ii) provides estimates that are smoothed in respect to any random fluctuations that may arise as an artifact of the data gathering process in any individual year (e.g., for estimates of p_{2000}), and iii) results in the analytic formulae that represent a simple forecasting model of disease-specific prevalence proportions under the assumptions that the trend averaged over 1998-2003 will hold. Simultaneous visualizations of these estimates for all study conditions at the same time allow for a clear representation of integral picture of the epidemiological trends in prevalence.

Other approaches to identifying disease prevalence were tested in sensitivity analysis. These included: i) usage of all Medicare sources, ii) using only inpatient/outpatient records, iii) requiring a second verification claim during the look-back period, and iv) using only records with non-zero Medicare payments. No significant differences in the estimates of the APC were identified in sensitivity analysis.

Results

Diseases that were selected by our algorithm are presented in Table 1. Analysis of the rank of each study disease as a major cause of death showed that 87.13% of deaths among people aged 65+ were due to i) diseases of the circulatory system (390-459)—46.3% of all deaths, ii) neoplasms (140-239)—22.5% of all deaths, iii) diseases of the respiratory system (460-519)—11.6% of all deaths, iv) endocrine, nutritional and metabolic diseases, and immune disorders (240-279)—3.69% of all deaths; and v) diseases of the digestive and renal systems (520-579)—3.04% of all deaths. The six top three digit ICD-9 codes and respective diseases (with frequencies above 4%) were: 414—Other forms of chronic ischemic heart disease (12.95%), 410—Acute myocardial infarction (9.77%), 162—Malignant neoplasm of trachea, bronchus, and lung (6.29%), 436—Acute, but ill-defined, cerebrovascular disease (4.93%), 496—Chronic airway obstruction, not elsewhere classified (4.22%), and 486—Pneumonia, organism unspecified (4.04%). One surprising finding was the high proportion of “unspecified disease” (e.g., “other forms of”, “ill-defined”, “not elsewhere classified”) as the underlying cause of death in each disease group.

For the selected diseases, we reconstructed the individual disease prevalence trajectories and their age-patterns. The month-specific estimates for the age-adjusted disease-specific prevalence were calculated using both HRS-Medicare and SEER-Medicare (Figures 1–4). All curves are renormalized to allow them to be represented on the same scale. Rescaling factors shown in the right-upper corners allow the comparison of relative sizes of prevalence for different diseases. The prevalence of most of the studied diseases increased over time. The most substantial increases in prevalence among cancers were observed for cancers of the pancreas (from 0.114% in 1998 to 0.158% in 2013 using SEER-Medicare), kidney (from 0.318% to 0.437%), and melanoma (from 0.341% to 0.495%). Among non-cancer diseases, substantial increases in prevalence were registered for senility in HRS-Medicare (from 0.142% to 0.316%), diabetes (from 17.7% to 29.9%), kidney disease (from 5.9% to 18.3%), depression (from 5.32% to 13.8%), dementia/Alzheimer’s disease (from 5.79% to 9.03%), pulmonary heart (from 3.48% to 5.71%), and upper/lower limb fracture (from 10.8% to 26.1%). Significant increases in the rates of relatively low-profile diseases were identified: septicemia (from 1.56% to 2.11%), anemia (from 19.0% to 26.9%), weight deficiency (from 4.39% to 6.99%), and disorders of fluid, electrolyte, and acid-base balance (from 9.47% to 13.7%). The prevalence of tobacco abuse (from 2.00% to 12.7%) alcohol abuse (from 0.709% to 1.27%), as well as drug/medication abuse (from 0.156% to 0.350%) also increased over this time period. A more modest number of diseases demonstrated improvement over the study time period: colorectal cancer (from 1.42% to 1.16% using SEER-Medicare), several cardiovascular diseases such as heart failure (from 11.1 to 9.5%), myocardial infarction (from 2.32% to 1.81%), and cardiomyopathy (from 10.7% to 9.4%), pneumonia/influenza (from 8.1% to 5.8%), peptic ulcer (from 3.44% to 1.92%) and gastrointestinal bleeding (from 4.25% to 3.29%), and inflammatory bowel disease (from 3.97% to 3.07%).

