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Time trends of incidence of age-associated diseases in the US elderly population: medicare-based analysis

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Abstract

Objectives: time trends of age-adjusted incidence rates of 19 ageing-related diseases were evaluated for 1992–2005 period with the National Long Term Care Survey and the Surveillance, Epidemiology and End Results Registry data both linked to Medicare data (NLTCS-Medicare and SEER-Medicare, respectively).
Methods: the rates were calculated using individual medical histories (34,077 individuals from NLTCS-Medicare and 199,418 from SEER-Medicare) reconstructed using information on diagnoses coded in Medicare data, dates of medical services/procedures and Medicare enrolment/disenrolment.
Results: increases of incidence rates were dramatic for renal disease [the average annual percent change (APC) is 8.56%, 95% CI = 7.62, 9.50%], goiter (APC = 6.67%, 95% CI = 5, 90, 7, 44%), melanoma (APC = 6.15%, 95% CI = 4.31, 8.02%) and Alzheimer's disease (APC = 3.96%, 95% CI = 2.67, 5.26%), and less prominent for diabetes and lung cancer. Decreases of incidence rates were remarkable for angina pectoris (APC = −6.17%, 95% CI = −6.96, −5.38%); chronic obstructive pulmonary disease (APC = −5.14%, 95% CI = −6.78,−3.47%), and ulcer (APC = −5.82%, 95% CI = −6.77, −4.86%) and less dramatic for carcinomas of colon and prostate, stroke, hip fracture and asthma. Incidence rates of female

breast carcinoma, myocardial infarction, Parkinson's disease and rheumatoid arthritis were almost stable. For most diseases, an excellent agreement was observed for incidence rates between NLTCS-Medicare and SEER-Medicare. A sensitivity analysis proved the stability of the evaluated time trends.

Conclusion: time trends of the incidence of diseases common in the US elderly population were evaluated. The results show dramatic increase in incidence rates of melanoma, goiter, chronic renal and Alzheimer's disease in 1992–2005. Besides specifying widely recognised time trends on age-associated diseases, new information was obtained for trends of asthma, ulcer and goiter among the older adults in the USA.

Keywords: *Medicare, disease onset, time trends, comorbidity, age-associated disease, older people*

Introduction

The estimates of the time trends in health indicators (e.g. disease incidence rates) provide valuable information for policymakers and governmental institutions working in the area of medical technology and population health. These trends are associated with changes in socio-economic status and demographic structure of population, risk factors prevalence (e.g. smoking, obesity etc.), as well as changes in prevention, screening and diagnostic strategies. The estimates of time trends become especially important in populations with increasing proportions of the elderly for which maintaining good health is an important issue. While mortality trends have been studied more often, studies on morbidity trends are rare. Part of the difficulties in performing analysis of morbidity trends relate to a definition of chronic disease onset. In the elderly population, studies of the time trends of age-associated diseases are not common because these require large population-based data sets that are costly to collect and maintain. Valuable information about morbidity patterns and time trends in the USA can be extracted from the Medicare Files of Service Use (MFSU) and from two data sets linked with it—the National Long Term Care Survey (NLTCS-Medicare) and the Surveillance, Epidemiology, and End Results (SEER-Medicare); they are both capable of providing the estimates of time trends at the national level.

Data and methods

Data

Both SEER-Medicare and NLTCS-Medicare represent the set of individual Medicare records from each institutional (inpatient, outpatient, skilled nursing facility, hospice or home health agency) and non-institutional (Carrier-Physician-Supplier and durable medical equipment providers) claim types. Enrolment date and the last date of individual follow-up (i.e. the date of death or censoring in the end of 2005) are available for each individual. The SEER-Medicare data set includes the standard 5% sample of Medicare beneficiaries residing in areas covered by SEER. The number of individuals is year-specific: from 230,286 individuals in 1992 to 300,695 individuals in 2005. The sample represents the US general elderly population [1]. The NLTCS-Medicare uses a sample of individuals drawn from the national Medicare enrolment files for an interview and subsequent 5-year follow-up. The cohorts formed in 1994 and 1999 are used in this analysis. In total, 34,077 individuals were followed-up for 5 years. So-called 'screener weights' released with the NLTCS were used in this study to produce the national population estimates (see Akushevich *et al.* [2] for recent discussion). These data sets allow for reconstruction of individual histories of medical service use and, therefore, for modelling of individual follow-up from age 65 to death or the onset of a disease of interest.

