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Surveillance Of Stroke Occurrence in the Calgary Health Region during 1995 - 2004

by

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Abstract

We assessed the use of administrative data for passive stroke surveillance by linking the emergency room visits (ER) data with IP data (named merged IP-ER). We examined the validity of merged IP-ER, IP, and ER in three time periods, and found that the PPV for all stroke, TIA and ICH are very good but not sound for AIS and SAH in the merged IP-ER data. Data quality is much better in the IP data and when using the ICD-10 algorithm. The validity of data became excellent for AIS in merged IP-ER if unspecified stroke codes were excluded.

We observed a declining trend of age-adjusted rate for overall stroke, which is accompanied by increasing number of strokes, and declining in-hospital case-fatality. The burden of stroke is much higher applying merged IP-ER than using IP only. Non-specific stroke codes (query stroke and unspecified stroke) affect the reported number and patterns of stroke.

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Dedication

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To my lovely little boy, **Sean**, who has brought me a lot of fun and happiness during my study.

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List of Symbols, Abbreviations and Nomenclature

Abbreviations	Definition
AIS	Acute Ischemic Stroke
AOR	Adjusted odds ratios
BRFSS	Behavioural Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CHR	Calgary Health Region
CI	Confidence Interval
CIHI	Canadian Institute for Health Information
CV	Cardiovascular diseases
CVD	Cerebrovascular disease
DALY	Disability-adjusted life years
ER	Emergency Room Data
HSFC	Heart and Stroke Foundation of Canada
ICD - 10	International Classification of Diseases, 10th edition
ICD - 9	International Classification of Diseases, 9th edition
ICH	Intracerebral hemorrhage
IP	Hospital Discharge Abstract Inpatient Data
Merged IP-ER	Merged Hospital Discharge Abstract Inpatient Data & Emergency Room Data
MONICA	Monitoring Trends and Determinants in Cardiovascular Disease Project
NCDs	Non-communicable diseases
NHDS	National Hospital Discharge Survey

NPV	Negative Predictive Value
PHAC	Public Health Agency of Canada
PHN	Personal Health Number
PPV	Positive Predictive Value
QSHI	Quality Safety Health Information
RCSH	The Registry of the Canadian Stroke Network
SAH	Subarachnoid hemorrhage
SE	Sensitivity
SP	Specificity
TIA	Transient ischemic attacks
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

Surveillance is the gateway to information about etiology, risk, prognosis, prevention and intervention as well as disease distribution and time trends [1]. In this thesis project, passive surveillance will be conducted using administrative data to portray the pattern of stroke occurrence and in-hospital case-fatality in the Calgary health region (CHR) over the last decade 1995-2004. These data will provide useful information for the prevention of stroke, health care planning and resource allocation within the CHR. We hope through this pilot project, that those algorithms that are developed with CHR data may be generalized to the rest of Alberta to help establish a complete provincial, and potentially national stroke surveillance system.

1.1 Burden of Stroke

What is a stroke? A stroke [2] is a sudden loss of brain function caused by the interruption of the flow of blood to the brain (an ischemic stroke) or the rupture of blood vessels in the brain (a hemorrhagic stroke). The interruption of the blood flow or the rupture of blood vessels causes brain cells (neurons and glia) in the affected area to die. The effects of a stroke depend upon both where the brain was injured, and how much damage occurs. About 80% of strokes are ischemic, while 20% of strokes are hemorrhagic, including two main types - subarachnoid hemorrhage and intracerebral hemorrhage.

Stroke represents a major public health challenge throughout the world. According to estimates from the World Health Organization (WHO) [3], nearly 5.5 million stroke-related deaths occurred in 2002 [3]. Every ten minutes someone in Canada suffers a “brain attack”, making stroke the most common serious neurological condition requiring hospital admission [4]. Each year, about 50,000 Canadians are admitted to hospital because of stroke and stroke accounts for about 16,000 deaths annually [4]. In Canada, the number of hospitalizations for cerebrovascular disease (mainly stroke) has been increasing for the past twenty years and is projected to continue to increase over the next twenty years [5].

The greatest burden of stroke, apart from death, is serious long-term physical and mental disability. Approximately one third of stroke victims die within 1 year, and an equal number of patients are permanently disabled [6]. Long-term disability resulting from stroke constitutes an enormous drain on personal, family, and institutional resources. However, effective treatments are limited once an attack has occurred.

Moreover, the burden is expected to increase as a result of the “greying of Canada”, since after age 55, the risk of stroke doubles every ten years and a stroke survivor has a 20% chance of having another stroke within two years [4]. According to the 2001 Census, seniors aged 65 and over constituted 13% of the Canadian population in 2001. This proportion is projected to reach 15% by 2011 and just over 20% by 2025 [4]. Therefore, the number of strokes across Canada is expected to increase over the next two decades with the aging of the “Baby Boom” generation – one of the major factors pushing up the number.

The economic burden of stroke is very heavy. The cost associated with treatment of stroke is staggering. Stroke costs the Canadian economy $2.7 billion a year and the average acute care cost is about $27,500 per stroke [7]. Since we are facing an urgent burden of stroke in the future, stroke prevention should be a primary focus for all health care providers [8].

1.2 Risk Factors for Stroke

For decades, a wide range of non-modifiable and modifiable risk factors for stroke have been identified or proposed. Among the nonmodifiable risk factors are age, sex, ethnicity, and heredity; and among the modifiable risk factors are hypertension, cardiovascular diseases (CV), diabetes mellitus, hyperlipidemia, cigarette smoking, and alcohol abuse [9-12]. Statistics Canada reports that eighty percent of the Canadian population has at least one modifiable risk factor for stroke; nearly one-third has two risk factors; and another 11% have three or more [4].

Of the modifiable risk factors for stroke, hypertension has been the most thoroughly investigated. Hypertension has been considered an underlying factor in almost 70% of stokes [13]. The presence of hypertension increases the incidence of ischemic or hemorrhagic stroke in individuals of both sexes and all ages [14]. The second most important modifiable risk factor – tobacco use, increases the risk of ischemic stroke about two-fold. There is a dose-response relationship such that heavy smokers are at higher risk for stroke than light smokers [15].

1.3 Background of Surveillance

1.3.1 Definition of Surveillance

From the Centers for Disease Control and Prevention, surveillance is defined as "The ongoing systematic collection, analysis, and interpretation of health data, essential to the planning, implementation, and evaluation of public health practices, closely integrated with the timely dissemination of these data to those who need to know. The final link in the surveillance chain is the application of these data to prevention and control. A surveillance system includes a functional capacity for data collection, analysis, and dissemination linked to public health programs."[16]

1.3.2 History of Surveillance

The history of public health surveillance and the first real public health action related to surveillance can be traced back to efforts to control the bubonic plague in the 14th century, when public authorities boarded ships in the port near the Republic of Venice to prevent persons suffering from a plague-like sickness from disembarking [17-19]. Then in the 1680s, John Graunt published the Natural and Political Observations Made Upon the Bills of Mortality, which defined disease-specific death counts and rates, and the concept of disease patterns, some of the fundamental principles of public health surveillance [18, 19]. Actually, William Farr (1807-1883) was renowned for formulating the concepts of surveillance we know today. Farr collected, analyzed, interpreted and evaluated vital statistics. He disseminated his results to the responsible authorities and to the general public [18-20]. Until 1950, surveillance was restricted to watching contacts of communicable diseases such as smallpox, in order to detect early signs and symptoms so that these contacts could be isolated to prevent spread of the disease. In 1963, Langmuir further formulated modern concepts of public health surveillance by emphasizing the role of surveillance in describing the health of populations. In the 1968 twenty-first World Health Assembly, which focused on the national and global surveillance of communicable diseases, Langmuir's 1963 description of surveillance was endorsed and three main features of surveillance were described [18, 19]. At that assembly, the WHO broadened its concept of surveillance to include a full range of public health problems (beyond communicable disease) such as childhood poisoning, leukemia, congenital malformation, injuries and behavioral risk factors. In the 1980s, the introduction of microcomputers began to transform surveillance systems, allowing decentralized data analysis and electronic linkages of participants in surveillance networks. The central role of surveillance was emphasized in 1998 when the Institute of Medicine defined three fundamental functions of public health: “1) assessment of the health of communities, which depends largely on surveillance; 2) policy development based on the “community diagnosis” and prognosis established through surveillance; and 3) assurance that necessary services are provided, using surveillance as one measure of the impact of programs” [19].

Gradually, with the broadening of the concepts of surveillance outside communicable diseases, a wide spectrum of surveillance activities including stroke surveillance were initiated. The public, health professionals and policy-makers all agree on the need for timely, accurate and relevant data. Forecasting and tracking changes as well as monitoring progress are integral parts of achieving health for all [4]. Therefore, surveillance is necessary to understand and meet the future demands that illness will be placed on health care.

1.4 Stroke Surveillance

1.4.1 Status of Noncommunicable Diseases Surveillance

Currently noncommunicable diseases (NCDs) represent 43% of the global burden of disease. By the year 2020 this figure is expected to rise to 60% with NCDs representing 70% of all deaths [21]. This prediction, resulting from recently gathered country-level data, indicates the emerging epidemic of NCDs. Surveillance is crucial in helping countries monitor and evaluate emerging patterns and trends of disease. However, surveillance of non-communicable diseases has been neglected in modern public health. Most countries have well-established infectious disease surveillance systems, yet lack non-communicable disease surveillance systems. One of the key differences between communicable and NCDs surveillance is that the first focuses mainly on identifying individuals and reporting counts, and the latter focuses on the population burden and distribution of risk factors and conditions [22].

1.4.2 The Need for Stroke Surveillance

Stroke is a disease which is suitable for surveillance. Stroke is a clinically defined disease, which makes it possible to identify trends in different countries irrespective of access to technological equipment [23]. Therefore, stroke surveillance can be undertaken without access to highly specialized diagnostic equipment. In addition, stroke meets many of the criteria that warrant the establishment of a surveillance system: it is a major public health problem that has a major impact in all countries, it is largely preventable and may be used as an indicator for the effect of public health initiatives [22]. Stroke surveillance would allow us to develop an overall picture of stroke in the population, do time trend analyses, better explore the geographic distribution of stroke and better understand stroke risk and care in important subpopulations. Moreover, a surveillance system would help to guide policy decisions concerning programs and research for specific populations [24].

CHAPTER TWO: LITERATURE REVIEW

The first part of this chapter summarized the purposes of surveillance, different approaches to surveillance, key elements of a surveillance system and how to evaluate a surveillance system according to books and documents from Buchler et al [19-30]. Part two, the literature review, synthesized studies of stroke surveillance in the world identified through Medline and the Cochran system.

2.1 Purposes of Surveillance

The most common objectives of surveillance include [19]:

a. Descriptive epidemiology of health problems: by monitoring the trends in incidence or prevalence of specific health problems, documenting their impact in defined populations and characterizing affected persons and those at greatest risk.

b. Links to service: at the community level, surveillance information can direct health departments in providing services to individuals. Surveillance data can also be used to guide and evaluate health programs.

c. Links to research: although surveillance data are useful in describing the basic epidemiology of health problems, they infrequently provide sufficient detail for examining more in-depth epidemiology hypotheses. Therefore, surveillance can provide an important conduit to researchers by providing clues for further investigation of health problems and by identifying individuals who may be subjects in specific research projects.

d. Evaluation of interventions: by charting trends in the numbers or rates of events, or characteristics of affected individuals, surveillance may help in the assessment of the impact of intervention programs.

e. Projections: since public health planners often need to predict future demands for health services, surveillance data can be used to estimate future trends through a combination of the observed trends in disease incidence coupled with other information about populations at risk.

f. Education and policy: after information is obtained by the collecting organization and returned to those who need it, the cycle of surveillance becomes complete when that information is applied. Surveillance information educates those directly responsible for providing health care and those who influence the distribution of health resources.

2.2 Approaches to Surveillance

A broad range of methods can be employed in conducting surveillance activities depending on information needs and resources. Some of the approaches [19-26] used include:

a. Active and passive surveillance: An "active" surveillance refers to a system where public health staffs seek reports on diseases on a regular basis. A "passive" approach means that the organization conducting surveillance does not regularly contact potential reporters but rather leaves the initiative for reporting to them [19]. While the terms "active" and "passive" surveillance are conceptually useful, "they are insufficient for describing a surveillance method" [19] since surveillance systems may not be either totally active or totally passive. Rather than describing whether a system is active or passive, it is more important to describe how surveillance was conducted, who was contacted and how often and what if any, back-up procedures were in place to identify cases.

b. Laboratory-based surveillance: The use of diagnostic laboratories as the basis for surveillance can be highly effective, with the ability to identify patients seen by different physicians, specifically when the laboratory testing and services are centralized.

c. Notifiable disease reporting: Based on legally mandated reporting of certain diseases, this approach has mainly been used (not exclusively) for infectious diseases.

d. Volunteer providers: When information needs exceed the capabilities of routine approaches such as notifiable disease reporting, special networks are sometimes developed to meet such needs.

e. Registries: These include listings of all occurrences of a disease, or classes of diseases within a distinct area (e.g. cancer, birth defects). Because they collect relatively detailed information, registries may identify patients for long-term follow up or for specific laboratory or epidemiologic investigation.

f. Information Systems: These are large database collected for general, rather than disease specific purposes. They can be applied to the surveillance of specific conditions, and more often, the use of these systems for monitoring health may be secondary to other objectives. Since these systems serve multiple objectives, their use for surveillance requires caution, as the data collected may not encompass stringent data quality procedures. Examples of such systems include: vital records, hospital discharge records, and insurance billing records.

g. Sentinel surveillance: This approach involves a limited number of selected reporting sites, from which reports may be generalizable to the whole population, making this type of surveillance useful to common conditions where complete case counting is neither important nor feasible, and where public health action is not determined by individual reported cases. Aggregate data from sentinel surveillance are usually collected on a weekly basis by telephone, fax, or electronic mail. An example of a sentinel surveillance is monitoring the annual incidence of influenza [25].

h. Record linkages: By linking records from different sources, their usefulness for surveillance may be enhanced. As an example, linkage of birth certificates (which list birth weight) and infant death certificates (which do not list weight) may be used to determine trends in birth weight-specific neonatal death rates. The ease of performing such linkages depends on the accuracy and specificity of identifying information.

i. Surveys: Periodic or regular/ongoing surveys can be an important approach to collecting surveillance data by providing a method for monitoring an array of factors influencing health and disease such as behaviors associated with disease, knowledge/attitudes that influence health behaviors, personal attributes that affect disease risk, self-reported disease occurrence and use of health services.

The uses of surveillance information can be organized on the basis of three categories of timeliness: immediate, annual or biannual, and archival [18, 26]:

a. Immediate use – detecting epidemics, newly emerging health problems and changes in health practices.

b. Annual or biannual use – estimating the magnitude of health problems, assessing control activities, setting research priorities, testing hypotheses, monitoring risk factors and changes in health practices and documenting distribution and spread of health problems.

c. Archival use – storing readily accessible data that can be used to conduct research into the predictors of adverse health events and to document the evolving health status of populations.

2.3 Key Elements of a Surveillance System

Several key elements make up a surveillance system: [27-29]

1. *Establish objectives / rationale*. The objective should answer the question: what do people need to know? It should be outcome oriented, measurable and feasible; and should include elements that are directly linked to the outcome or determinant (risk factor) of interest.
2. *Case definitions.* Should include clear criteria related to person, place, and time; incorporate clinical and laboratory diagnostic information (including diagnostic imaging); include a clear and concise description of the epidemiological features of the disease; include statements about limitations that impact the degree of certainty of a diagnosis, have high sensitivity and specificity. When both high specificity and sensitivity are desired, there is usually a trade off between them.
3. *Framework describing the population, health and illness events included in the surveillance system.* The needs of the decision makers who will use the data should be reflected in the health events included in a surveillance system. Populations included may range from individuals at specific institutions, to residents of a community or residents of a nation. Previously defined health goals should ideally determine the health events to be included in a surveillance system, and the data collected should point to policy decisions that are necessary to improve these goals.

4. *Data collection*. Data collection must produce valid and reliable data. Factors to be considered in the data collection component of a surveillance system include: amount of time needed for data collection, data sources, data collectors and methods of data transmittal. If existing sources of data such as administrative databases are used, caution must be sought since these sources often present limitations in terms of timeliness and comprehensiveness, because their original intent was not for surveillance.
5. *Data analysis.* A determination of the appropriate analytic approach should be an integral part of the planning of any surveillance system. Development of a data analysis plan confirms what will be done, how often and by whom. In addition, the plan must consider whether the data analysis will be centralized or performed by the organizations that collect the data. Generally, routine analyses are conducted in response to pre-designed requirements of the system, while special analyses are done to explore various findings that emerge from the routine analyses or to probe into specific research questions.
6. *Interpretation and reports*. Data must be analyzed and presented in a convincing and forceful manner so that decision makers at all levels can readily understand the implications of the information. Routine reports are produced in response to the timing requirements of decision and policy makers.
7. *Information dissemination*. A comprehensive dissemination plan should be integral to the planning of any surveillance system. Depending on the type of surveillance system, the audience for the information includes: health planners and decision makers, non-governmental organizations, the private sector and the general public.

Privacy and confidentiality issues should be considered in the dissemination plan. The internet is a great medium for providing readily available information to a large portion of the population.

8. *Use of surveillance information.* Surveillance information must be turned into intelligence, where the information is both understood and used by the receivers. Ideally those who will use the information (e.g. health planners and managers) should be involved in the development and modification of the system to ensure that it will meet their needs.
9. *Evaluation and revision*. Evaluation of a surveillance system should be an integral part of its operations. The evaluation should address the structure, processes or activities and outcomes of the system. Periodic evaluation coupled with a formal process for review and recommending change, assures that the system remains vibrant in meeting its goals and objectives.

2.4 Evaluation of Surveillance Systems

The overall purpose of evaluating public health surveillance is to obtain feedback about the operation of the system to promote the most optimal use of health resources. The evaluation should assess whether a system is serving a useful public health function and is meeting its stated objectives [30-32].

2.4.1 Evaluation Guidelines

In 2001, the Centers for Disease Control and Prevention (CDC) published “Updated Guidelines for Evaluating Surveillance Systems”, which is by far the most widely accepted approach to conduct evaluations of surveillance systems. CDC recommended that all public health surveillance systems should be evaluated periodically, and the evaluation should include recommendations for improving quality, efficiency and usefulness [33]. Summarized descriptions about CDC's recommended Tasks for evaluating a public health surveillance system are as below: [33]

Task A. Engage the Stakeholders in the Evaluation

These stakeholders include: public and private health practitioners, all levels of governments, health care providers, data providers and users and representatives of affected communities.

Task B. Describe the Surveillance System to be Evaluated

Describe the public health importance, purpose and operation of the system, and the resources used to operate it.

Task C. Focus the Evaluation Design

Task D. Gather Credible Evidence Regarding the Performance of the Surveillance System

Describe each of the following system attributes: simplicity, flexibility, data Quality, acceptability, sensitivity, Positive Predictive Value (PPV), representativeness, timeliness and stability.

Task E. Justify and State Conclusions, and Make Recommendations

Task F. Ensure the Use of Evaluation Findings and Share Lessons Learned

Make deliberate efforts to ensure that the findings from the evaluation are used and disseminated appropriately.

2.4.2 Summary

There is no perfect surveillance system; tradeoffs must always be made. Because public health surveillance systems vary in methods, scope, purpose, and objectives, attributes that are important to one system might be less important to another. Efforts to improve certain attributes (e.g., the ability of a public health surveillance system to detect a health-related event [sensitivity]) might detract from other attributes (e.g., simplicity or timeliness). Therefore, an evaluation of the public health surveillance system must consider those attributes that are of the highest priority for a given system and its objectives. Each system is unique and must balance benefit versus personnel, resources, and cost allocated to each of its components if the system is to achieve its intended purpose and objectives. [33, 34]

2.5 Previous Stroke Surveillance in the World

Stroke surveillance from the United States, Finland, France, Sweden, Russia, Japan, China, Canada and WHO were reviewed to represent the circumstances of stroke surveillance in the world.

2.5.1 United States

2.5.1.1 Behavioral Risk Factor Surveillance System (BRFSS) survey

BRFSS is a state-based, random-digit-dialled telephone survey of the non-institutionalized, U.S. civilian population aged >=18 years. Using 2003 BRFSS, two studies have assessed the prevalence of multiple risk factors for heart disease and stroke and identified racial/ethnic and socioeconomic disparities in risk status among the population. By estimating the differences in the prevalence of multiple risk factors with respect to age, race/ethnicity, education etc, DK Hayes et al [35] found that a high proportion of the U.S. population had multiple risk factors for heart disease and stroke, particularly certain population subgroups defined by race/ethnicity and socioeconomic status. Consistently, by examining adjusted odds ratios (AORs), another study [36] concluded that prevalence of stroke was higher among blacks than among whites. Prevalence of stroke was higher in the southeastern states where persons tended to have lower education levels than in the non-southeastern states.

2.5.1.2 Brain Attack Surveillance in Corpus Christi (BASIC) Project

The BASIC project [37] is a population-based stroke surveillance study conducted in southeast Texas. All stroke cases were ascertained through active and passive surveillance form January 2000 through April 2002 and compared with population estimates from a random-digit telephone survey. Four studies have been published regarding this project. **One study** [37] analyzed whether a computer algorithm or abstractor could diagnose stroke as well as a fellowship-trained stroke neurologist, and reported that the use of computer verification or abstractors may obviate the need for physician stroke verification and may greatly improve study efficiency. **Piriyawat et al** [38] conducted a study that provided a quantitative means of assessing the utility of active and passive surveillance for cerebrovascular disease to choose an optimal stroke surveillance method. They suggested that more uniform surveillance methods would allow comparisons across studies and communities. Another two studies compared stroke incidence, and biological risk factors among Mexican Americans and non-Hispanic Whites. **Morgenstern et al** [39] concluded that Mexican Americans experienced a substantially greater incidence of ischemic stroke and intracerebral hemorrhage, incidence compared with non-Hispanic Whites. Additionally, **Smith et al** [40] found that Mexican American stroke patients were less likely to have graduated from high school, more likely to earn less than 20 000 dollars per year, and more likely to have diabetes compared with non-Hispanic white stroke patients. Stroke disparities between these populations may be explained only partially by differences in the prevalence of some biological and social factors.

2.5.1.3 Minnesota Heart Survey

The Minnesota Heart Survey [41] is a population-based study designed to monitor and explain trends in cardiovascular mortality, morbidity, and risk factors. Through this surveillance time-trends study, **Mcgovern et al** found that there was a substantial decline in stroke mortality of more than 50% from 1960 to 1990 in Minneapolis-St Paul, which appears to have been attributable to both primary and secondary prevention.

2.5.1.4 National Hospital Discharge Survey (NHDS)

NHDS has obtained a nationally representative sample of discharge records from nonfederal short-stay hospitals in the United States from 1965. This survey covers discharges from noninstitutional hospitals, not including federal, military, and Veterans Administration hospitals. Only short-stay hospitals (average length of stay <30 days) are included. **Fang et al** [42] estimated trends of stroke hospitalization and in-hospital case fatality during 1988-1997 using data from NHDS, and discovered a declining age-adjusted stroke mortality accompanied by a fall in hospital case fatality rates in the United States.

2.5.1.5 Hospitalization surveillance data in California

In 2002, the California Department of Health Services published a document [43] to describe the burden of heart disease and stroke in California and to help prevent future disease through risk modification. In Mortality Surveillance Data, stroke death trends were presented (1979–99), by sex (1979–99) and by race/ethnicity (1985–99). Hospitalization surveillance data provides hospitalization rates and costs due to heart disease and stroke in California. Data were acquired from the Office of Statewide Health Planning and Development and were age-adjusted to the 2000 U.S. standard population.

2.5.1.6 Paul Coverdell National Acute Stroke Registry

Paul Coverdell National Acute Stroke Registry [44] was established by the Centers for Disease Control and Prevention (CDC) in 2001 to track and improve the delivery of care to stroke patients, to provide important, consistently available data to monitor progress in reducing the incidence of stroke and associated disabilities and mortality. The data elements recommended by an expert panel included patient-level data to track the process of delivering stroke care from symptom onset through transport to the hospital, emergency department diagnostic evaluation, use of thrombolytic therapy when indicated, other aspects of acute care, referral to rehabilitation services, and 90-day follow-up. Hospital-level measures pertaining to stroke center guidelines were also recommended to augment patient-level data. Several studies have been carried out using data from this state-wide stroke registry.

Reeves et al [45] published the first article describing key features of acute stroke care from four prototype registries in Georgia (Ga), Massachusetts (Mass), Michigan (Mich), and Ohio. Each prototype developed its own sampling scheme to obtain a representative sample of hospitals. Acute stroke admissions were identified using prospective (Mass, Mich) or retrospective (Ga, Ohio) methods. All prototypes used a common set of case definitions and data elements. Weighted site-specific frequencies were generated for each outcome. They observed that a minority of acute stroke patients had been treated according to established guidelines. Quality improvement interventions, targeted primarily at the health care systems level, are needed to improve acute stroke care in the United States. Later **Mullard AJ et al**[46] examined use of and predictors for in-hospital lipid testing and Lipid-lowing therapy (LLT) in a study that included only IS and TIA cases discharged alive. The study found that many hospitalized acute IS and TIA patients with indications for LLT are untreated at discharge. Efforts to close treatment gaps in lipid evaluation and treatment require sustained quality improvement efforts and should pay particular attention to high-risk patients. **Deng YZ et al** [47] recently conducted a study using a modified stratified sampling scheme to assess the use of IV recombinant tissue plasminogen activator (rt-PA) in a statewide hospital-based stroke registry and to identify factors associated with its use among eligible patients. They concluded that treatment with IV rt-PA was underutilized in this hospital-based stroke registry. The primary reason for nontreatment was delayed presentation.

2.5.1.7 North Carolina Stroke Prevention and Treatment Facilities Survey

This survey [48] is one of the first comprehensive statewide assessments of hospital-based stroke-related prevention and treatment services which was conducted in North Carolina in 1998. A single-page survey was mailed to the directors of each inpatient medical facility in North Carolina. Data collected included the availability of selected diagnostic tests, programs, and services. Facilities were categorized as providing basic (emergency department, brain CT, treatment with rtPA, transthoracic echocardiography, carotid ultrasonography, cerebral angiography, carotid endarterectomy) or advanced (basic services plus brain MRI, MR angiography, transesophageal echocardiography, transcranial Doppler ultrasonography, interventional radiology) services to identify underserved regions and target educational efforts. The 1988 survey identified that services which may improve outcomes and reduce costs are not widely used, even in centers with full basic capabilities. In 2003, a one-page questionnaire was sent to each facility in the state, and results were compared with the 1998 survey[49], to measure changes in these services that may have occurred over the last 5 years. Certain technologies have become more widely available, but hospital investments in stroke-related programs have not appreciably increased.

2.5.2 Finland

Numminen et al [50] carried out a study comparing the results of three Population-Based Stroke Registers to determine trends in stroke incidence, mortality rates, case-fatality rates, and their relation in Finland from 1972-1991. They found a declining trend in the stroke incidence rate combined with a decreasing case-fatality rate at that time.

Pajunen et al [51] using administrative data from the Cardiovascular Disease Register, linked the Finnish Hospital Discharge Register and the National Causes of Death Register, including data on 410 760 cerebrovascular events (ICD-10 codes I60-I69). They analyzed the trends in fatal and nonfatal strokes during 1991-2002 and found that a favourable development in stroke incidence, mortality, and case-fatality had continued in Finland during that period.

2.5.3 France

Lemesle et al [52] evaluated the time trends associated with the incidence of all the subtypes of ischemic stroke and transient ischemic attacks in Dijon France from 1985 to 1994 through the Dijon Stroke Registry. This Registry that is based on clinical data and CT findings, has recorded all first-ever strokes and first-ever transient ischemic attacks (TIAs) occurring since 1985 in the city of Dijon. The researchers concluded that these preliminary data emphasized the importance of stroke surveillance in considering the variations of the different mechanisms (causes) of ischemic cerebrovascular disease.

2.5.4 Sweden

Stegmayr et al [53] examined acute first-ever stroke (except subarachnoid haemorrhage) and monitored the change in stroke incidence, case fatality and neurological deficits in the age group 25-74 years in northern Sweden during the years 1985-1993 within the framework of the WHO Monitoring Trends and Determinants in Cardiovascular Disease Project (MONICA). A declining case fatality was observed in both sexes. Among patients with non-haemorrhagic stroke, the decline was confined to patients with minor deficits.

2.5.5 Russia

A study [54] was conducted to investigate the incidence of stroke and 30-day case-fatality rates for stroke in a defined Russian population. All residents of an administratively defined and typical district of Novosibirsk who had an incident (first-ever) stroke from 1982, through December 31, 1992, were registered. Results show that stroke incidence rates in Novosibirsk are among the highest in the world (202/100 000 population). A decline in stroke incidence but little change in 30-day case-fatality rates in Novosibirsk from 1982 through 1992 was found.

2.5.6 Japan

Disease surveillance and population surveys of risk characteristics in a northeast rural community of Japan were combined in an attempt to relate morbidity and risk factor trends for coronary heart disease and stroke during 1964 to1983 [55]. Another stroke surveillance study was conducted by **Sankai et al** [56] between 1979 and 1987 to investigate the proportion by type of stroke in communities based on CT findings in Japan. This study showed a higher proportion of cerebral infarction and infarction in penetrating artery regions, and indicated that the proportion of cerebral hemorrhage and infarction in penetrating artery regions was higher and that of infarction in cortical artery regions lower in Japanese than in Caucasians.

2.5.7 China

He BL et al [57] analyzed the data on stroke surveillance from 1985 to 1989 in Beijing and found that the annual average occurrence rate (incident and recurrent) was 189/100,000, and the incident rate was 134/100,000 in the population aged 25-74. The trend of incidence from 1985 to 1989 was relatively steady. It is suggested to conduct the prevention of cerebrovascular disease (CVD) in Beijing. **A wide spread** [58] community-based cardiovascular disease surveillance program in the China Multicenter Collaborative Study of Cardiovascular Epidemiology was conducted to clarify the proportion of stroke types in China between 1991 and 2000. Results show that Ischemic stroke was more frequent and its proportion was higher than hemorrhagic stroke in Chinese populations. Although hemorrhagic stroke was more frequent in Chinese than in Western populations, the variation in the proportion of stroke types among Chinese populations could be as large as or larger than that between Chinese and Western populations.

To provide information for preventing and managing ICH, **Yang et al** [59] undertook a study supervising and determining the annual first-ever average incidence of cerebral hemorrhage from 1986 to 2000 in Changsha. Data from 24 well-defined communities were obtained from the census register of the local administrative office. Every year, they checked up on the population and carried out door-to-door inquiries to verify the new cases of ICH and stroke. The study found a higher proportion of ICH compared to other jurisdictions in China. Changsha has one of the highest incident rates of ICH in the world. Hypertension is the prominent risk factor.

Jiang et al [60] examined the incidence and trends of stroke and its major subtypes during the 1990s in 3 cities in China using stroke cases registered between 1991 to 2000 through the stroke surveillance networks established in Beijing, Shanghai, and Changsha. They observed that there is a geographic variation in the incidence of stroke and its subtypes among these 3 cities, but the incidence of overall and hemorrhagic stroke in China is generally higher than that in the Western countries.

Zhang et al [61] examined the association between smoking by husbands and stroke prevalence among women non-smokers in Shanghai, China, where two thirds of men but few women smoke. They analyzed baseline survey data (1997-2000) from a population-based cohort study, the Shanghai Women's Health Study. Information on husbands' smoking status and history of physician-diagnosed stroke was obtained through in-person interviews. The authors found that women non-smokers who lived with husbands who smoked had an elevated prevalence of stroke, and prevalence increased with increasing intensity and duration of husbands' smoking.

Huang et al [62] estimated the trend of incidence, mortality of stroke and the risk factors at the community level in the 1990's in Shanghai, and tried to establish a network of disease surveillance. Both incidence and mortality of stroke were surveyed in the 35 - 74 age group during 1991 - 1999 using the method of WHO MONICA. The study found that incidence of stroke and some relative risk factors seemed to increase in the 1990s, while the mortality of stroke decreased in the communities in Shanghai.

Hong et al [63] conducted a study investigating the temporal trends of incidence rate, mortality rate, and case fatality of stroke in urban and rural Shanghai in the 1980s from a community-based registry. Study method adhered to the methods and definitions of the WHO MONICA protocol. They observed a decline in stroke mortality rate, yet no significant changes in stroke incidence in rural and urban Shanghai. Also, case fatality appeared to have decreased, in particular among men living in rural areas and women living in urban areas.

2.5.8 Canada

Mayo et al [64] examined hospital discharge abstracts in Quebec to analyze trends in stroke incidence in Quebec from 1981 to 1988, and noticed that changes in the hospitalization rates for hemorrhagic stroke were not accompanied by consistent decreases in the case-fatality rate. They further conducted two studies [65, 66] analyzing the hospitalization and case-fatality rates for subarachnoid hemorrhage and stroke respectively, in Canada from 1982 through 1991 respectively, using the hospital discharge abstract database at CIHI again. The results show that although rates of hospitalization for SAH declined, total case-fatality rate remains high. For hemorrhages, there was a 44% increase over the 10-year period for men, and a 34% increase for women. In-hospital case-fatality rates for cerebral infarctions increased with age but did not differ by sex when age was considered. For intracerebral hemorrhage, the in-hospital case-fatality rates declined significantly over time.

Petrasovits et al [67] investigated mortality from stroke using administrative data (death certificates), and found a declining trend in stroke mortality from 1951 to 1991, which demonstrates Canada has one of the lowest stroke mortality rates globally.

Hill et al [68] examined hospitalizations for stroke in the Calgary Health Region between 1994 and 2002 using a similar approach and found a continuing decline in age-adjusted stroke hospitalizations and stroke deaths. However, due to the combination of increases in intracerebral hemorrhage and ischemic stroke admissions, the absolute number of stroke hospitalizations is rising rapidly. Hill, M. D and his colleagues carried out two other studies in the province of Alberta in the 1999/2000 fiscal year using administrative data. One study [69] evaluated the magnitude of risk of stroke and predictors of stroke after transient ischemic attack (TIA), and showed that the early risk is not predicted by clinical and demographic factors. In another paper [70], the pattern of incidence and health service utilization of cerebrovascular disease cases in urban and rural areas was examined and similar mortality was found. However, they found a large proportion of rural residents received diagnoses and treatment for cerebrovascular disease in urban areas. Location of service and location of death differs between rural and urban cases of cerebrovascular disease.