Estimates of the APC in the prevalence of each study condition are presented in Figure 5. Among the diseases with increasing prevalence, the APC was most dramatic for renal disease: this is the only disease with an APC>5% and a year 2000 prevalence of >10% in

both datasets. The highest APC was observed for pancreas cancer (5.85 % in HRS-Medicare) and melanoma (4.93% in HRS-Medicare), atherosclerosis (4.37% in HRS-Medicare), senility (4.10% in HRS-Medicare), renal disease (8.04% in HRS-Medicare and 7.22% in SEER-Medicare), chronic liver disease (5.51% in HRS-Medicare), upper/lower limb fracture (5.10% in HRS-Medicare), depression (5.12% in HRS-Medicare), HIV/AIDS (5.87% in HRS-Medicare and 6.18% in SEER-Medicare), and tobacco abuse (9.97% in HRS-Medicare and 7.59 in SEER-Medicare). Decreasing APCs were observed for colorectal cancer, several cardiovascular diseases (such as heart failure, other ischemic heart disease, and cardiomyopathy), pneumonia/influenza, inflammatory bowel disease, and gastrointestinal bleeding.

Eight diseases showed discordant trend directions between SEER-Medicare and HRS-Medicare estimates. Five diseases, colorectal cancer, solid cancers with fast progression, myocardial infarction, ulcer, and rheumatoid arthritis showed decreasing APC in SEER-Medicare and increasing in HRS-Medicare; three others, leukemia/lymphoma, cerebrovascular disease, and drug/medicines abuse showed decreasing APC in HRS-Medicare but not in the SEER-Medicare dataset.

Discussion

The results of our study provide insight into the temporal changes of a wide spectrum of cancers and non-cancer diseases in older U.S. adults over the 1998-2013 period. They demonstrate several expected trends in the prevalence of certain diseases: increasing prevalence of atherosclerosis, arterial hypertension, diabetes, and Alzheimer's diseases, or decreasing prevalence of peptic ulcer and gastrointestinal bleeding. However, results also showed some trends that were not expected and require special attention. In general, many of the observed increases in disease-specific prevalence can be explained by increasing numbers of cases due to the early-stage disease diagnosis (e.g., due to better screening procedures), improving survival (due to advances in disease treatment and early diagnosis), and longer life spans observed in the U.S. However, other factors can also contribute to the changes of certain disease trends.

Increasing trends of cancer prevalence

Among cancers, only colorectal cancer and the group of fast progression cancers demonstrated a slight decrease in prevalence, while other site-specific cancers or system-specific groups of cancers had increasing or unchanged trends. Higher cancer prevalence could be due to better screening and/or earlier diagnoses that result in improved survival, especially for cancers with slow progression such as prostate and female breast cancer.

Our results demonstrated increasing prevalence of cancers of kidney, pancreas, and melanoma, consistent with other studies reporting increasing incidence^{34,35} of these conditions. Even accounting for the rising fraction of early-stage kidney cancers and improvements in survival for kidney cancer and melanoma (and to a much lesser extent pancreatic cancer), there is still a substantial contribution of increases of the incidence of these cancers to their prevalence trends, including advanced-stage malignancies³⁶. Quantitatively the components contributing to cancer trends can be quantified using an

approach based on the partitioning of diseases prevalence as suggested by Akushevich et al.³⁷. This presents an interesting avenue of future study.

Lung cancer remains the number one cancer cause of death among U.S. males and females aged 60+³⁶. As our results show, its prevalence is much lower when compared to other common cancers (female breast, prostate, and colorectal) and does not increase with time (in SEER-Medicare data). This is likely due to the lower effectiveness of its early-stage diagnostics and lower patient survival: the 5-year survival of lung cancer patients increased from 12% to 18% from 1975 to 2009 and still remains low^{36,38}.