Age of onset definitions, calculation of rates and evaluation of time trends

Nineteen diseases of various systems were selected for analyses: (i) most common (lung, colon, female breast and prostate) or highly prevalent with increasing incidence (skin melanoma) cancers; (ii) highly prevalent diseases of cardio- (MI, angina pectoris, HF) and cerebrovascular (stroke) system, respiratory system (COPD, asthma) and kidney and gastrointestinal tract (chronic renal disease/failure, ulcer); (iii) highly prevalent (Parkinson's and Alzheimer's) neurodegenerative diseases; (iv) highly prevalent endocrine disease (diabetes) or disorder with growing prevalence and public health concern (goiter); (v) highly prevalent autoimmune disease with high disability (rheumatoid arthritis) and (vi) trauma/injury associated with high medical costs and disabilities (hip fracture). No diseases were initially selected but later excluded from analysis. The ages at their onsets were reconstructed from the MFSU data using the scheme described in Akushevich *et al.* [2, 3]. In brief, the individual medical histories of the applicable disease were reconstructed from MFSU combining all records with their respective ICD-9 codes (listed in Table 1), then a special computational procedure was applied for individuals with the history of the considered disease to separate incident and prevalent cases and to identify the age at disease onset. This procedure was based on two conditions applied to each medical history. The first condition allowed for the identification of the first occurrence of disease code, and the second was required for confirmation of disease presence. The individual Medicare history contains all records with respective disease ICD-9 code; however, only records with primary ICD-9 code and only from the so-called base Medicare sources (inpatient care, outpatient care, physician

Table 1. The ICD-9 codes used for the considered conditions

Group of diseases	Disease with ICD-9 codes
Cardio- and cerebrovascular	Myocardial infarction (410.xx), angina pectoris (413.xx), stroke (431.xx, 433.x1, 434.x1, 436.xx), heart failure (428.xx)
Malignancies	Lung cancer (162.xx), colon cancer (153.xx), breast cancer (females) (174.xx), prostate cancer (185.xx), skin melanoma (172.xx)
Neurodegenerative	Parkinson's disease (332.xx), Alzheimer's disease (331.0)
Pulmonary	Chronic obstructive pulmonary disease (COPD) (490.xx, 491.xx, 492.xx, 493.xx, 494.xx, 495.xx, 496.xx), asthma (493.xx)
Bones/skeletal	Hip fracture (820.xx, 821.xx)
Endocrine and metabolic	Diabetes mellitus (250.xx), goiter (240.xx, 241.xx, 242.0x, 242.1x, 242.2x, 242.3x)
Miscellaneous	Chronic renal diseases with renal failure (403.xx, 404.xx, 585.xx, 250.4x, 249.4x), ulcer (531.xx, 532.xx, 533.xx, 534.xx), rheumatoid arthritis (714.0x, 714.1x, 714.2x, V82.1x)

services and skilled nursing facilities) were used for the disease onset identification.

For NLTCS-Medicare, the age adjusted rates were calculated for cohorts formed in 1994 and 1999 years. Five-year follow-up was considered for each cohort. Only individuals with the mean coverage of health maintenance organisation (HMO) not to exceed 5% of all months of individual follow-up were kept for the analysis resulting in 27,607 individuals. For SEER-Medicare, individuals from geographic areas of the SEER Registers observed since 1992 or earlier were selected. The beginning of individual follow-up was estimated as the latest date among (i) date of 66 years old, (ii) date of enrolment into Medicare, and (ii) earliest date of living in one of the areas of the SEER registers. Only individuals with HMO coverage not >1 month/year were kept for the analysis. The final number of selected individuals is year-specific: from 199,418 in 1992 to 241,693 in 2005. The fraction of unselected individuals because of the HMO cut was from 15 to 25% (maximum in 1999), similar for both genders, and higher for ages 66–70 vs. 71+ (e.g. 24 and 22% in 2000).