Statistics Canada is Canada's central statistical agency. Statistics Canada's data collection includes Health theme, from which it generates many publications and data sets. Every five years the Census provides Statistics Canada with an updated national portrait. Some of the information comes from existing administrative data, most is collected through businesses and household surveys. Tables on "Mortality for all stroke (ICD-10 I60-I66), by sex, Canada, provinces and territories in 2001"; "30-day in-hospital stroke mortality rate"; "Age-standardized 180-day net survival rate for all stroke (ICD-9), by sex, population aged 45 and over, selected provinces, annual (Percent)" can be viewed from the Statistics Canada website [71].

Statistics Canada in collaboration with the Canadian Institute for Health Information, Health Canada, and the Heart and Stroke Foundation of Canada, published "The Changing Face of Heart Disease and Stroke in Canada 2000" [72], the fifth in a series of reports from the Canadian Heart and Stroke Surveillance System (CHSSS), and "The Growing Burden of Heart Disease and Stroke in Canada 2003" [73], the sixth in a series of reports from the CHSSS. The goals of these two reports are to provide health professionals and policy makers with an overview of current trends in risk factors, interventions and services, and health outcomes of heart disease and stroke in Canada.

The Registry of the Canadian Stroke Network (RCSN), a project funded by the Canadian Stroke Network, was established in 2001 and was the first national prospective database of stroke patients, which collects high quality clinical data from approximately 10,000 consecutive stroke patients seen at 21 acute care institutions across Canada annually. Patient data collected will characterize the entire stroke event allowing investigators to obtain a clear understanding of the proportions of stroke-types and the prevalence of risk factors. This resource is intended to be part of a comprehensive stroke surveillance system that will monitor and evaluate approaches to stroke care, inform policy makers and formulate recommendations for best practices in stroke management [74]. **Kapral et al** used data from phase 1 of the RCSN (June 2001 to February 2002) to determine the use of evidence-based acute stroke care interventions in participating institutions. They found that patients in institutions participating in the RCSN received high-quality stroke care based on a number of performance measures. However, gaps exist in the provision of other elements of stroke care, particularly organized inpatient stroke care and warfarin for atrial fibrillation. Later they used data [75] from phase 1 and phase 2 (June to December 2002) of the RCSN to compare sex differences in stroke presentation and management and found no major sex differences among patients participating in the RCSN. **Nadeau et al** [76] sought to describe the use of stroke thrombolysis and its outcomes in RCSN and found that at selected hospitals in Canada, thrombolysis use is higher than previously reported rates. Thrombolysis continues to be safe and effective in Canada.

2.5.9 WHO

Sarti et al [77] analyzed the available information from the World Health Organization (WHO) data bank for deaths on international trends in stroke mortality for the last available 5 years, in 51 industrialized and developing countries from different parts of the world. Large differences were observed in mortality rates from stroke around the world together with a wide variation in mortality trends. A widening gap was observed between 2 groups of nations, those with low and declining stroke mortality rates and those with high and increasing mortality, in particular, between western and Eastern Europe.

WHO MONICA Project

The World Health Organization Monitoring Trends and Determinants in Cardiovascular Disease Project (WHO MONICA Project) used standardized methods to monitor the trends and determinants of cardiovascular disease in 37 defined populations in 21 countries and provides a unique opportunity to perform cross-sectional and longitudinal comparisons of stroke epidemiology in many populations[78]. Several studies have been conducted within the MONICA Project framework. During the first years of this project, it was concluded that large differences in stroke incidence and case-fatality rates contributed to the more than threefold differences in stroke mortality rates among populations [78]. Consistently, another study [79] showed that the highest stroke rates, which were found in Russia and Finland, were more than three-fold higher than the lowest rate, which was found in Friuli, Italy. **Sarti et al** [80] examined that changes in stroke mortality, whether declining or increasing, were shown to be principally attributable to changes in case fatality rather than changes in event rates. **Stegmaye et al** [81] reported that the variation in conventional risk factors contributed to the variation in stroke incidence among these populations. Prevalence of smoking and elevated blood pressure explains a substantial proportion of the variation of stroke attack rates between populations. However, **Tolonen et al** [82] indicated that variations in stroke trends between populations can be explained only in part by changes in classic cardiovascular risk factors. The associations between risk factor trends and stroke trends are stronger for women than for men.

2.6 A Global Perspective for Stroke Surveillance from the WHO

The Global Burden of Disease Study [83, 84] described a measure that integrates the sum of life-years lost due to premature mortality and years lived with disability-adjusted life years (DALY). In 1999 cerebrovascular disease accounted for 50 million DALY worldwide, representing 3.5% of all DALY [85]. Cardiovascular disease, which accounts for 20.3% of DALY lost in more developed countries and already for 8.1% of those lost in less-developed countries, is a major contributor to the global burden of disease [86]. Projections to year 2020 show that 61 million DALY are likely to be lost due to cerebrovascular disease each year. Therefore, it is essential to have information on the pattern of disease and exposure to risk factors in the population for preventive strategies to be planned and evaluated in order to reduce the burden of cerebrovascular disease.

The WHO [23] is intensifying the development and implementation of simple, sustainable surveillance systems that can be used in many different settings around the world, since basic epidemiological data such as mortality rates are reported for less than one-third of the world's population and are almost exclusively from developed countries. A stepwise approach to increasing detail in the data to be collected for surveillance of stroke is suggested. This will allow countries with different levels of resources and capacity in their health systems to collect useful information for policy.

2.7 Commentary on the Literature Review

2.7.1 Strengths of Current Global Stroke Surveillance

1. Except for a few active surveillance studies, most surveillance reports utilized passive surveillance approaches, registries, surveys and information systems using hospital discharge records, vital records, or other administrative data source. They varied in methods, scope, and objectives.
2. Most surveillance projects monitored the mortality, morbidity, and provided information on the magnitude of stroke occurrence in defined population to describe the basic epidemiology of health problems.
3. Some surveillance projects interpreted the geographical and temporal trends of stroke for health care planning and resource allocation and to allow close monitoring of quality of stroke services to improve stroke prevention.
4. A few surveillance projects have helped to assess the impact of intervention procedure, measured the progress and efficacy of preventive efforts already in

operation. For instance, evaluation of the use of thrombolytic therapy - tPA treatment in acute ischemic stroke.

5. Several studies have been conducted within the WHO MONICA Project framework using a standard method, making it possible for the international comparisons of stroke burden in a given jurisdiction.

2.7.2 Weaknesses of Current Global Stroke Surveillance

1. Some surveillance projects are typically episodic, research-oriented and single-jurisdiction analyses in a defined population.
2. Longitudinal comparisons of stroke epidemiology in some populations were limited due to a lack of ongoing systematic collection, analyses, and interpretation of stroke related data at the national or, provincial level in some countries.
3. Information and analyses on subtypes of stroke in most countries are limited as well.
4. Difficulties in case ascertainment and changing understanding of stroke, and uncertain quality of administrative data have limited accurate descriptive stroke epidemiology in surveillance.
5. Only hospital discharge abstract (IP) or hospitalization information were applied in most of trend studies or passive surveillance for many countries. However, strokes in emergency room visits or in merged data of IP and ER were not considered in any studies.
6. Inter-linking existing databases or more comprehensive data at the local/regional, provincial/territorial, and national levels in some countries have been unable to establish sustainable surveillance systems for stroke.

2.8 Background of the International Classification of Diseases

The International Classification of Diseases, 9th edition (ICD – 9) was issued in 1977 and was published in 1978 to be a worldwide source of taxonomy. With an extension developed in the US, called Clinical Modification (CM), it was intended to meet two objectives: 1) to serve as a useful tool in the area of classification of morbidity data for indexing of medical records, medical care review, and ambulatory and other medical care programs as well as for basic statistics, and 2) to describe the clinical picture of the patient, with more precise codes than those needed for statistical grouping and trend analysis [87].

The 10th revision of ICD (ICD-10) system was introduced in 1992 as an enhancement to ICD-9-CM [88]. The new ICD-10 system is more comprehensive than ICD-9. Improvements in areas such as number of codes and an expanded external cause framework are expected to make the ICD-10 a more streamlined system for practitioners [89, 90]. The Canadian ICD-10-CA system is being implemented in an attempt to keep up with medical advancements and establish national standards [91]. This system has been in place in Alberta since April 2002 and currently, all provinces use this new system of coding.

The ICD codes are abstracted to the administrative discharge abstract database (DAD). There are up to 16 diagnosis fields that identify the most responsible diagnosis for the admission and other diagnoses of the condition of the patient using ICD codes. The discharge abstract is coded and completed by coders who retrieve standardized summary information from the chart when the patient is discharged. The discharge abstract contains: 1) demographic data – date-of-birth, gender, postal code; 2) administrative data – admission date and time, discharge date and time; 3) diagnostic data.

In Canada the Canadian Institute for Health Information (CIHI) maintains DAD. CIHI is an independent, not-for-profit organization that provides essential data and analysis on Canada's health system and the health of Canadians [43]. CIHI tracks data in many areas, such as hospitals, regional health authorities, medical practitioners, governments, or other sources. Discharge abstracts are sent directly to CIHI from hospitals throughout the year. CIHI receives approximately 4.3 million records annually.

2.9 Validity of Administrative Data

The discharge abstract database, as one of the administrative data sources, has been used to quantify trends in stroke; however, it has been criticized for lack of accuracy with low sensitivity and specificity [92-97]. Nevertheless, stroke coding has been reviewed previously and found to be useful for high-level comparisons, particularly when compared against other diseases [98]. The time period between coding switched from ICD-9 to ICD-10 allowed for learning on the new ICD-10 system, which may impact the accuracy of coding. In 2005, Hill et al. investigated the coding of stroke and stroke risk factors using ICD-9 and 10. They found that stroke coding was equally good with ICD-9 (90% [CI_{95} 86 to 93] correct) and ICD-10 (92% [CI_{95} 88 to 95] correct). Their data concluded that passive surveillance using administrative data are a useful tool for identifying stroke and its risk factors using both ICD-9 and ICD-10 [98]. However, they indicated previously that there exists wide variation in stroke coding using ICD-9 in rural compared with urban hospitals [70]. Rural hospitals tended to code stroke using more general codes, whereas urban coding was more specific.

Previously, four studies that used either a registry or chart review as the gold standard demonstrated that ICD-9-CM codes 434 and 436 were the most predictive of ischemic strokes [99-102]. In October 1992, a fifth digit was added to ICD-9-CM codes 433 and 434: 0 = without cerebral infarction and 1 = with cerebral infarction. Making use of this fifth digit furthers increases specificity and positive predictive value (PPV) [97].

Another validation study conducted by Tirschwell et al. demonstrated that stroke patients (ischemic, ICH, and SAH) could be identified from administrative data [92]. Consistently, Ellekjær and his colleague concluded that hospital discharge diagnoses were valuable sources of stroke incidence data for both health service planning and epidemiological research [102].

2.10 Commentary

Accuracy of hospital discharge diagnoses have been validated in several studies performed at different times and in different populations [102]. Coding accuracy is affected by diagnosis definitions, interpretation of the codes, the local diagnostic tools and coding practices that may vary across hospitals and regions, which may explain the discrepancies between studies. It is suggested that a diagnostic accuracy of ≥ 85% is adequate for assessing trends over time [98].

Passive surveillance based on administrative data has advantages, including large number of cases, consistent data across patients, and low cost necessary to obtain and analyze data. Nevertheless, caution is due to the relevant inaccuracies of coding, as validity of collected data are the foundation for a high quality study. In this thesis project, an effective approach - chart review will be applied for the validation of administrative data case definitions in three periods (see **Chapter Four: Methodology and Data Analysis**).

CHAPTER THREE: RATIONALE AND OBJECTIVES

3.1 Study Rationale

Over the past ten years, Alberta has experienced rapid population growth. During this time, treatment of stroke has undergone a number of improvement, including centralization of stroke services, the introduction of stroke thrombolysis and the opening of some designated in-patient stroke units [68]. Recent trends suggest that stroke occurrence may be stabilizing or increasing.

Counting strokes is highly relevant because we cannot treat what we do not manage. Policy and resource allocation depend upon knowing numbers. Changes in stroke occurrence have direct relevance to the understanding of risk factors and to public health policy. Moreover, accurate descriptive stroke epidemiology is limited by difficulties in case ascertainment and changes in understanding and definitions of stroke. However, recent developments in neuro-imaging have resulted in a new understanding of minor acute ischemic stroke and transient ischemic attack such that the use of an imaging-based definition would classify more patients with TIA as ischemic stroke [103, 104].

To date, hospitalizations and emergency visits for stroke in the Calgary Health Region are less well quantified, and patterns over time are not known at the region level. Therefore surveillance Stroke is a disease which is suitable for surveillance. Stroke is a clinically defined disease, which makes it possible to identify trends in different countries irrespective of access to technological equipment for stroke with linked hospitalization and emergency visit information is helpful for us to interpret the temporal trends of the disease for health care planning and resource allocation and to allow close monitoring of the quality of stroke services. It will also provide useful information for the study of stroke prevention in Calgary Health Region.

In the present thesis research, we focused on two themes to develop the stroke surveillance: a) validation of administrative data; b) a portrait of the trends of stroke in the CHR – the first step of a passive stroke surveillance system in the Calgary Health Region using administrative data.

a) Validation of administrative data

Since we study stroke with linked hospitalization and emergency visit information, it is necessary to know whether the validation of linked administrative data are good or not, given no relevant validation for linked data reported. We are also interested in assessing the validity in various strata with respect to: (a) query diagnoses of stroke; (b) codes for unspecified stroke; and (c) hospitalization data vs. emergency visit data.

b) Portrait of the trend of stroke in CHR

Within the CHR data set we planned to count all stroke occurrences and study the age- and gender-adjusted rates and absolute counts of stroke and stroke types using linked hospitalization and emergency visits data in the CHR. We assessed the role of the query diagnoses by excluding them and reporting rates with and without this diagnosis. Similarly, we report age- and gender-adjusted rates and counts with and without the "stroke unspecified codes" (code 436 in ICD-9 or code I64 in ICD-10).

3.2 Study Objectives

The purpose of this thesis study is:

1) To assess the validity of three kinds of administrative data (linked hospital discharge abstract (IP) with emergency room data (ER), only IP data, and only ER data coded in

ICD-9-CM and ICD-10 in the following sections. Validation for diagnosis in ICD-10 was divided into two periods - first six months training period & later period for stroke identification.

A. To determine the positive predictive value (PPV) of the old ICD-9 coding for all strokes, four stroke types (AIS, TIA, ICH, SAH), unspecified stroke (coded as 436) and query stroke in linked IP-ER data within the Calgary Health Region (CHR) between April 1995 and March 2002 against a gold standard of chart review with positive results during the same time period.

B. To determine the PPV of the new ICD-10 coding for all strokes, four stroke types, unspecified stroke (coded as I64) and query stroke in linked IP-ER data within the Calgary Health Region (CHR) between April 2002 and September 2002 against a gold standard of chart review with positive results during the same time period.

C. To replicate ‘B’ applying linked IP-ER data from a more recent ICD-10 period (October 2002 to March 2005).

D. To replicate ‘A’, ‘B’ and ‘C’ applying only IP data and only ER data.

E. To replicate ‘A’, ‘B’ and ‘C’ applying linked IP-ER data, only IP data, and only ER data excluding query diagnoses respectively.

F. To replicate ‘A’, ‘B’ and ‘C’ applying linked IP-ER data, only IP data and only ER data excluding unspecified stroke (code 436 in ICD-9, or code I64 in ICD-10) respectively.

G. To replicate ‘A’, ‘B’ and ‘C’ applying linked IP-ER data, only IP data, and only ER data excluding both query diagnoses and unspecified stroke respectively.

2) To monitor time trends in stroke occurrence and in-hospital case-fatality in the Calgary Health Region over the last decade,1995-2004 fiscal years in the following sections:

A. Evaluation of age and gender specific stroke occurrence applying merged IP-ER data.

B. Evaluation of age and gender specific stroke occurrence by stroke type applying merged IP-ER data.

C. To replicate ‘A’ and ‘B’ applying merged IP-ER data excluding query diagnoses.

D. To replicate ‘A’ and ‘B’ applying merged IP-ER data excluding unspecified stroke.

E. To replicate ‘A’ and ‘B’ applying merged IP-ER data excluding both query diagnoses and unspecified stroke.

F. To replicate ‘A’ to ‘E’ applying only IP data, and only ER data respectively.

G. Evaluation of age and gender specific in-hospital case-fatality for all stroke.

H. Evaluation of age and gender specific in-hospital case-fatality by stroke type.

3) To predict the future based upon the past: establishing a stroke surveillance program in the Calgary Health Region.

I hope through this pilot project, that those algorithms that are developed in the Calgary Health Region can be generalized to the whole of Alberta, and potentially the rest of the country, so that a complete national stroke surveillance system can be derived on an annual basis. This project will link with ongoing efforts being conducted by the Alberta Provincial Stroke Strategy, the Canadian Stroke Strategy and the Public Health Agency of Canada.

CHAPTER FOUR: METHODOLOGY AND DATA ANALYSIS

4.1 Study Design and Setting

The present study was conducted in the Calgary Health Region (CHR), which is one of the largest fully integrated, publicly-funded health care systems in Canada. CHR currently includes 12 hospitals, four comprehensive health centers, 41 care centers, and a variety of community and continuing care sites, serving over 1.4 million people from the city of Calgary as well as a constellation of smaller communities in southern Alberta. Over the course of the 10 year time frame of this study, the political boundaries of the CHR have evolved such that it did not always include the rural population as it does now. However, the data we obtained from the CHR during the past 10 years are based on current designated boundaries including rural areas as well.

The study was designed based on two themes: a) validation of administrative data by chart review; b) surveillance of stroke – a portrait of the trends in stroke occurrence over the last decade. Some common sections addressing data source, data management and case ascertainment for both themes are addressed at the beginning of this chapter; subsequently, specific methods and analyses are stated separately for the two themes.

4.2 Study Approach – Passive Surveillance

The universal nature and richness of administrative data collection are big advantages of the Canadian health system. Like other provinces, all residents of Alberta are eligible for coverage under a publicly funded and universally available health care system. The only exceptions are members of the Canadian Military and the Royal Canadian Mounted Police (less than 1% of the Alberta population) who receive health care coverage through the federal government. Each resident covered by the plan has a unique lifetime personal health number (PHN) that can be used to link to a variety of data sources. Therefore, compared to labor intensive and expensive active surveillance, utilizing readily available administrative data sets to conduct a passive surveillance is more rapid, less expensive and practical for this study.

4.3 Data Source

In Canada, publicly funded health insurance systems routinely generate person-specific administrative data every time there is an encounter with the health system. Hospital care is reported as a legislated requirement of the hospital board and medical billing to the provincial governments in linked with one or more diagnostic codes. Two such administrative databases for a ten-year period beginning April 1, 1995 and ending March 31, 2005 were obtained from the Calgary Health Region:

a. *Hospital discharge abstracts inpatient data (IP)*: is a nationally standardized collection of hospital morbidity data. These data are collected locally, reported provincially and then each province reports to the Canadian Institute for Health Information (CIHI) so that national statistics may be amassed. IP contains details regarding inpatient hospitalizations including the unique lifetime personal health care number (PHN), admission/discharge dates, site of hospital, age, gender, discharge disposition (died, discharged, and signed out), 16 discharge diagnoses and 10 intervention codes and suffixes. Data are available from 1988/89 onward.

b. *Ambulatory Care Classification System (ACCS)*: ACCS is an emergency department data set, which contains information on emergency department services, day surgeries, outpatient treatment programs/clinics, using up to 16 diagnostic codes and 10 procedure codes. For this study, we are only interested in emergency room visits of stroke in ACCS. Therefore, day surgeries, outpatient treatment programs/clinic or other procedures were excluded. We named ER – 'emergency room visits data' for this part of ACCS database in our study. Complete data are available from April 1997 in Calgary Health Region.

The two above data systems provide the information for the identification of cases resulting in hospitalization and emergency room visits, and the follow-up of cases through the health service system. All diagnosis and procedures in these two data systems are coded using ICD-9-CM until March 31, 2002, and ICD-10-CM codes from April 1, 2002 onward.

These two databases were linked using the unique lifetime personal health care number (PHN) as illustrated in Figure 4.1 (see 4.5.2). Since administrative data sources are available, cost-efficient, and multi-year data sets can be assembled for review, the linking of multiple databases may provide a complete picture of stroke occurrence in the CHR, not only for those recorded in hospital, but found in emergency rooms as well.

4.4 Case Definition and Classification

According to the World Health Organization (WHO) MONICA criteria, stroke was defined as [105]: a sudden onset of focal (or global) disturbance of cerebral function lasting > 24 hours (unless interrupted by surgery or death) with no apparent nonvascular cause. Stroke comprises four major types:

a. Acute ischemic stroke (AIS) and transient ischemic attack (TIA) – due to artery blockage in the brain.

b. Intracerebral hemorrhage stroke (ICH) – bleeding into the parenchyma of the brain.

c. Sub-arachnoid hemorrhage stroke (SAH) – bleeding into the subarachnoid space around the brain.

Acute ischemic stroke and transient ischemic attack make up about 85% of all strokes and the two hemorrhagic forms of stroke make up 7-8% each. All stroke types were relatively easily determined using administrative coding for this study as below.

4.4.1 Identification of 'Stroke' Cases

All patients with a discharge diagnosis code (ICD-9-*Clinical Modification*) of 362.31, 430, 431, 433.00 to 433.91, 434.00 to 434.91, 435.0 to 435.9, 436 prior to April 2002 and the 10th Revision (ICD-10) code of G45.0, G45.1, G45.2, G45.3, G45.8, G45.9, H34.1, I60.0 to I60.9, I61.0 to I61.9, I63.0 to I63.9 or I64 subsequently were identified for stroke cohort with correspondent four major stroke types (see Table 4.1 for detail) in both IP and ER data. We used careful definitions of stroke and its types based on ICD-9 using the fourth and fifth digit modifier codes. All patients with a diagnosis of stroke in the primary diagnostic position comprised the sampling frame. This approach has been shown to result in high specificity and positive predictive value (PPV) [2].

Table 4.1 Administrative Coding of Stroke Type in ICD-9 & ICD-10

	ICD-9-CM		ICD-10	
Type	**Code**	**Definition**	**Code**	**Definition**
AIS	362.3	Retinal vascular occlusion	H34.1	Central retina artery occlusion
	433.x1	Occlusion and stenosis of precerebral arteries	I63.x	Cerebral infarction
	434.x1	Occlusion of cerebral arteries	**I64.x**	Stroke, not specified as hemorrhage or infarction
	436	Acute, but ill-defined cerebrovascular disease		
ICH	431.x	Intracerebral hemorrhage	I61.x	Intracerebral hemorrhage
SAH	430.x	Subarachnoid hemorrhage	I60.x	Subarachnoid hemorrhage
TIA	435.x	Transient cerebral ischemia	G45.x	Transient cerebral ischemic attacks and related syndromes

Notes: excludes 433.x0 (occlusion and stenosis of precerebral arteries without mention of cerebral infarction), 434.x0 (occlusion of cerebral arteries without mention of cerebral infarction), 437.x (other and ill-defined cerebrovascular disease), 438.x (late effects of cerebrovascular disease), I65.x (occlusion and stenosis of precerebral arteries not resulting in cerebral infarction), I66.x (occlusion and stenosis of cerebral arteries not resulting in cerebral infarction), I67.x (other cerebrovascular diseases), I69.x (sequellae of cerebrovascular disease), and G45.4 (transient global amnesia). These criteria are investigator derived.

4.4.2 Identification of 'Non-Stroke' Cases

In order to test negative predictive value for non-stroke cases, all patients with a primary discharge diagnosis code of hypertensive encephalopathy, hypoglycemic coma/encephalophaty, acute seizure, complex migraine, vertigo, CABG, abdominal aortic aneurysm surgery, aortobifemoral bypass or femoral-popliteal artery bypass (see Table 4.2), which were most likely coded as stroke (suggested by an experienced neurologist), were identified as non-stroke cohort in both IP and ER data.

Table 4.2 Codes for Diagnoses of Non-Stroke Cases

Diagnosis of Not Stroke	ICD-9-CM	ICD-10
Hypertensive encephalopathy	437.2	I67.4
Hypoglycemic coma	251.0	E15
Complicated Migraine	346.00, 346.01, 346.10, 346.11, 346.20, 346.21, 346.80, 346.81, 346.90, 346.91	G43.3
Convulsions	780.3	R56.8, H81.3
Dizziness and giddiness	780.4	R42
CABG (Coronary artery bypass graft)	36.10 -36.19	1IJ76
Abdominal aortic aneurysm surgery	38.36	1KE87
Aortobifemoral bypass or femoral-popliteal artery bypass	36.10 – 36.11, 39.25	1KA76

4.4.3 Identification of 'Unspecified Stroke' Cases

As shown in Table 1, code 436 in ICD-9 is defined as "Acute, but ill-defined cerebrovascular disease", and code I64 in ICD-10 is defined as "Stroke, not specified as hemorrhage or infarction". We cannot tell exactly what type of stroke they belong to from the definition. However, we classified both of them as AIS according to clinical experience and literature review (see Table 4.1).

4.4.4 Query diagnoses

"Q" in field "Prefix" is assigned to identify questionable or query diagnoses for all diagnoses recorded in IP and ER administrative data.

4.5 Data management

4.5.1 Data Cleaning

The quality of the data is checked in the initial stage for both IP and ER databases. For example, missing values of personal health number (PHN) with a value of ‘0’, ‘1’ or blank were checked using computer software and eliminated prior to data analysis.

4.5.2 Linkage of Data Files and Developing New Databases

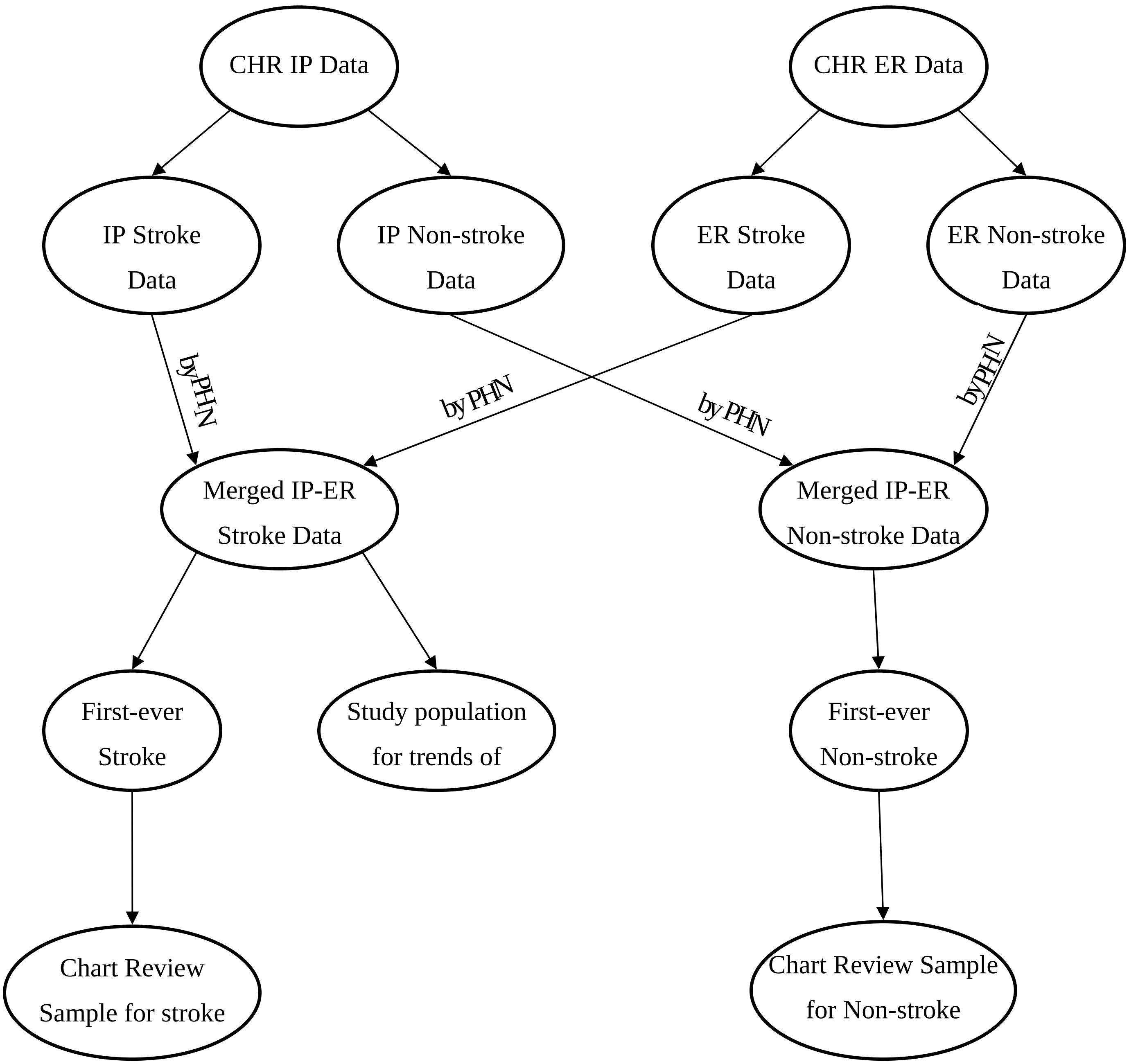
After data cleaning, as illustrated in Figure 1, both IP and ER data were classified into stroke and non-stroke cohorts before the linkage. The stroke cohort in IP determined the study population for stroke trends monitoring in hospital. In ER stroke cohort, duplicated PHN within 24h visits in emergency room were regarded as same stroke cases and were deleted to leave only the first emergency visit, and to form the study population for stroke trends study in emergency department. Then we linked IP stroke cohort with ER stroke cohort using the unique PHN to build a merged IP-ER stroke dataset. Next, two new databases were developed according to two themes of study:

a. For the validation purpose: in merged IP-ER stroke data, data with duplicated PHN were eliminated to generate the first-ever stroke. Only subjects admitted to three sites (FMC, PLC and RGH, see 4.6.2 for detail) were retrieved as a pool for chart review sample of stroke patients.

b. For monitoring trends of stroke over ten years, the merged IP-ER stroke data were used. Those duplicated PHN having both IP and ER admission within 3 days difference were dropped to build a study population for stroke trends study as they were regarded as likely the same stroke event.

A similar approach was employed to link IP data of non-stroke diagnoses with ER data of non-stroke diagnosis to develop a merged IP-ER data of non-stroke diagnoses. Finally, duplicated PHN cases were deleted and those subjects outside of three sites were excluded; thus a pool for the chart review sample of non-stroke patients was formed.

Figure 4.1 Data Source and Linkage



4.6 Chart Review

4.6.1 Study Period

The chapter review was separated into three time periods. The first period (April 1995 – March 2002) involved administrative data coding in ICD-9-CM format. The second period (April 2002 – September 2002) was the initial six months after the switch to the ICD-10 format, permitting an early assessment of whether the validity of administrative data were better (or worse) in ICD-10 relative to ICD-9-CM and providing a washout period where learning will have occurred in the use of the new coding system. The last period (October 2002 – December 2003) started after six months learning period for new ICD-10 coding, allowing us to evaluate whether the validity of stroke coding changed over time. It is recognized that the performance of administrative data may be suboptimal during first six months after the new ICD-10 coding system was implemented. However, some coding problems may subsequently disappear, as coders familiarize themselves with the new coding system and rules.

4.6.2 Sites and Sample Size

Data for chart review were retrieved from the merged database of hospital discharge abstracts (IP) and emergency room visits (ER) from ACCS (see Figure 4.1 in 4.5.2). Simple random samples of charts from patients admitted with stroke to three adult hospitals in Calgary in each period were reviewed to determine the accuracy of the coding using administrative data case definitions. Three adult acute care sites include a university hospital (Foothills Medical Centre - FMC) and two community hospitals (Peter Lougheed Centre – PLC, and Rockyview General Hospital - RGH) in the Calgary health region. These sites serve a population of approximately 1.2 million people. Each of the three acute care sites houses a computed tomography (CT) and MRI scanner. The sampling frame consisted of all patients admitted as hospital inpatients as well as those seen at the emergency department and discharged without admission with primary stroke diagnosis. It does not include patients who were seen in an outpatient clinic or physician's office. The use of this kind of sampling frame allowed us to get a measure of the positive predict value (PPV) of stroke coding, yet was not suitable for sensitivity and specificity assessment because we retrospectively review charts for correspondent patients in administrative data by matched chart numbers.

In order to test negative predictive value for 'non-stroke' cases, random sample of charts from patients admitted to three adult hospitals as well as emergency rooms with hypertensive encephalopathy, hypoglycemic coma/encephalophaty, acute seizure, complex migraine, vertigo, CABG, abdominal aortic aneurysm surgery, aortobifemoral bypass or femoral-popliteal artery bypass were extracted.

The size of the sample for each period was based on an expected precision of the PPV defined by a 10% 95% CI width. We deliberately inflated the sample size for stroke in ICD-10 training period to allow for a better assessment of codes. In total we requested 800 charts of stroke patients and 235 charts of non-stroke patients divided into three time periods (see Table 4.3 for detail). Chart numbers were provided to the Health Record Department to extract in-site charts or order off-site charts.

Table 4.3 Proposed Random Sample Size for Chart Review

	ICD-9 period (Apr 1, 1995 – Mar 31, 2002)	**ICD-10 training period** (Apr 1, 2002 – Sep 30, 2002)	**ICD-10 later period** (Oct 1, 2002 – Mar 31, 2005)	**Total**
Stroke	400	100	300	800
Non-stroke	100	35	100	235
Total	500	135	400	1035

4.6.3 Process of Chart Review

Patient charts were reviewed in detail by a trained research assistant. The sample of suspected events was performed by an experienced neurologist to confirm and ensure validity of review. Since some patients may have had multiple hospitalizations, we restricted chart review to the first hospitalization for such patients during the study interval. Physician history and physical examination notes, physician progress notes, CT and MRI imaging reports (if available), and discharge summaries were used to ascertain the diagnosis most responsible for hospital length of stay and to assign a code. Strokes were coded as TIA if they resolved within 24 hours of onset, and if imaging was performed, no detectable changes were evident. Using our determination (chart review results) as the gold standard, the correct proportion of hospital coding of AIS, TIA, ICH and SAH using ICD-9 and ICD-10 were then calculated and compared. For practical reasons, chart reviewers were not blinded to how the charts had been coded by the health records technologist.

