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## Circulatory Diseases in the U.S. Elderly in the Linked National Long-Term Care Survey-Medicare Database: Population-Based Analysis of Incidence, Comorbidity, and Disability

Igor Akushevich<sup>1</sup>, Julia Kravchenko<sup>2</sup>, Svetlana Ukraintseva<sup>1,2</sup>, Konstantin Arbeev<sup>1</sup>, and Anatoli I. Yashin<sup>1,2</sup>

<sup>1</sup>Center for Population Health and Aging, Duke University, Durham, NC, USA

<sup>2</sup>Duke Cancer Institute, Duke University, Durham, NC, USA

### Abstract

Incidence rates of acute coronary heart disease (ACHD; including myocardial infarction and angina pectoris), stroke, and heart failure (HF) were studied for their age, disability, and comorbidity patterns in the U.S. elderly population using the National Long Term Care Survey (NLTCS) data linked to Medicare records for 1991–2005. Incidence rates increased with age with a decrease in the oldest old (stroke and HF) or were stable at all ages (ACHD). For all diseases, incidence rates were lower among institutionalized individuals and higher in individuals with higher comorbidity indices. The results could be used for understanding currently debated effects of biomedical research, screening, and therapeutic innovations on changes in disease incidence with advancing age as well as for projecting future Medicare costs.

### Keywords

Medicare data; incidence rates; circulatory diseases; age pattern; disability; comorbidity; elderly

### Introduction

Heart disease and stroke have been the leading causes of death and major causes of disability (including long-term severe disability) in the United States for about 80 years, resulting in substantial health care expenditures: for example, in 2007 a projected cost was about \$151.6 billion for coronary heart disease and \$62.7 billion—for stroke (Greenlund, Giles, & Keenan, 2006; Rosamond et al., 2007). Mortality rates of heart disease and stroke steadily declined during past decades; however, they are still ranked as number 1 and number 3 causes of mortality in the United States, being responsible for about 36% of total deaths in populations of 65 years and older (cancer keeps the second position; Centers for Disease Control and Prevention/ National Center for Health Statistics [CDC/NCHS], 2006; Xu, Kochanek, Murphy, & Tejada-Vera, 2010). Mortality rates of heart and cerebrovascular

Corresponding Author: Igor Akushevich, Center for Population Health and Aging, Duke University, P.O. Box 90408, Durham, NC 27708, USA. igor.akushevich@duke.edu.

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diseases increase with age: being 518.9 and 101.1 per 100,000 at age 65–74. At ages 85+, they become 4,778.4 and 1,141.8 per 100,000, respectively (National Center for Health Statistics [NCHS], 2009). To better address the health demands in the elderly and to reduce economic burdens on society, it is important to understand the key factors driving the onset and progression of aging-related chronic diseases such as heart disease and stroke. However, identification of circulatory disease age patterns with sufficient precision requires large population-based data sets that are costly to collect. This is a reason why studies on age patterns of diseases in the United States along with investigations of factors affecting them are not common in the elderly population. Among aging-associated diseases, cancer incidences are better studied at a national level in the United States, predominantly using data from the SEER registry (Altekruse et al., 2009). Age patterns of incidence of cardio- and cerebrovascular (Arnold et al., 2005) diseases were recently studied in the Cardiovascular Health Study (CHS); however, the results of this study cannot be considered as nationally representative.

## Description of the Problem

Incidence rates can be calculated using data from the national registers or from the surveys representing the U.S. population. In the latter case, special procedures are needed to generalize survey results to the national level. One way to do that is to use a weight function (possibly time-dependent) assigned to each individual in the sample—for example, “weighted” sums (means) over individuals in the sample give quantities at the national level. One national survey with such a design is the 1982–2005 National Long-Term Care Survey (NLTC), which focuses on the U.S. elderly (65+) population. Since the NLTC is linked with the Medicare records and with the Vital Statistics files, this is a unique data set with continuous recording of health services, age of death, and detailed reassessment of health status performed by survey every 5 years (except for the first two waves in 1982 and 1984). Several analyses of the NLTC data have provided consistent results on functional disability, active life expectancy, and chronic disease incidence and prevalence in the U.S. elderly (Akushevich, Kulminski, Akushevich, & Manton, 2006; Akushevich & Yashin, 2008; Kulminski et al., 2006; Manton, Corder, & Stallard, 1997; Manton & Gu, 2001; Manton, Gu, & Lamb, 2006; Manton, Stallard, & Corder, 1998; Stallard, 2006), proving that this data set could be a valuable source of information on health status in the elderly. To get a more comprehensive data set allowing for dealing with more detailed information on disease onset and outcome as well as comorbidity and other important health-related issues, the NLTC data set was linked to the Medicare Service Use (MSU) files providing detailed information about diagnoses and dates of medical service use allowing for estimates of the date of disease onset.