For both data sets, the empirical time- and age-specific rates ($\lambda_a(t)$) (i.e. cohort-specific rates for NLTCS-Medicare and year-specific rates for SEER-Medicare) were calculated as a ratio of weighted numbers of cases to weighted person-years at risk: $\lambda_{\mathrm{a}}(t) = n_{\mathrm{a},t}/P_{\mathrm{a},t}$; where $n_{\mathrm{a},t} = \sum_n w_n$, $P_{\mathrm{a},t} = \sum_{\mathrm{i}} w_{\mathrm{i}}$ and w_{i} is the individual weight (the screener weights for NLTCS-Medicare and unit weights for SEER-Medicare); n runs over all disease onsets detected in the age group, and i runs over all selected individuals at risk in the age group. The standard error (SE) was calculated as $\sigma_E = \sqrt{\lambda_{\mathrm{a}}(t)(1-\lambda_{\mathrm{a}}(t))/P_{0\mathrm{a},t}}$, where $P_{0\mathrm{a}}$ is the number of person-years estimated for unit weights. Thus, the SE was calculated based on the number of actually measured individuals. The age-adjusted rates (or directly standardised incidence rates) are calculated for the population aged 66+ as $\lambda(t) = \sum_{\mathrm{a}=66}^{105+} \lambda_{\mathrm{a}}(t) P_{\mathrm{a},2000} \left(\sum_{\mathrm{a}'=66}^{105+} P_{\mathrm{a}',2000}\right)^{-1}$, where $P_{\mathrm{a},2000}$ are age-specific counts of US 2000 standard population. The SE for the age-adjusted rate was estimated using the approach based on the approximation suggested by Keyfitz [4]: $\mathrm{SE} = \lambda(t)/\sqrt{n_0}$, where n_0 was unweighted sum of the cases.

Among many measures appropriate for the analysis of time trends, we deal with the average annual percent change in incidence rates (or the annual rate of change of the incidence rate) estimated using the log-linear model in the form $\log(r(t)) = \mathrm{a} + bt + \varepsilon_t$, where $t$is a calendar time, and ε_t is the error term of the regression. The estimate of the average annual percent change is given by $100b$ and expressed in percent [5]. The model estimation is based on weighted least squares where weights are reciprocal of variance estimated for each annual rate. Thus, this approach allows us to take into account the SEs for incidence rates and therefore this approach is preferable rather than simple averaging of empirically estimated annual percent change.

Sensitivity analysis

One issue often present in analyses of large administrative data sets is the existence of factors which could produce systematic over- or underestimation of the number of diagnosed diseases or of the age at onset. The reasons for such uncertainties could be the incorrect date of disease onset, latent disenrolment and incorrect reporting of date of birth and date of death: while the first affects the age at onset, the latter tends to reduce or increase the number of person-years at risk. To evaluate the effects of these uncertainties, we performed calculations with different definitions of disease onset including: (i) all Medicare sources were used for completion of individual medical histories, (ii) all codes (not only primary) were used in MedPAR (i.e. inpatient) records, (iii) confirmation of the diagnosis was not required if the first record was from inpatient source, (iv) combining definitions (ii) and (iii) and (v–vi) the cut-offs on frequencies of the HMO coverage (i.e. coverage by an alternative insurance) at 6 and 12 months, respectively.

Results

The age-adjusted disease-specific incidence and total mortality rates calculated using both NLTCS-Medicare and SEER-Medicare are presented in Figure 1. In both data sets, a slow decrease in total mortality was detected; however in SEER-Medicare this trend was observed since 2000. For most of the studied diseases, an excellent agreement was observed for rates between two data sets. For several diseases such as female breast cancer, myocardial infarction, heart failure and hip fracture, a tendency was observed for NLTCS-Medicare rates to be higher and for