Our results suggest that the dynamics in the trends of some cancers and non-cancer diseases of the same organ/site appear be related: e.g., increasing trends of kidney (renal) disease and kidney cancer, increasing prevalence of diabetes and pancreatic cancer, or decreasing trends of inflammatory bowel disease and colorectal cancer. Analysis of these trends could provide some insight into the mechanisms of cancer/non-cancer disease interactions and should be addressed in future studies. For example, increased prevalence of obesity and hypertension in the aging U.S. population could be risk factors for renal cell carcinoma³⁹ and chronic kidney disease¹¹. In addition, patients on dialysis have increased risk of kidney cancer suggesting carcinogenic effects of certain primary renal diseases and shared common risk factors (i.e., toxins)^{40,41}. Finally, increasing trends in the prevalence of many established risk factors (e.g. cigarette smoking, obesity and hypertension) could be related to substantial increase in kidney cancer incidence³⁹.

We also observed increasing trends of diabetes and pancreatic cancer in our study. Findings from meta-analysis strongly support that diabetes is associated with an increased risk of pancreatic cancer (relative risk: up to 1.94; 95% confidence interval: 1.66–2.27) suggesting that diabetes could be an etiologic factor for this type of cancer⁴² independently of obesity and smoking⁴³. Analyses of Medicare data show a little higher pancreatic cancer hazard ratio (2.17) for patient with (vs. without) diabetes⁴⁴. Insulin or insulin secretagogues use has been shown to be associated with increased risk of pancreatic cancer in diabetic patients (as opposed to the antidiabetic drug metformin that could reduce the risk)⁴⁵. Important information about components of time trends for disease prevalence is provided by partitioning analyses. For trends of diabetes prevalence this analysis showed that primary contributors to this trend were (in order of magnitude): improved survival at all ages, increased prevalence of T2D prior to age of Medicare eligibility, and decreased incidence of T2D after age of Medicare eligibility⁴⁶.

Increasing trends of prevalence of non-cancer diseases

We observed increasing prevalence of anemia, weight deficiency, and electrolyte/fluid disorders in older patients that seem to be underestimated both by health specialists and researchers (only a small amount of publications on this topic were published in the last two decades). Not treating these conditions could result in increasing disability and mortality in older U.S. adults, because they can lead to severe complications that could substantially contribute to both mortality and medical expenditures. In the literature, increasing prevalence of anemia is related to increasing rates of chronic kidney disease (also observed in our study): e.g., in the U.S. anemia is observed in 53.4% of patients with advanced stage 5

of chronic kidney disease⁴⁷ and this percent can be even higher among older patients. On the other hand, anemia in older patients is often associated with weight deficiency and with risk of falls and trauma⁴⁸ (also observed in our study). Increasing prevalence of underweight people aged 65+ could be due to insufficient consumption of dietary protein by community-dwelling patients and that should be of particular concern as age-related sarcopenia leads to a greater risk of functional impairment and mortality^{49,50}. Other observed problems such as the increasing prevalence of electrolyte and fluid imbalance among older U.S. adults could also be closely associated with anemia, weight deficiency, chronic kidney disease, and imbalanced diet. Electrolyte abnormalities could also be a side-effect of long-term use of laxatives (34% of women and 26% of men aged 84+ consider themselves to be constipated)⁵¹, while constipation, in turn, can be caused by insufficient fluid intake and an imbalanced diet⁵².

Another group of diseases with interrelating mechanisms and risk factors that requires attention is cerebrovascular/neurodegenerative/cognitive disorders. Our study showed increasing prevalence of cerebrovascular disease (in SEER-Medicare data) and almost zero dynamic in the prevalence of cerebrovascular disease (i.e., stroke) with complications. While a longer life span and better survival of patients with stroke (i.e., stroke declined from the third to the fourth leading cause of death in the U.S., making a first rank transition among causes of mortality in nearly 75 years⁵³) are the positive tendencies, stroke remains a leading cause of disability and cognitive impairment in the U.S. and the total annual costs of stroke are projected to increase to \$240.67 billion by 2030⁵⁴. Further, cerebrovascular disease increases the risk of dementia and Alzheimer's disease for which we observed increasing prevalence trends in both SEER-Medicare and HRS-Medicare datasets. Other studies demonstrated decreasing prevalence⁵⁵ and incidence⁵⁶ of dementia in the U.S. over the recent two-three decades, explaining that observation by an increase in education level and an improvement in cardiovascular health over time. However, these trends were based on self-reports of study participants. The prevalence of dementia and Alzheimer's disease based on clinical studies demonstrates increasing trends.^{57,58} The non-concordant trends can be explained by trends in disease severity and ascertainment⁵⁹.