## Purpose

The primary goal of this study was to estimate the patterns of age-adjusted and age-, disability-, and comorbidity-specific incidence rates of circulatory diseases in the U.S. elderly population (including the oldest elderly) using the NLTC data linked to the MSU files (NLTC-M). The NLTC-M data is a good candidate for this analysis because (i) the results are representative at the national level, (ii) the spectrum of old ages available for age-

pattern analysis is wider than in many other data sets, and (iii) information on disability and comorbidity can be included in the analysis, which is very important for studies among elderly. Thus, the circulatory disease incidence estimates for advanced ages presented here could be valuable for both understanding age-specific risks of circulatory diseases in the U.S. population which could provide an insight into the mechanisms of age-related diseases, and for projections of the health trends and forecasting the future Medicare expenditures associated with circulatory diseases in the U.S. elderly population.

## Data and Methods

### NLTCS and Medicare files of Service Use

The NLTCS data include 1982, 1984, 1989, 1994, 1999, and 2004/2005 waves and contain longitudinal and cross-sectional information on a nationally representative sample of over 49,258 U.S. elderly aged 65+ years, with 17,000–20,000 age-eligible survivors in each of the six waves (Manton et al., 2006). The universe of interest for NLTCS is the population of Medicare enrollees aged 65 and older in the United States. Geographically, NLTCS is interested in people living within the United States, including Alaska and Hawaii. To reduce the cost of the survey, the NLTCS samples were clustered in 173 primary sampling units (PSUs) that consisted of individual counties and groups of adjoining counties.

The NLTCS provides hundreds of variables measured at each wave including demographic factors, residence type, income, assets, height, weight, alcohol and cigarette use, exercise, 28 major medical conditions, disability (7 activities of daily living [ADLs] and 9 instrumental activities of daily living [IADLs]) measured as the inability to perform respective ADLs/IADLs without help for 90 or more days, 7 functional limitation items (Nagi, 1976), subjective health status, and cognition. The response rate in all NLTCS waves is high (95%).

The NLTCS individuals are linked to Medicare claims data for 1991–2005 to allow for tracking of mortality, health histories, and health maintenance organization (HMO) enrollment/disenrollment. Medicare records are available for each institutional (inpatient, outpatient, skilled nursing facility, hospice, or home health agency) and noninstitutional (Carrier–Physician–Supplier and durable medical equipment providers) claim types. The percentage of coverage by Medicare is high: in January 2001, 95.85% had both Part A and B coverage, 3.46% of sample persons had Part A only, and 0.69% had Part B only. Continuous medical records in Medicare data allow us to reconstruct the individual histories of medical service use and, therefore, investigate disease incidence in the cohort design style.

Two of the six waves, namely cohorts of 1994 and 1999, are used in the analysis. These specific waves were chosen primarily because the high-quality Medicare follow-up data are available only starting from 1991, and also because the complete 5-year follow-up after the NLTCS interview for later than 1991 is accessible only for these two waves. The cohort of 1994 year consists of longitudinal portion (i.e., 13,631 persons eligible for 1989 survey), 5,000 newly selected individuals aged 65+, and supplementary selected sample of 540 persons aged 95+. The cohort of 1999 year includes 13,775 individuals from the longitudinal portion, 5,500 newly selected individuals of age 65+, and 600 individuals from the

supplement of age 95+. Excluding the nonrespondents, 34,077 individuals were followed up between 1994 and 2004.

Individuals from these two cohorts (i.e., cohorts formed in 1994 and 1999 years) are followed up during 5 years from the date of interview. The following variables collected for all individuals in 1994 and 1999 cohorts are used in analysis: (i) sex, (ii) age at interview, (iii) disability index (with outcomes nondisabled, IADL only, 1–2 ADLs, 3–4 ADLs, 5–6 ADLs, Institutionalized) measured at the date of interview, that is, at the beginning of the follow-up, (iv) Charlson comorbidity index according to the specifications described in (Charlson, Pompei, Ales, & Mackenzie, 1987; Quan et al., 2005; this index has been validated for ischemic heart disease, ischemic stroke, as well as studied in Medicare part B claims data (see DHoore, Bouckaert, & Tilquin, 1996; Goldstein, Samsa, Matchar, & Horner, 2004; Klabunde, Potosky, Legler, & Warren, 2000) measured at the date of interview using Medicare records during a year prior to the date of interview, (v) the set of individual Medicare records covering the entire follow-up period used for date at onset identification, (vi) fraction of months additionally covered by HMO during the follow-up period, and (vii) the sample weight provided by the U.S. Census Bureau.