4.6.4 Data Analysis

4.6.4.1 Primary Analysis

Statistical comparisons were made to estimate PPV and NPV using Fisher's exact test applying three administrative data – merged IP-ER data, hospital discharge data (IP), and emergency room data (ER) for three time periods. A variable '_merge' created by Stata after we merged IP and ER data can be used to discriminate the source of correspondent subjects on whether they were from both IP and ER (_merge = 3), or from IP only (_merge = 1), or from ER only (_merge= 2). All proportions are presented with exact binomial 95% confidence intervals (CIs). The PPVs and NPV were arbitrarily categorized as "poor" (<70%), "good" (70% to 79%), "very good" (80% to 89%), or "excellent" (≥90%). We believed a diagnostic accuracy of ≥85% is adequate for assessing trends over time.

4.6.4.1.1 Positive Predictive Value Calculations (PPV) for Stroke Diagnosis in Merged IP-ER, IP data, and ER data

The estimates of PPV for total stroke and each of the stroke types were based on a two-by-two table as below [administrative diagnosis of stroke type (positive/negative) versus chart review diagnosis (gold standard) stroke type (yes/no)]. Cells a and b in this two-by-two table were completed using the chart review diagnosis and administrative ICD-9 or ICD-10 coding of stroke, AIS, TIA, ICH and SAH in each study period.

		Chart review diagnosis of stroke or stroke type (gold standard)	
		Yes	No
Administrative diagnosis of stroke or stroke type	Positive	a	b

Cell ‘a’ = True positives (TP), the number of common positive cases (stroke or correspondent stroke type) in both chart review and administrative coding. Cell ‘b’ = False positives (FP), the number of discrepant cases that negative (not stroke or not matched stroke type) in chart review but positive (stroke or correspondent stroke type) in administrative coding. Predictive value of a positive test (PPV) = a / (a + b) = TP / (TP + FP)

4.6.4.1.2 Positive Predictive Value Calculation (PPV) for Unspecified Stroke in Merged IP-ER, IP data, and ER data

Specific predictive value test for unspecified stroke (coded as 436 in ICD-9 or I64 in ICD-10) was calculated among AIS cases in chart review in merged IP-ER data, IP data and ER data for three time periods. Although code 436 and I64 are defined as unspecified stroke, they were generally classified as acute ischemic stroke (AIS) in many literatures. It is important to know the probability of AIS given a positive ICD-9 coding of 436 or ICD-10 coding of I64 in administrative data. The estimate of PPV for these two codes of unspecified stroke was based on the two-by-two table as below:

		Chart review diagnosis of AIS (gold standard)	
		Yes	No
Administrative diagnosis of AIS coded as 436 in ICD-9 or I64 in ICD-10	Positive	a	b

Cell ‘a’ = True positives (TP), the number of common positive AIS cases in both chart review and administrative coding. Cell ‘b’ = False positives (FP), the number of discrepant AIS cases that negative (not AIS) in chart review but positive (AIS) in administrative coding. Predictive value of a positive test (PPV) = a / (a + b) = TP / (TP + FP)

4.6.4.1.3 Predictive Values of a Negative Test (NPV) Calculations for Diagnosis of ‘non-stroke’ in Merged IP-ER Data, IP data and ER data

The estimates of NPV for not stroke cases in merged IP-ER data, IP data and ER data were based on a two-by-two table as below [administrative diagnosis of ‘not stroke’ (positive/negative) versus chart review diagnosis (gold standard) stroke type (yes/no)]. Cells c and d in this two-by-two table were completed using the chart review diagnosis and administrative ICD-9 or ICD-10 coding of ‘non-stroke’ (see Table 4.2 for coding) in each study period.

		Chart review diagnosis of stroke (gold standard)	
		Yes	No
Administrative sis of ‘non-stroke’	Positive	c	d

Cell ‘c’ = False negatives (FN), the number of discrepant cases that were positive (stroke) in chart review but negative (not stroke) in administrative coding. Cell‘d’ = True negatives (TN), the number of common negative cases (not stroke) in both chart review and administrative coding. Negative Predictive value (NPV) = d / (c + d) = TN / (FN + TN).

4.6.4.1.4 Comparison of PPV for Stroke and Stroke Type among Three Time Periods

Comparisons on PPV for stroke and stroke type across three time periods were performed using cross-tabulations and either Fisher’s exact or chi-square tests of significance.

4.6.4.2 Secondary Analysis

Secondary analysis of chart review was stratified by query diagnoses, unspecified stroke codes (436 in ICD-9 & I64 in ICD-10), and query diagnoses with unspecified stroke codes for all stroke and stroke types applying merged IP-ER data, only IP data and only ER data respectively. The estimate of PPV for stroke and stroke type coded in correlated administrative data were computed in each stratum as in primary diagnosis. Differences of PPV between relevant strata were further compared.

4.7 Monitor Trends of Stroke

4.7.1 Primary Analysis

Patients with stroke were defined by the principal diagnostic code in ICD-9 before April 2002 and in ICD-10 afterwards. Data collection and case ascertainment have been stated in 4.4 and 4.5.2. In order to have a better and complete evaluation of the burden of stroke in the Calgary Health Region, we monitored trends of stroke from the following perspectives:

a. Examine the absolute cases by stroke and stroke type, crude stroke occurrence rates, crude occurrence rates by stroke type, age-gender adjusted stroke occurrence rates, age-gender adjusted occurrence rates by stroke type in linked hospital discharge abstract and emergency room visits database (merged IP-ER data) (see 4.5.2) for each year during fiscal 1997 to 2004, given no complete data available in ER data before fiscal year 1997.

b. Examine the absolute hospitalization cases by stroke and stroke type, the crude stroke hospitalization rates, crude hospitalization rates by stroke type, age-gender adjusted stroke hospitalization rates, age-gender adjusted stroke hospitalization rates by stroke type in hospital discharge abstract (IP data, see 4.5.2) for each year during fiscal 1995 to 2004.

c. Examine the absolute emergency visit cases by stroke and stroke type, the crude emergency stroke rates, crude emergency stroke rates by stroke type, age-gender adjusted emergency stroke rates, age-gender adjusted emergency stroke rates by stroke type in emergency room visits database (ER data, see 4.5.2) for each year during fiscal 1997 to 2004.

d. Evaluation of in-hospital case-fatality by stroke type and gender using IP data for each year during fiscal 1995 to 2004.

4.7.2 Formulas for Calculation

The following formulas were used to calculate crude occurrence rate and in-hospital case-fatality for stroke:

Crude Occurrence Rate = (Total # of CHR people with a stroke admission date in the current fiscal year) / (Total CHR population count for current fiscal year)

In-hospital Case-fatality = (Total # of deaths among CHR people with stroke in hospital during the current fiscal year) / (Total # of CHR people with stroke in hospital during the current fiscal year)

In the numerator for occurrence rate, total number of people with stroke admission was computed using merged IP-ER data, IP data and ER data. In the denominator for occurrence rate, a population in the CHR is obtained by the Alberta Registry where total numbers of residents in the CHR are calculated at the end of March for each past fiscal year. When rates were calculated for men and women separately, denominators for these rates were the numbers of persons in each sex stratum as determined by each year.

All age and gender adjusted rates were adjusted to the Canadian population using the direct method to the 2001 Canadian census to account for differences in population age structure over time, and expressed in terms of events per 100,000 person-years. Trends in adjusted occurrence rates over time were assessed using Poisson regression. Models were also constructed using simple linear regression to test and plot time trends of number of stroke occurrence by stroke type and to extrapolate future time trends when possible.

To explore the possibility of non-linear trends in our data, we applied quadratic models to the data with no significant linear trends in linear regression models, and plotted curvilinear trends for these data in merged IP-ER and IP data sets.

Since there is high correlation between independent variables 'year' & '$year^2$' (r = 1), which is against the assumption of linear regression models, we centered the original 'year' and squared the centered year in models. The correlation between two exposures then reduced to 0.447. We fit the quadratic models with centered year, and plotted the curvilinear trends. Only significant quadratic trends were displayed in the Results chapter.

4.7.3 Secondary Analysis

In secondary analysis, all above rates in primary analysis were stratified by query diagnoses, unspecified stroke, and query diagnoses with unspecified stroke codes for all stroke and stroke types. Trends of stroke rates in relevant strata were further determined, monitored and compared.

4.8 Statistical software used for the analyses

The data were managed and analyzed using STATA Version 8.0 (Stata, College Station TX).

4.9 Ethical Considerations

Ethical approval has been received from the Conjoint Ethics Review Board at the University of Calgary, and approval is attached (APPENDIX on page 249). This project is performed within the protected environment of Calgary Health Region, which is governed by CHR legislative guidelines on the confidentiality of health information. These data capture nearly the entire population and included a unique, anonymous personal identifier allowing linkage between databases. Therefore, all data are considered confidential and anonymous.

CHAPTER FIVE: RESULTS FOR CHART REVIEW

5.1 Study Population for chart review

Figure 5.1 summarizes how we determined the study population for chart review through the following steps:

a) Data Cleaning in IP & ER data

We identified and excluded 891 (4%) subjects with missing PHN (PHN is blank, or recorded as “0” or “1”) among 21,992 subjects from the Hospital Discharge Abstract (IP) data in the Calgary Health Region. Of 47,056 subjects in the emergency room data from CHR, we deleted 1,516 (3%) missing PHN as well. Both data sets (IP and ER) were divided into two groups– stroke and non-stroke groups based on the diagnostic codes.

b) Linkage of IP and ER data by PHN

We linked the group of IP stroke data (n=10,733) with the group of ER stroke data (n=16,967) using the unique PHN as the primary merging variable, and constructed a merged IP-ER (stroke) cohort that contained 20,304 subjects. Similarly, the group of subjects with non-stroke diagnoses in IP data (n=10,368) was linked with group of non-stroke diagnoses in ER data (n=28,573), and created a merged IP-ER (non-stroke) cohort (n=37,658).

c) Random Sample for Chart Review in Three Periods

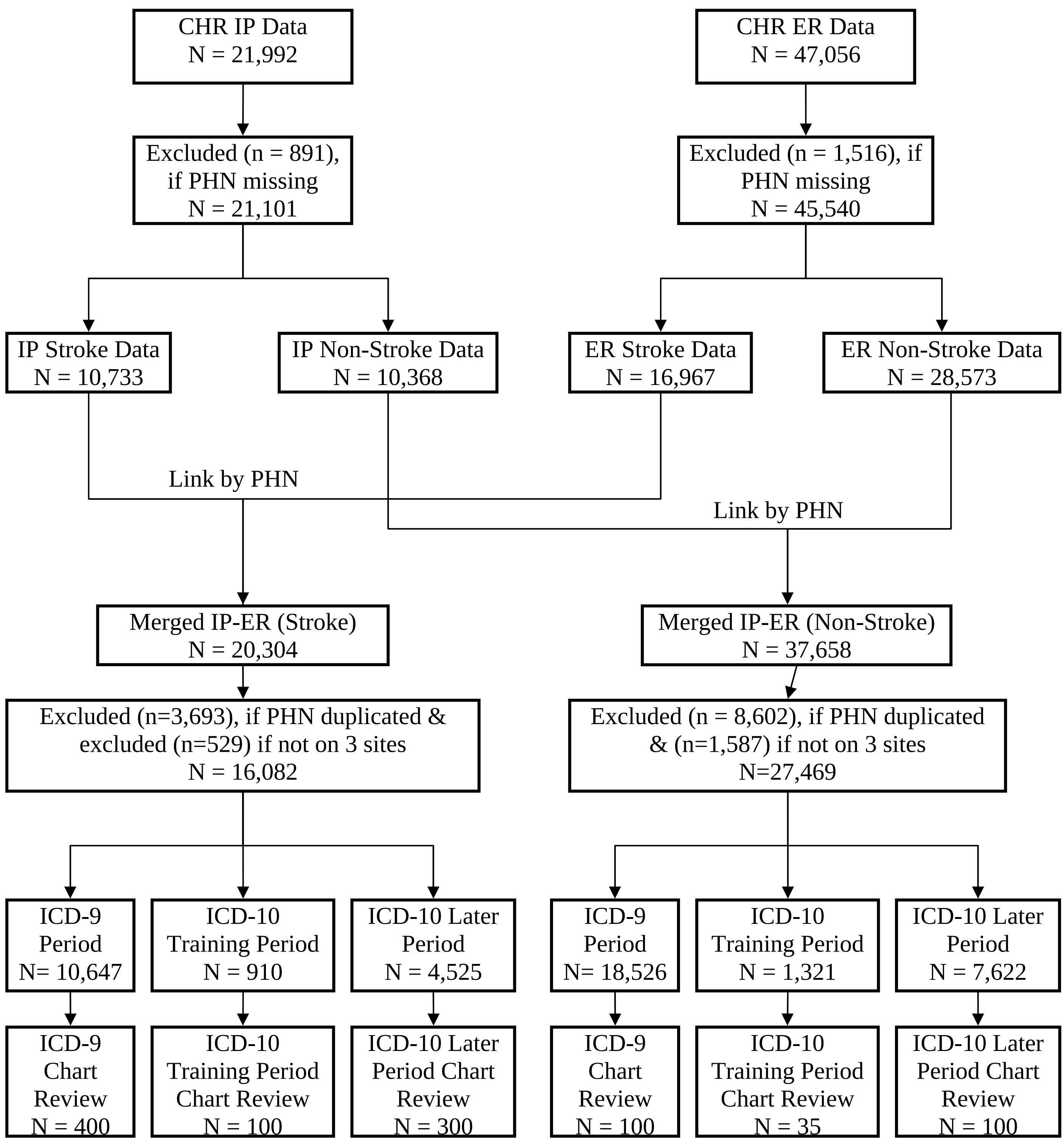
Next we eliminated duplicated PHN (n=3,693 in the stroke cohort & n=8,602 in the non-stroke cohort) to exclude recurrent stroke for chart review, and those cases that not occurred in three sites (FMC, PLC and RGH, see 4.6.2) in both cohorts (n = 529 for stroke & n = 1,587 for not stroke), and generated the database for stroke patients (n=16,082) as well as for subjects with non-stroke diagnoses (n=27,469). Groups were stratified into three time periods (ICD-9 period, ICD-10 training period, and ICD-10 later period) and were further classified based on the admission date. We randomly selected 800 stroke patients and 235 non-stroke patients for each of the three periods (see table 5.1 for detail) and requested corresponding chart numbers from the Health Record Department in CHR for chart review. Approximately 7% of charts were not available for the stroke cohort and 5% charts were missing for the non-stroke cohort. We finally obtained 742 charts for the stroke cohort and 223 charts for the non-stroke patients for chart review (as shown in Table 5.1).

Table 5.1 Random Sample Size (available vs. requested) for Chart Review

	Apr 1, 1995 – Mar 31, 2002 **(ICD-9 period)**			Apr 1, 2002 – Sep 30, 2002 **(ICD-10 training period)**			Oct 1, 2002 – Mar 31, 2005 **(ICD-10 later period)**			**Total**		
	pull	order	Prop.	pull	order	Prop.	pull	order	Prop.	pull	order	Prop.
Stroke	379	400	95%	89	100	89%	274	300	92%	742	800	93%
Non-stroke	90	100	90%	35	35	100%	98	100	98%	223	235	95%

Notes: Here ‘pull’ = available charts; ‘order’ = requested charts; Prop. = Proportion of available charts among requested charts

Figure 5.1 Flow Chat of the Study Population for Chart Review



5.2 Findings for Chart Review in Merged IP-ER Data

5.2.1 Baseline Characteristics

In stroke patients, a total of 379 charts from April 1995 to March 2002 (ICD-9 period), 89 from April to September 2002 (ICD-10 training period), and 274 charts from October 2002 to March 2005 (ICD-10 later period) were reviewed. The median age of stroke patients was 72 - 73 yr for both ICD-9 and ICD-10 training periods, and 70 - 71 yr for ICD-10 later period, with no significant difference. Female accounted for almost 50% stroke patients over time. Table 5.2 presented that the demographic characteristics between merged IP-ER database and chart review data across three periods were similar except for the significant different distribution of stroke type found in ICD-9 period.

Table 5.2 Demographic Characteristics for Merged IP-ER Data & Chart Review Data

	ICD-9 Period		ICD-10 training period		ICD-10 later period	
	Merged IP-ER Database	Chart Review Data	Merged IP-ER Database	Chart Review Data	Merged IP-ER Database	Chart Review Data
Number	10,647	379	910	89	4,525	274
Mean age (SD), y	69 (16)	69 (15)	69 (16)	69 (16)	69 (16)	68 (15)
Median age (IQR), y	72 (60-80)	73 (62-80)	72 (59-80)	73 (60-82)	71 (58-81)	70 (58-79)
Female, n (%)	5,476 (51)	193 (51)	478 (52)	44 (49)	2,242 (50)	135 (49)
Stroke Type, n (%) [a b]						
AIS	5,753 (54)	243 (64)	479 (53)	47 (53)	2,360 (52)	147 (54)
TIA	3,120 (29)	85 (22)	313 (34)	28 (31)	1,469 (32)	87 (32)
ICH	855 (8)	27 (7)	76 (8)	9 (10)	343 (8)	18 (7)
SAH	919 (9)	24 (6)	42 (5)	5 (6)	353 (8)	22 (8)
P *	**0.003**		0.83		0.92	

Note: [a] There is no significant difference in the distribution of stroke type in chart review data over time (P = 0.54); [b] No significant difference were found comparing the distribution of stroke type in merged IP-ER database among three time periods (P = 0.65); * P-value of Fisher's exact in the comparison of distribution of stroke type between administrative merged IP-ER database and chart review in each time period. Significant difference was found in ICD-9 period (p = 0.003).

5.2.2 PPV for Stroke and Stroke type

The positive predictive value (PPV) for all stroke, and stratified stroke type (AIS, TIA, ICH, SAH) among three time periods were computed and listed in Table 5.3:

Table 5.3 PPV for Administrative Classification of Stroke Type Compared With Chart Review Diagnosis (Gold Standard) in Merged IP-ER Data in Three Periods

	ICD-9 period			**ICD-10 training period**			**ICD-10 later period**		
Stroke type	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**
AIS	243	157	**65 (58-71)**	47	36	**77 (62-88)**	147	103	**70 (62-77)**
TIA	85	70	82 (73-90)	28	25	89 (72-98)	87	69	80 (70-87)
ICH	27	22	81 (62-94)	9	7	78 (40-97)	18	17	94 (73-99.9)
SAH	24	14	**58 (37-78)**	5	3	**60 (15-95)**	22	16	**73 (50-89)**
All stroke	379	317	84 (80-87)	89	83	93 (86-97)	274	244	89 (85-92)

Overall, ICD-9 coding was good with 84% (CI_{95}, 80 to 87) of strokes correctly coded. ICD-10 coding in training period was excellent with 93% (CI_{95}, 86 to 97) correct. ICD-10 later period was as good as early training period with PPV of 89% (CI_{95}, 85 to 92).

However, in stratified stroke types, PPV for AIS and SAH were relatively low in all three time periods ranging from 65% (ICD-9) to 77% (ICD-10 training period) for AIS, and 58% (ICD-9) to 73% (ICD-10 later period) for SAH. TIA was correctly coded over 80% over time, while PPV for ICH varied from 78% (ICD-10 training period) to 94% (ICD-10 later period) with sound correct rate.

5.2.3 PPV for Stroke in Different Strata

PPV was further calculated in strata for those stroke excluding unspecified stroke (code 436 in ICD-9 or code I64 in ICD-10), and stroke excluding query diagnoses which is defined by "Q" in the field of "prefix" in administrative data among three time periods. As shown in Table 5.4, PPV increased to excellent (88% to 96%) when unspecified strokes or query diagnoses excluded from chart review, and rose to almost perfect (from 96% to 98%) when both diagnosis eliminated through all time periods.

Table 5.4 PPV for Administrative Identification of Stroke in different Strata in Merged IP-ER Data among Three Periods

	ICD-9 period			**ICD-10 training period**			**ICD-10 later period**		
Stroke in administrative data	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**
All stroke	379	317	84 (80-87)	89	83	93 (86-97)	274	244	91 (85-92)
Stroke excl. code 436/I64	249	220	88 (84-92)	77	72	94 (85-98)	229	211	92 (88-95)
Stroke excl. query diagnoses	302	286	95 (92-97)	81	78	96 (90-99)	237	220	93 (89-96)
Stroke excl. 436//I64 with query stroke	203	198	98 (94-99)	69	67	97 (90-99.6)	200	192	96 (92-98)

5.2.4 PPV for Stroke type in Different Strata

We also observed improved PPV for all stroke types when query diagnoses (Table 5.5) or unspecified strokes (Table 5.6) were excluded in chart review. Compared to Table 5.3, PPV for SAH rose from 58% to 92% in ICD-9, from 60% to 67% in ICD-10 training period, and from 73% to 94% in ICD-10 later period after query diagnoses was excluded. PPV for AIS improved almost 10% from 65% to 74% in ICD-9 when query diagnosis was excluded; not much change was seen in the two other periods.

Table 5.5 PPV for Stroke Type Excluding Query Diagnoses Compared with Chart Review Diagnosis (Gold Standard) in Merged IP-ER Data among Three Periods

	ICD-9 period			**ICD-10 training period**			**ICD-10 later period**		
Stroke type	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**
AIS	210	154	74 (67-79)	47	36	77 (62-88)	136	101	74 (66-81)
TIA	54	51	94 (85-99)	22	21	95 (77-99.9)	66	56	85 (74-92)
ICH	25	22	88 (69-97)	9	7	78 (40-97)	18	17	94 (73-99.9)
SAH	13	12	**92 (64-99.8)**	**3**	**2**	**67 (9-99)**	**17**	**16**	**94 (71-99.9)**

When unspecified stroke (coded as 436 in ICD-9 or I64 in ICD-10) was eliminated, PPV for AIS increased in the ICD-9 period (from 65 % to 79%), from 77% to 83% in ICD-10 training period, and 70% to 80% in ICD-10 period (Table 5.6). There was no further difference in PPV for AIS when query diagnoses were additionally eliminated for all time periods.

Table 5.6 PPV for AIS excluding Unspecified Stroke (code 436 & I64) vs. excluding Both Unspecified Stroke & Query Diagnoses in Merged IP-ER data

	ICD-9 period			ICD-10 training period			ICD-10 later period		
Stroke type	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**PPV (%,CI_{95})**
AIS [1]	113	89	79 (70-86)	35	29	83 (66-93)	102	82	80 (71-88)
AIS [2]	111	89	80 (72-87)	35	29	83 (66-93)	99	80	81 (72-88)

Note: [1] – exclude unspecified stroke (code 436 or I64) in merged IP-ER data; [2] – exclude both unspecified stroke and query diagnoses in merged IP-ER data

5.2.5 NPV for Diagnoses of 'Non-Stroke'

For non-stroke patients, a total of 90 charts from April 1995 to March 2002 (ICD-9 period), 35 charts from April to September 2002 (ICD-10 training period), and 98 charts from October 2002 to March 2005 (ICD-10 later period) were reviewed. Predictive values of a negative test (NPV) for stroke in all time periods are 100% (Table 5.7), calculated as NPV = 90 / (0+90) = 100% in ICD-9.

Table 5.7 NPV for Diagnoses of 'non-stroke' in Merged IP-ER Data Compared With Chart Review Diagnoses (Gold Standard) in Three Time Periods

	ICD-9 period			ICD-10 training period			ICD-10 later period		
	Merged IP-ER data (n)	Chart review (n)	**NPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**NPV (%,CI_{95})**	Merged IP-ER data (n)	Chart review (n)	**NPV (%,CI_{95})**
Case of not stroke	90	90	100 (96-100)	35	35	100 (90-100)	98	98	100 (96-100)

5.2.6 PPV for Unspecified Stroke Codes

The PPV for codes of unspecified stroke (436 in ICD-9 or I64 in ICD-10) varies about 50%, ranging from 47% in ICD-10 later period to 58% in ICD-10 training period (Table 5.8).

Table 5.8 Chart Review Results for Unspecified Stroke Codes in Merged IP-ER data

Code for Unspecified stroke	Identified in chart review in hospital discharge records or emergency room records					PPV for code 436 as AIS* (%,CI_{95})
	AIS (n, %)	TIA (n, %)	ICH (n, %)	SAH (n, %)	Not stroke (n, %)	
436 (ICD-9) n=130	68 (52)	22 (19)	1 (2)	1 (0.8)	34 (26)	52 (43-61)
I64 (ICD-10 training period) n=12	7 (58)	4 (33)	0	0	1 (8.3)	58 [1] (28-85)
I64 (ICD-10 later period)n=45	21 (47)	11 (24)	1 (2)	0	12 (27)	47 [2] (32-62)

Note: * There is no significant difference for PPV for unspecified stroke codes over time (P = 0.73); [1] P = 0.39 indicates no significant difference of PPV for unspecified stroke codes between ICD-9 and ICD-10 training period; [2] P = 0.12 indicates no significant difference of PPV for unspecified stroke codes between ICD-10 training period and ICD-10 later period

5.2.7 Comparison of PPV for Stroke Type in Merged IP-ER Data over Time Periods

In Table 5.9 below, results comparing the positive predictive value (PPV) among three periods are presented. PPV for merged IP-ER data in ICD-9 period was compared against that in ICD-10 training period as there was a coding change from ICD-9 to ICD-10 between these two periods. PPV varied from 84% to 93% between ICD-9 and ICD-10 training period for all stroke (P = 0.05), although no significant difference were discovered for PPV of stroke type during these two periods. We also compared the ICD-10 training period against the ICD-10 later period to see if there was some difference to account for the learning curve between early period (ICD-10 training period) of new coding and later period of new coding (ICD-10 later period). We found no differences for all stroke (p = 0.60), AIS (p = 0.26), and TIA (P = 0.08), but noticed significantly improved PPV for ICH (p = 0.001) and SAH (p = 0.05). There was a substantial improvement for PPV of ICH (p = 0.005) and SAH (p = 0.03) as well when comparing the ICD-10 later period with the ICD-9 period.

Table 5.9 Comparison of PPV for Stroke Type in Merged IP-ER Data in Three Periods

PPV for Stroke type	ICD-9 period (%,CI_{95})	ICD-10 training period (%,CI_{95})	ICD-10 later period (%,CI_{95})	P^1	P^2	P^3
All Stroke	84 (80-87)	93 (86-97)	91 (85-92)	0.05	0.60	0.13
AIS	65 (58-71)	77 (62-88)	70 (62-77)	0.06	0.26	0.45
TIA	82 (73-90)	89 (72-98)	80 (70-87)	0.16	0.08	0.72
ICH	81 (62-94)	78 (40-97)	94 (73-99.9)	0.60	0.001	0.005
SAH	58 (37-78)	60 (15-95)	73 (50-89)	0.77	0.05	0.03

Note: P^1 – comparing ICD-9 period and ICD-10 training period; P^2 – comparing ICD-10 training period and ICD-10 later period; P^3 – comparing ICD-9 period and ICD-10 later period

5.3 Findings for Chart Review in Hospital Discharge Data vs. Emergency Room Data

We further divided the merged IP-ER data into separate hospitalization data (IP) and emergency room data (ER), and performed stratified analysis for chart review matched with IP and ER databases respectively.

5.3.1 Baseline Characteristics

Table 5.10 illustrates that the demographic characteristics for the IP database and the chart review data are comparable.

Table 5.10 Demographic Characteristics for Hospital Discharge Database & Chart Review Data

	ICD-9 Period		ICD-10 training period		ICD-10 later period	
	IP Database	**Chart Review Data**	**IP Database**	**Chart Review Data**	**IP Database**	**Chart Review Data**
Number	5,934	222	555	51	2,644	163
Mean age (SD), y	71 (15)	72 (13)	71 (14)	73 (14)	70 (15)	70 (14)
Median age (IQR), y	74 (63-81)	76 (66-81)	74 (61-82)	75 (66-84)	73 (61-82)	73 (61-82)
Female, n (%)	3,019 (51)	113 (51)	290 (52)	28 (55)	1,291 (49)	80 (49)
Stroke Type, n (%) [a b]						
AIS	3,934 (66)	160 (72)	364 (66)	37 (71)	1,607 (61)	103 (63)
TIA	871 (15)	27 (12)	117 (21)	8 (15)	614 (23)	35 (21)
ICH	639 (11)	24 (11)	54 (10)	7 (13)	239 (9)	13 (8)
SAH	490 (8)	11 (5)	20 (4)	0	184 (7)	12 (7)
P *	0.20		0.17		0.91	

Note: [a] There is no significant difference in the distribution of stroke type in chart review from IP data in three time periods (P = 0.49); [b] No significant difference were found comparing the distribution of stroke type in IP database among three time periods (P =

0.71) ; * P-value of Fisher's exact in the comparison of distribution of stroke type between administrative IP data and chart review did not show significant difference.

5.3.2 PPV for stroke type in IP Data

PPV for all stroke type in hospital discharge data (Table 5.11) are higher than those in merged IP-ER data and emergency room data (Table 5.15).

Table 5.11 PPV for Stroke Type in Hospital Discharge Abstract (IP)

	ICD-9 period			ICD-10 training period			ICD-10 later period		
Stroke type	IP (n)	Chart review (n)	**PPV (%,CI_{95})**	IP (n)	Chart review (n)	**PPV (%,CI_{95})**	IP (n)	Chart review (n)	**PPV (%,CI_{95})**
AIS	160	118	74 (66-80)	37	30	81 (65-92)	103	83	81 (72-88)
TIA	27	24	89 (71-98)	8	8	100 (63-100)	35	31	89 (73-97)
ICH	24	21	88 (68-97)	7	5	71 (29-96)	13	12	92 (64-99.8)
SAH	11	10	91 (59-99.8)	0	0	N/A	12	12	100 (74-100)
All Stroke	222	173	78 (72-83)	52	43	83 (70-92)	163	138	85 (78-90)

5.3.3 PPV for stroke type in IP Data Excluding Query Diagnoses

PPV is almost identical for all stroke type in hospital discharge abstract after excluding query diagnoses in chart review (Table 5.12) given only few query diagnoses were found (n=2 in ICD-9 and n=3 in ICD-10).

Table 5.12 PPV for Stroke Type in Hospital Discharge Abstract (IP) excluding Query Diagnoses (Q)

	ICD-9 period			ICD-10 training period			ICD-10 later period		
Stroke type	IP exclude "Q" (n)	Chart review (n)	**PPV (%,CI_{95})**	IP exclude "Q" (n)	Chart review (no)	**PPV (%,CI_{95})**	IP exclude "Q" (n)	Chart review (n)	**PPV (%,CI_{95})**
AIS	159	118	74 (67-81)	37	30	81 (65-92)	101	82	81 (72-88)
TIA	26	24	92 (75-99)	8	8	100 (63-100)	34	30	88 (73-97)
ICH	24	21	88 (68-97)	7	5	71 (29-96)	13	12	92 (64-99.8)
SAH	11	10	91 (59-99.8)	0	0	N/A	12	12	100 (74-100)
All Stroke	220	173	79 (73-84)	52	43	83 (70-92)	160	136	85 (79-90)

5.3.4 Comparison of PPV for Stroke Type in IP Data over Time Periods

As shown in table 5.13, PPV increased slightly from 78% to 83% for all stroke, and from 74% to 81% for AIS between ICD-9 and ICD-10 training period with no significant difference ($P = 0.37$ for all stroke, $P = 0.24$ for AIS), and remained at 81% in both ICD-10 periods. PPV for TIA improved to 100% in ICD-10 training period from 89% in ICD-9 period with significant difference ($P = 0.003$), then dropped to 89% again in ICD-10 later period. PPV for ICH varied over time, from 88% in ICD-9 decreased to 71% ($P = 0.003$), then improved apparently to 92% after the learning curve with significant difference ($p = 0.0001$). We could not compare the PPV for SAH over time as there was no observation in ICD-10 training period, but the PPV for SAH (91%) in ICD-9 and ICD-10 later period (100%) are excellent. There was no much difference in terms of PPV for stroke type between ICD-9 and ICD-10 later period, except for difference in SAH ($p= 0.01$), as PPV for SAH in ICD-10 later period is 100% compared to 91% in ICD-9.

Table 5.13 Comparison of PPV for Stroke Type in Hospital Discharge Abstract (IP) in Three Periods

PPV for Stroke type	ICD-9 period (%,CI_{95})	ICD-10 training period (%,CI_{95})	ICD-10 later period (%,CI_{95})	P^1	P^2	P^3
All Stroke	78 (72-83)	83 (70-92)	85 (78-90)	0.37	0.70	0.20
AIS	74 (66-80)	81 (65-92)	81 (72-88)	0.24	1.0	0.24
TIA	89 (71-98)	100 (63-100)	89 (73-97)	0.003	0.003	0.99
ICH	88 (68-97)	71 (29-96)	92 (64-99.8)	0.003	0.0001	0.35
SAH	91 (59-99.8)	N/A	100 (74-100)	N/A	N/A	0.01

Note: P^1 – comparing ICD-9 period and ICD-10 training period; P^2 – comparing ICD-10 training period and ICD-10 later period; P^3 – comparing ICD-9 period and ICD-10 later period

5.3.5 Baseline Characteristics in ER Data vs. Chart Review Data

Table 5.14 showed that patients in chart review from ER data are younger (mean age = 66 yr with median 68 yr) than those from IP and merged IP-ER data. Similarly, female accounted for half patients. Overall, the distributions of stroke types is similar between the ER database and the chart review data over time, except for higher AIS and lower TIA in the chart review in the ICD-9 period (p= 0.003).