Another alarming trend is the increasing prevalence of depression among older U.S. adults. Other studies have projected depression to be the second (following heart disease) contributor to the global burden of disease by 2020 (as measured by disability-adjusted life years)⁶⁰. That makes it very important to better enable older adults and their health care providers to recognize this condition and to optimize treatment strategy of this disease in older patients.

Our study showed an increasing prevalence of upper and lower extremity fractures among older U.S. adults. With prevalence increasing with age, osteoporosis and related fractures constitute one of the most significant public health concerns for aging populations. Studies in Medicare beneficiaries showed that the incidence and mortality rate of hip fracture (the most devastating of limb fractures) declined over recent decades¹. However, the degree of this decline was more prominent for incidence rates than for mortality and was either smaller or nonexistent in certain racial groups⁶¹. Other studies showed that hospitalization rates for severe fall-related injuries increase among older U.S. adults and this trend is likely to

continue⁶². Taking into account increasing prevalence of these conditions among older U.S. adults, accompanied by increasing severity of inpatient cases and increasing comorbidity level in these patients¹, limb fractures in older individuals represent an important issue for U.S. health system.

One of the unexpected findings in our study is an increasing prevalence of septicemia among older U.S. adults. Other studies showed that comorbidities, institutionalization, instrumentation, immunosenescence, and malnutrition all place older individuals at higher risk for bacteremia and sepsis; moreover, these conditions often remain underdiagnosed in older patients who may not exhibit the typical manifestations of the systemic inflammatory response syndrome⁶³. Over recent decades incidence rates of sepsis increased 20.4% faster among older patients than among younger patients, with urinary tract infections being more frequent source of sepsis⁶³. This problem currently does not receive adequate level of attention from public health specialists; however, it requires special strategies to optimize diagnostics and treatment for such patients⁶⁴. Together with alarming trends in the increasing prevalence of weight deficiency, electrolytes and liquid disbalance, chronic kidney disease, and anemia, increasing prevalence of sepsis forms a sort of a “cluster” of alarming under-recognized life-threatening conditions for older U.S. adults.

We also observed increasing prevalence of abuse of alcohol, tobacco, and drugs/medicines among older U.S. adults. While in the U.S. the Healthy People 2020 programs goal is to reduce tobacco use among adults to 12.0%⁶⁵ and proportion of adults (who drank excessively in the previous 30 days) to 25.4%, as well as to reduce non-medical use of pain relievers, tranquilizers, stimulants, and sedatives (no clear targets are defined)⁶⁵, older people do not seem to meet these targets because they do not respond effectively to preventive measures. Based on our analysis, we can speculate that the observed increase is predominantly due to severe consumptions/abuses – i.e., conditions that are coded with respective ICD codes. Other studies demonstrated a decline in adults who smoked 20–29 cigarettes per day (from 34.9% to 27.4%) or 30 cigarettes per day (from 12.7% to 6.9%)⁶⁶. However, this smoking status was self-reported, the study did not include institutionalized populations and persons in the military and had a notable non-response bias. Substances abuse significantly increase the risk of hospitalization, nursing home placement and death among older adults^{67,68}. While the number of adults aged 50+ with substance use disorder is projected to reach 5.7 million in 2020⁶⁹, health professionals tend to overlook this condition among older adults, attributing the symptoms instead to dementia/Alzheimer’s disease, depression or other problems. Furthermore, drug and alcohol treatment programs designed specifically for older adults are not available widely in the U.S. However, as the baby-boomers age, the consequences of elderly substance abuse will place a tremendous burden on the U.S. healthcare delivery and financing system, families, and society in general⁷⁰. With much of the current substance abuse treatment in the U.S. separated from primary care providers and focused upon younger patients, increased treatment availability and more integrated approaches are definitely needed to address the substance abuse problems among current older adults and individuals approaching older ages⁶⁹.