Each interviewed person in the NLTCs received a screener wave-specific weight. This weight is calculated by the U.S. Census Bureau using a multistage procedure in which the final screener weight is the product of four factors: (i) screener base weight, (ii) screener non-interview adjustment factor, (iii) first-stage (ratio estimate) factor, and (iv) second-stage (ratio estimate) factor. The screener base weight is the inverse of the probability of selection of an individual in a sample. These weights are the same for all individuals in the 1982 survey and different for subsequent surveys because of variety of sample components (longitudinal parts, newcomers, healthy supplements, etc.). The screener non-interview adjustment factor in a cell  $h$  is calculated as,  $(I_h + NI_h)/I_h$ , where  $I_h$  and  $NI_h$  denote the weighted number of interviews and non-interviews in  $h$ th cell, respectively. The cells are defined by the age groups (65–74, 75–79, 80–84, and 85+), the reason for Medicare entitlement (for the first age group only) and the PSUs. Special cell collapsing procedures are applied wherever necessary. The first-stage ratio estimate factors adjust for differences between the characteristics of the NLTCs sample and respective population within PSUs. The cells for the first-stage factors are based on the regions (North, North-Central, South, and West), age groups (65–74, 75–79, 80–84, and 85+), and residential status (Standard Metropolitan Statistical Area or not). The second-stage factors represent the ratio adjustments to correct for the difference between weighted sample counts of persons and independent estimates of the total number of persons, within certain defined cells. The independent estimates or “population controls” were projections based on the Census population counts. The second-stage factor cells are based on age groups (65–69, 70–74, 75–79, 80–84, and 85+), race (Black or non-Black), and sex. Thus, the individual weights are defined such that weighted sums of characteristics of sample individuals produce the national cross-sectional estimates of persons aged 65 (Manton & Gu, 2001).

## Date of Onset Definitions

To calculate the age-specific disease incidence rates, one needs to know the date of disease onset. The MSU files provide dates of claims for medical service, which are accompanied by the corresponding ICD-9-CM codes (the International Classification of Diseases, Ninth Revision, Clinical Modification). Therefore, it is reasonable to assume that an individual might experience an onset of a disease during the period of observation if there are one or several records with the ICD-9-CM code corresponding to this disease on institutional claim/claims. Actually, Medicare data do not contain information on whether the appearance of an ICD-9-CM code is a “true” disease onset or just a visit to treat a disease with its onset possibly first registered outside (before) the observation period. Therefore, the date of onset can be identified using information collected in the Medicare Claims files with specific assumptions, which outline the specific calculation algorithm. Note, the date of onset of a certain chronic disease is a quantity which is not defined as precisely as mortality. Besides, different strategies can be used in clinical practice for different diseases. Thus, there is certain arbitrariness in defining the date of onset, which can be used for constructing a unified definition of date of onset appropriate for population studies. The scheme used in this article has resulted from the review of the approaches used in several published studies for different diseases (Nattinger, Laud, Bajorunaite, Sparapani, & Freeman, 2004, 2006; Sloan, Brown, Carlisle, Ostermann, & Lee, 2003). The unified scheme offered for defining the date of onset is useful for comparative analyses of effects of different diseases on medical cost and is also appropriate for prediction purposes.

The ages at onsets of the circulatory diseases were reconstructed from the MSU data using the following scheme. First, the individual medical histories of the applicable disease were reconstructed from Medicare files combining all records with their respective ICD-9 codes. The following ICD-9 codes were used for the considered cases of diseases of the circulatory system: (i) ischemic heart disease (referred in the manuscript as ACHD (acute coronary heart disease), as referred in Luepker et al., 2003), including acute myocardial infarction (MI; 410), other acute and subacute forms of ischemic heart disease (411), and angina pectoris (AP; 413); (ii) cerebrovascular diseases including intracerebral hemorrhage (431), occlusion and stenosis of precerebral arteries with cerebral infarction (433.x1), occlusion of cerebral arteries with cerebral infarction (434.x1), and acute but ill-defined cerebrovascular disease (436); and (iii) heart failure (HF; 428). Then individuals with the history of the considered disease before the date of interview in 1994 or in 1999 were excluded from the cohort studies for the onset of this disease. The detailed individual records in Medicare files are available from 1991, so we have a sufficient time period to reject prevalence cases. The numbers of individuals in the pooled cohort without prevalent cases for each disease are shown in Table 1. All individual trajectories were reviewed by empirical methods (e.g., stratification) resulting in the base algorithm (Algorithm A) for identification of the date of onset. In Algorithm A, a date of a Medicare record (referred to as “*this record*” below in this subsection) is identified with the date of onset of applicable disease if both of the conditions mentioned below are met:

- i. *This record* is the earliest record with respective ICD code as a primary diagnosis in one of four Medicare sources (inpatient care, outpatient care, physician services,

and skilled nursing facilities). This choice is in accordance with the general practice of reconstruction of the date at onset from Medicare data (Nattinger et al. 2004; Nattinger et al. 2006).