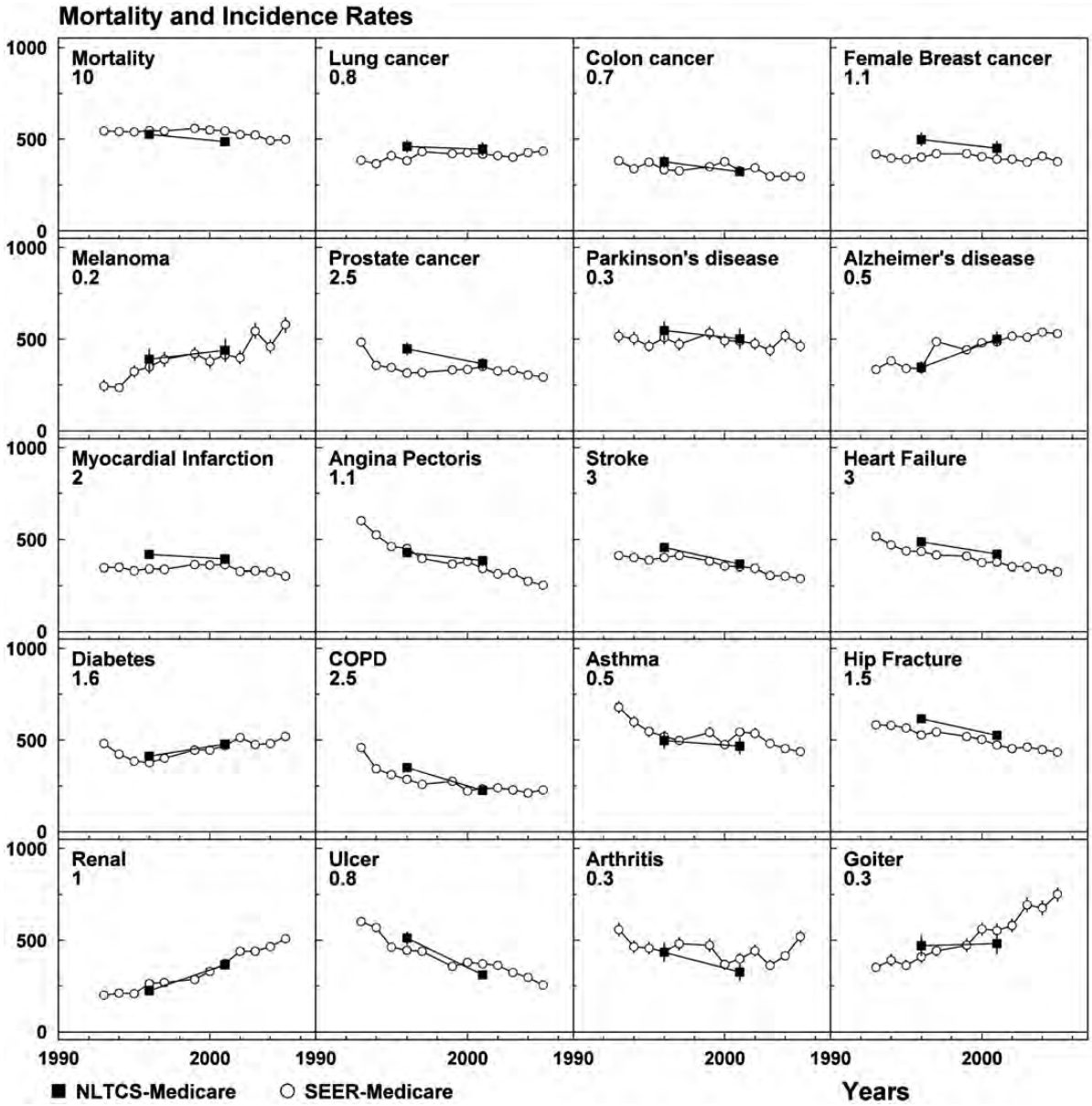

Figure 1. Time dependence of age-adjusted rates of total mortality and disease incidence calculated using NLTCS-Medicare (squares) and SEER-Medicare (open dots). Rates for different diseases are rescaled to use the same scale on all plots to compare rates for different diseases: the original rate (per 100,000) can be calculated by multiplying the values obtained from plot by the rescaled factor.

rheumatoid arthritis—lower than for SEER-Medicare (higher NLTCS-Medicare rates could be due to the partial disagreement detected in our earlier study for age patterns [3]).

As expected three types of time patterns were detected: with increased, decreased and stable (statistically insignificant) time trends. Quantitatively, the time trend is evaluated using the log-linear model as the average annual percent change. The results of these estimates are presented in Table 2 (see 'Base calculation' column). The estimates and their confidence intervals confirm the above conclusions of qualitative analyses of time patterns.

Among the diseases with decreasing incidence rates, average annual percent changes were most dramatic for angina pectoris, COPD and ulcer (>5% of annual decline). For colon and prostate carcinomas, as well as for stroke, heart failure, hip fracture and asthma decreases were also significant, but less prominent (between 1.5 and 3.4%). For certain diseases, increasing trends were observed: the highest rise of an incidence rate was for renal diseases, goiter and melanoma (>6% of annual increase), trends of the Alzheimer's disease and diabetes were less dramatic (between 1.7 and 4%), and an increase of lung cancer incidence was <1% annually. Changes in incidence rates of female breast cancer, myocardial infarction, Parkinson's disease and arthritis were non-significant over the studied period.