Finally, we observe increasing HIV/AIDS prevalence among older U.S. adults. Effective antiretroviral therapy has reduced the risk of AIDS over the recent decade and dramatically

prolonged the survival of HIV-infected people in the U.S. Consequently, increases in non-AIDS-defining cancers in the U.S. are mainly driven by growth and aging of the HIV/AIDS infection population⁷¹. Less is known about another aspect of this disease—i.e., that in addition to better diagnosis and improved survival, higher HIV prevalence in older people could be also due to increasing risk of being infected. Nowadays older individuals remain sexually active longer and are less likely than their younger counterparts to practice safe sex⁷². Contributions of these factors in the increase in HIV prevalence among older adults remains unexplored and requires further study.

Decreasing trends of disease prevalence: time to celebrate?

While increasing prevalence of a disease implies increased toll on health care costs, decreasing prevalence is usually recognized as a positive trend. Decrease of disease prevalence could be due to the lower disease incidence (usually, this is a positive trend), lower patient survival (a negative trend), or a combination of these factors. Keeping this in mind, we briefly discuss several diseases for which we observed decreasing trends in prevalence below.

Our study showed that the prevalence of colorectal cancer decreases (decrease of 1.7% in SEER-Medicare data; slight increases in HRS-Medicare data). This is consistent with other studies reporting that in the U.S. colorectal cancer incidence rates gradually declined since the mid-1980s for an average of 2.2%-2.8% per year (varying by sex)⁷³. This improvement was largely attributed to cancer screening programs and detection of precancerous polyps⁷⁴.

We also observed a decrease in inflammatory bowel disease prevalence in our study: it showed a 1.5% APC decrease in SEER-Medicare data. Other studies reported slightly increasing prevalence of Crohn's disease and ulcerative colitis in younger patients, but they have excluded patients older than 65 from analysis⁷⁵. Patients with inflammatory bowel disease (including ulcerative colitis and Crohn's disease) have an increased risk of developing colorectal cancer (up to 2.4-fold for ulcerative colitis)^{76,77}, therefore, a decreasing trend in inflammatory bowel disease can, to a certain extent, contribute to decreases in colorectal cancer rates. Over the last twenty years, hospital admissions in the U.S. for inflammatory bowel disease increased⁷⁸, even though current patients require surgery⁷⁹ less often and have lower in-hospital mortality (it decreased by 17% from 1994 to 2006, largely for hospitalizations associated with ulcerative colitis). These trends are unlikely due to hospitalizations of patients with less severe forms of disease⁸⁰.

Heart Failure imposes one of the highest disease burdens among other medical conditions in the U.S. which is why the decreasing prevalence observed in this study is important. Regardless of recent projections that predict that the prevalence of heart failure will increase by an estimated 50 % (approximately 3 million additional patients) by 2030⁸¹, our study showed decreasing heart failure prevalence in older U.S. adults. It has been reported in other studies that the hospitalization rate for heart failure declined substantially over two decades, patients have better survival, and slightly lower mortality rates (however, it still remains high)³. It is important to note that while recent declines in the rates of heart failure were primarily due to decreasing incidence of ischemic heart disease and improved control over arterial hypertension (both are common precursors for heart failure), the underlying cause of

heart failure-related deaths for adults aged 45+ during the recent decade became more likely to be other cardiovascular diseases and also some non-cardiovascular diseases (such as cancer, diabetes, chronic lower respiratory diseases, and kidney disease) (the latter accounted for 29.4% of heart failure deaths in 2014)⁸². Moreover, while in-hospital heart failure - related deaths decreased, more deaths now occur at a descendant's home and in other places (such as an outpatient clinic or hospice facility)⁸². Therefore, while there are generally positive trends in heart failure rates, the fact that it remains among the leading causes of death in the U.S. and that its underlying cause and place-of-death patterns change over time require special attention.

Our study also showed decreasing prevalence of myocardial infarction—an important precursor of heart failure. Significant decrease in myocardial infarction hospitalization rates has been reported over last decade, with most of the U.S. states showing over 20% decline⁸³. Among Medicare beneficiaries, heart failure hospitalization following myocardial infarction also decreased, likely indicating an improvement in myocardial infarction treatment⁸⁴. However, survival after heart failure following myocardial infarction remains poor, demonstrating that challenges still remain in disease management.