- ii. In addition to *this record*, there is another record with its respective ICD code as the primary diagnosis from one of the four Medicare sources listed in (i) which appeared with a date different from the date of *this record* and not later than 0.3 years after *this record*. Death occurred during this period (i.e., 0.3 years after *this record*) is also considered as the second record.

The first condition allows for identifying the first occurrence of disease code, and the second condition is required for confirmation of disease presence. In acute conditions (e.g., ACHD, MI, AP), the requirement of confirmation by occurrence of another record is superfluous because of the definition of acute conditions and because of high mortality after these conditions. Therefore, we define also the Algorithm B, in which only the first condition is valid. Compared with MI, AP cannot be viewed as only acute condition, this is why it could be often registered not only as primary disease and second record is required for disease confirmation. Being heterogeneous by these characteristics, the ACHD group is analyzed both entirely and separately for MI and AP.

This algorithm was used to study recovery after stroke (Yashin et al., 2010), medical cost trajectories before and after age-related disease onsets (Akushevich et al., 2011b), wide spectrum of geriatric diseases incidence using two Medicare-based data sets (Akushevich et al., 2012), and the role of behavior factors in cancer risk (Akushevich et al., 2011a).

### Estimates for U.S. Elderly Population

Age patterns of incidence rates are assessed by stratifying the sample into relevant age categories. For age-adjusted rates, 1-year interval age groups were chosen for ages 66–94, and longer intervals were used for grouping in advanced ages: 95–96, 97–99, and 100+ years. Slightly different grouping was used for evaluation of age-specific rates: 66–67, 68–70, 71–73, 74–76, 77–81, 82–85, 86–89, 90–94, 95–99, and 100+ years old. Empirical age-specific rates ( $\lambda_a$ ) are calculated as a ratio of weighted numbers of cases to weighted person-years at risk:  $\lambda_a = n_a / P_a$ ; where  $n_a = \sum_n w_n$ ,  $P_a = \sum_i w_i$ , and  $w_i$  is the individual weight;  $n$  runs over all disease onsets detected in the age group, and  $i$  runs over all individuals at risk in the age group. The effects of study design also influence the calculation of standard error ( $SE$ ) and confidence intervals of rate estimates. The generalized variance function (Lohr,

2009) is used for calculation of approximate  $SE$ :  $\sigma_E = \sqrt{b\lambda_a(1-\lambda_a)/P_a}$ , where  $b$  is the factor correcting the estimate of  $SE$  on the study design. The  $SE$  calculated with this factor provides the estimate of the approximate  $SE$  at the national level. The factors provided by the NLTCs data providers are different for noninstitutional ( $b=1,545$ ) and institutionalized ( $b=1,079$ ) persons and equal for both cohorts of 1994 and 1999.

Age-adjusted rates (or directly standardized incidence rates) are averages of age-specific rates. For population aged 66+, they are calculated as  $\lambda = \sum_{a=66}^{105+} \lambda_a P_a \left( \sum_{a'=66}^{105+} P_{a'} \right)^{-1}$ . Age-specific rates  $\lambda_a$  and population counts  $P_a$  are defined above through weighted sums;

therefore, the age-adjusted  $\lambda$  rates are both standardized and weighted towards the U.S. population age distribution. Comorbidity- and disability-specific patterns are calculated using the same equations for stratified populations. The standard error for the age-adjusted rate is estimated assuming that the numbers of events observed in each age group are independent or/and have Poisson distributions (Breslow & Day, 1987). The hypothesis about the difference of age-adjusted rates is tested by comparing the difference between age-adjusted estimates of two compared rates (i.e., for 1994 and for 1999) with *SE* for this difference evaluated as the square root of the sum of their standard errors squared. Formally *t*-test is applied for which the approximate *t*-statistics is calculated as a ratio of the rate difference and its *SE*. Since the estimates of rates were obtained based on the large number of cases, respective *t*-distribution with large degrees of freedom is well approximated by the normal distribution. In this case  $|t| < 2$  approximately corresponds to *p* value  $< .05$ .

## Results

The age-adjusted incidence rates of diseases of the circulatory system are presented in Figure 1 for cohorts of 1994, 1999, and both cohorts pooled for males/females and for total population. For males, the ACHD (which included MI and AP) had a leading position, while for females stroke had the highest rates among analyzed diseases for cohorts of 1994, 1999, and for both cohorts pooled. Males of all cohorts had higher rates of ACHD and MI than females, and females had higher rates of stroke than males. Higher rates of HF in males were observed for 1994 cohort and in pooled analysis. For AP, higher rates in males were detected for 1999 cohort and pooled cohort. Because the weights used provided the estimates at the national level, the results (both for age-adjusted rates and SEs) appear to be valid for the U.S. elderly population.