Table 2. Evaluated averaged annual percent change in the incidence rate using the time series analysis for SEER-Medicare data set for the base calculation (described in Subsection 'Date of onset definitions, calculation of rates, and evaluation of time trends') and for several alternative approaches such as (A) all Medicare sources, (B) all codes in inpatient records, (C) no requirement for diagnosis confirmation for inpatient records, (D) combining conditions in (B) and (C), (E) HMO frequency cut-off 6 month and (F) no cut-off on HMO frequency

Outcome	Base calculation	Alternative calculations					
		A	B	C	D	E	F
Mortality (total)	−0.70 (−1.12, −0.27)	−0.70	−0.70	−0.70	−0.70	−0.37[a]	−0.67
Lung cancer	0.85 (0.22, 1.48)	0.71	0.69	0.74	0.50[a]	0.91	0.26[a]
Colon cancer	−1.58 (−2.57, −0.57)	−1.64	−1.67	−1.71	−1.69	−1.48	−2.15
Melanoma	6.15 (4.31, 8.02)	5.98	6.06	6.17	6.15	6.18	5.66
Breast cancer (Fem)	−0.49 (−1.02, 0.04)[a]	−0.65	−0.53[a]	−0.72	−0.78	−0.38[a]	−1.18
Prostate cancer	−2.28 (−3.77, −0.77)	−2.32	−2.34	−2.42	−2.61	−2.18	−2.87
Parkinson's disease	−0.38 (−1.22, 0.47)[a]	−0.40[a]	−0.18[a]	−0.35[a]	0.23[a]	−0.22[a]	−0.85[a]
Alzheimer's disease	3.96 (2.67, 5.26)	3.63	3.63	4.25	2.96	4.10	3.60
Myocardial infarction	−0.65 (−1.40, 0.12)[a]	−0.97	−0.33[a]	−0.94	−0.43[a]	−0.62[a]	−1.47
Angina pectoris	−6.17 (−6.96, −5.38)	−6.49	−6.27	−6.55	−6.31	−6.16	−6.86
Stroke	−2.89 (−3.59,−2.18)	−3.14	−2.89	−3.15	−3.19	−2.83	−3.64
Heart failure	−3.37 (−3.79, −2.94)	−3.47	−3.12	−3.58	−3.26	−3.28	−3.96
Diabetes	1.69 (0.47, 2.93)	2.32	1.52	1.62	1.21	1.88	1.46[a]
COPB	−5.14 (−6.78, −3.47)	−3.95	−4.87	−5.13	−4.63	−5.01	−5.65
Asthma	−2.46 (−3.55, −1.36)	−0.42[a]	−1.81	−2.33	−0.18[a]	−2.40	−3.06
Hip fracture	−2.51 (−2.82, −2.19)	−2.62	−2.55	−2.58	−2.53	−2.51	−3.51
Renal disease	8.56 (7.62, 9.50)	8.42	7.57	8.04	5.96	8.62	8.15
Ulcer	−5.82 (−6.77, −4.86)	−5.97	−5.33	−5.21	−4.64	−5.80	−6.53
Rheumatoid arthritis	−1.11 (−2.87, 0.67)[a]	−1.68	−1.03[a]	−1.37[a]	−0.69[a]	−1.05[a]	−1.74[a]
Goiter	6.67 (5.90, 7.44)	6.64	6.48	6.62	5.65	6.69	6.21

[a]non-significant.

Sensitivity analysis was performed for the effects of uncertainties described in 'Methods' section. No significant differences between estimates of time trends within the base and multiple alternative scenarios were found (see Table 2).

Discussion and conclusion

While total mortality and incidence rates of many diseases (such as prostate cancer, stroke and HF) among the US older adults have been reported to decrease over recent several decades, there are still diseases with rising incidence (e.g. chronic kidney disease, skin melanoma, asthma, diabetes) [6–9]. Trends of some diseases such as Alzheimer's, Parkinson's, coronary heart disease and stroke were not straightforward [5, 10–14]. It is important to evaluate time trends of incidence rates of chronic diseases for elderly population—a fast growing group in the USA—using a nationally representative data set, thus making the results valuable for planning of screening, prevention and medical expenditures. In this study, time trends were calculated using Medicare-linked NLTCS-Medicare and SEER-Medicare data which represent the estimates at the national level.