In our study, we observed decreasing prevalence of pneumonia/influenza among older U.S. adults. The rank of pneumonia/influenza as a leading cause of death in the U.S. population aged 65+ is falling: from #6 in 2005 (55,453 deaths) to #8 in 2015 (48,774 deaths)⁸⁵. Predominantly, the decrease in mortality among seniors was due to pneumonia (the rate decreased from 164.6 per 100,000 in 1999 to 107.3 in 2013) and not influenza (its rate varied from 0.3 per 100,000 to 6.0, depending on the year)⁸⁶. There are certain years (i.e., major epidemics) when the pneumonia/influenza death rate increased (e.g., up to 9% increase in 2012-2013, predominantly, due to influenza), but according to the general trend, mortality for this diseases declines since 1999 at average of 3.8% per year^{86,87}. Hospitalization rates for older patients also declined⁸⁷. Recent advances in vaccination reduced disease risk among older individuals, even among unvaccinated persons through the effect^{88,89} of herd immunity. However, because of high fluctuations in mortality during epidemics and the fact that 90% of influenza-related deaths occur among persons aged 65+⁹⁰, it is important to further improve effectiveness of vaccine and vaccination programs particularly among elderly⁹¹, especially because older patients often have respiratory, circulatory, renal, and neurodegenerative diseases, diabetes, and other comorbidities that increase the risk of influenza-associated mortality^{92,93}.

We observed a significant decline in the prevalence of ulcer and gastrointestinal bleeding among older U.S. adults. Other studies report substantial decline in ulcer-related hospital admissions, surgery and mortality in all-age population, predominantly due to the program of control of *H. Pylori* infection in the U.S. that also contributed to decreases in gastrointestinal bleeding; however, the proportion of patients aged 65+ hospitalized for duodenal or gastric ulcer increases⁹⁴. Another risk factor for ulcer and gastrointestinal bleeding is consumption of non-steroidal anti-inflammatory drugs (NSAIDs) also contributed to disease trend: e.g., introduction of COX-2 selective inhibitors might have decrease the risk of ulcer bleeding (but it, probably, gives a small increased risk for cardiovascular events). However, because older age and severe comorbidities significantly

increase the risk of gastrointestinal bleeding and death among older patients, it remains difficult to further decrease mortality in this population⁹⁴.

Summary and Conclusion

In this study, we have provided current prevalence estimates for multiple high-impact cancer and non-cancer diseases and analyzed their trends in older U.S. adults for the 1998 to 2013 period. Analysis of trends of multiple diseases performed simultaneously within one study design with focus on the same time interval and the same population for all diseases allowed us to: i) provide a birds-eye view of the trends in the prevalence of multiple diseases calculated using a unified approach within the framework of a single study, ii) identify alarming negative trends and/or unexpected tradeoffs that could reflect current deficiencies in medical practice, iii) identify areas where prior interventions have proved successful. Specifically, we found that prevalence of cancer increases over time except for colorectal cancer, other fast progressive cancers (Table 1), and metastatic cancers. Prevalence of high-severity cardiovascular diseases (myocardial infarction, heart failure, cardiomyopathy) decreases over time, while others (most notably stroke, endo/pericardium, aneurysm/arterial embolism/thrombosis) demonstrated increasing prevalence. Other considered diseases demonstrated increasing prevalence with exception of gastroenterological diseases (ulcer, gastrointestinal bleeding, inflammatory bowel disease). Increased prevalence of a group of possibly interrelated diseases (e.g., electrolytes and liquid disbalance, anemia, weight deficiency, septicemia, and chronic kidney disease) could be indicating an emerging situation in public health deserving of urgent attention. These diseases, previously overshadowed by high-severity cardiovascular disease, are having an increasing effect on morbidity and mortality of the U.S. elderly population as cardiovascular care improves and prevalence of high-severity cardiovascular diseases decreases.

In summary, the current generation of individuals who reach age 65 can expect to live longer than their counterparts from the earlier birth-cohorts. However, this longer lifespan is accompanied by higher rates of multimorbidity. A growing elderly population living with multiple co-existing conditions brings the role of interactions between these diseases, their diagnostic algorithms, treatment choice and effectiveness, problems of polypharmacy, and the adverse effects of treatment, as well as the optimization of prevention strategies for older U.S. adults to the forefront.

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Figure 1.