The results on gender disparities and time trends in the age-adjusted incidence rates are shown in Table 2. There was a significant 5-year decline for incidences of ACHD, stroke, and HF.

The age, disability, and comorbidity patterns were analyzed for all considered diseases (see Figure 2). All patterns were obtained using both strategies for disease onset identification (with or without the requirement for another record with primary diagnosis) implemented in Algorithms A and B. As it was discussed in the Date of Onset Definitions section, the latter approach can be more appropriate for acute diseases. As expected, the rates obtained using Algorithm A were significantly higher (Figure 2); however, no substantial changes in the shape of patterns of incidence rates were observed for all studied diseases while Algorithm A or B were used. The patterns presented in Figure 2 substantially differed for males and females: for ACHD and for HF, males had higher rates for all three patterns analyzed. The evaluated person-years for each age group were higher than 500 years (except the group of 95+ years old males with 434 years for HF), the numbers of individuals in each disability or comorbidity sex-specific groups were higher than 250. The incidence rates were increasing with age for MI, stroke, and HF. Rates of ACHD and AP had a tendency to be more stable for all ages. For MI, stroke (females), and HF (males), the changes of incidence age patterns were observed for advanced ages (e.g., 85+) compared to younger elderly (e.g., 65–85 years

old): incidence rates decreased in the oldest old opposite to the trends observed at younger ages.

For MI (males), stroke, and HF (males), the incidence rates were higher for individuals with severe disabilities. Interestingly, for all the considered diseases, institutionalized individuals have lower rates. Among individuals with higher comorbidity indices (i.e., Charlson index), the higher rates were observed for all the considered circulatory diseases.

## Discussion

In this article, three types of the patterns of incidence of several circulatory diseases (such as ACHD, HF, and stroke) were analyzed: age-, disability-, and comorbidity-specific rates were calculated. At our knowledge, this kind of analysis was performed for the first time. While there are several studies characterizing age-patterns of incidence of aging-related diseases among elderly population (aNational Institutes of Health/National Heart, Lung and Blood Institute [NIH/NHLBI], 2006a), patterns of circulatory disease incidence among individuals with various disabilities and comorbidities were not studied at the national level. Data from the linked NLTCS-Medicare files made the analysis of various types of the patterns in the same population—such as U.S. older adults—possible. Below, we discuss why the results of this study could be treated as nationally representative for the U.S. elderly population and how the different algorithms of evaluation of disease onset influence incidence rates.

### **NLTCS/Medicare Information as a Source of Information about the Referent Values of Incidence Rates for the U.S. Elderly Population**

An increasing number of elderly in the United States makes studies on the most prevalent aging-related diseases very important—it is essential to know how incidence rates of circulatory diseases change with age in males and females, what the disability prevalence and patterns for each disease are, and how common and how severe comorbidities in the U.S. elderly are. In this article, such estimates were obtained using the NLTCS-M data, which are capable of providing the estimates that may serve as referent values for different studies designed in the United States and abroad. We used several strategies of identifying the disease onset. One of the schemes is considered basic: it requires occurrence of repeated claims containing chosen ICD code as a prime diagnosis in basic Medicare sources. Such definition is in accordance with the practice of onset identification for many diseases (Nattinger et al., 2004; Nattinger et al., 2006; Sloan et al., 2003). We have described how NLTCS-M data set could be very useful for answering the spectrum of questions on elderly health in the United States from both medical and economical perspectives. These data are population based, minimizing selection bias with respect to geographic region, urban versus rural location, racial health disparities with a whole spectrum of race- and ethnic-specific populations, and socioeconomic characteristics. Each of these factors are important predictors of disease risk, progression, treatment availability, and response—actually this information is limited in databases from more restricted populations (Nattinger et al., 2004).

## Identified Properties of Incidence Rates

Patterns of majority of diseases are well described by the base algorithm. The most important features of the algorithm include occurrence of primary diagnosis in one of four Medicare sources (inpatient care, outpatient care, physician services, and skilled nursing facilities) and confirmation of the diagnoses in another record. Patterns of several diseases require certain corrections to the base algorithm to be adequately described. For example, only one record has to be required for ACHD. In addition, disability and comorbidity patterns of disease incidence were evaluated. Disability was measured using self-reported information, while comorbidity was estimated using Medicare records during the year before the date of interview and beginning of 5-year follow-up period. Because of using the special weight, the results appear to be valid at the national level. Properties of these patterns were briefly discussed in the Results section.