Table 5.14 Demographic Characteristics for Emergency Room Data & Chart Review Data

	ICD-9 Period		ICD-10 training Period		ICD-10 later Period	
	ER Database	**Chart Review Data**	**ER Database**	**Chart Review Data**	**ER Database**	**Chart Review Data**
Number	4,713	157	355	38	1,881	111
Mean age (SD), y	66 (17)	66 (17)	66 (17)	64 (18)	66 (17)	66 (16)
Median age (IQR), y	70 (56-79)	69 (54-80)	69 (55-79)	68 (50-76)	68 (55-79)	67 (55-76)
Female, n (%)	2,490 (52)	80 (51)	189 (53)	16 (42)	1,013 (53)	56 (50)
Stroke Type, n (%) [a b]						
AIS	1,847 (39)	83 (53)	115 (32)	11 (29)	765 (40)	44 (40)
TIA	2,282 (48)	58 (37)	196 (55)	20 (53)	874 (46)	52 (47)
ICH	224 (4)	3 (2)	22 (6)	2 (5)	107 (6)	5 (5)
SAH	438 (9)	13 (8)	23 (6)	5 (13)	171 (9)	10 (9)
P *	**0.003**		0.11		0.99	

Note: [a] There is no significant difference in the distribution of stroke type in chart review data from IP across the periods (P = 0.68); [b] No significant difference was found among the comparison of distributions of stroke type in IP database across the periods (P = 0.91); * P-value of Fisher's exact in the comparison of distribution of stroke type between administrative ER data and chart review. Significant difference was found in ICD-9 period (p = 0.003).

5.3.6 PPV for Stroke Type in Emergency Room Records (ER)

Except for TIA, PPV for most stroke types in emergency room are relatively low, ranging from 57% to 76% for all stroke, from 45% to 60% for AIS, and 31% to 60% for SAH.

Table 5.15 PPV for Stroke Type in Emergency Room Records (ER)

	ICD-9 period			**ICD-10 training period**			**ICD-10 later period**		
Stroke type	ER data (n)	Chart review (n)	PPV (%,CI_{95})	ER data (n)	Chart review (no)	PPV (%,CI_{95})	ER data (n)	Chart review (n)	PPV (%,CI_{95})
All Stroke	157	90	57 (49-65)	37	28	76 (59-88)	111	67	60 (51-70)
AIS	83	39	47 (36-58)	10	6	60 (26-88)	44	20	45 (30-61)
TIA	58	46	79 (67-89)	20	17	85 (62-97)	52	38	73 (59-84)
ICH	3	1	33 (1-91)	2	2	100 (16-100)	5	5	100 (48-100)
SAH	13	4	31 (9-61)	5	3	60 (15-95)	10	4	40 (12-74)

5.3.7 Comparison of PPV for Stroke Type in ER Data over Time Periods

Table 5.16 indicates that the PPV for all strokes increased significantly from 57% to 76% (P = 0.0044) after codes transferred from ICD-9 to the beginning of ICD-10, yet dropped again to 60% during the later ICD-10 period (P = 0.015). However, the 100% PPV for a small sample sized (only 2 patients) chart review for ICH in the ICD-10 training period could affect PPV for all strokes in that period and bias the validity of stroke, leading to an overestimate for the different PPV in ICD-10 training period compared to other two periods. The PPV for AIS rose from 47% in ICD-9 to 60% in ICD-10 training period (with no significant difference), yet decreased to 45% in ICD-10 later period (P = 0.03). Similarly for PPV in TIA, there is a rising trend from 79% in ICD-9 to 85% in ICD-10 training period (P = 0.07), yet dropped to 73% in ICD-10 later period (P = 0.04).

Table 5.16 Comparison of PPV for Stroke Type in Emergency Room in Three Time Periods

PPV for Stroke type	ICD-9 period (%,CI_{95})	ICD-10 training period (%,CI_{95})	ICD-10 later period (%,CI_{95})	P [1]	P [2]	P [3]
All Stroke	57 (49-65)	76 (59-88)	60 (51-70)	0.0044	0.015	0.67
AIS	47 (36-58)	60 (26-88)	45 (30-61)	0.07	0.03	0.78
TIA	79 (67-89)	85 (62-97)	73 (59-84)	0.27	0.04	0.32
ICH	33 (1-91)	100 (16-100)	100 (48-100)	<0.0001	1	<0.0001
SAH	31 (9-61)	60 (15-95)	40 (12-74)	<0.0001	0.005	0.18

Note: P [1] – comparing ICD-9 period and ICD-10 training period; P [2] – comparing ICD-10 training period and ICD-10 later period; P [3] – comparing ICD-9 period and ICD-10 later period

5.3.8 PPV for Stroke Type in Emergency Room Records (ER) Excluding Query Diagnoses

Almost all PPV improved a quite bit when query diagnoses was excluded from the chart review in ER data (Table 5.17), especially for AIS. PPV increased from 47% to 67% in ICD-9 and 45% to 54% in ICD-10 later period, yet no change was seen for the ICD-10 training period with the same PPV of 60%. The PPV for TIA reached to excellence at 93% in ICD-9 and ICD-10 training periods, and had a better PPV of 81% compared to 73% when query diagnoses was included in ICD-10 later period. The sample size for both ICH and SAH charts in emergency room were so small that PPV for hemorrhagic stroke were not representative.

Table 5.17 PPV for Stroke Type in ER excluding Query Diagnoses (Q)

	ICD-9 period			ICD-10 training period			ICD-10 later period		
Stroke type	ER excl. "Q" (n)	Chart review (n)	**PPV (%,CI_{95})**	ER excl. "Q" (n)	Chart review (no)	**PPV (%,CI_{95})**	ER excl. "Q" (n)	Chart review (n)	**PPV (%,CI_{95})**
AIS	54	36	67 (53-79)	10	6	60 (26-88)	35	19	54 (37-71)
TIA	30	28	93 (78-99.2)	14	13	93 (66-99.8)	32	26	81 (64-93)
ICH	1	1	100 (3-100)	2	2	100 (16-100)	5	5	100 (48-100)
SAH	2	2	100 (16-100)	3	2	67 (9-99)	5	4	80 (28-99.5)

5.3.9 PPV for AIS excluding Unspecified Stroke in IP vs. ER

Table 5.18 showed that the PPV for AIS increased slightly in IP and in ER data if unspecified stroke codes were excluded in all time periods. However, since unspecified stroke codes accounted for approximately 70% of all AIS (Table 5.28) in the emergency room data set, the sample size decreased to fewer than 10 in chart review for three time periods, making PPV unrepresentative.

Table 5.18 PPV for AIS excluding Unspecified Stroke in IP vs. ER

	ICD-9 period			ICD-10 training period			ICD-10 later period		
Data	AIS excl. 436 (n)	Chart review (n)	**PPV (%,CI_{95})**	AIS excl. I64 (n)	Chart review (no)	**PPV (%,CI_{95})**	AIS excl. I64 (n)	Chart review (n)	**PPV (%,CI_{95})**
IP	109	86	79 (70-86)	32	27	84 (67-95)	93	77	83 (74-90)
ER	4	3	75 (19-99.4)	3	2	67 (9-99)	9	5	56 (21-86)

5.3.10 PPV for AIS excluding both Unspecified and Query Diagnoses in IP vs. ER

The PPV did not change much for AIS when query diagnoses was excluded from IP and ER data after unspecified stroke codes were eliminated.

Table 5.19 PPV for AIS excluding both Unspecified Stroke and Query Diagnoses in IP vs. ER

	ICD-9 period			ICD-10 training period			ICD-10 later period		
Data	AIS excl. 436 & query(n)	Chart review (n)	**PPV (%,CI_{95})**	AIS excl. I64 & query(n)	Chart review (no)	**PPV (%,CI_{95})**	AIS excl. I64 & query(n)	Chart review (n)	**PPV (%,CI_{95})**
IP	107	86	80 (72-87)	32	27	84 (67-95)	92	76	83 (73-90)
ER	4	3	75 (19-99.4)	3	2	67 (9-99)	7	4	57 (18-90)

5.4 Findings for Chart Review for Unspecified Stroke Codes

Specific stratified analyses were developed in chart review data for unspecified stroke codes in three kinds of database.

5.4.1 Chart Review for Unspecified Stroke Codes in Merged IP-ER Data

As shown in Table 5.20, the PPV for unspecified stroke (code I64) in merged IP-ER data varied from 47% in ICD-10 later period to 58% in ICD-10 training period, with averagely 52% correct rate for code 436 in ICD-9. We identified that about 26% unspecified stroke in merged IP-ER data were actually not stroke patients based upon chart review, and a much higher proportion of non-stroke diagnosis in unspecified stroke with query diagnoses were identified in both the ICD-9 and ICD-10 periods. 20% to 33% charts coded as unspecified stroke were found to be TIA in all periods.

Table 5.20 Chart Review Results for Unspecified Stroke Codes in Merged IP-ER Data

Code	AIS (n, %)	TIA (n, %)	ICH (n, %)	SAH (n, %)	Not stroke (n, %)	PPV for AIS (CI_{95})
436 in ICD-9 (n=130)	68 (52)	25 (19)	2 (2)	1 (1)	34 (26)	52 (43-61)
436 in ICD-9 with Q (n=31)	*3 (10)*	*5 (16)*	*0*	*0*	*23 (74)*	*10 (2-26)*
436 in ICD-9 excl. Q (n=99)	65 (66)	20 (20)	2 (2)	1 (1)	11 (11)	66 (55-75)
I64 in ICD-10 training period (n=12)	7 (58)	4 (33)	0	0	1 (8)	58 (28-85)
I64 in ICD-10 training period with Q (n=0)	*0*	*0*	*0*	*0*	*0*	*N/A*
I64 in ICD-10 training period excl. Q (n=12)	7 (58)	4 (33)	0	0	1 (8)	58 (28-85)
I64 in ICD-10 later period (n=45)	21 (47)	11 (24)	1 (2%)	0	12 (27)	47 (32-62)
I64 in ICD-10 later period with Q (n=8)	*0*	*3 (38)*	*1*	*0*	*3 (38)*	*N/A*
I64 in ICD-10 later period Excl. Q (n=37)	21 (57)	7 (19)	0	0	9 (24)	57 (39-73)

5.4.2 Chart Review for Unspecified Stroke Codes in IP vs. ER Data

PPV for unspecified stroke in hospital discharge data are around 60% across the periods, which is slightly higher than PPV in merged IP-ER data, and is much better than

PPV of 45% shown in emergency room (Table 5.21 & Table 5.22). Patients of non-stroke diagnoses accounted for over 30% unspecified stroke codes in ER data in ICD-9 and ICD-10 later period, and accounted for much higher proportion with query diagnoses. Around 20% patients detected in chart review for code 436 were TIA in both databases in ICD-9 period, while higher proportion of patients (40%) were found as TIA for code I64 in IP data than in ER data (20%) in either ICD-10 period. However, since only a few charts with code I64 were found in ICD-10 period, the unexpected observed higher TIA for code I64 is not representative.

Table 5.21 Chart Review Results for Unspecified Stroke in ICD-9 (code 436) in IP vs. ER Data

Code	AIS (n, %)	TIA (n, %)	ICH (n, %)	SAH (n, %)	Not stroke (n, %)	PPV for code 436 (CI_{95})
436 (ICD-9) in IP (n=51)	32 (63)	11 (22)	1 (2)	1 (2)	6 (12)	63 (48-76)
436 (ICD-9) with Q in IP (n=2)	*0*	*0*	*0*	*0*	*2 (100)*	*0 (0)*
436 (ICD-9) excl. Q in IP (n=49)	32 (65)	11 (22)	1 (2)	1 (2)	4 (8)	65 (50-78)
436 (ICD-9) in ER (n=79)	36 (46)	14 (18)	1 (1)	0	28 (35)	46 (34-57)
436 (ICD-9) with Q in ER (n=29)	*3 (10)*	*5 (17)*	*0*	*0*	*21 (72)*	*10 (2-27)*
436 (ICD-9) excl. Q in ER (n=50)	33 (67)	9 (18)	1 (6)	0	7 (14)	67 (51-79)

Note: IP - In-hospital Discharge Data; ER – Emergency Room Data; 'with Q' means with query diagnoses.

Table 5.22 Chart Review Results for Unspecified Stroke in ICD-10 (code I64) in IP vs. ER Data

Code	AIS (n, %)	TIA (n, %)	ICH (n, %)	SAH (n, %)	Not stroke (n, %)	PPV for code I64 (CI_{95})
I64 (ICD-10 training period) in IP (n=5)	3 (60)	2 (40)	0	0	0	60 (15-95)
I64 (ICD-10 training period)with Q in IP (n=0)	*0*	*0*	*0*	*0*	*0*	*N/A*
I64 (ICD-10 training period) excl. Q in IP (n=5)	3 (60)	2 (40)	0	0	0	60 (15-95)
I64 (ICD-10 training period)in ER (n=7)	4 (57)	2 (29)	0	0	1 (14)	57 (18-90)
I64 (ICD-10 training period) with Q in ER (n=0)	*0*	*0*	*0*	*0*	*0*	*N/A*
I64 (ICD-10 training period) excl. Q in ER (n=7)	4 (57)	2 (29)	0	0	1 (14)	57 (18-90)
I64 (ICD-10 later period) in IP (n=10)	6 (60)	4 (40)	0	0	0	60 (26-88)
I64 (ICD-10 later period) excl. Q in IP (n=9)	6 (67)	3	0	0	0	67 (30-93)
I64 (ICD-10 later period)with Q in IP (n=1)	*0*	*1 (100)*	*0*	*0*	*0*	*N/A*
I64 (ICD-10 later period) in ER (n=35)	15 (43)	7 (20)	1 (3)	0	12 (34)	43 (26-61)
I64 (ICD-10 later period)with Q in ER (n=7)	*0*	*3 (43)*	*1 (14)*	*0*	*3 (43)*	*N/A*
I64 (ICD-10 later period) excl. Q in ER (n=28)	15 (54)	4 (14)	0	0	9 (32)	54 (34-72)

5.5 Summary for Comparison of PPV in Three Databases across the Periods

We summarized the comparison of PPV for stroke type in different strata regarding unspecified stroke in each database across the periods and presented the findings in Table 5.23 -Table 5.25 and Figure 5.1 – Figure 5.3. The summarized table 5.23 illustrates that PPV for unspecified stroke are poor, with the highest rates from 63% to 60% in hospital discharge abstract across the periods. However PPV for unspecified stroke in emergency room are lower than in hospital discharge abstract and merged IP-ER data. In ER data, PPV for code 436 in ICD-9 is 46%, rising to 57% for code I64 in ICD-10 training period (P = 0.12), but decreased to 43% in ICD-10 later period (P = 0.05). Similarly, PPV for 436 in ICD-9 in merged IP-ER is 52%, then improved slightly to 58% for I64 in ICD-10 training period (P = 0.39), finally decreased to 47% in ICD-10 later period (P = 0.12).

After query diagnoses were excluded, PPV for unspecified stroke did not change for ICD-10 training period, but did increase 10% to 20% in two other periods in all three databases, especially for code 436 in ICD-9, with a substantial improvement in merged IP-ER data and ER data.

Table 5.23 Comparison of PPV for Unspecified Stroke Code with & without Query Diagnoses in Three Periods

Administrative Data	436 in ICD-9 period (%,CI_{95})		I64 in ICD-10 training period (%,CI_{95})		I64 in ICD-10 later period (%,CI_{95})	
	With Q	Excl. Q	With Q	Excl. Q	With Q	Excl. Q
Merged IP-ER Data	52 (43-61)	66 * (55-75)	58 (28-85)	58 (28-85)	47 (32-62)	57 (39-73)
Hospital Discharge Abstract (IP)	63 (48-76)	65 (50-78)	60 (15-95)	60 (15-95)	60 (26-88)	67 (30-93)
Emergency Room (ER)	46 (34-57)	67 * (51-79)	57 (18-90)	57 (18-90)	43 (26-61)	54 (34-72)

Note: * indicates significant increase in PPV for unspecified stroke after query diagnoses excluded ($p < 0.05$).

5.5.1 Comparison of PPV for AIS in different Strata in Three Periods

5.5.1.1 Comparison of PPV for AIS in Merged IP-ER data in Different Strata across the Periods

Continually rising trends for PPV of AIS were noticed (Figure 5.1) when query diagnoses were excluded, unspecified stroke were excluded, and both query and unspecified stroke were excluded (see Table 5.24 & Table 5.25 for detail). PPV in each stratum are relatively consistent across the periods. The highest PPV (black bar) (around 80%) was shown in AIS excluding both unspecified stroke and query diagnoses for each time period, and improved almost 10% - 15% compared to original AIS (lightest bar).

Figure 5.2 Comparison of PPV for AIS in Merged IP-ER in Different Strata in Three Periods

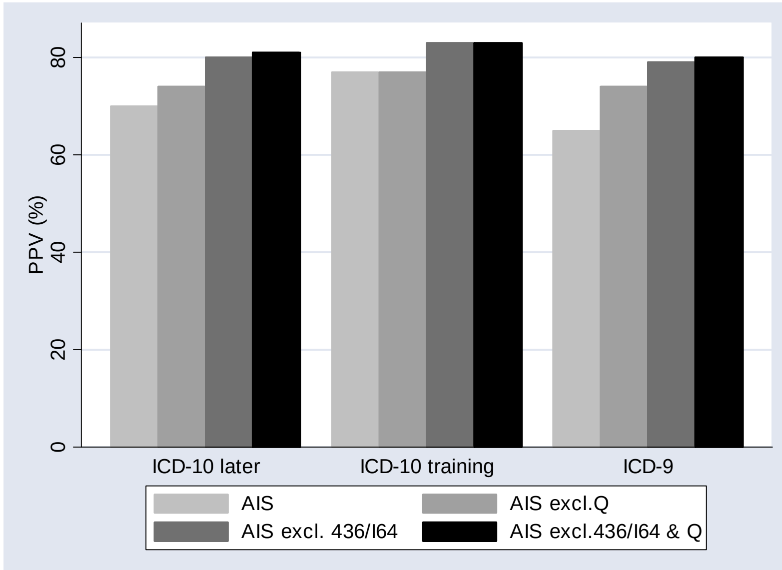


Table 5.24 Comparison of PPV for AIS with & without Query Diagnoses in Three Periods

Administrative Data	ICD-9 period (%,CI_{95})		ICD-10 training period (%,CI_{95})		ICD-10 later period (%,CI_{95})	
	With Q	Excl. Q	With Q	Excl. Q	With Q	Excl. Q
Merged IP-ER Data	65 (58-71)	74 (67-79)	77 (62-88)	77 (62-88)	70 (62-77)	74 (66-81)
Hospital Discharge Abstract (IP)	74 (66-80)	74 (67-81)	81 (65-92)	81 (65-92)	81 (72-88)	81 (72-88)
Emergency Room (ER)	47 (36-58)	67 (53-79)	60 (26-88)	60 (26-88)	45 (30-61)	54 (37-71)

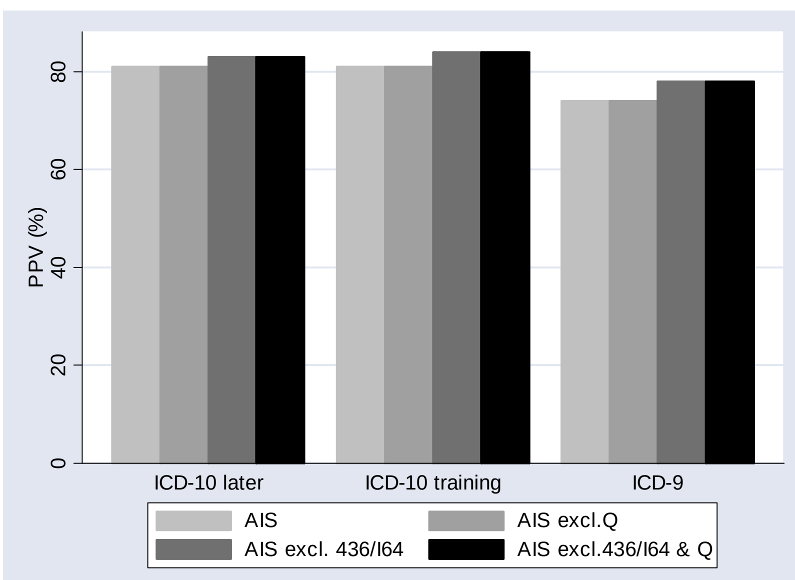
Table 5.25 Comparison of PPV for AIS Excl. Unspecified Stroke & Excl. both Unspecified Stroke and Query Diagnoses in Three Periods

Administrative Data	ICD-9 period (%,CI_{95})		ICD-10 training period (%,CI_{95})		ICD-10 later period (%,CI_{95})	
	Excl. 436	**Excl. 436 & Q**	**Excl. I64**	**Excl. I64 & Q**	**Excl. I64**	**Excl. I64 & Q**
Merged IP-ER Data	79 (70-86)	80 (72-87)	83 (66-93)	83 (66-93)	80 (71-88)	81 (72-88)
Hospital Discharge Abstract (IP)	78 (69-85)	78 (70-85)	84 (67-95)	84 (67-95)	83 (74-90)	83 (73-90)
Emergency Room (ER)	75 (19-99.4)	75 (19-99.4)	67 (9-99)	67 (9-99)	56 (21-86)	57 (18-90)

5.5.1.2 Comparison of PPV for AIS in IP in Different Strata across the Periods

No differences for PPV of AIS in IP data over time are seen when query or unspecified strokes were eliminated (Figure 5.2).

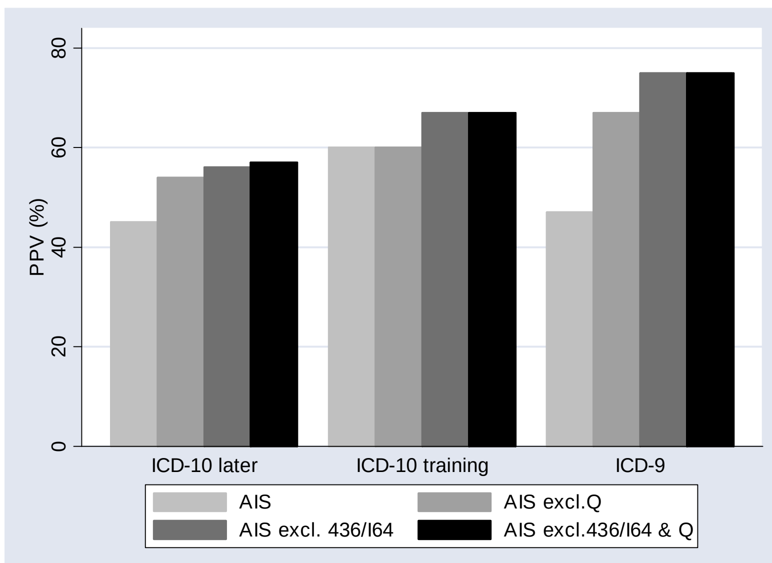
Figure 5.3 Comparison of PPV for AIS in IP in Different Strata in Three Periods



5.5.1.3 Comparison of PPV for AIS in ER in Different Strata across the Periods

Similar to trends observed in the merged IP-ER data, PPV for AIS in the emergency room improved continuously when query diagnoses were excluded, when unspecified stroke codes were excluded, and when both query and unspecified stroke were excluded, especially in ICD-9 period (Figure 5.3). The PPV varied within strata over time with higher PPV (47% -75%) in ICD-9 and lower PPV (45% - 57%) in ICD-10 later period.

Figure 5.4 Comparison of PPV for AIS in ER in Different Strata in Three Periods



5.5.2 Comparison of PPV for SAH with/without Query Diagnoses across the Periods

The PPV for SAH in merged IP-ER data and ER data are poor. However, PPV improved significantly after excluding query diagnoses in both databases in ICD-9 and ICD-10 later period ($p < 0.05$) (Figure 5.4 & 5.5 & Table 5.26).

Figure 5.5 Comparison of PPV for SAH with / without Query Diagnoses in Merged IP-ER in Three Periods

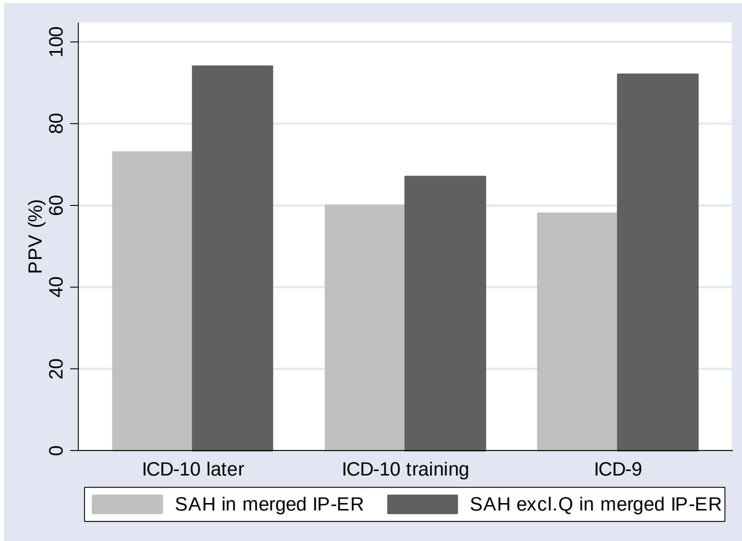


Figure 5.6 Comparison of PPV for SAH with / without Query Diagnoses in Emergency Room Data in Three Periods

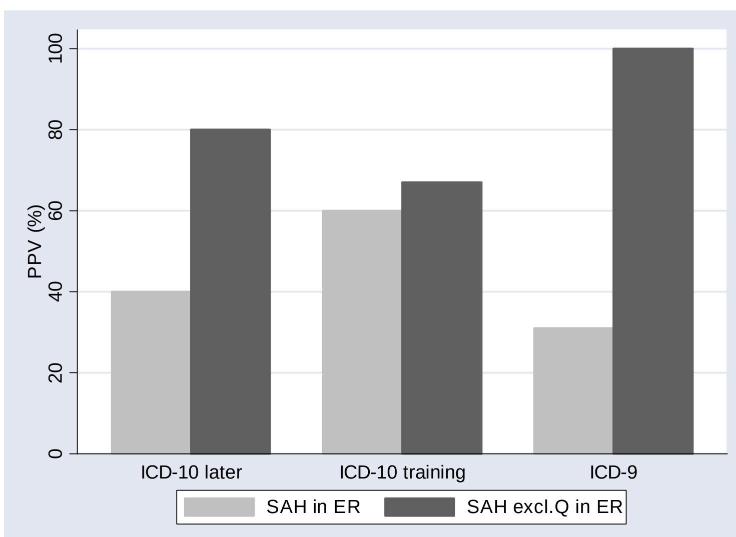


Table 5.26 Comparison of PPV for SAH with & without Query Diagnoses in Three Periods

Administrative Data	ICD-9 period (%,CI_{95})		ICD-10 training period (%,CI_{95})		ICD-10 later period (%,CI_{95})	
	With Q	Excl. Q	With Q	Excl. Q	With Q	Excl. Q
Merged IP-ER Data	58 (37-78)	92 * (64-99.8)	60 (15-95)	67 (9-99)	73 (50-89)	94 * (71-99.9)
Hospital Discharge Abstract (IP)	91 (59-99.8)	91 (59-99.8)	N/A	N/A	100 (74-100)	100 (74-100)
Emergency Room (ER)	31 (9-61)	100 * (16-100)	60 (15-95)	67 (9-99)	40 (12-74)	80 * (28-99.5)

* indicates significant increase in PPV for SAH after query diagnoses excluded ($p < 0.05$)

5.5.3 Comparison of Unspecified Stroke in Three Databases among Three Periods

Table 5.27 reflects the distribution of unspecified stroke in administrative data in chart review. We detected a high proportion of code 436 in ICD-9 period, especially in emergency data (50%) and in merged IP-ER data (34%), which can partially explain why PPV are relatively lower for all stroke in ICD-9 period.

Table 5.27 Distribution of Unspecified Stroke in Administrative Data for Chart Review

	Merged IP-ER			IP			ER		
	No. of stroke	No. of 436 / I64	**Prop. of 436 / I64**	No. of stroke	No. of 436 / I64	**Prop. of 436 / I64**	No of stroke	No. of 436 / I64	**Prop. of 436 / I64**
ICD-9 period	379	130	**34%**	222	51	**23%**	157	79	**50%**
ICD-10 training period	89	12	**13%**	52	5	**10%**	37	7	**19%**
ICD-10 later period	274	45	**16%**	163	10	**6%**	111	35	**32%**

We further looked at the distribution of unspecified stroke in administrative data that were coded as AIS in chart review. We found that a majority of AIS patients were coded as unspecified stroke in ER data over time, while over half of AIS were coded as unspecified stroke in merged IP-ER data in ICD-9 period. A lower proportion (20% - 30%) of unspecified stroke was observed in IP data over time and in merged IP-ER data in ICD-10. A higher proportion (70%-80%) of unspecified stroke was observed in AIS diagnosis in ER data during two ICD-10 periods compared to a lower percentage (26%-31%) in merged data and lowest (6% to 14%) of AIS in IP data in the same periods.

Table 5.28 Distribution of Unspecified Stroke in Administrative Data coded as AIS for Chart Review

	Merged IP-ER			**IP**			**ER**		
	No. of AIS	No. of 436 / I64	**Prop. of 436 / I64**	No. of AIS	No. of 436 / I64	**Prop. of 436 / I64**	No. of AIS	No. of 436 / I64	**Prop. of 436 / I64**
ICD-9 period	243	130	**53%**	160	51	**32%**	83	79	**95%**
ICD-10 training period	47	12	**26%**	37	5	**14%**	10	7	**70%**
ICD-10 later period	147	45	**31%**	103	10	**6%**	44	35	**80%**

5.5.4 Comparison of Query Diagnoses in Three Databases among Three Periods

As shown in table 5.29, query diagnoses accounted for a high proportion of diagnoses in the emergency room data, varying from 45% in ICD-9 to 22% in ICD-10 training period, and to 31% in ICD-10 later period. As expected, only a few query diagnoses were found in hospital discharge abstract (IP).

Table 5.29 Distribution of Query Diagnoses in Administrative Data Related to Chart Review

	Merged IP-ER			IP			ER		
	No. of stroke	No. of "Q"	**Prop. of query diagnoses**	No. of stroke	No. of "Q	**Prop. of query diagnoses**	No. of stroke	No. of "Q	**Prop. of query diagnoses**
ICD-9 period	379	77	**20%**	222	7	**3%**	157	70	**45%**
ICD-10 training period	89	1	**1%**	52	0	**0**	37	8	**22%**
ICD-10 later period	274	37	**14%**	163	3	**2%**	111	34	**31%**

5.6 Summarized Comparison of Query Diagnoses and Unspecified Stroke in Three Time Periods

When we compared the distribution of query diagnoses and unspecified stroke among three time periods in administrative data related to chart review (Table 5.30 & Table 5.31), we found that no query diagnoses existed for AIS and SAH in ICD-10 training period. This could be a reason why PPV were relatively high for all stroke type, especially for AIS in this period.

Table 5.30 Distribution of Query diagnoses for Stroke Type among Three Time Periods

Proportion of Query diagnoses	ICD-9 n, %, CI_{95}	ICD-10 training period n, %, CI_{95}	ID-10 later period n, %, CI_{95}
All Stroke	77 (20) (16-25)	8 (9) (4-17)	37 (14) (10-18)
AIS	33 (14) (10-19)	0	11 (7) (4-13)
TIA	31 (36) (26-48)	6 (21) (8-41)	21 (24) (16-35)
ICH	2 (7) (1-24)	0	0
SAH	11 (46) (26-67)	2 (40) (5-85)	5 (23) (8-45)

In addition, Table 5.31 illustrated that unspecified stroke accounted for significantly higher AIS (53%) in ICD-9 period, and higher stroke (34%) than in any other periods (P < 0.0001). Therefore, PPV for AIS and for all strokes in ICD-9 period were the lowest (65% & 84%) among three periods.

Table 5.31 Proportion of Unspecified Stroke among Three Time Periods

Proportion of Unspecified Stroke	ICD-9 period n, %, CI_{95}	ICD-10 training period n, %, CI_{95}	ID-10 later period n, %, CI_{95}	P
AIS (n= 243, 47, 147)	130 (53) (47-60)	12 (26) (14-40)	45 (31) (23-39)	< 0.0001
All Stroke (n=379, 89, 274)	130 (34) (30-39)	12 (13) (7-22)	45 (16) (12-21)	< 0.0001

Table 5.32 & Table 5.33 show that unspecified stroke accounted for a very high proportion of query AIS in ICD-9 (94%) as well as in ICD-10 later period (73%) with significant 21% difference (p=0.05) in merged IP-ER. Concordantly, unspecified stroke accounted for 8% query diagnoses for all stroke in ICD-9 period, with significantly 5% higher proportion than in ICD-10 later period. These findings explained why the lowest PPV for AIS (65%) and for all stroke (84%) were found in ICD-9 period. We can not compare the proportion of unspecified stroke in query AIS between ICD-10 training period and other periods given no unspecified questionable AIS found in that period. This might be the reason why PPV for AIS in ICD-10 training period is the highest (77%) among all periods.

Table 5.32 Proportion of Unspecified Stroke in Query AIS among Three Time Periods in Merged IP-ER

Proportion of Unspecified Stroke	ICD-9 (N = 33) n, %, CI_{95}	ICD-10 training period (N = 0)	ID-10 later period (N = 11)	P
Query AIS	31 (94) (80-99)	0	8 (73) (39-94)	0.05

Table 5.33 Proportion of Unspecified Stroke with Query diagnoses in All Strokes among Three Time Periods in Merged IP-ER

Proportion of Unspecified Stroke	ICD-9 (N = 379) n, %, CI_{95}	ICD-10 training period (N = 89)	ID-10 later period (N = 274)	P
All Stroke	31 (8) (6-11)	0	8 (3) (1-6)	0.005

CHAPTER SIX: DISCUSSION ON CHART REVIEW

6.1 Significance

In present study, we have addressed the accuracy of stroke codes in merged hospital discharge abstract and emergency room visit data, as well as the validation reports on separate database. To our knowledge, this is the first design to estimate the validity of stroke codes in merged hospitalization database and emergency room database. Furthermore, we also compared the performance of stroke codes by stroke type among three time periods from ICD-9 to early learning curve of ICD-10 and to ICD-10 later period. In addition, in order to estimate the effect of query diagnoses and unspecified stroke codes on the validity of stroke codes, we stratified many analyses in three kinds of administrative data by query diagnoses and unspecified stroke. Therefore, we provided enriched information regarding the validity of stroke and stroke type in different administrative databases and different coding algorithms, which is novel and significant for the validation study of administrative data in the stroke field compared to other literature.

6.2 Validation for Stroke in Merged IP-ER Data

Using medical records (chart review) as golden standard, we estimated the predictive value of positive test of stroke (PPV) and predictive value of negative test of stroke (NPV). We found the PPV for all stroke patients was good in all periods, ranging from 84% to 93% using merged IP-ER data. By stroke type, the PPV for TIA and ICH is sound as well. However, PPV for AIS and SAH are poor over time.