For the majority of diseases, the calculated time trends were in agreement with other studies: e.g. decreasing trends were observed for COPD [15], hip fracture [16] and cancers of prostate, colon and female breast [6]. Observed decline in the incidence of heart disease and stroke also was in agreement with recent studies [11, 14]. It is likely attributable to reduction in smoking prevalence, earlier diagnoses and treatment of hypertension and diabetes, and general improvements of the lifestyle. While the incidence rates of asthma and ulcer decreased significantly in our study, results of other studies varied from trend stabilisation to their decrease [17–20]. These studies were performed in the general population or among children and young adults but not among elderly, thus making it difficult to compare with our results.

While decreasing incidence of some diseases could prove an effectiveness of preventive strategies, rising incidence of certain diseases are of a great concern. Observed increasing rate of melanoma is in agreement with other studies, and could be predominantly related to increased exposure to ultraviolet radiation [21, 22]. Opposed to melanoma, increase of lung cancer incidence in our and other studies recently became less pronounced; this phenomenon could reflect its long (∼30 years) latency, making tumour risk—regardless of decreased smoking prevalence—still significant among those who are older than 65 [7]. The reasons for rising incidence of several non-cancer diseases such as Alzheimer's, renal disease, diabetes and goiter among the US elderly are not well understood. In part, it could be due to a methodological factor (case finding); however, increases could be true and be explained by earlier detection of disease and increasing risk factors

prevalence. For example, observed in our study dramatic increase in incidence of renal disease also has been showed in recent studies that have associated its rise with an increasing prevalence of diabetes and hypertension [23]. In its turn, the rising rate of diabetes—which cannot be explained by active screening alone—could be due to increased prevalence of obesity in population, and, probably, of several other still unidentified behavioural factors [24, 25]. Studies on trends of goiter incidence in the US elderly are not available; however, its incidence rises among children and in general population, probably, due to iodine deficiency and more frequent diagnoses via screening [26]. Substantial increase (probably, due to increasing prevalence of diabetes, midlife obesity and depression, among other factors [27]) of highly disabling Alzheimer's disease in our study agreed with other studies, including several Medicare claim-based analyses [10, 28, 29]; however, this increase have not been confirmed in several community-based studies [11].

A unifying approach to the identification of disease onset and the calculation of the incidence rates was used for all considered diseases. This assumption does not restrict the generality of our calculation because there is always certain arbitrariness in defining the date of onset. For example, the diagnostic criteria of different heart studies reviewed by the NHI/NHLBI [30] resulted in different incidence rates observed in these studies. This arbitrariness was used for constructing a unified definition of the date of the onset of all diseases of interest. The effects of alternative onset definitions on time trends were not expected because there are no essential time-dependent factors involved in the date-at-onset definition, and were not found in sensitivity studies. Another issue is that times trends of single diseases are considered without relations to the trends in concurrent diseases e.g., increasing survival from CHD contributes to an increase in the cancer incidence rate if survived individuals were initially susceptible to both diseases. And finally changes in billing practices and office procedures may affect records and produce the errors in the estimates of respective rates and trends.

The evaluated time trends represented in the form of the average annual percent change can be used for projections of future incidence rates for selected diseases under the current-tendencies scenario. The results of this study can be used in analysis of trends of Medicare costs associated with a disease including future Medicare cost projection. Further progress in developing forecasting models can be achieved using specific information from the Medicare-linked data sets: e.g., NLTCS-Medicare can provide disability-specific incidence rates allowing for projecting the estimates for the whole US population, and SEER-Medicare allows to investigate comorbidity effects and detailed cancer characteristics such as histotype- and grade-specific cancer rates. Thus, the approach and reported results of this study have a potential of contributing to policy debates about the effects of current prevention strategies, risk factors prevalence and diagnostic algorithms on disease incidence for the elderly—a rapidly growing sector of the US population.

Key points

- Medicare data are a powerful source for analysing time trends of disease incidence.
- Dramatic increases of incidence rates of goiter, melanoma, chronic renal and Alzheimer's diseases in 1992–2005 were detected.
- Medicare-based data provide reliable estimates valid for the US elderly population.
- New information was obtained for trends of asthma, ulcer and goiter among the US oldest adults.
- For most diseases, an excellent agreement was observed for incidence rates between NLTCS-Medicare and SEER-Medicare data sets.

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Conflicts of interest

None declared.

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