Two definitions of disease incidence and two respective computation algorithms were developed and applied to data. To check which of the definitions better corresponds to those used in other studies on incidence rate evaluation, the definitions were compared with diagnostic criteria typically used (reviewed in (NIH/NHLBI, 2006a)). We found that the base definition involving the requirement of quick confirmation of the original diagnosis better corresponds to widely used definitions for HF and stroke, while the algorithm without this requirement better corresponds for MI and AP. The diagnostic criteria of different heart studies reviewed in appendix of ref. (NIH/NHLBI, 2006a) do not allow us to unambiguously conclude that our choice exactly corresponds to those made in these studies. However, the difference between the results obtained in our study with Algorithms A and B (that could be, for example, due to the fraction of the patients with transitional circulatory attacks whose diagnoses were not confirmed by the second examination or who did not appear at the follow-up exams due to the improved health condition) was more prominent for stroke than for MI. It allows for speculations about more strict criteria required for MI diagnosis in all compared studies than for the stroke.

Several types of age patterns were observed in our study: monotonic increase with age (HF), the shape with a maximum (such as increasing with age with subsequent decrease after age 90—MI and stroke), and the shape with a tendency of decreasing with age (AP). ACHD pattern can be described as flat or a plateau. In spite of larger statistical uncertainty estimated for this age region, the occurrences of shapes with a maximum and, especially, with monotonic decline may be interpreted to contradict the hypothesis that risk of geriatric diseases correlates with accumulation of adverse health events (genetic mutations, deterioration of vascular system, immunosenescence, etc.). There are three basic concepts that are basically attracted to explain such shape of age patterns. Appearance of such effects can be attributed to the effect of selection (Vaupel et al., 1998), where frail individuals do not survive to advanced ages. The frailty models are popular in cancer modeling and were successfully applied to SEER data (Manton, Akushevich, & Kravchenko, 2009; Trussell & Richards, 1985; Yashin et al., 2009). Another explanation is related to possible under-registration of diagnoses at advanced ages—which, however, cannot be proved with available data (Enright, McClelland, Newman, Gottlieb, & Lebowitz, 1999; Solomon & Murphy, 2005). Other possible biologically motivated explanations are discussed in

Ukrainitseva and Yashin (2001): the authors suggested the existence of the mechanisms of possible contribution of individual aging to the shape of mortality curve by subdividing the individual age-associated changes into three components differed by the influence on morbidity and mortality (i.e., basal, ontogenetic, and time-dependent).

In our study, incidence rates of stroke (in males and females) and HF (in males) were higher in elderly with severe disabilities. There are very few studies analyzing incidences of circulatory diseases in populations with certain preexisting levels of functional disability—usually, disabilities are studied as consequences of these diseases rather than preexisting and/or accompanying conditions. Our results are in agreement with other observations that patients with severe disability had a higher chance to be hospitalized with several diseases, including stroke and congestive HF, during the year of follow-up (i.e., about 50–75% cases) than slightly disabled or individuals without disability (i.e., about 15–22% cases; Ferrucci, Guralnik, Pahor, Corti, & Havlik, 1997). Taking into account, that about 24–30% of elderly could recover from their ADL function or improve them within a couple of years as it has been demonstrated in several longitudinal studies (Gill, Robison, & Tinetti, 1997; Katz et al., 1983; Manton, Corder, & Stallard, 1993), it has been suggested that some factors (such as poor nutrition, over-medication, and other risk factors) may directly impede ADL recovery and thus patients who cannot increase their functional level could be at higher risk of developing certain aging-related diseases, for example, HF or stroke. Lower rates of diseases of the circulatory system observed in our study among institutionalized individuals could be explained, at least in part, by the fact that institutionalized patients get treatment which decreases risk of ACHD and stroke. Our findings that individuals with high comorbidity indices had the higher rates of all studied circulatory diseases are in agreement with observations from other studies (Fang & Alderman, 2001; Levy, Larson, Vasan, Kannel, & Ho, 1996; Wenger, 2003).

Comparison of the results obtained for cohorts formed in 1994 and 1999 showed 5-year declines in incidence rates for all studied circulatory diseases. The highest and lowest 5-year declines were detected for stroke (–20%) and MI (–10%), respectively. Comparison of cohort specific age-, disability-, and comorbidity-patterns (not shown) allows us to reveal that (i) the decline in the incidence rate was reached for ages 75–90 (for MI—for ages 95+), (ii) the decline was detected for nondisabled individuals for ACHD, for individuals with IADL only and 5–6 ADLs for HF and stroke, (iii) no decline (even increase for ACHD and HF) was detected for institutionalized individuals, and (iv) no noticeable dependence on comorbidity was found. From the perspectives of sex disparities (see Figure 1 and Table 2), the decline in incidence of HF was more prominent among male, and sex-specific patterns of the decline are comparable for other diseases. Further investigation of the time trend of circulatory diseases as well as other diseases whose incidence rate is capable of detection from Medicare data is required.