The use of the query code in front of a diagnosis mattered. The PPV for SAH improved dramatically to excellent (> 90%) when query diagnoses were excluded in

ICD-9 and ICD-10 later period. Due to the very small sample size (n=3) in ICD-10 training period, the interpretation of PPV of 67% for SAH without query diagnoses is cautious.

The PPV for AIS increased 10% in ICD-9 period when query diagnoses codes were excluded, yet improved only slightly in ICD-10 later period, with no change in ICD-10 training period. We noticed a quite big difference for the PPV of AIS when unspecified stroke was excluded. All PPV of AIS improved to very good (80%) from poor (<70%) across the periods indicating the high effect of unspecified stroke on validity of AIS diagnosis. Those codes for AIS diagnosis are relatively correct when code 436 in ICD-9 or code I64 in ICD-10 is excluded.

NPV is perfect or near perfect with 100% correct across the periods, indicating that those non-stroke patients diagnosed as hypertensive encephalopathy, hypoglycemic coma/encephalophaty, acute seizure, complex migraine, vertigo, CABG, abdominal aortic aneurysm surgery, aortobifemoral bypass or femoral-popliteal artery bypass were less likely coded as stroke patients. It suggests these non-stroke conditions, chosen because they may present as stroke mimics to the emergency room, are not often miscoded.

We did specific analysis on PPV for unspecified stroke codes, and found that around half of codes of 436 and I64 were not correctly diagnosed as AIS across all three time periods.

6.2.1 Comparison of PPV in Merged IP-ER between ICD-9 and ICD-10 Coding Algorithm

The ICD coding systems were developed to classify morbidity and mortality records. Although the ICD-9 contains a large volume of clinical codes it does have its limitations and is not a comprehensive clinical data set. Overall, the new ICD-10 system has more codes and is more comprehensive allowing for richer coding of clinical information. We did identify that PPV improved significantly, reaching to 'excellent' in ICD-10 from 'very good' in ICD-9 period for stroke in merged data. This occurred in all stroke types, but was most pronounced for hemorrhagic forms of stroke.

We reviewed the first 6-month period of ICD-10 coding separately from the later period as we recognized that the first 6-months of ICD-10 may not provide the best estimate of administrative data validity in a new coding system. We therefore allowed for a "learning curve" for health record coders to learn the new rules and system. Interestingly, PPV increased obviously for ICH and SAH ($p < 0.05$ for both) compared to the learning curve.

6.3 Validation for stroke in IP and ER data

PPV for all stroke type in hospital discharge data are higher than those in merged IP-ER data and emergency room data (Table 5.16) with a sound correct rate from 74% to 100% across the periods. PPV for AIS is very good between 74% and 81%, and is excellent for SAH (> 90%). As expected, PPV in IP data are almost identical with query diagnoses dropped, because only a very small number of query diagnoses were detected (n=2 in ICD-9 and n=3 in ICD-10).

6.3.1 Comparison of PPV in IP between ICD-9 and ICD-10 Coding Algorithm

A slightly improved PPV for all stroke and stroke type were found in ICD-10 period. The PPV for TIA (100%) in ICD-10 training period was significantly higher than the two other periods, while PPV for ICH during the learning curve was the lowest. The PPV for ICH in ICD-10 later period is impressively higher (92%) than other periods ($p < 0.005$). PPV for SAH is excellent in both ICD-9 and ICD-10, yet we were not able to compare with the ICD-10 training period given no observation were found there.

6.3.2 Comparison of PPV in ER between ICD-9 and ICD-10 Coding Algorithm

PPV for stroke and most stroke types were poor in ER data, except for TIA (PPV was very good from 73% to 85%) in three periods. PPV for stroke and all stroke type in ICD-10 training period are significantly higher than two other periods. PPV for stroke, AIS, TIA and SAH are quite close in ICD-9 and ICD-10 later period. The highest PPV for ICH (100%) in ICD-10 training period could be biased as only a few charts of ICH available. When query diagnoses were excluded, PPV improved a quite bit, especially for TIA, reaching to excellent in the first two periods and very good in the last period. The role of the query diagnosis code is previously unappreciated for ED chart coding. As the ambulatory care coding systems become more entrenched throughout the country, attention to the lack of specificity implied by the query diagnoses will be important not only for stroke but more many other common ED diagnoses as well.

6.4 Unspecified Stroke & Query diagnoses

In practice, unspecified stroke (codes 436 to 437) was usually aggregated with ischemic stroke (codes 433 to 434), and was classified as AIS which may be based on clinical experience, or perhaps lack of input into coding algorithms by neurologists. We did not count code 437 in our study as one study reported that PPV for code 437 is only 14% (95% CI 10%-18%) compared to PPV of 61% (95% CI 56%-67%) for code 436 [106].

In chart review, we detected high proportion of code 436 in ICD-9 period, especially in ER data (50%) and in merged data (34%), which can partially explain why the PPVs were relatively lower for all stroke in ICD-9 period in ER and merged data. The majority of AIS patients (95%) were coded as unspecified stroke in ER data, while over half of AIS were coded as unspecified stroke in merged data in ICD-9 period. Lower proportions (20% -30%) of unspecified stroke was observed in IP data over time and in merged IP-ER data in ICD-10, leading to a good validity of stroke diagnosis in both data sets during that period.

Query diagnoses accounted for a lot of the codes in ER data, varying from 45% in ICD-9 to 22% in ICD-10 training period, and to 31% in ICD-10 later period. Unspecified stroke accounted for a very high proportion of query AIS in ICD-9 (94%) compared to in ICD-10 later period (73%) with significant 21% difference (p=0.05) in merged IP-ER, indicating the higher association between query diagnoses and unspecified stroke codes.

6.5 Comparison with literature

Hill et al have examined the accuracy of stroke coding using ICD-9 vs. ICD-10 in hospital discharge data in the Calgary Health Region for fiscal year 2000 and 2002. They identified a bit higher PPV for all stroke type in ICD-9 period than in the present study, yet with no significant difference. The PPV in ICD-10 period were quite close, but they did not discriminate the ICD-10 period into two periods.

It is possible and likely that the validity of stroke coding, especially for stroke types has improved gradually with the development of diagnostic imaging technology and familiarity of stroke type codes in the ICD-10 later period. The larger amount of stroke occurred from 1995 to 1999 in our chart review may account for the relatively lower PPV in ICD-9 compared to Hill's study. On the other hand, since validation in IP data in the present study was just a stratified analysis, which makes smaller sample size for ICH and SAH stratum compared to Hill's study, and this could be the reason that attributes to the variance in our results.

Almost all available literature regarding validity of stroke codes were conducted among hospital discharge charts, not from emergency room charts or mixed charts (from hospital discharge or emergency room charts). Therefore, we can only compare the chart review results of IP data in the present study with other researches. Various studies that have estimated the sensitivity of stroke codes in IP data have reported that results vary depending on the ICD-9-CM algorithm used, particularly for ischemic stroke [97, 101, 107-109]. Although ICD-9-CM codes show relative agreement with medical record reviews for stroke [97, 107], it is recognized that there may be some inaccuracies in the classification of patients with ischemic stroke[99].

Overall, accuracy of the primary ICD-9 codes in our study was higher than that found in large population-based samples [99, 101, 107]. Previous studies indicated that the majority of patients with ischemic stroke were classified with ICD-9 codes 433, 434, and 436 [99, 101, 107]. Goldstein reported that codes with the highest proportions of incident ischemic stroke cases were 434.11 (85%), 434.91 (82%), and 436 (79%), with a combined sensitivity of 0.81 and specificity of 0.90 [97].

Four studies [99, 101, 107, 110] presented a PPV of code 436 for stroke diagnosis with a range between 64% and 86%, and a combined PPV of 72%. However, no study reported the validity of unspecified stroke codes in ICD-10 (I64) to the date. Neither did we find any research stating the PPV of code 436 for AIS diagnosis.

Coding accuracy is affected by diagnosis definitions and interpretation of the codes. At the beginning of 2002, the 10th revision replaced ICD-9 province-wide. Compared with ICD-9, ICD-10 is qualitatively more intuitive and specific for the diagnosis of ischemic stroke and in parallel we did find higher PPV in ICD-10 than in ICD-9.

A recent study found that ill-defined strokes (code 436 & 437 in ICD-9) constituted > or =25% of all stroke diagnoses [111]. The authors identified that an ill-defined diagnosis (or say unspecified stroke) was less likely with a reported procedure code for MRI but more likely with a bill indicator for CT scan. In addition, they concluded that ER presentation and an admission diagnosis of ill-defined stroke were highly associated with a discharge diagnosis of ill defined stroke.

6.6 Reason for lower PPV of Ischemic Stroke in ER

One recent study in the BASIC Project conducted emergency department evaluation of ischemic stroke. They stated that neurologists were seldom involved with acute cerebrovascular care in the emergency department (ED), especially in patients with TIA. Only 8% of patients received an in-person neurology consultation in the ED. Therefore, greater neurologist involvement, as is seen in the Calgary Health Region, may improve acute stroke diagnoses and treatment efforts in the ED. [112]

6.7 Limitation

The study on chart review is subject to several limitations.

First, we did not capture data from those individuals who did not seek medical attention or who were only seen in outpatient clinics or offices. For stroke, this could result in a slight bias to more severe strokes because patients with only mild symptoms may not seek medical attention. A Texas study identified some stroke cases by active surveillance that were missed completely by the passive surveillance system. Interestingly, the converse was also true in that some cases identified by passive surveillance were missed by the active surveillance system [38].

We were unable to blind the chart reviewer to the health records coding because of practical limitations. Further, our system includes an active dialogue between the health records coder and the Calgary Stroke Team in ICD-9 period, meaning that our results may not be as generalizable to other populations of patients.

Thirdly, although applying the first position diagnosis improves the specificity of diagnosis, it may limit sensitivity. Therefore, our sampling frame was limited to stroke identified in the primary diagnostic position; those coded in other diagnostic positions may have missed. Typically, however, stroke is a clinical diagnosis that is most responsible for the length of stay and therefore is coded in the primary position.

Fourthly, we evaluated the positive predict value for three kinds of administrative data in our study, so that we can predict the proportion of reported cases that actually have a stroke event under surveillance. However, our study design is retrospective in nature and does not allow computation of sensitivity or specificity of ICD-9 codes. Therefore, we are not able to know the proportion of stroke detected by the surveillance system due to the absence of sensitivity, which is a limitation for this study. A recent study assessed the validation of the Finnish Hospital Discharge Register on stroke diagnoses, and reported 88% to 83% sensitivity on all first stroke events from ICD-9 to ICD-10 [113]. A similar fairly good sensitivity was also stated in Italy by Rinaldi etc. They found that the sensitivity of the ICD-9 codes was 82% for all diagnostic levels and 76% for the first level diagnosis in one general hospital [114]. Another prospective study in a US community reported a sensitivity of 76% for stroke events [97]. Overall, the sensitivity for stroke in ICD-9 is good ranging from 76% to 90% in the world studies [97, 101, 102, 106]. Only few studies examined the sensitivity of classified stroke type and identified optimal results [92, 102]. Since the validity of the present study is highly dependent on the accuracy of the positive predictive values of the ICD-9 and ICD-10 codes, a lack of sensitivity and specificity in the merged IP-ER data may reduce the strength of our validation study.

Finally, the small sample size in the hemorrhagic stroke strata in chart review is also a limitation, which may bias the PPV results.

6.8 Conclusion

The relative high proportion of stroke patients who receive an unspecified stroke diagnosis on discharge suggests a continued need for improvements in early response and prompt evaluation of strokes. The unspecified code most likely represents a lack of sophistication by the attending team in determining the stroke type diagnosis.

It is important to promote evidence-based guidelines for evaluating and diagnosing stroke types to physicians, and provide additional efforts and mechanisms to give them feedback. Efforts are also needed in some hospital systems to improve medical reporting of stroke-related procedures and diagnoses on hospital records. Reimbursement practices and public health efforts that promote hospital stroke policies are critical to improve disease reporting as well as clinical outcomes.

Caution is urged when using unspecified stroke codes in administrative data to identify patients with stroke, especially for AIS diagnosis.

6.9 Future Research on Chart Review

a) Enlarge the samples for chart review and oversample the sample size for unspecified stroke and hemorrhagic stroke.

b) Add chart review in rural area.

c) Stratify analysis by teaching hospital (like FMC) and community hospital (like RGH) to compare the validation of administrative data between them.

d) Stratify validation analysis for each individual ischemic stroke code in ICD-9 and ICD-10 coding algorithm.

e) Expand chart review on diagnosis of stroke other than the first position of stroke in administrative data, so all diagnostic levels would be included and results of PPV would be compared among them.

f) Add validation on risk factors of stroke in terms of hypertension, diabetes, coronary / ischemic heart disease, history of cerebravascular diseases, hyperlipidemia, renal diseases and tobacco use, etc.

g) Expand the chart review to other places in Alberta, including Edmonton, Lethbridge, Medicine Hat, etc.

h) Collaboration with hospitals in other provinces to perform further nationwide chart review among several large provinces across the country.

i) All above proposed chart review would be developed among three time periods as the present study and compared over time (from IC-9 period to ICD-10 training period and to ICD-10 later period).

CHAPTER SEVEN: RESULTS FOR TRENDS OF STROKE IN MERGED DATA

7.1 Study Population

Figure 7.1 below illustrated the flow chart of study population for trends of stroke.

a) Data Cleaning in IP & ER data

Same as the first step for study population of chart review, we extracted only stroke subjects in both database after cleaning missing PHN in both IP & ER data.

b) Study Population in IP & ER Data

After data cleaning, we obtained a study population of 10,733 stroke subjects in IP data that can be used for analysis on trends of stroke in IP data as well as an IP database prepared for linkage. We treated multi-visits within 1 day (± 1 day) for same patients in the emergency room as the same visit, and we excluded such duplicated subjects (same PHN within 24 hours admission in ER data), deriving a study population of 16,251 stroke subjects in ER data.

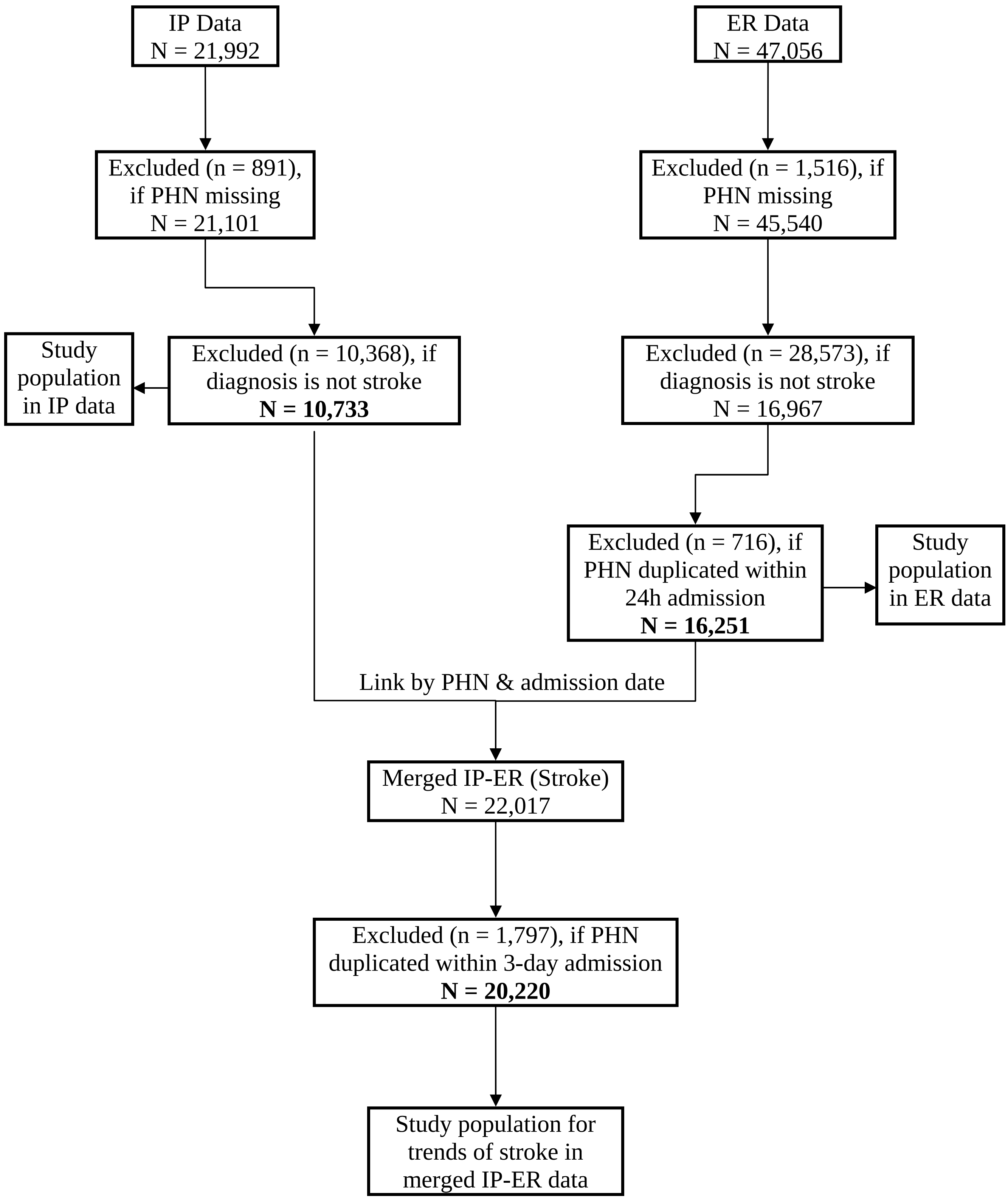
c) Linkage of IP and ER data by PHN and Admission Date

We linked the group of IP stroke data (n=10,733) with the group of ER stroke data (n=16,251) applying unique PHN and admission date as primary merging variables to form a merged IP-ER (stroke) cohort that included 22,017 subjects. The missing 4967 patients after the linkage (missing 4967 = 10,733 + 16,251 – 22,017) were patients who visited the emergency room first because of their strokes and then were admitted to hospitals on the same day of their emergency visits.

d) Study Population in Merged IP-ER Data

In the merged IP-ER data, duplicated cases were eliminated when a patient has an emergency room visit three days before or after his/her hospital admission. The definition on this duplicated stroke is based on an experienced neurologist's suggestion. We did not eliminate recurrent stroke because we tend to record all stroke occurrence and keep multi-admissions for one patient in the study population. We obtained 20,220 study population in the final merged IP-ER data.

Figure 7.1 Flow Chat of the Study Population for Trends of Stroke



7.2 Trends of Stroke in Merged IP-ER Data

7.2.1 Description of Study Population in Merged IP-ER Data

The median age for stroke patients is 73 yr, ranging from 59 – 81 yr over time. Female accounted for almost 51% in stroke patients. The distributions of stroke type are compatible over time with 53% for AIS, 33% for TIA, 7% for ICH and 8% for SAH (Table 7.1).

Table 7.1 Demographic Characteristics for the Study Population in Merged IP-ER Data, 1995 - 2004

Fiscal year	***1995***	***1996***	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Total**
Number	*989* [a]	*1644* [b]	1912	2004	2347	2289	2351	2187	2225	2271	20219
Mean age (SD), y	*71 (14)*	*70 (15)*	70 (15)	70 (15)	69 (16)	69 (16)	69 (16)	69 (16)	69 (16)	68 (16)	69 (16)
Median age (IQR), y	*73 (64-81)*	*73 (62-81)*	73 (63-81)	73 (63-81)	73 (61-81)	73 (59-81)	73 (60-81)	73 (60-81)	73 (60-81)	71 (58-81)	73 (61-81)
Female, n (%)	*490 (50)*	*783 (48)*	992 (52)	1024 (51)	1219 (52)	1190 (52)	1233 (52)	1161 (53)	1092 (49)	1154 (51)	10338 (51)
Stroke Type, n (%)											
AIS	*661 (67)*	*904 (55)*	1018 (53)	1062 (53)	1185 (50)	1219 (53)	1190 (51)	1155 (53)	1166 (52)	1157 (51)	10717 (53)
TIA	*155 (16)*	*487 (30)*	626 (33)	644 (32)	807 (34)	759 (33)	804 (34)	757 (35)	769 (35)	780 (34)	6588 (33)
ICH	*101 (10)*	*137 (8)*	144 (8)	140 (7)	174 (7)	138 (6)	177 (8)	158 (7)	166 (7)	160 (7)	1495 (7)
SAH	*72 (7)*	*116 (7)*	124 (6)	159 (8)	181 (8)	173 (8)	180 (8)	117 (5)	124 (6)	174 (8)	1420 (7)

Note: [a] In Merged IP-ER database, ER data starts from July 1996, therefore we were not able to know the stroke occurrence from ER data in fiscal 1995, that is why the number of stroke in 1995 are smaller than other years in Table 7.1.

[b] Three months ER data (from April to June) were not available for stroke patients in fiscal 1996. For consistency, we only studied the trend of stroke in merged IP-ER data from 1997 to 2004.

7.2.2 Trends of Stroke Admission Cases

7.2.2.1 Trends of Overall Stroke Admission

Table 7.2 showed the absolute number of stroke occurrence in merged IP-ER data from year 1997 to 2004 in different strata. Figure 7.2 to 7.4 illustrated the trends of stroke admission cases that identified from hospital discharge abstract and emergency room data.

Table 7.2 Number of Stroke Admission in Merged IP-ER

Year	Stroke	Stroke Excl. Q	Stroke Excl. I64	Stroke Excl. Q & I64
1997	1912	1441	1336	1009
1998	2004	1585	1481	1190
1999	2347	1811	1743	1375
2000	2289	1733	1706	1317
2001	2351	1894	1840	1512
2002	2187	1878	1731	1493
2003	2225	1868	1763	1514
2004	2271	1884	1800	1525

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query and unspecified stroke.

The number of stroke admission cases increased 18.8% from 1912 in year 1997 to 2271 in 2004. During this eight years, stroke cases rose dramatically from 2004 in year 1998 to 2347 in 1999, reaching the peak, and then decreased a bit to 2289 in year 2000, and back to 2351 in year 2001. In 2002, the number of stroke admission dropped to 2187, yet started to go up (Figure 7.2), showing significant curvilinear trends for number of stroke occurrence (Figure 7.5).

When query diagnoses or unspecified stroke excluded, the number of stroke admission presented a continuous increasing trend from 1997 to 2004 (all p < 0.02 in regression analysis, see Figure 7.2 & 7.4.), with no peak admission in 1999.

Figure 7.2 Number of Stroke Admission in Merged IP-ER, 1997-2004

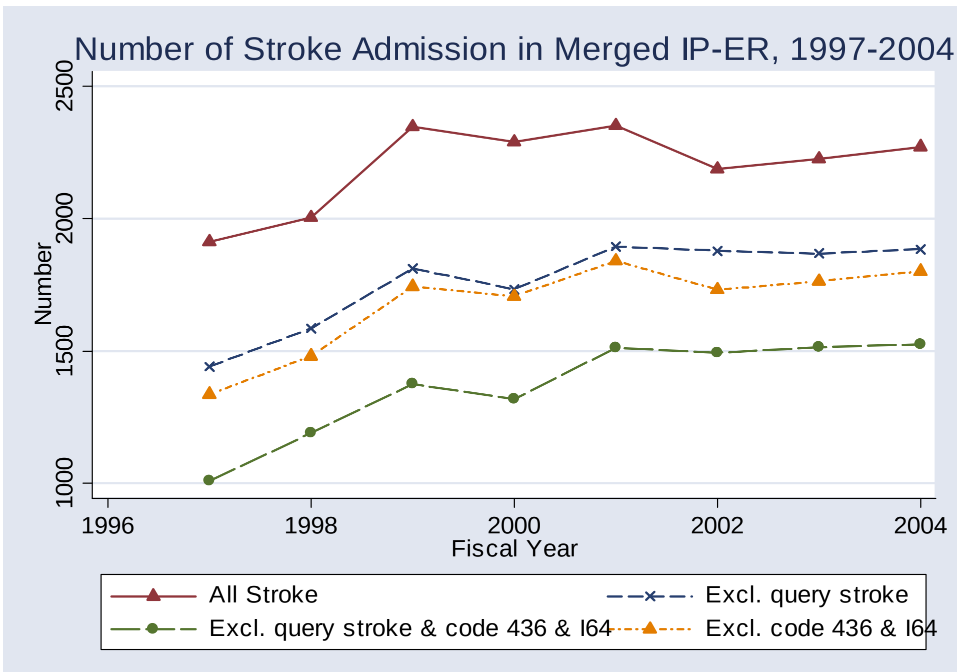
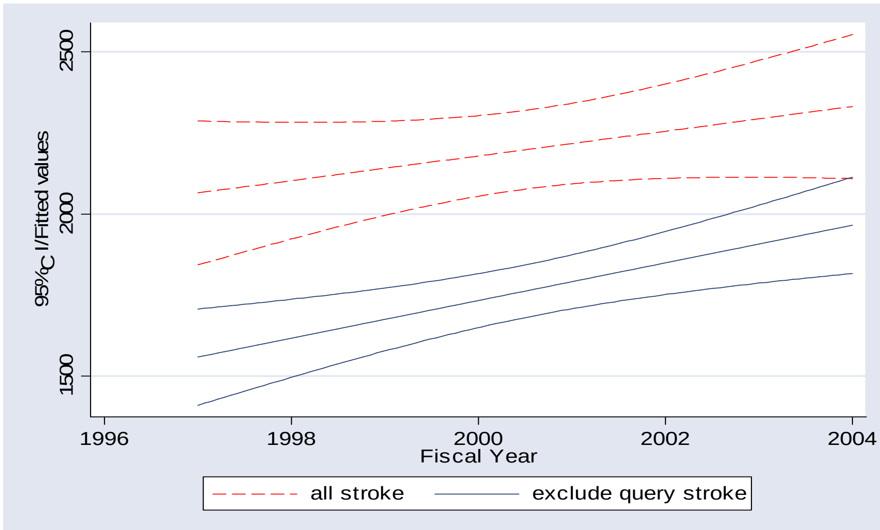
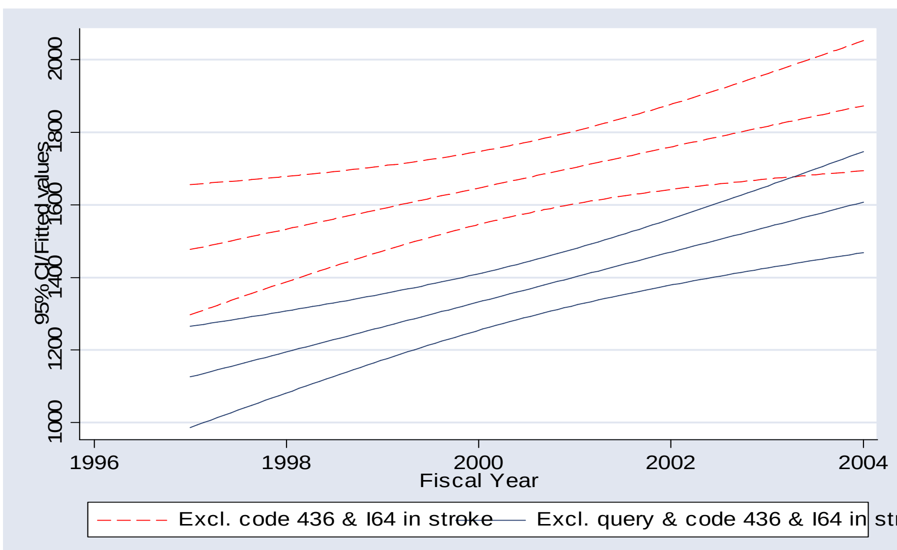


Figure 7.3 Trend of Stroke Admission in Merged IP-ER, 1997-2004 (1)



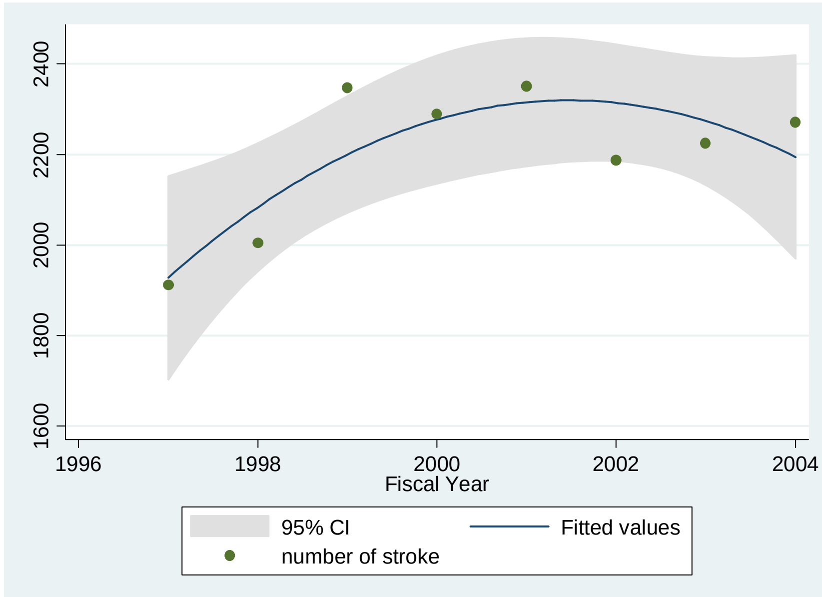
Note: The curved lines represent 95% confidence bands around the regression lines

Figure 7.4 Trend of Stroke Admission in Merged IP-ER, 1997-2004 (2)



Note: The curved lines represent 95% confidence bands around the regression lines

Figure 7.5 Curvilinear Trend for Number of Stroke Occurrence in Merged IP-ER



Linear projections of the stroke number into the future imply an average increase of 38 strokes per year (95%CI: -15 to 91) with a greater increase predicted when query diagnoses, unspecified stroke, or both were excluded in the projection (Table 7.3).

Table 7.3 Projection of Increased Stroke Cases in Future in Merged Data (per year)

	All stroke	Excl. query stroke *	Excl. unspecified stroke *	Excl. both query & unspecified stroke *
Number of increased stroke (per year)	38	58	57	69
95% CI	(-15) - 91	23 - 94	14 - 99	36 -102

Note: * Linear projection is significant with p value < 0.02

7.2.2.2 Trends of Stroke Admission by Stroke Type

Table 7.4 below presented the detailed numbers of stroke admission by stroke type from 1997 to 2004.

Table 7.4 Number of Stroke Admission by Stroke Type in Merged IP-ER

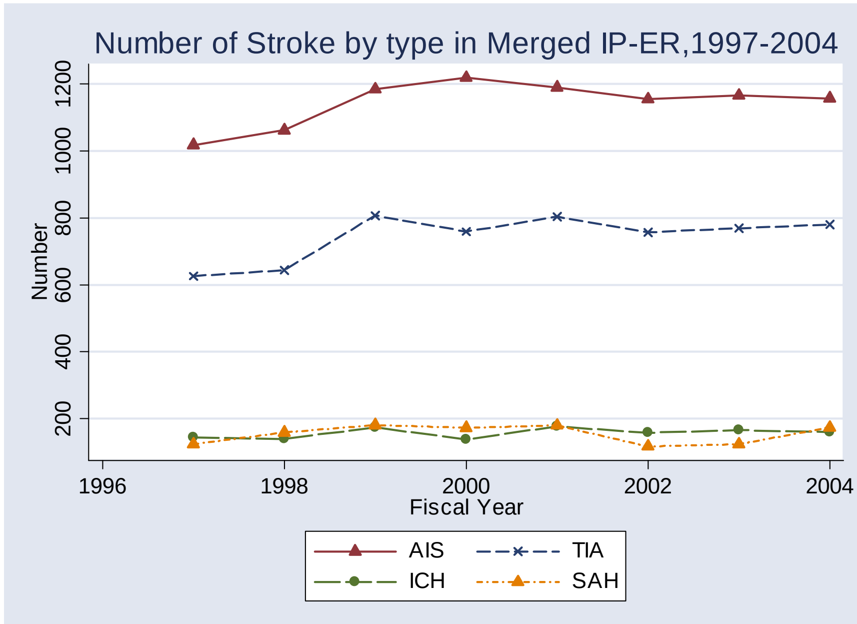
Year	**AIS**	**TIA**	**ICH**	**SAH**	**AIS Excl.Q**	**TIA Excl.Q**	**ICH Excl.Q**	**SAH Excl.Q**	**AIS Excl.I64**	**AIS Excl.Q&I64**
1997	1018	626	144	124	860	363	132	86	442	428
1998	1062	644	140	159	909	435	137	104	538	514
1999	1185	807	174	181	981	558	166	106	581	545
2000	1219	759	138	173	1010	489	131	103	636	594
2001	1190	804	177	180	1033	572	168	121	679	651
2002	1155	757	158	117	1068	556	157	97	699	683
2003	1166	769	166	124	1038	574	164	92	704	684
2004	1157	780	160	174	1023	573	157	131	686	664

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q&I64 = Exclude query & unspecified stroke

Figure 7.6, 7.8 indicated that the number of hemorrhagic stroke increased slightly during eight year period from 144 to 160 for ICH, and 124 to 180 for SAH with stable trends whether query diagnoses were eliminated or not (all $p > 0.1$).

The number of AIS admission increased 13.7% from 1018 in 1997 to 1157 in 2004 in hospital admission and emergency visits (Figure 7.6). The occurrence of AIS continuously increased from 1997 to year 2000 with the highest number of 1219, and then declined to stable after year 2002 ($p = 0.127$) (Figure 7.6), showing a significant curvilinear trend (Figure 7.9).

Figure 7.6 Number of Stroke by Type in Merged IP-ER, 1997-2004



However, the rising trend of AIS became obvious (all of $p < 0.01$) (Figure 7.7 & 7.8 & 7.10) if query diagnoses or unspecified stroke were dropped, and reached to the peak at year 2002 instead of 2000.