Time dependence of age-adjusted prevalence of neoplasms calculated using HRS-Medicare (thin lines; marked by “H”) and SEER-Medicare (thick lines; marked by “S”). Prevalence proportions for different diseases are rescaled to use the same scale on all plots to compare rates for different diseases: the original proportion (in %) can be calculated by multiplying the values obtained from plot by the rescaled factor.

Figure 2.

Time dependence of age-adjusted prevalence of cardio- and cerebrovascular diseases calculated using HRS-Medicare (thin lines; marked by "H") and SEER-Medicare (thick lines; marked by "S"). Other notation as in Figure 1.

Figure 3.

Time dependence of age-adjusted prevalence of diseases of respiratory, mental, and endocrine systems calculated using HRS-Medicare (thin lines; marked by "H") and SEER-Medicare (thick lines; marked by "S"). Other notation as in Figure 1.

Figure 4.

Time dependence of age-adjusted prevalence of digestive/renal, Infectious, and Blood as well as injuries and several other diseases calculated using HRS-Medicare (thin lines; marked by "H") and SEER-Medicare (thick lines; marked by "S"). Other notation as in Figure 1.

Figure 5.

Estimates of the annual percent change (b) and prevalence in 2000 in the model $p_{2000} \exp(0.01 \cdot APC \cdot (t - 2000))$. Closed and open dots correspond to SEER-Medicare and HRS-Medicare data.

Table 1.

ICD-9-CM codes for selected disease clusters.

System	Disease (ICD-9-CM)
Neoplasms	Non-solid (leukemias and lymphomas) (200-208), Female Breast (174), Pancreas (157), Kidney (189), Prostate (185), Melanoma (172), Lung (162), Colorectal (153, 154), Other Solid Fast Progressive (150-152, 155, 156, 158, 159, 163-165, 170, 171, 175, 176, 179, 182, 183, 188, 191, 192, 194, 195, 209.0-209.3), Other Solid Slow Progressive (140-149, 160, 161, 173, 180, 184, 186, 187, 190, 193), metastatic cancer (MTS) (196-198), Other Nonspecified (199, 238, 239).
Circulatory	Hypertension (401-405), Myocardial infarction (410), Other ischemic heart disease (IHD) (411, 413, 414), Endo/Pericardium (420, 421, 423, 424), Cardiomyopathy (425, 429, 422), cardiac arrhythmia (426, 427), Heart failure (428), Cerebrovascular disease (stroke) (430-437, 348), Cerebrovascular disease with complications (438, 342, 344), Atherosclerosis (440, 272), Diseases of peripheral vein (451-454, 456, 459), Aneurysm/Arterial Embolism/Thrombosis (441-445, 447, 557).
Respiratory	Chronic obstructive pulmonary disease (COPD) (490-496), Pulmonary Heart (415, 416, 514), Pneumonia and Influenza (480-488), Other Lung Diseases (510-519).
Mental	Dementia/Alzheimer's disease (290, 294, 331.0, 331.1, 331.2, 331.9), Parkinson's disease (332, 331.82), Depression (301.12, 300.4, 309.0, 309.1, 296.2, 296.3, 296.5, 298.0, 311), Alcohol abuse (305.0, 357.5, 425.5, 535.3, 571.0-571.3, 291, 303, 980), Drug/Medicine Abuse (292, 304.1, 305.4, 305.8, 305.9), Tobacco abuse (989.84, V15.82, 305.1).
Endocrine	Diabetes (250), Electrolytes (276).
Digestive/	Chronic Liver (571-573, 070.2-070.7, 070.9), Inflammatory bowel disease (556, 555, 558, 538), Ulcer (531-534),
Renal	Gastrointestinal hemorrhage/bleeding (578), Renal disease (580-589, V56, 593).
Infectious	Septicemia (038), HIV/AIDS (042).
Blood	Anemia (286.5, 286.7, 286.9, 280, 281, 283-285, 287, 289, V78).
Injury	Upper/Lower Limb Fracture (V82.81, V54.13, V13.5, 905.2-905.5, 810-813, 817-821, 823-825, 827, 828, 733, V54).
Other	Rheumatoid Arthritis (714,725), Senility (797), Weight Deficiency (783.2, 783.7, 799.4, 783.0, 783.3, 783.9, 260-263).