### **Importance of the Results for Heart Disease and Stroke**

Heart disease and stroke account for more than 40% of all deaths among persons aged 65 to 74 years and almost 60% of those aged 85 years and older (Kissela et al., 2004; NIH/NHLBI, 1998; Williams, 2001). However, no nationally representative data are available on

incidence, severity, or recurrence of acute coronary or stroke events in either the inpatient or out-patient settings, with the performance measures that are not consistent across databases (Goff et al., 2007). For heart disease and stroke, most of the readily available statistics in the United States are data sets with self-reported diseases and conditions, and results obtained from their analyses are predominantly on disease prevalence rather than on incidence events (NIH/NHLBI, 2005; NIH/NHLBI, 2006b; Thom et al., 2006). While most of the hospital-based surveillance programs are research projects rather than public health surveillance programs, the population-oriented surveys (such as those studying various risk factors prevalence) often have limited or no data on disease onset, detailed diagnosis, treatment, comorbidities, and so on. Therefore, the linked NLTCs-Medicare data equally representing both genders and various race/ethnic groups, and, specifically, having large enough number of incident cases of circulatory diseases could be very useful in estimating diseases incidence events in the U.S. elderly, together with associated medical costs, as well as comorbidities and disability (Feigin, Lawes, Bennett, & Anderson, 2003).

### Limitations of the Study

The following points have to be kept in mind in interpreting the results of the study. Only primary diagnoses were taken into account. Secondary diagnoses can escape registration. The approximate statistical errors for age-specific and age-adjusted rates were obtained using a correction on sample design. Age-adjusted rates represent aggregated effects of different age groups with, maybe, different time trends (time trends of age-specific rates are discussed in Akushevich and Yashin [2008]). The rates obtained with alternative definitions of age at onset can differ and therefore, a detailed sensitivity analysis and the comparison of obtained rates to those obtained in other studies is a useful extension of this study which will be a subject of another investigation.

### Conclusion

The performed analyses suggested that the national age-specific incidence patterns of circulatory diseases can be adequately evaluated from the Medicare Files of Service use. The NLTCs-M data set allows for bringing in additional information such as data allowing for analysis of comorbidity and disability patterns, data on use of medical procedures, data on case fatality assessment, specifically for ACHD and stroke, and so on. This information is extremely important for detailed analysis of health related effects in the U.S. elderly and cannot be obtained from the existing data sets. In addition, an advantage of the Medicare data is that they relate these age-specific incidence patterns to Medicare costs and, using NLTCs files, to disability prevalence. These results are timely and important as they may inform current scientific and policy debates about the effects of biomedical research and therapeutic innovations on disease incidence at increasingly advanced ages when effective therapeutic interventions are actively introduced in coming decades.

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## Biographies

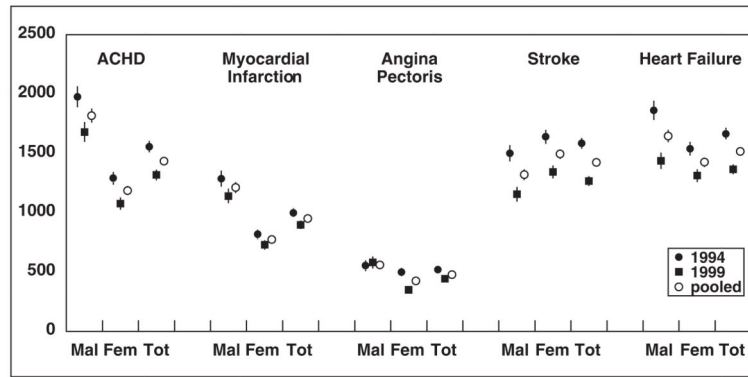
**Igor Akushevich** is a senior research scientist at the Center for Population Health and Aging, Duke University. He received PhD in Theoretical and Mathematical Physics from the Byelorussian Academy of Sciences. He works in the area of biodemography of aging with special interest to studying geriatric-disease epidemiology from large-scale data.

**Julia Kravchenko** is a research scientist at the Duke Cancer Institute, Duke University. She received PhD in Medicine and Biochemistry from the Belorussian Medical Academy of Postgraduate Education. She works in the areas of cancer epidemiology, population-based disease risk studies, disease mechanisms modeling, clinical data analyses, and environmental/behavioral risks analyses.