Figure 7.7 Number of AIS Exclude Query & Unspecified Stroke in Merged IP-ER Data, 1997-2004

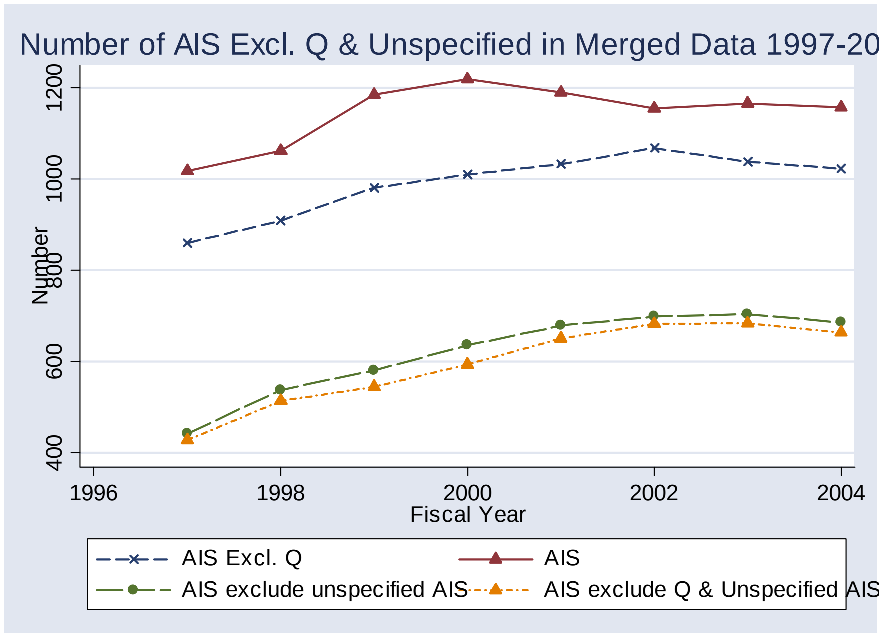


Figure 7.8 Number of Stroke by Type Excl. Query Stroke in Merged IP-ER Data, 1997-2004

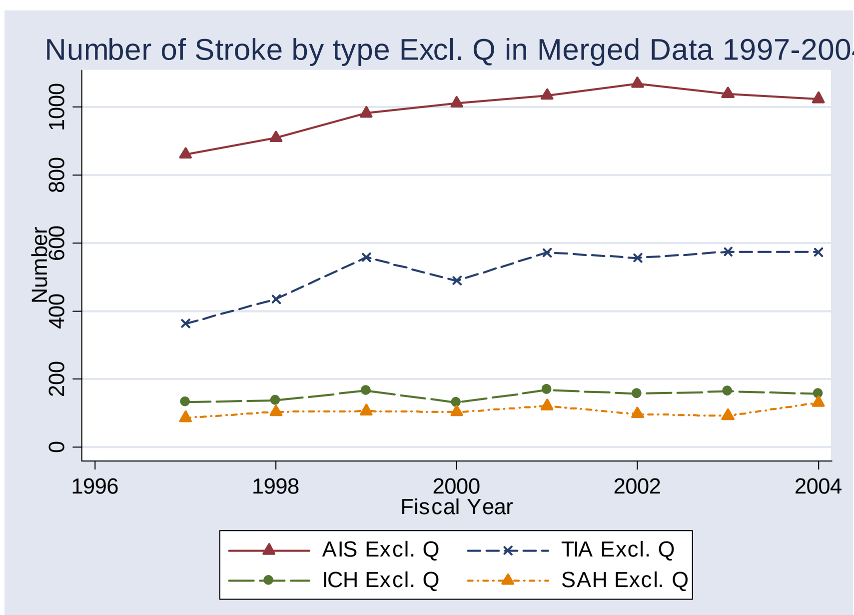
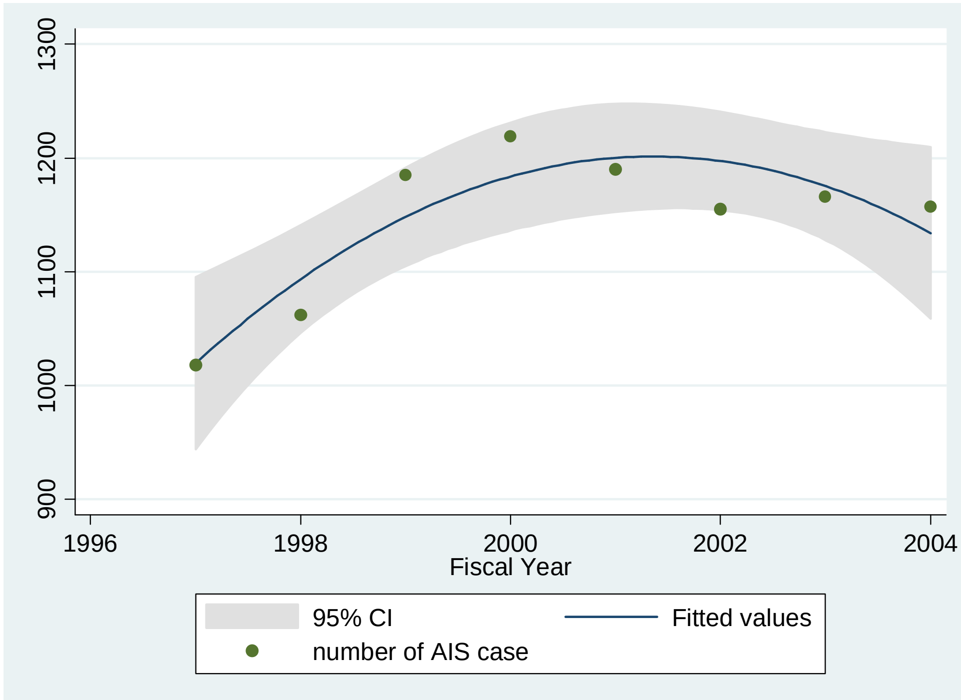
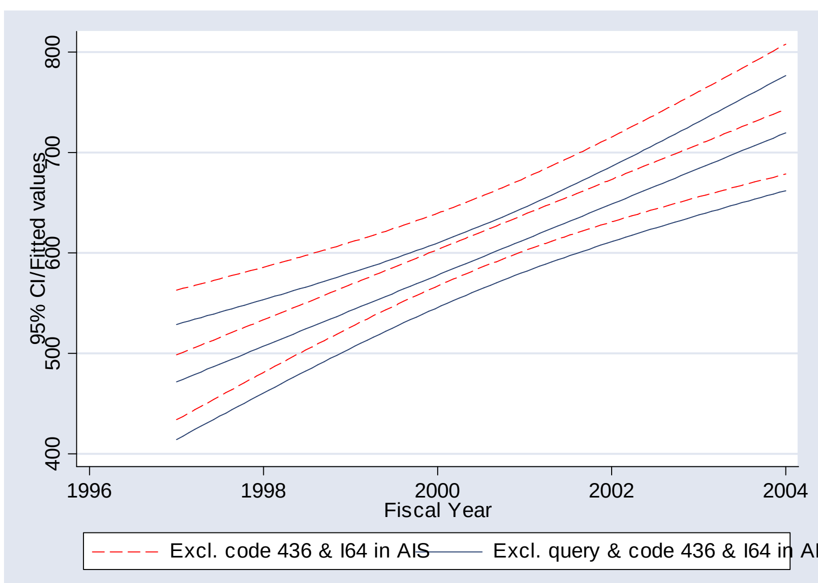


Figure 7.9 Curvilinear Trend for Number of AIS Occurrence in Merged IP-ER



Note: The curved lines represent 95% confidence bands around the regression lines

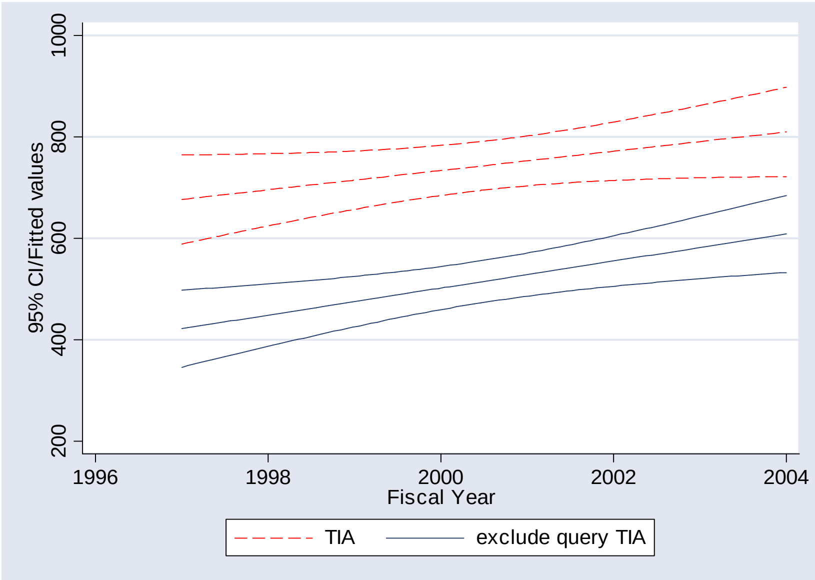
Figure 7.10 Trend of AIS Admission Excluding Unspecified Stroke in Merged IP-ER, 1997-2004



Note: The curved lines represent 95% confidence bands around the regression lines

The number of TIA admission rose 24.6% from 626 in 1997 to 780 in year 2004, with significant difference (p=0.05) (Figure 7.6 & 7.11). The increasing change turned to bigger with substantial difference (p = 0.01) when query diagnoses were excluded.

Figure 7.11 Trend of TIA Admission in Merged IP-ER, 1997-2004



Note: The curved lines represent 95% confidence bands around the regression lines

7.2.2.3 Trends of Stroke Admission by Sex

In stratified analysis by sex, we plotted the trend of overall stroke admission as well as trend for each stroke type during the same period.

7.2.2.3.1 Trends of Overall Stroke Admission by Sex

Table 7.5 Number of Stroke Admission by Sex in Merged IP-ER

Year	Stroke-Female	Stroke – Male	Stroke Excl. Q-F	Stroke Excl. Q-M	Stroke Excl. I64-F	Stroke Excl. I64-M	Stroke Excl. Q & I64 - F	Stroke Excl. Q & I64 - M
1997	992	920	728	713	718	618	529	480
1998	1024	981	794	791	760	721	602	588
1999	1219	1128	908	903	895	848	682	693
2000	1190	1099	880	853	874	832	662	655
2001	1233	1118	968	926	961	879	774	738
2002	1161	1026	988	890	919	812	782	711
2003	1092	1133	913	955	865	898	738	776
2004	1154	1117	936	948	912	888	754	771

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query & unspecified stroke; F = Female; M = Male

There was an increasing trend of number of stroke in both sexes over time ($p \leq 0.05$) (Table 7.5, Figure 7.12 – 7.13). When query stroke or unspecified stroke was excluded, the same trends were evident in both sexes (all of $p<0.02$) (Figure 7.14 – 7.16), though the number of stroke admissions reduced 200 to 300 each year.

Figure 7.12 Number of Stroke Admission in Merged IP-ER by Sex, 1997-2004

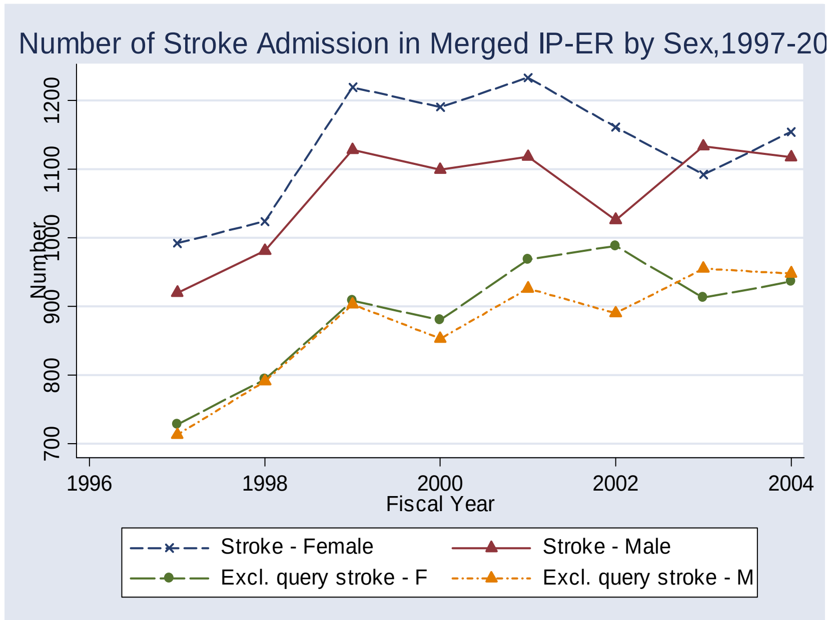


Figure 7.13 Trend of Stroke Admission by Sex in Merged IP-ER, 1997-2004 (1)

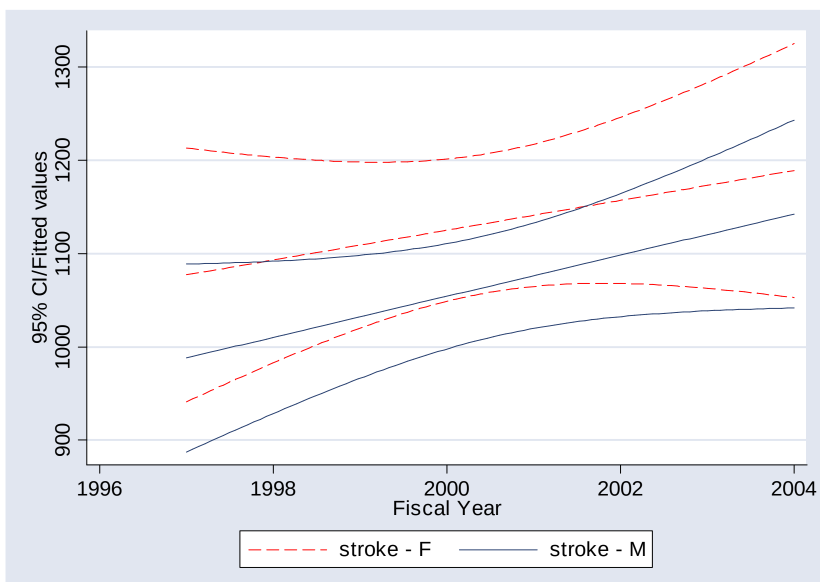


Figure 7.14 Trend of Stroke by Sex in Merged IP-ER, 1997-2004 (2)

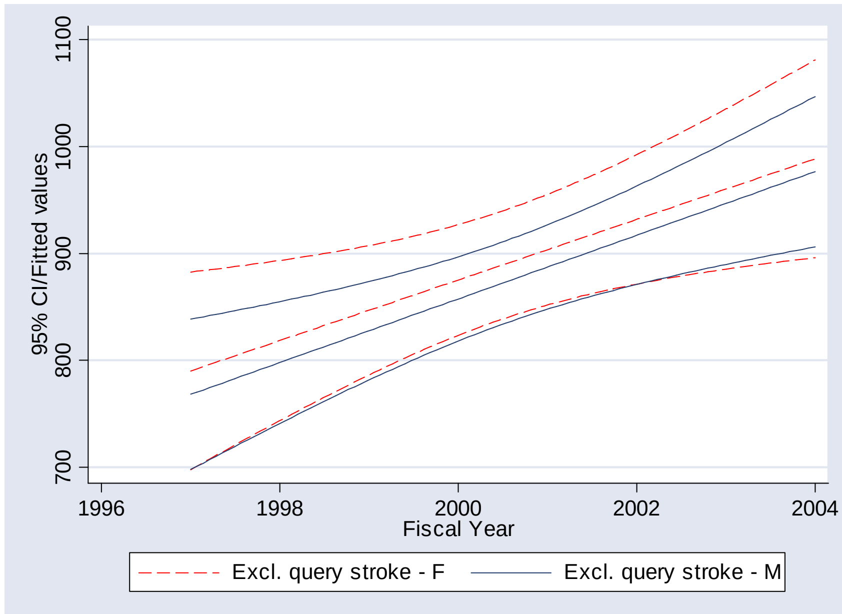


Figure 7.15 Number of Stroke in Merged IP-ER by Sex, 1997-2004

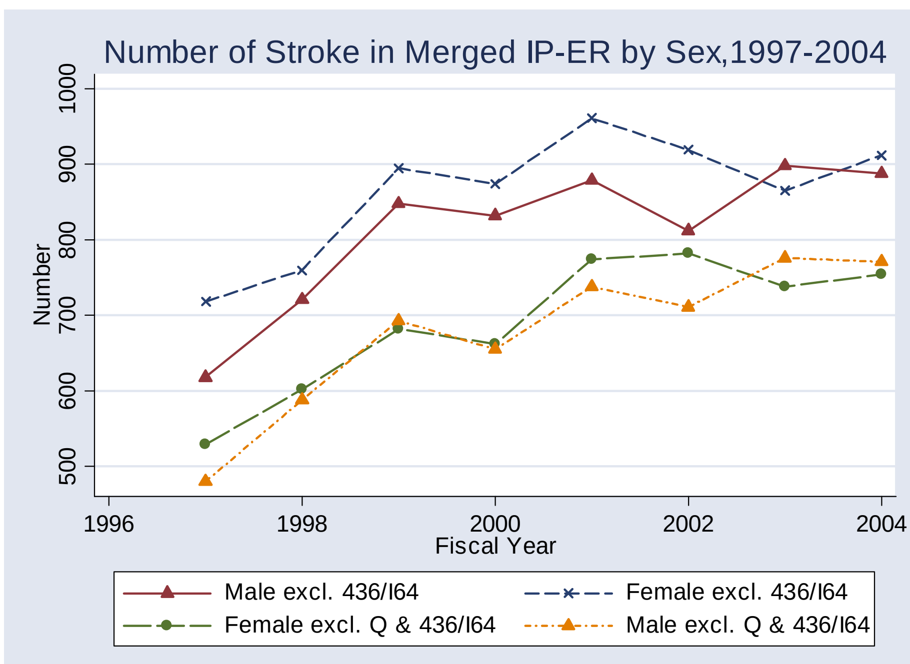
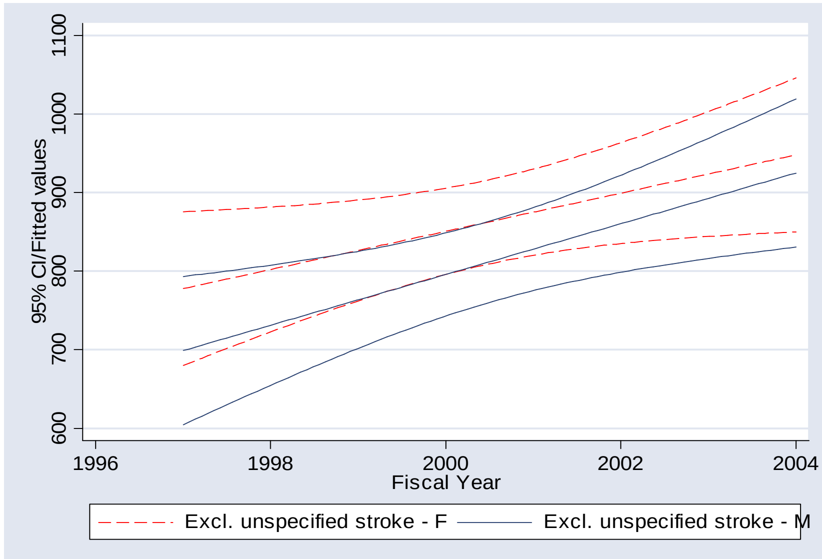


Figure 7.16 Trend of Stroke Exclude Unspecified Stroke in Merged IP-ER by Sex, 1997-2004



7.2.2.3.2 Trends of Stroke Admission by Stroke Type

Table 7.6& 7.7 show the detailed number of stroke admission by stroke type and sex in merged IP-ER data.

Table 7.6 Number of Stroke Admission by Stroke Type & Sex in Merged IP-ER (1)

Year	AIS_F	AIS_M	TIA_F	TIA_M	ICH_F	ICH_M	SAH_F	SAH_M	AIS Excl.Q-F	AIS Excl.Q-M
1997	512	506	348	278	70	74	62	62	428	432
1998	534	528	335	309	64	76	91	68	449	460
1999	608	577	426	381	79	95	106	75	494	487
2000	602	617	417	342	69	69	102	71	488	522
2001	600	590	433	371	85	92	115	65	510	523
2002	593	562	414	343	83	75	71	46	552	516
2003	553	613	384	385	75	91	80	44	492	546
2004	554	603	418	362	78	82	104	70	482	541

Note: Excl. Q = Exclude query diagnoses; F = Female; M = Male

Table 7.7 Number of Stroke by Stroke Type & Sex in Merged IP-ER (2)

Year	AIS Excl. Q & I64-F	AIS Excl. Q & I64-M	AIS Excl. I64 - F	AIS Excl. I64 - M	TIA Excl. Q - F	TIA Excl. Q - M	ICH Excl. Q - F	ICH Excl. Q - M	SAH Excl. Q - F	SAH Excl. Q - M
1997	229	199	238	204	190	173	67	65	43	43
1998	257	257	270	268	223	212	62	75	60	44
1999	268	277	284	297	276	282	73	93	65	41
2000	270	324	286	350	264	225	63	68	65	38
2001	316	335	328	351	300	272	80	88	78	43
2002	346	337	351	348	292	264	83	74	61	36
2003	317	367	326	378	285	289	74	90	62	30
2004	300	364	312	374	299	274	77	80	78	53

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query & unspecified stroke; F = Female; M = Male

——The overall increasing trend of AIS in men is significantly more obvious ($p=0.03$) than in women ($p=0.5$) as shown in Figure 7.17 & 7.18. The number of TIAs in women was higher than in men over time but with a stable trend ($p=0.14$), compared to a significant increasing trend in men ($p=0.05$) (Figure 7.19). With query diagnoses excluded, the trend of AIS in women changed with the peak admission shown in 2002 instead of in 1999. (Figure 7.20) The overall numbers of TIAs in men and women were very close with a rising trend over time ($p < 0.03$) when query diagnoses excluded.

Figure 7.21 to 7.23 illustrated the sharp increasing trends (all of $p < 0.02$) in AIS for men and women when unspecified stroke or both query and unspecified stroke were excluded.

Figure 7.17 Number of Ischemic Stroke in Merged IP-ER by Sex, 1997-2004

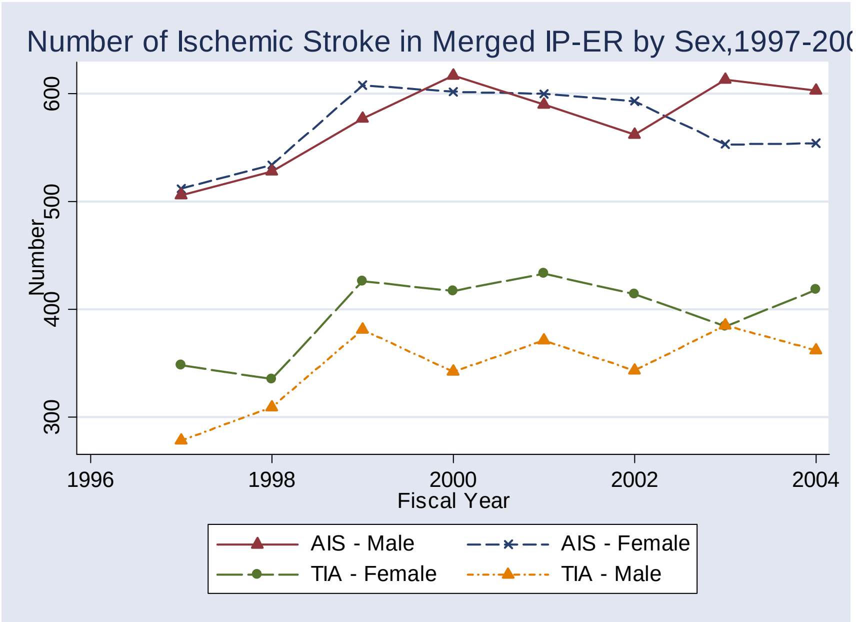


Figure 7.18 Trend of AIS in Merged IP-ER by Sex, 1997-2004

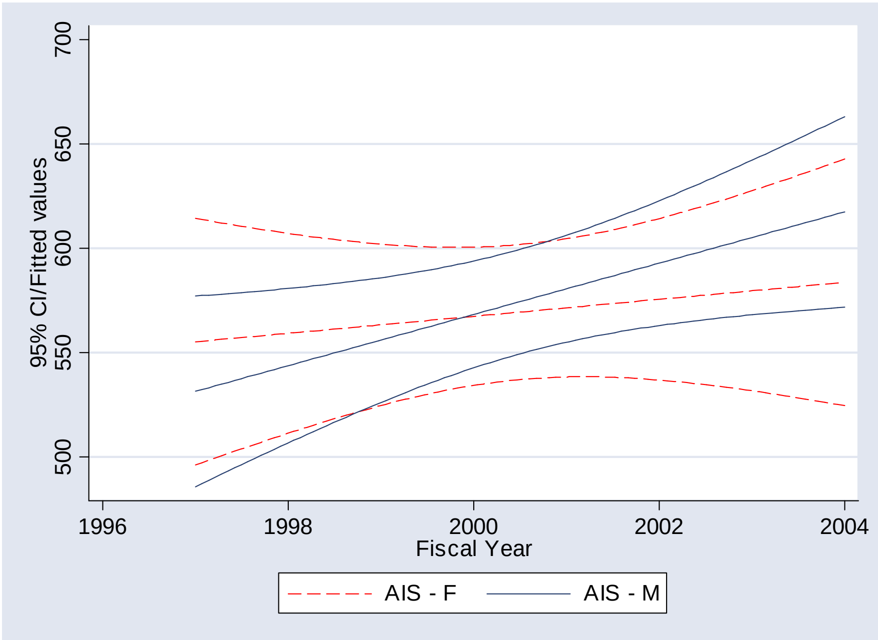


Figure 7.19 Trend of TIA in Merged IP-ER by Sex, 1997-2004

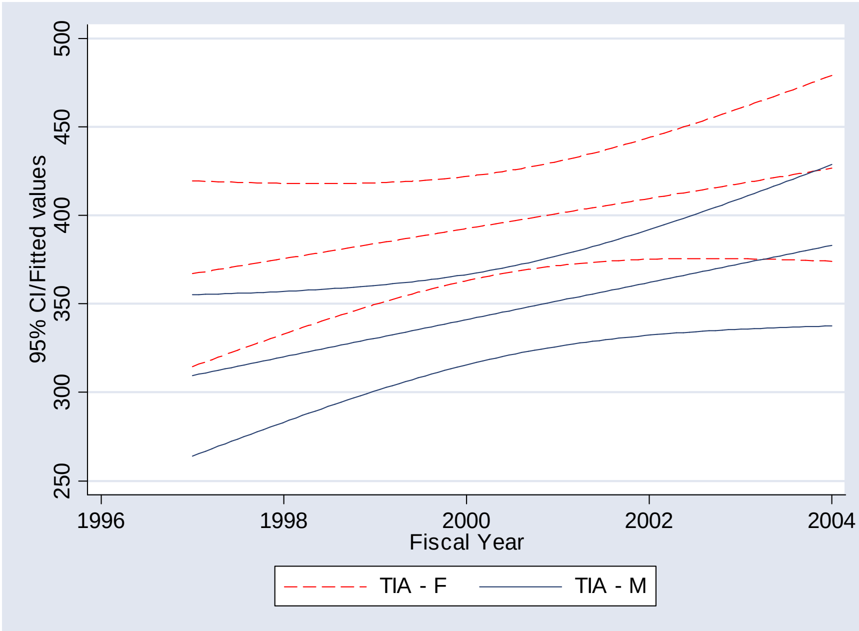
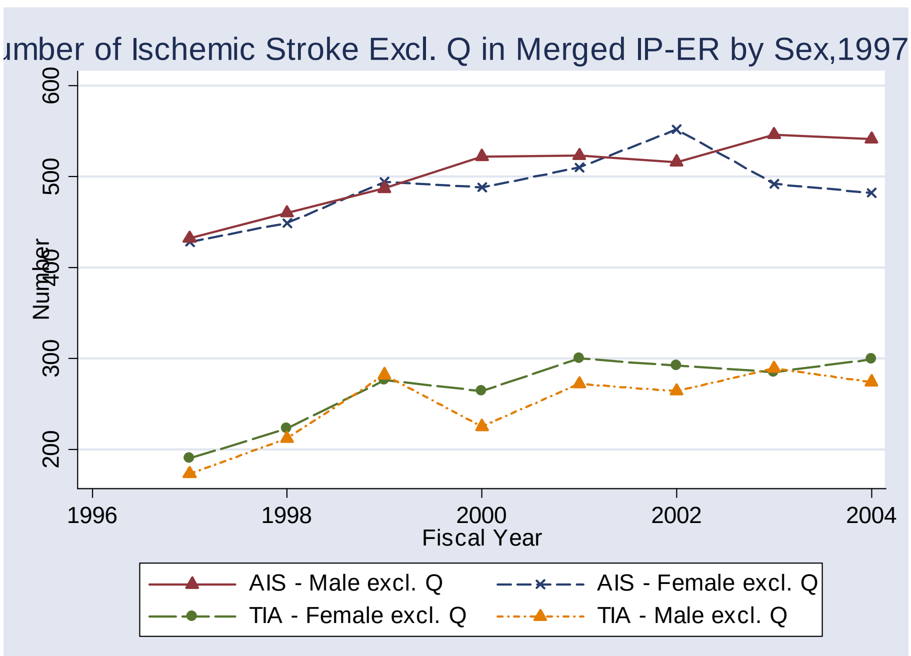
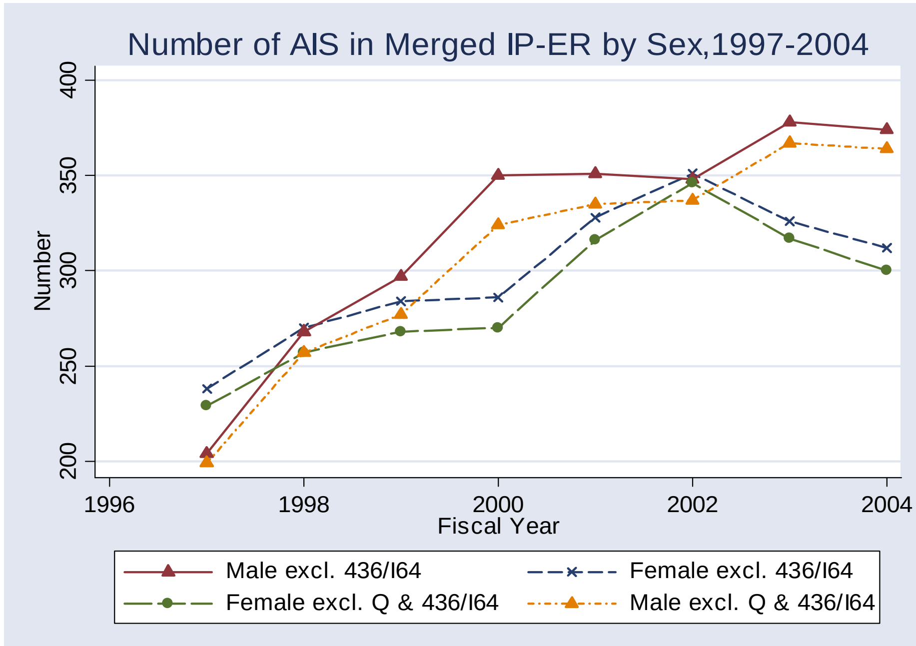


Figure 7.20 Number of Ischemic Stroke Exclude Query diagnoses in Merged IP-ER by Sex, 1997-2004



Note: Q = query diagnoses

Figure 7.21 Number of AIS in Merged IP-ER Exclude Unspecified Stroke by Sex, 1997-2004



Note: excl.436/I64 = exclude unspecified stroke

Figure 7.22 Trend of AIS Exclude Unspecified Stroke in Merged IP-ER by Sex, 1997-2004

Figure 7.23 Trend of AIS Exclude Query and Unspecified Diagnosis in Merged IP-ER by Sex, 1997-2004

Higher numbers of ICH admissions were found in men than in women over time, though trends of ICH admissions in both sexes were not stable towards a general upward trend (p = 0.05) whether query diagnoses were included or not (Figure 7.24 - 7.27). As expected, the number of SAH was much higher in women than in men with an overall increasing trend (p = 0.05) no matter whether query diagnoses were included or not (Figure 7.24, 7.25, 7.28 & 7.29). However, we observed declining trend of number of SAH in men (p = 0.05) and the trend turn to stable when query diagnosis excluded (p = 0.1) (Figure 7.25 & 7.29).