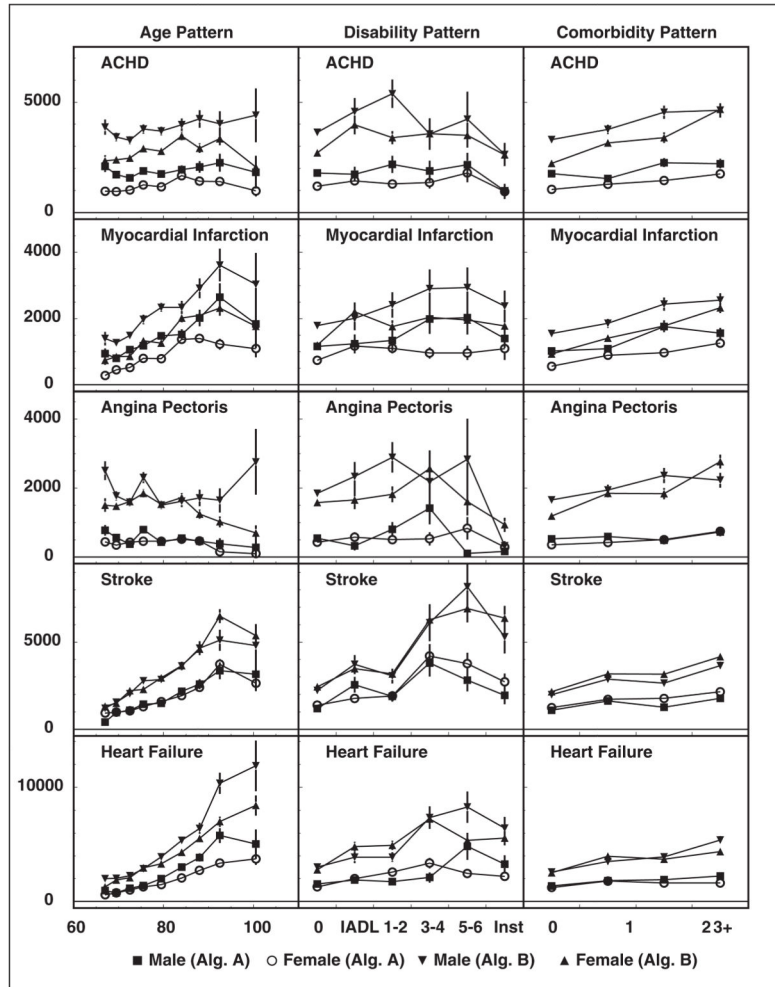
**Konstantin Arbeev** is a senior research scientist at the Center for Population Health and Aging, Duke University. He received PhD in Mathematics and Physics from Ulyanovsk State University (Russia). His research interests include development of stochastic models for analyses of dynamic mechanisms of aging from longitudinal measurements of physiological indices.

**Svetlana Ukraintseva** is a senior research scientist at the Center for Population Health and Aging, Duke University, USA. She received her PhD in Genetic Epidemiology from the Moscow Institute for Medical Genetics, Russia. Her research interests include factors and mechanisms responsible for connection between aging, aging-related chronic diseases, and longevity.

**Anatoli Yashin** is a professor at the Center for Population Health and Aging, Duke University, USA. He received his PhD in Theoretical Cybernetics and DSc in Applied Statistics from the USSR Academy of Sciences. He studies mechanisms of aging-related changes in humans using advanced methods of statistical modeling.



**Figure 1.** Age-adjusted incidence rates per 100,000 of circulatory diseases with standard errors.



**Figure 2.** Age (left columns), Disability (central columns), and comorbidity (right columns) patterns of the incidence rates (per 100,000) of geriatric diseases for males and females with error bars represented approximate SE. The aArguments are years (age), disability groups (nondisabled, IADL only, 1–2 ADLs, 3–4 ADLs, 5–6 ADLs, and institutionalized), and comorbidity group in the units of Charlson index (0, 1, 2, and 3 and more). The rates are calculated using Algorithms A and B.

**Table 1**

The Numbers of Individuals Followed-up for Onsets of Circulatory Diseases and the Total Numbers of Registered Onsets.

	Individuals in two waves	Individuals without HMO	Individuals without HMO and without prevalent cases	The number of onsets
ACHD	34,077	27,607	25,568	2,394
MI	34,077	27,607	26,785	1,991
AP	34,077	27,607	26,634	761
Stroke	34,077	27,607	26,408	2,768
HF	34,077	27,607	25,921	3,046

*Note.* ACHD = acute coronary heart disease; MI = myocardial infarction; AP = angina pectoris; HF = heart failure.

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**Table 2**

Estimates of *t*-Statistics for Time Trend and Male/Female Differences in the Age-Adjusted Incidence Rates of Geriatric Diseases.

	Time trends			Male/female differences		
	Males	Female	Total	1994	1999	Combined
ACHD	-2.45	-2.83	-3.59	6.62	6.18	8.91
MI	-1.59	-1.52	-2.02	5.93	5.58	8.04
AP	0.40	-3.31	-1.98	0.94	3.89	3.33
Stroke	-3.73	-3.64	-5.18	-1.51	-2.30	-2.81
HF	-4.04	-2.86	-4.72	3.25	1.43	3.33

*Note.* Absolute value of *t*-statistics larger than 2 approximately correspond to significant differences with  $p < .05$ .