Figure 7.24 Number of Hemorrhagic Stroke in Merged IP-ER by Sex, 1997-2004

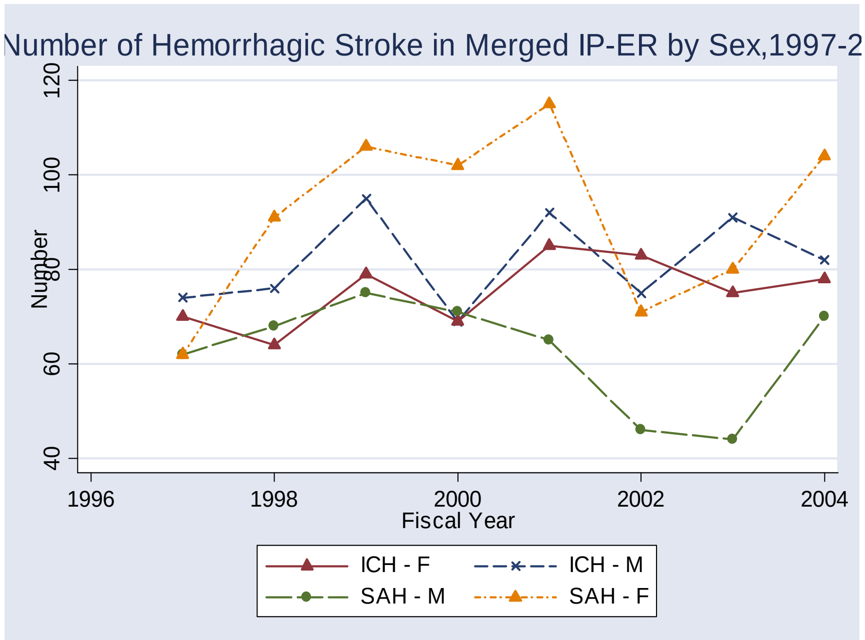


Figure 7.25 Number of Hemorrhagic Stroke in Merged IP-ER Exclude Query diagnoses by Sex, 1997-2004

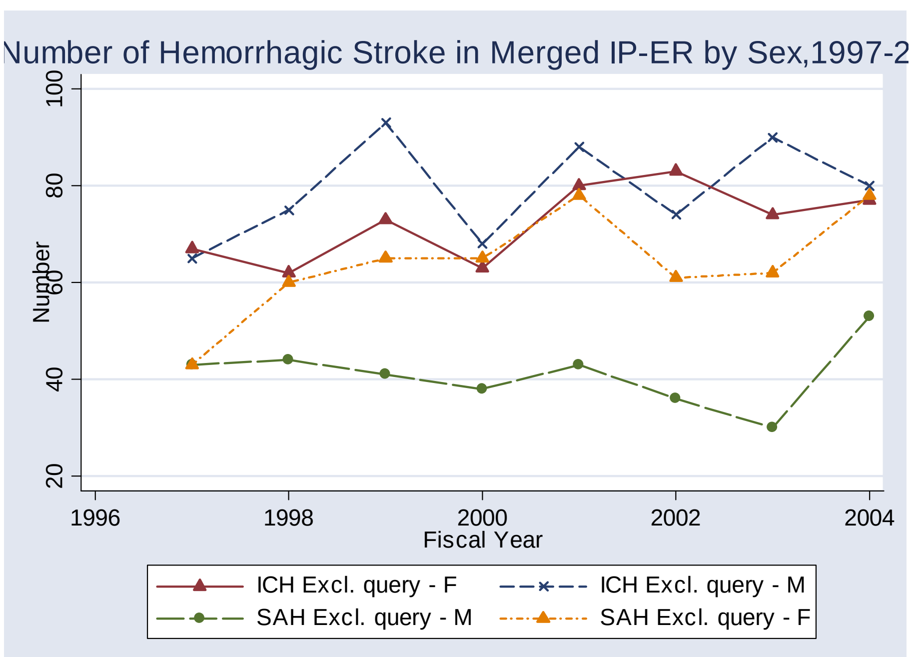


Figure 7.26 Trend of ICH in Merged IP-ER by Sex, 1997-2004

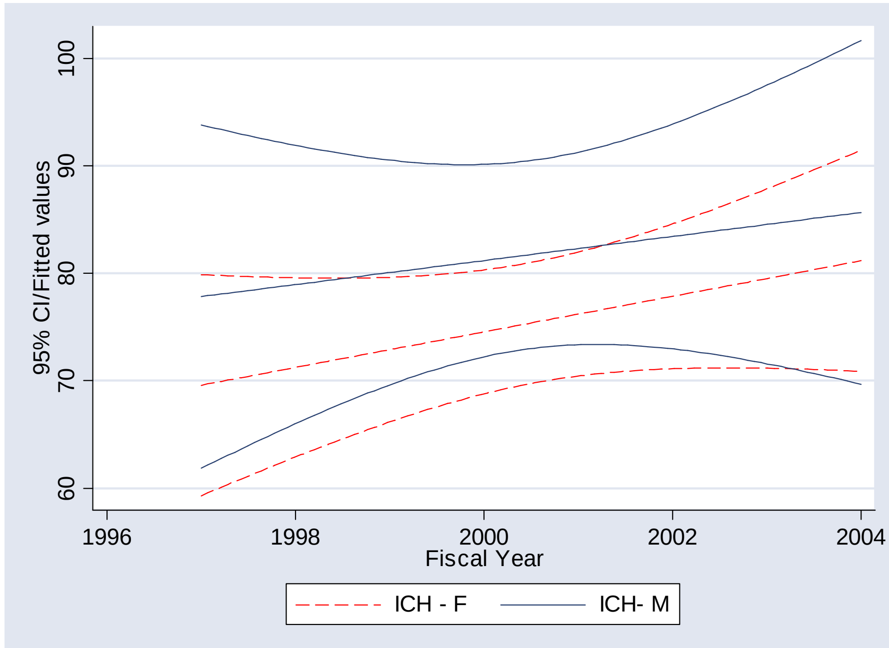


Figure 7.27 Trend of ICH Exclude Query diagnoses in Merged IP-ER by Sex, 1997-2004

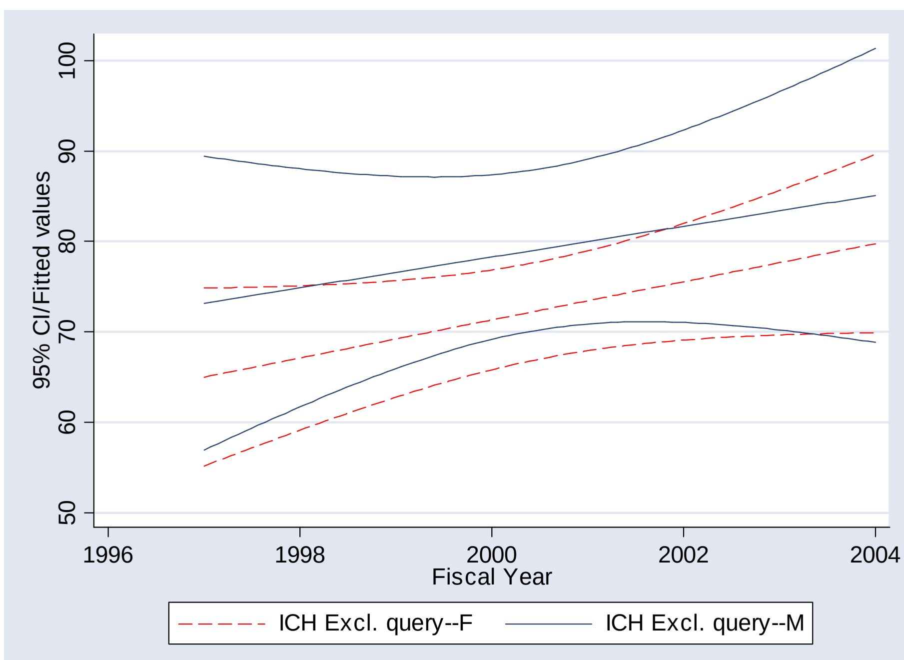


Figure 7.28 Trend of SAH in Merged IP-ER by Sex, 1997-2004

Figure 7.29 Trend of SAH Exclude Query diagnoses in Merged IP-ER by Sex, 1997-2004

7.2.2.3.3 Trends for Query Stroke & Unspecified Stroke in Merged IP-ER Data

We were pleased to observe the overall significant downward trends in number of unspecified stroke (p=0.02), query stroke, query or unspecified stroke, and query with unspecified stroke from 1997 to 2004 (Table 7.8 & Figure 7.30 to 7.32), although they once increased between 1999 and 2000. The proportion of query stroke, unspecified stroke, query / unspecified stroke, and query with unspecified stroke declined from 24.6% to 17%, 30.1% to 20.7%, 47.2% to 32.8%, 7.5% to 4.9% (all of $p < 0.01$) over the eight year period (Table 7.8 & Figure 7.33 – 7.35). This trend appears to correlate with the switch to ICD-10 coding.

Table 7.8 Number & Proportion of Query / Unspecified Stroke in Merged IP-ER

Year	Number of stroke	Query stroke (n, %)	Unspecified stroke (n, %)	Query or unspecified stroke (n, %)	Query with unspecified stroke (n, %)
1997	1912	471 (24.6)	576 (30.1)	903 (47.2)	144 (7.5)
1998	2004	420 (21)	524 (26.1)	815 (40.7)	129 (6.4)
1999	2347	536 (22.8)	604 (25.7)	972 (41.4)	168 (7.2)
2000	2289	556 (24.3)	583 (25.5)	972 (42.5)	167 (7.3)
2001	2351	457 (19.4)	511 (21.7)	839 (35.7)	129 (5.5)
2002	2187	309 (14.1)	456 (20.9)	694 (31.7)	71 (3.2)
2003	2225	357 (16)	462 (20.8)	711 (32)	108 (4.9)
2004	2271	387 (17)	471 (20.7)	746 (32.8)	112 (4.9)

Figure 7.30 Number of Query Stroke & Unspecified Stroke in Merged IP-ER, 1997-2004

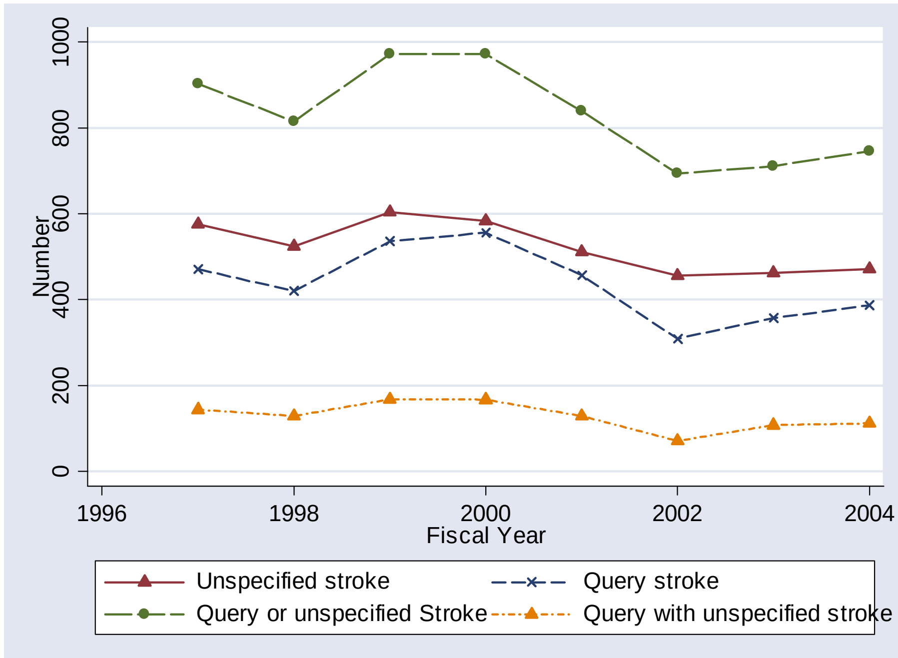


Figure 7.31 Trend of Number of Query Stroke & Unspecified Stroke in Merged IP-ER, 1997-2004 (1)

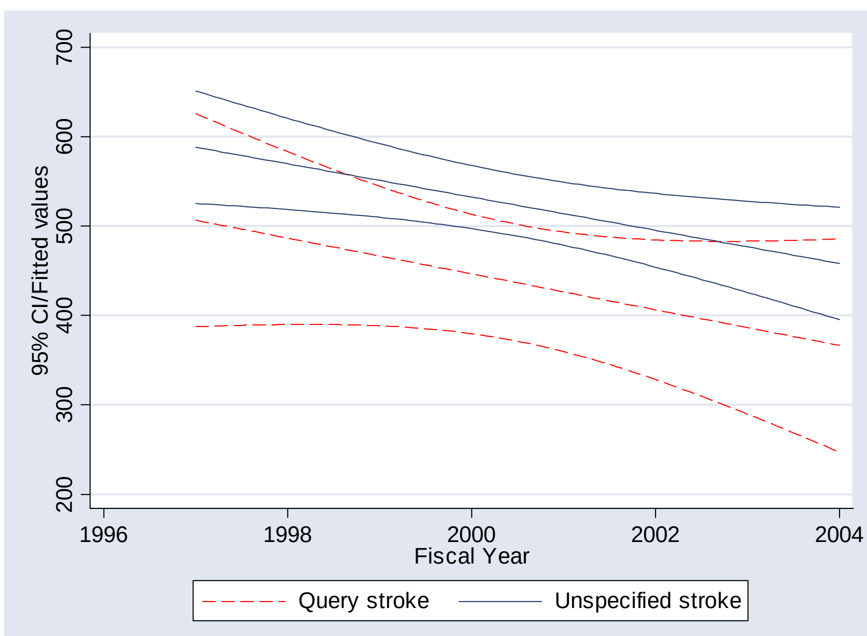


Figure 7.32 Trend of Number of Query Stroke & Unspecified Stroke in Merged IP-ER, 1997-2004 (2)

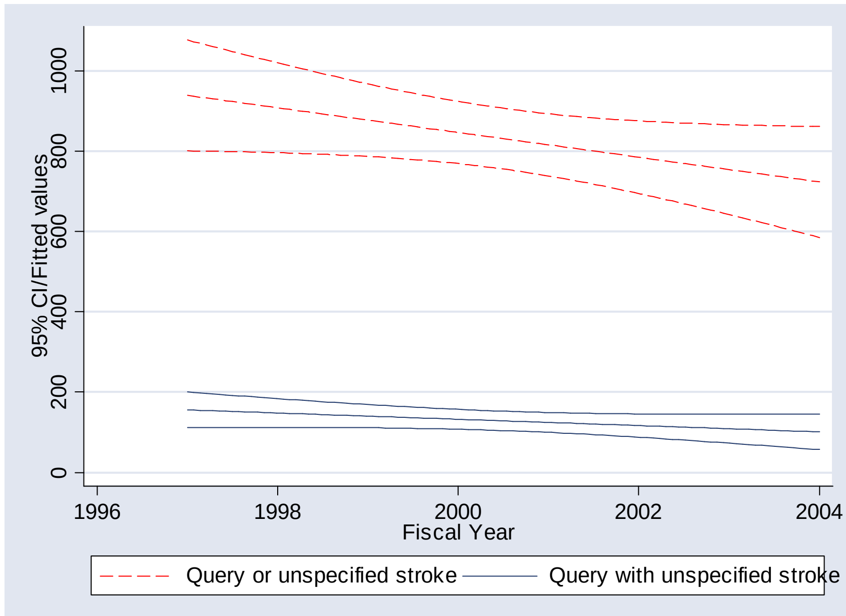


Figure 7.33 Proportion of Query & Unspecified Stroke in Merged IP-ER, 1997-2004

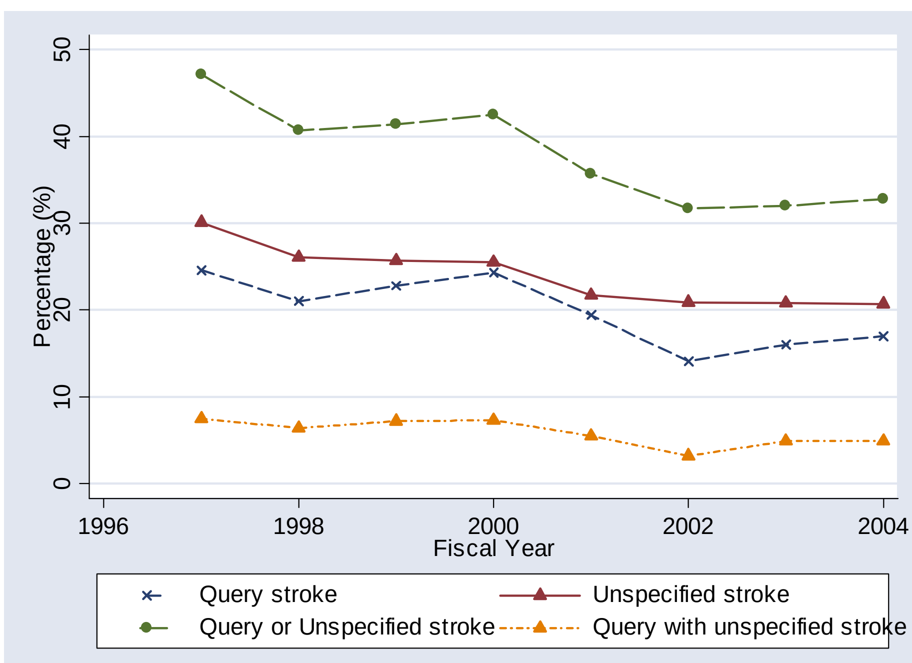


Figure 7.34 Trend of Proportion of Query & Unspecified Stroke in Merged IP-ER, 1997-2004 (1)

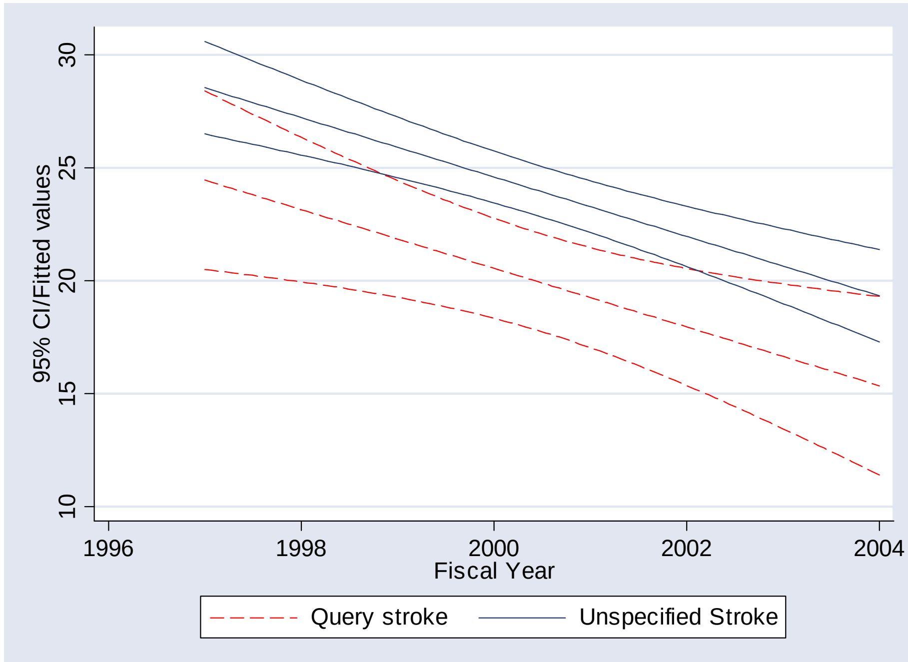
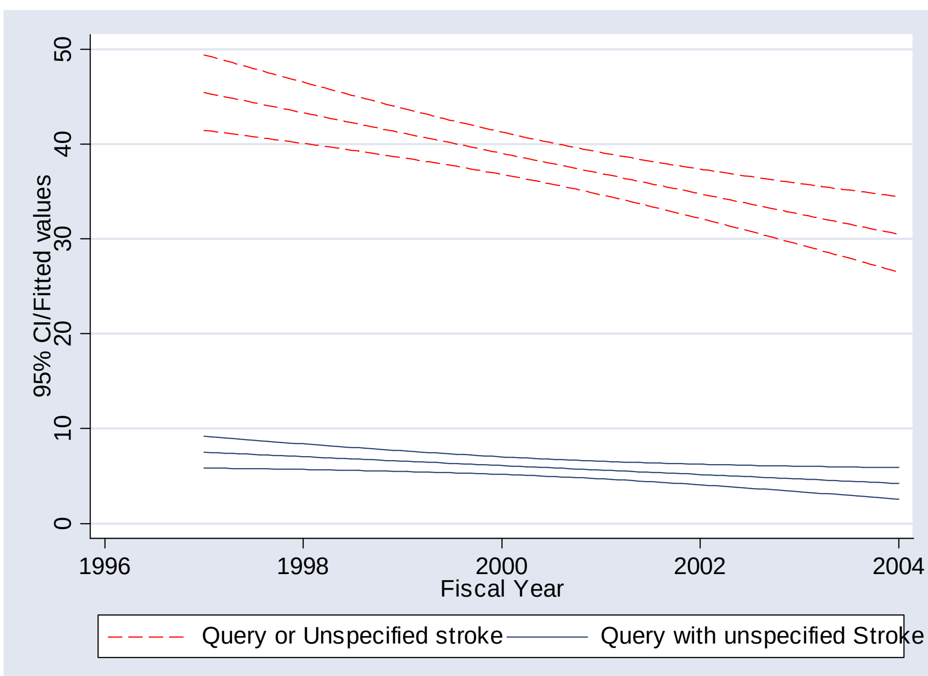


Figure 7.35 Trend of Proportion of Query & Unspecified Stroke in Merged IP-ER, 1997-2004 (2)



7.2.3 Trends of Stroke Occurrence Rate in Merged IP-ER Data

The age-adjusted rates of overall stroke and each stroke type were higher than corresponding crude rates, as shown in Table 7.9, Figure 7.36 & 7.37 (All rates presented here are with the unit of per 100,000 per year). From 1997 to 2004, age-adjusted stroke occurrence rate for overall stroke decreased significantly (p=0.02) (Figure 7.37 & 7.38), although the number of stroke occurrence increased over time (see section 7.2.2.1). However, the trends of age-adjusted stroke appeared to be stable with query stroke, or unspecified stroke excluded (all of p > 0.5) (Figure 7.37 – 7.39). Over the eight years, crude stroke occurrence rates have remained stable as shown in Figure 7.36 & 7.40, and had no obvious change when query or unspecified stroke were excluded (Figure 7.41). However, crude rates increased significantly when both query and unspecified stroke were excluded (p = 0.04). We have shown above that this is due to falling use of the query stroke and unspecified and rising use of more specific stroke codes with counterbalancing effect.

Table 7.9 Crude vs. Age-adjusted Stroke Occurrence Rate in Merged IP-ER

Year	C_stroke	A_stroke	C_stroke Excl. Q	A_stroke Excl. Q	C_stroke Excl. I64	A_stroke Excl. I64	C_stroke Excl. Q & I64	A_stroke Excl. Q & I64
1997	187.19	243.69	141.08	184.95	130.8	169.23	98.78	128.8
1998	190.05	246.39	150.31	196.67	140.35	180.38	112.85	146.35
1999	217.61	277.29	167.91	216.56	161.61	204.44	127.49	163.51
2000	207.29	258.09	156.94	197.85	154.5	191.46	119.27	149.85
2001	207.41	253.79	167.1	206.01	162.33	197.56	133.39	163.54
2002	188.68	226.99	162.02	195.96	149.34	179.56	128.81	155.68
2003	188.19	222.4	158	187.92	149.11	175.88	128.05	151.92
2004	188.96	217.9	156.76	182.03	149.77	172.99	126.89	147.41

Note: C = Crude rate; A = Age-adjusted rate; Excl. Q = Exclude Query diagnoses; Excl. I64 = Exclude unspecified stroke; Excl. Q & I64 = Exclude query & unspecified stroke

Figure 7.36 Crude Stroke Occurrence Rate, 1997-2004

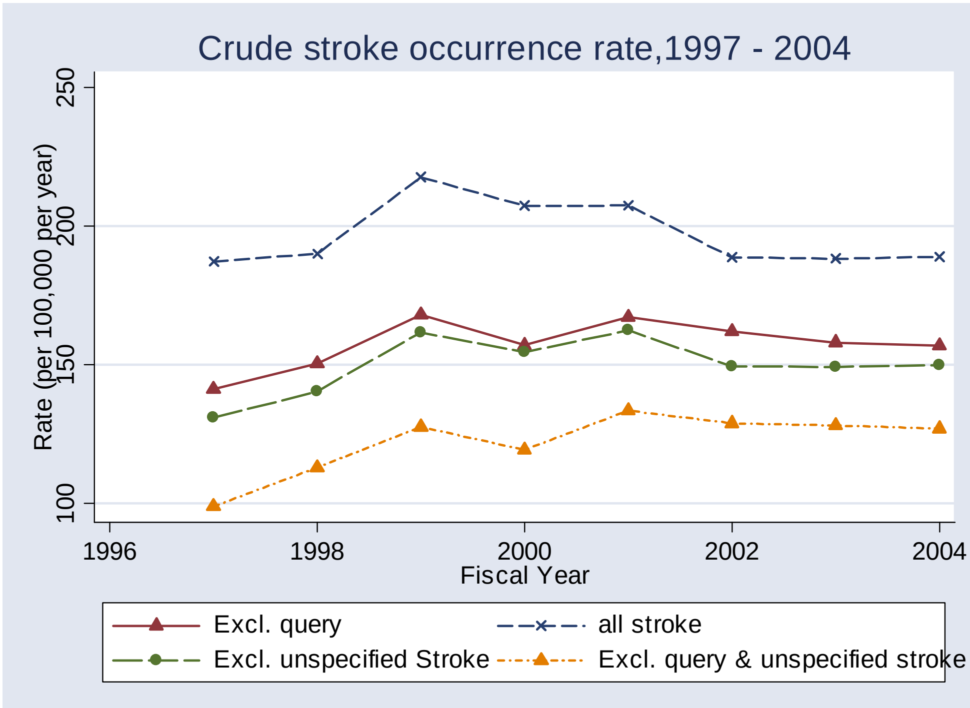


Figure 7.37 Age-adjusted Stroke Occurrence Rate, 1997-2004

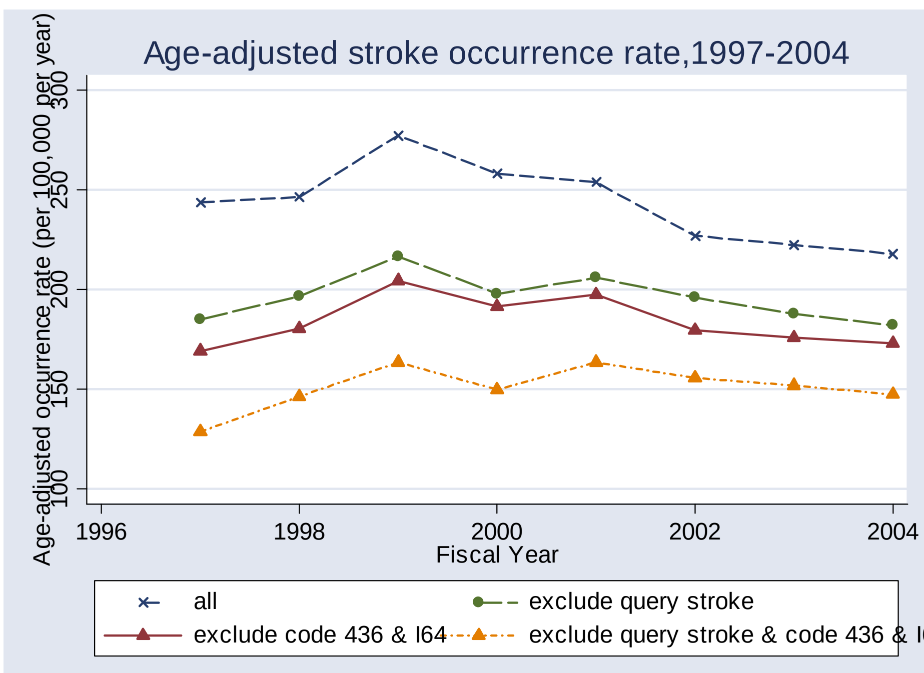


Figure 7.38 Trend of Age-adjusted Stroke Occurrence Rate in Merged IP-ER, 1997-2004 (1)

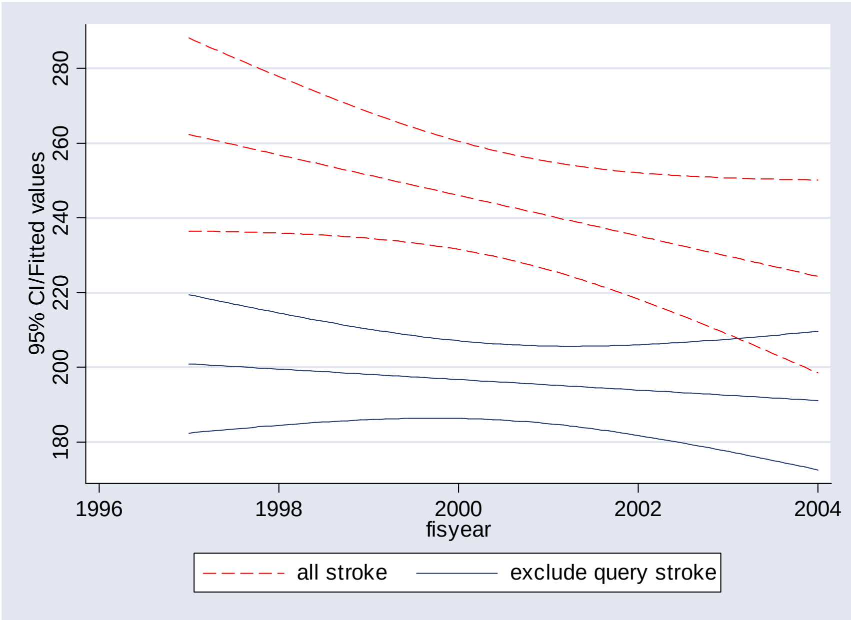


Figure 7.39 Trend of Age-adjusted Stroke Occurrence Rate in Merged IP-ER, 1997-2004 (2)

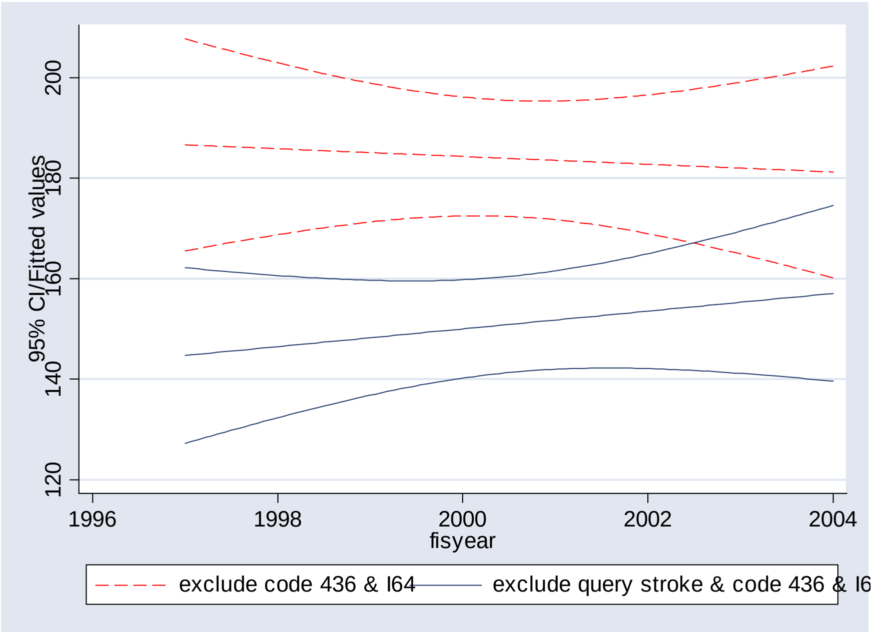


Figure 7.40 Trend of Crude Stroke Occurrence Rate in Merged IP-ER, 1997-2004 (1)

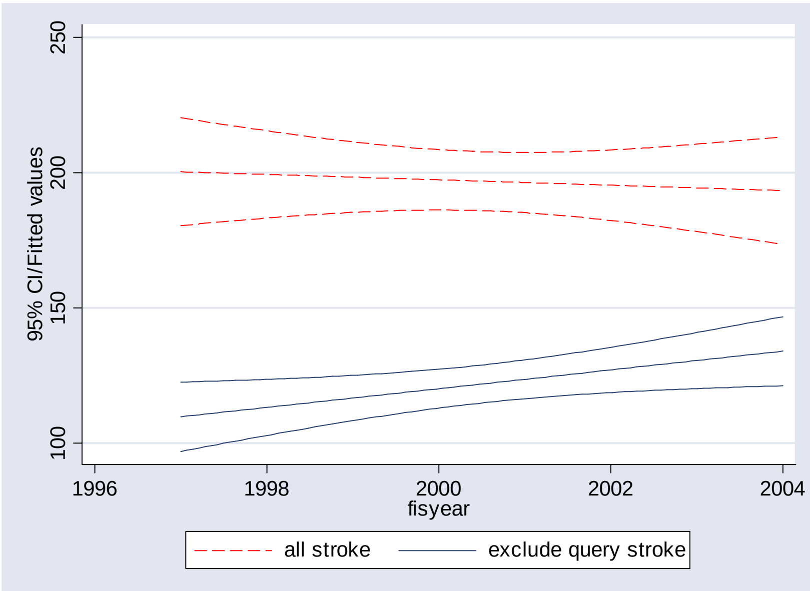
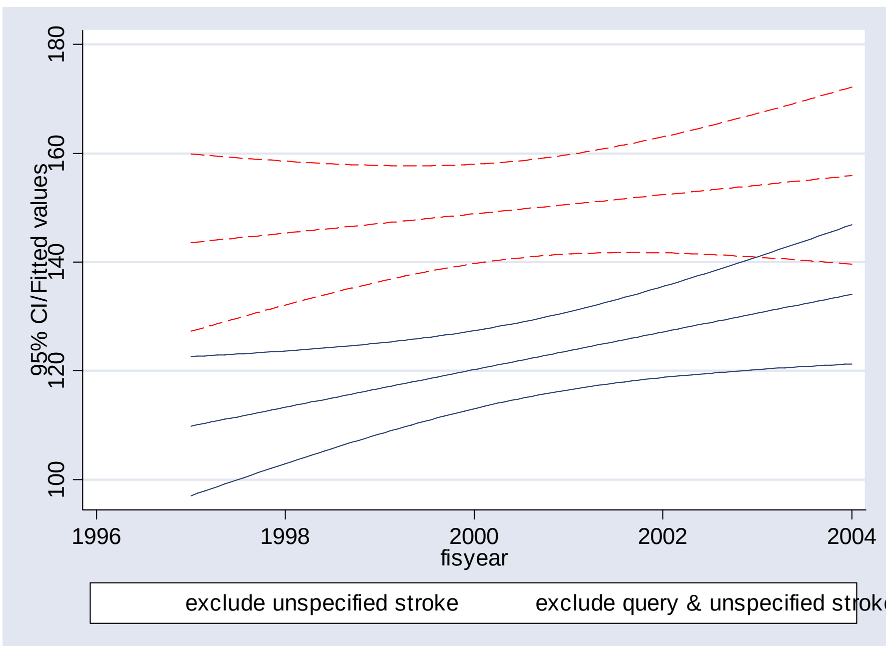


Figure 7.41 Trend of Crude Stroke Occurrence Rate in Merged IP-ER, 1997-2004 (2)



It seems that age-adjusted AIS occurrence rate decreased over time (p = 0.05), while crude AIS rate was steady. Crude and age-adjusted rates of TIA, ICH and SAH occurrence remained stable with no significant change over time (p > 0.5) whether query or unspecified stroke were excluded (Figure 7.42 to 7.43).

Figure 7.42 Trend of Age-adjusted Stroke Occurrence Rate by Type in Merged IP-ER, 1997-2004

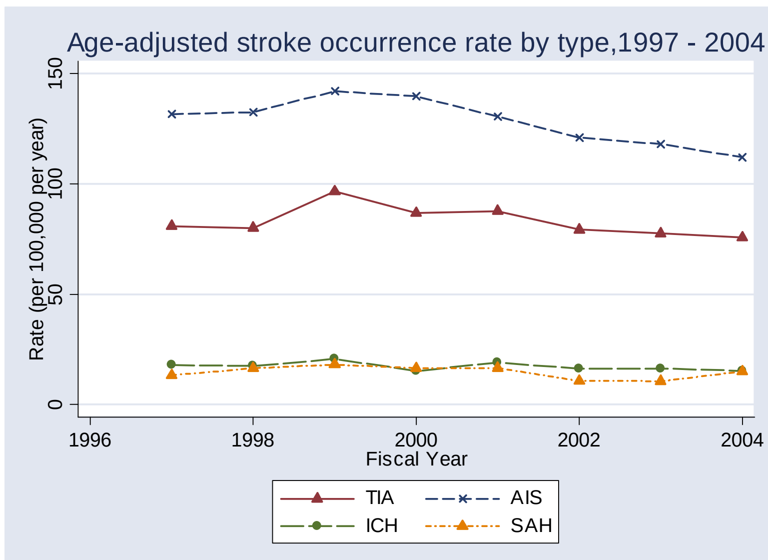
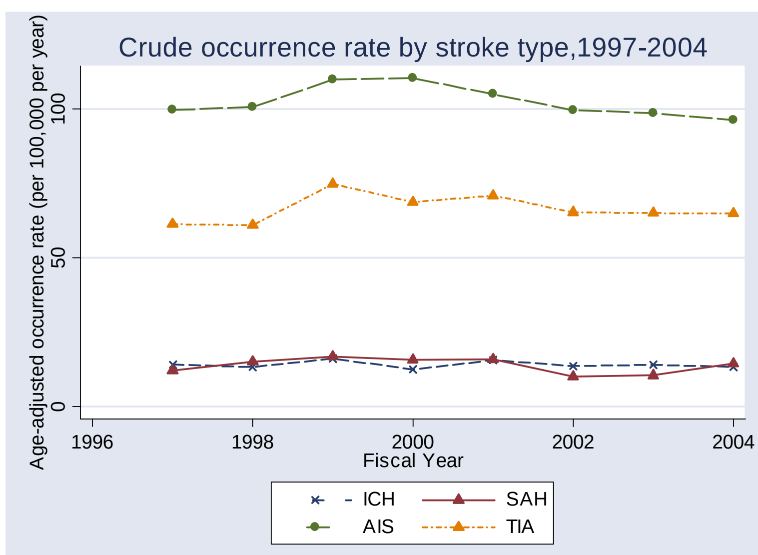


Figure 7.43 Trend of Crude Stroke Occurrence Rate by Type in Merged IP-ER, 1997-2004



7.2.3.1 Trend of Age-adjusted Stroke Occurrence Rate in Merged IP-ER by Stroke Type in Different Strata

Although we observed significant downward trend of age-adjusted AIS occurrence rate, the declining trend was not seen when query diagnoses (p = 0.3) or both of query and unspecified stroke were excluded (p>0.4) (Figure 7.44 – 7.46).

Figure 7.44 Trend of Age-adjusted AIS Occurrence Rate in Merged IP-ER by Strata, 1997-2004

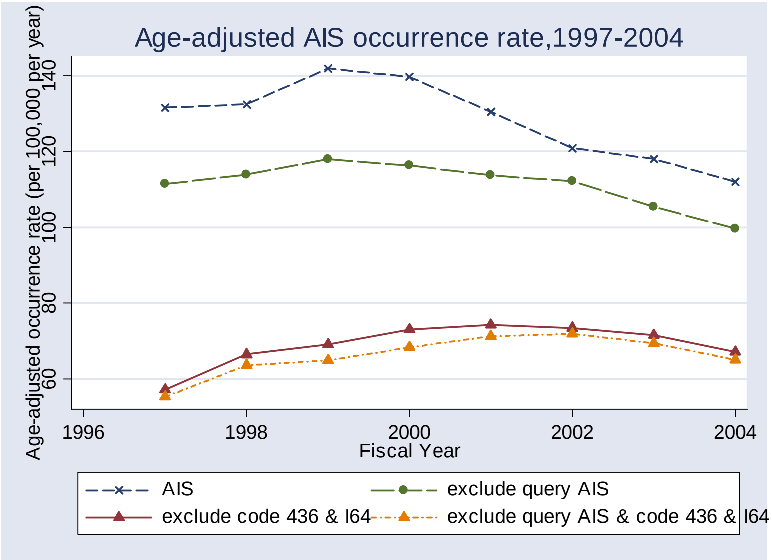


Figure 7.45 Trend of Age-adjusted AIS Occurrence Rate in Merged IP-ER, 1997-2004 (1)

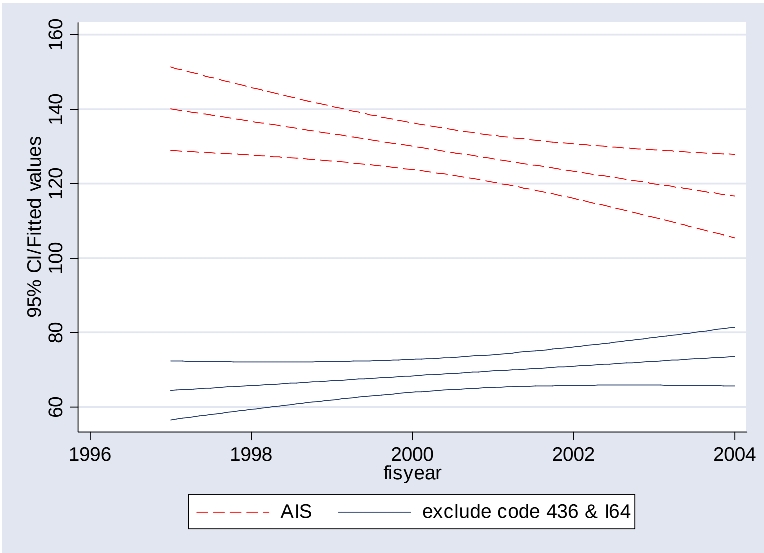
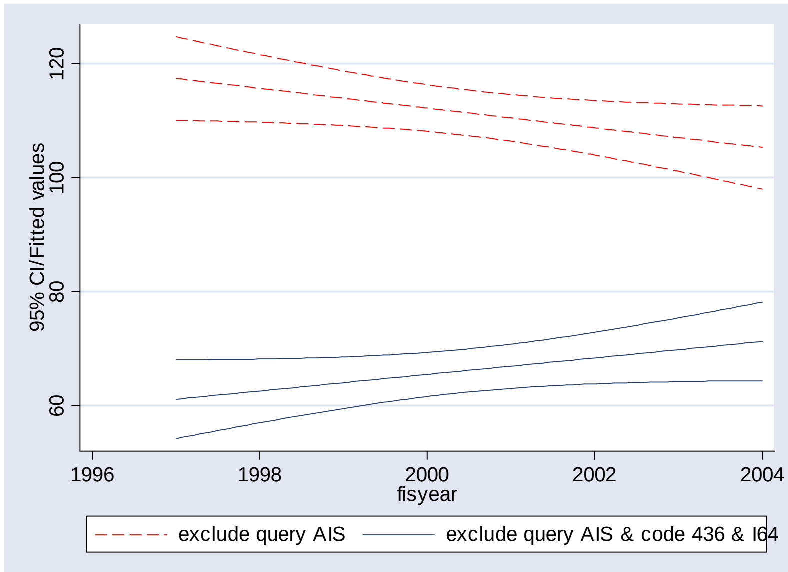


Figure 7.46 Trend of Age-adjusted AIS Occurrence Rate in Merged IP-ER, 1997-2004 (2)



7.2.3.2 Trends of Age-gender Adjusted Stroke Occurrence Rate in Merged IP-ER by Stroke Type in Different Strata

Table 7.10 to 7.12 demonstrate detailed age-gender adjusted stroke occurrence rates in merged IP-ER. We noticed higher age-gender adjusted stroke occurrence rates in women than in men whether query diagnoses were included or not. Age-gender adjusted stroke occurrence rates presented significant declining trends ($p < 0.03$) in both sexes, yet turned to steady when query diagnoses excluded (see Figure 7.47 – 7.49).

Table 7.10 Age-gender Adjusted Stroke Occurrence Rate in Merged IP-ER

Year	Stroke		AIS		TIA		ICH		SAH	
	F	M	F	M	F	M	F	M	F	M
1997	263.14	224.38	137.02	125.85	93.67	68.48	18.62	17.29	13.83	12.77
1998	261.87	230.66	138.89	125.66	86.37	73.75	16.93	17.79	19.68	13.46
1999	300.7	253.96	152.64	131.13	106.32	86.91	19.49	21.66	22.25	14.26
2000	281.18	235.07	145.03	133.68	99.79	74.16	15.94	14.4	20.43	12.83
2001	278.81	228.88	138.19	122.22	98.94	76.68	19.58	18.54	22.1	11.44
2002	254.75	199.98	131.93	109.95	91.36	67.51	17.88	14.53	13.57	7.99
2003	229.9	213.22	118.31	116.48	81.55	72.92	15.57	16.8	14.47	7.01
2004	234.71	200.83	113.82	109.26	85.91	65.73	15.85	14.6	19.13	11.23

Table 7.11 Age-gender Adjusted Stroke Occurrence Rate in Different Strata in Merged IP-ER (1)

Fiscal Year	Stroke Excl. I64		Stroke Excl. Q		Stroke Excl. Q & I64		AIS Excl. I64		AIS Excl. Q & I64	
	F	M	F	M	F	M	F	M	F	M
1997	189.8	149.26	194.04	175.59	140.47	117.33	63.68	50.72	61.22	49.45
1998	192.92	167.82	205.66	187.17	154.68	137.79	69.94	62.82	66.78	60.25
1999	218.89	189.87	226.44	206.02	168.74	157.64	70.84	67.04	66.9	62.59
2000	205.54	177.17	211.05	184.23	158.05	141.19	69.39	75.78	65.61	70.22
2001	216.21	178.98	220.86	190.65	175.51	151.22	75.59	72.32	72.77	69.18
2002	201.11	158.5	217.77	174.54	171.84	139.67	78.29	68.47	77.2	66.51
2003	181.67	168.72	193.54	180.77	155.95	146.59	70.08	71.98	68.01	69.87
2004	186	159.73	191.57	171.65	154.53	139.52	65.12	68.16	62.57	66.47

Note: Excl. I64 = Exclude unspecified stroke; Excl. Q = Exclude query diagnoses;

Excl. Q & I64 = Exclude query & unspecified stroke

Table 7.12 Age-gender Adjusted Stroke Occurrence Rate in Different Strata (2)

Fiscal Year	AIS Excl. Q		TIA Excl. Q		ICH Excl. Q		SAH Excl. Q	
	F	M	F	M	F	M	F	M
1997	114.79	107.72	51.5	43.13	17.97	15.47	9.78	9.27
1998	117.76	109.63	57.93	50.89	16.51	17.61	13.46	9.03
1999	124.6	110.97	69.3	65.18	18.07	21.27	14.47	8.59
2000	118.62	113.26	63.88	49.49	14.78	14.22	13.77	7.26
2001	118.12	108.62	68.62	56.43	18.43	17.77	15.68	7.83
2002	123.14	101.38	64.81	52.46	17.88	14.31	11.94	6.39
2003	105.6	104.05	61.17	55.21	15.42	16.64	11.34	4.86
2004	99.61	98.61	61.8	50.12	15.61	14.31	14.55	8.62

Note: Excl. Q = Exclude query diagnoses

Figure 7.47 Age-gender Adjusted Occurrence Rate for Stroke in Merged IP-ER, 1997-2004

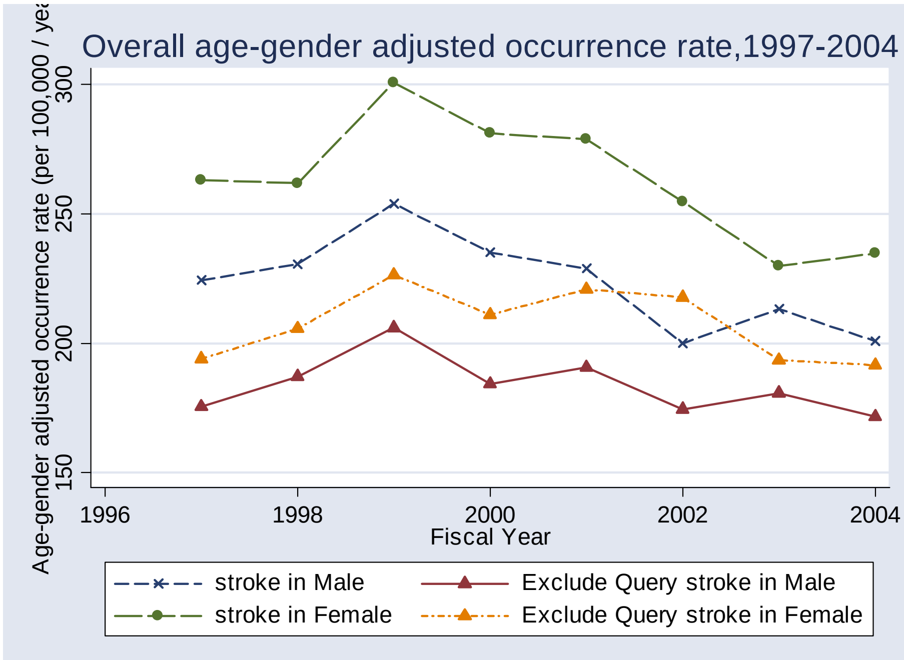


Figure 7.48 Trend of Age-gender Adjusted Occurrence Rate for Stroke in Merged IP-ER, 1997-2004

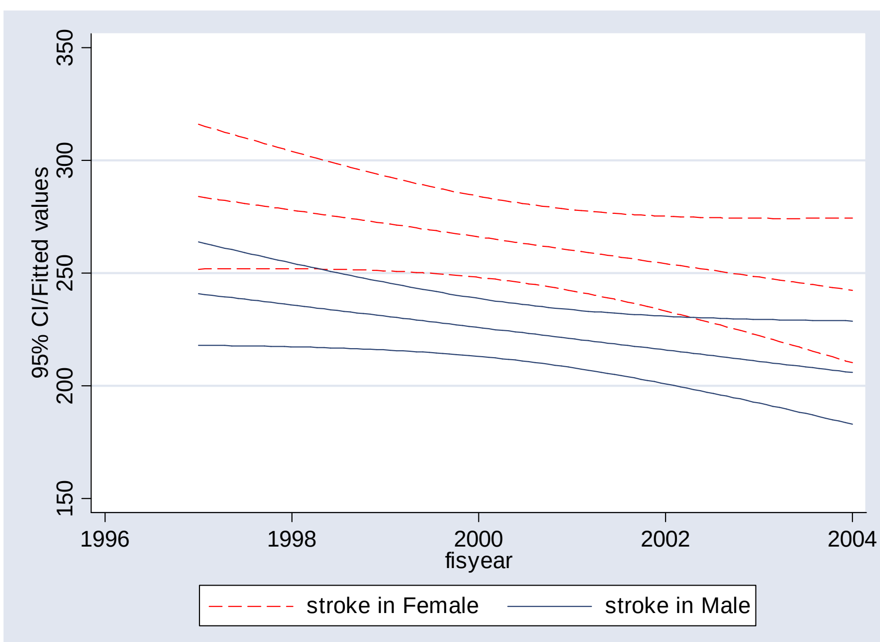
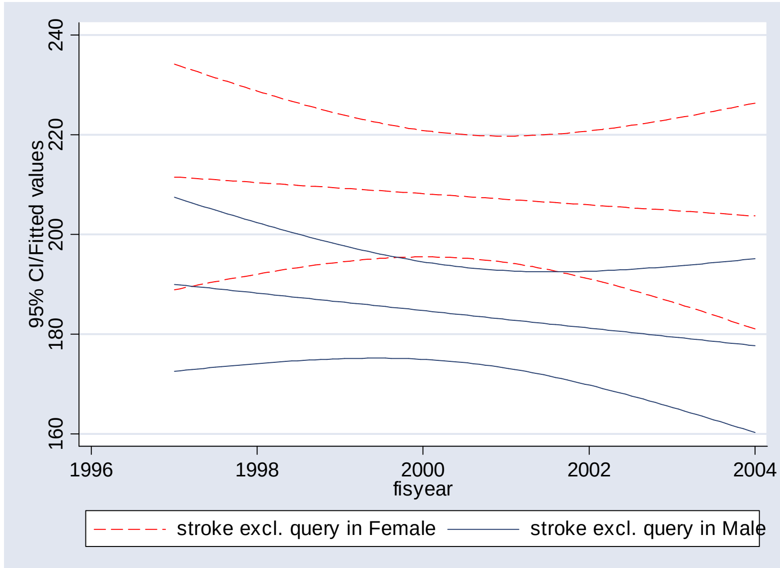


Figure 7.49 Trend of Age-gender Adjusted Occurrence Rate for Stroke Exclude Query diagnoses in Merged IP-ER, 1997-2004



Age-gender adjusted AIS occurrence rates are higher in women than in men, with significant downward trends over time in women (p = 0.03), yet not significant in men (p > 0.1) (Figure 7.50 - 7.54). All age-adjusted rates for AIS turned to stable when query or unspecified stroke were eliminated.

Figure 7.50 Age-gender Adjusted Occurrence Rate for AIS, 1997-2004

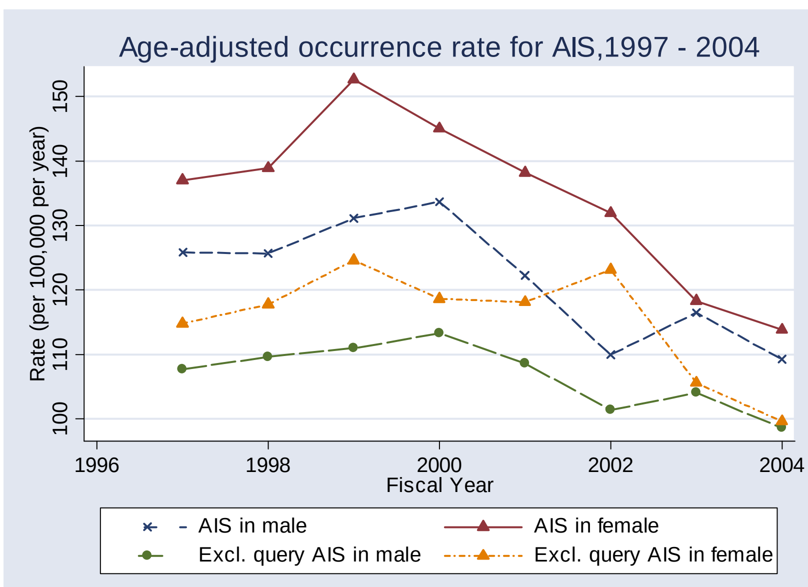


Figure 7.51 Trend of Age-gender Adjusted Occurrence Rate for AIS in Women, 1997-2004

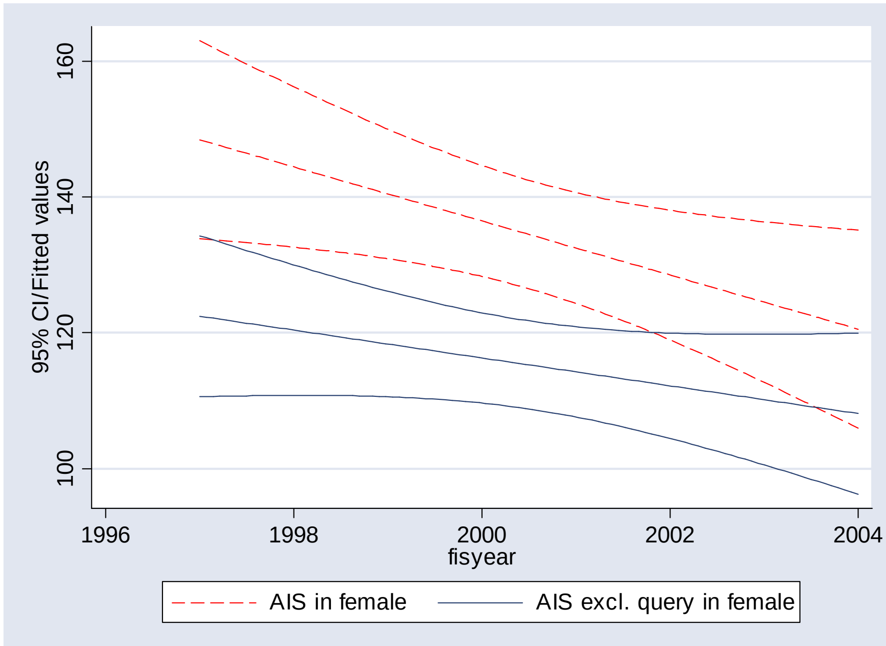


Figure 7.52 Trend of Age-gender Adjusted Occurrence Rate for AIS in Men, 1997-2004

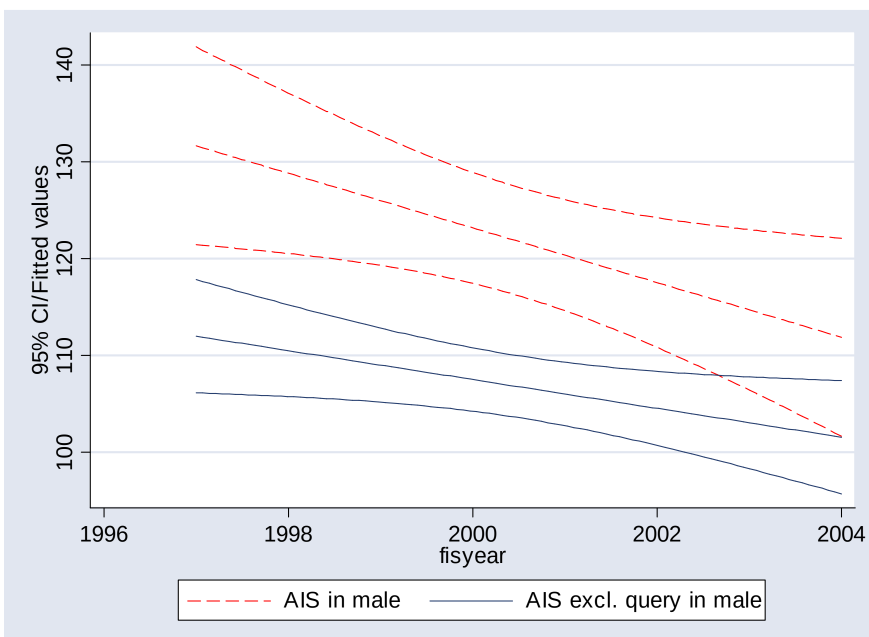


Figure 7.53 Age-gender Adjusted Occurrence Rate for AIS in Different Strata, 1997-2004 (1)

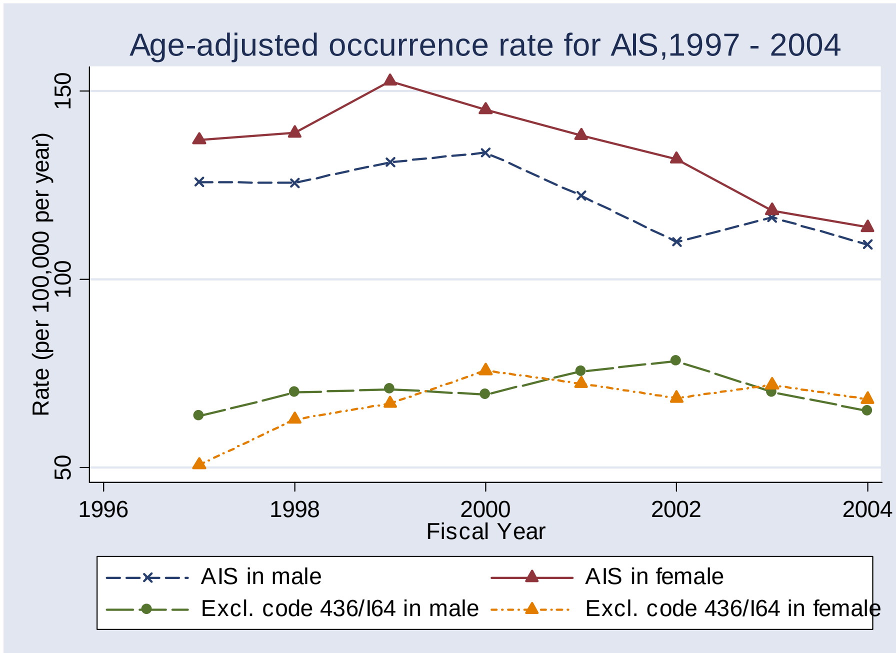


Figure 7.54 Age-gender Adjusted Occurrence Rate for AIS in Different Strata, 1997-2004 (2)

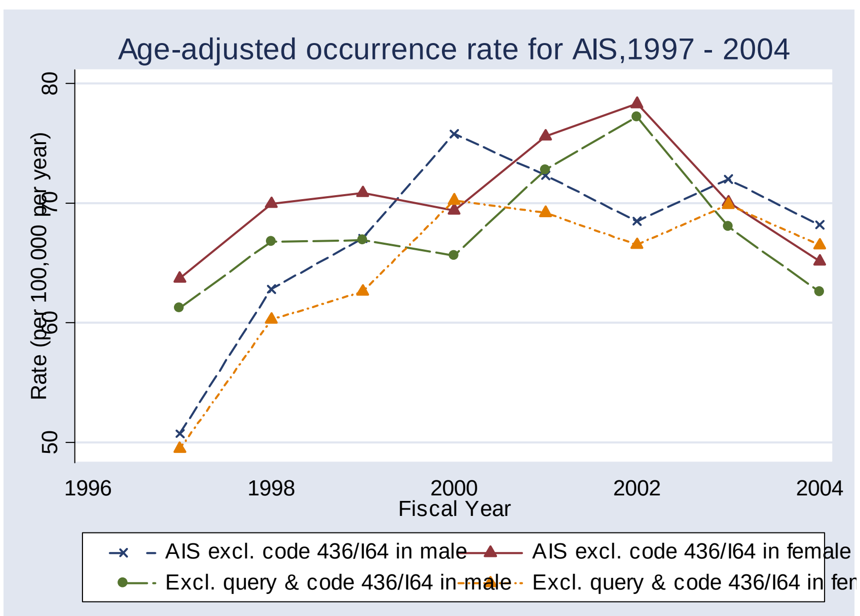
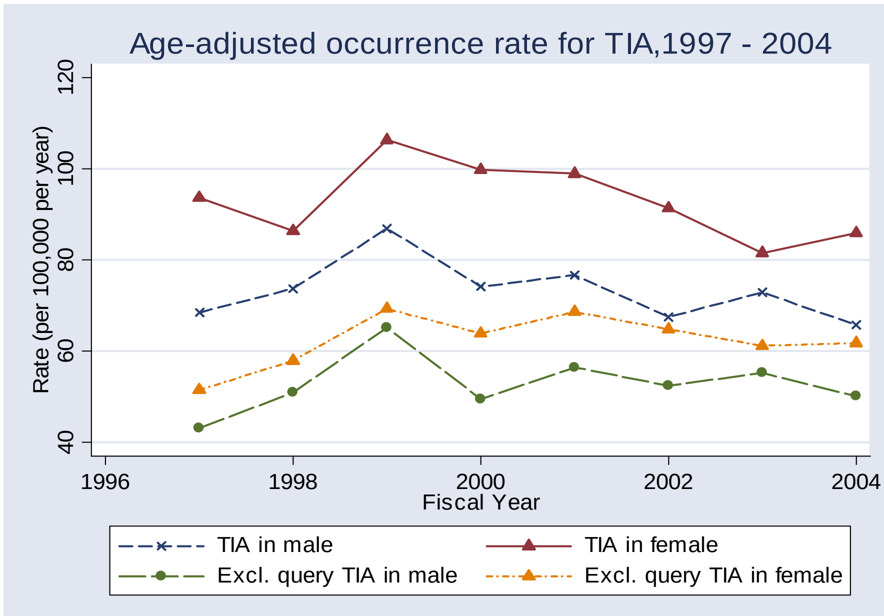


Figure 7.55 indicates that age-gender adjusted TIA occurrence rates were higher in women than in men with a stable trend (p >0.35) whether query diagnoses was included or not.

Figure 7.55 Age-gender Adjusted Occurrence Rate for TIA, 1997-2004



Age-gender adjusted ICH occurrence rates were similar for men and women with a stable trend (p > 0.5) whether query diagnoses were excluded or not (Figure 7.56). Age-gender adjusted SAH occurrence rates were higher in women than in man, with flat patterns in both sexes over time (Figure 7.57).

Figure 7.56 Age-gender Adjusted Occurrence Rate for ICH in Different Strata, 1997-2004

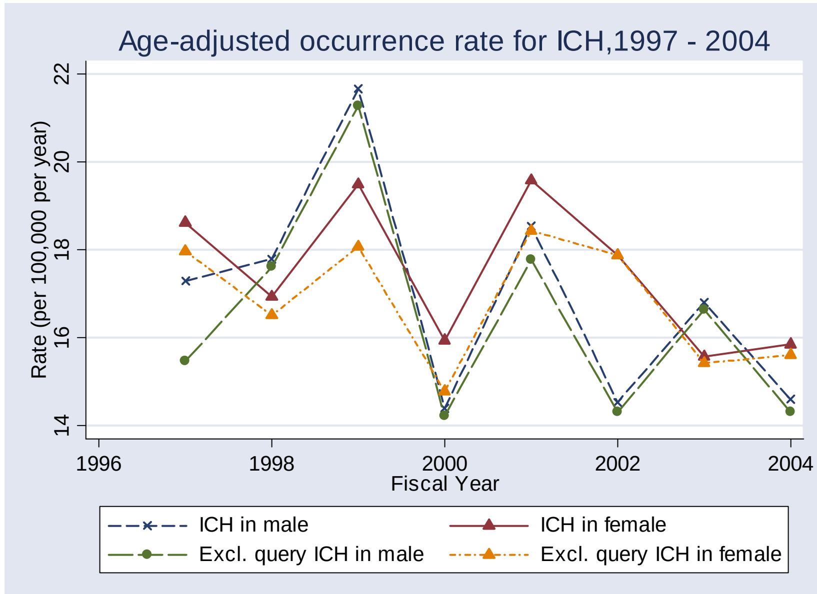
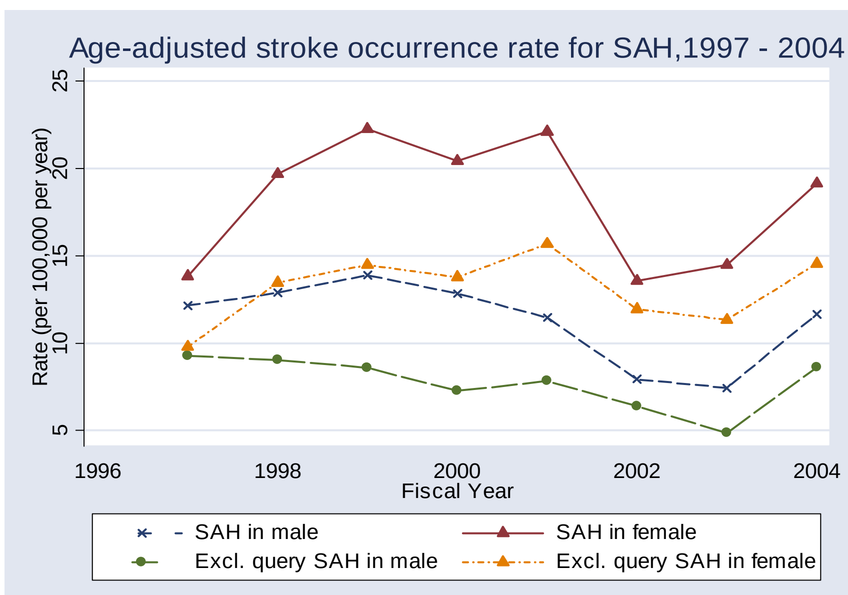


Figure 7.57 Trend of Age-gender Adjusted Occurrence Rate for SAH, 1997-2004



CHAPTER EIGHT: RESULTS FOR TRENDS OF STROKE IN HOSPITAL DISCHARGE ABSTRACT (IP)

8.1 Study Population in IP

Total 10,733 stroke subjects were identified in IP data for the analysis on trends of stroke in hospital admission between 1995 and 2004, as shown in Figure 7.1 flow chart.

8.2 Trends of Stroke in Hospital Discharge Abstract (IP)

8.2.1 Description of Study Population in IP Data

The median age for stroke patients in hospital admission ranged from 73 to 75 yr. Female accounted for almost 51% in stroke patients. The distributions of stroke type were similar over time with an average of 65% for AIS, 18% for TIA, 10% for ICH and 7% for SAH (Table 8.1). The proportion of TIA patients increased from 5% to 9% after 2002 ($p < 0.01$).

Table 8.1 Demographic Characteristics for the Study Population in IP, 1995 - 2004

Fiscal year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Number	989	967	879	1027	1095	1025	1076	1208	1225	1242	10,733
Mean age (SD), y	71 (14)	71 (15)	71 (14)	71 (14)	71 (15)	71 (15)	71 (15)	71 (15)	71 (15)	71 (15)	71 (15)
Median age (IQR), y	73 (64-81)	74 (63-81)	74 (65-81)	74 (64-82)	74 (63-82)	74 (62-82)	74 (64-82)	74 (61-82)	75 (63-82)	74 (62-82)	74 (63-82)
Female, n (%)	490 (50)	461 (48)	473 (54)	530 (52)	563 (51)	534 (52)	551 (51)	642 (53)	567 (46)	613 (49)	5424 (51)
Stroke Type, n (%)											
AIS	661 (67)	633 (65)	569 (65)	679 (66)	720 (66)	715 (70)	737 (68)	783 (65)	756 (62)	758 (61)	7011 (65)
TIA	155 (16)	146 (15)	149 (17)	157 (15)	169 (15)	142 (14)	144 (13)	245 (20)	288 (24)	296 (24)	1891 (18)
ICH	101 (10)	109 (11)	96 (11)	105 (10)	118 (11)	97 (9)	121 (11)	117 (10)	115 (9)	104 (8)	1083 (10)
SAH	72 (7)	79 (8)	65 (7)	86 (8)	88 (8)	71 (7)	74 (7)	63 (5)	66 (5)	84 (7)	748 (7)

8.2.2 Trends of Stroke Hospitalization Cases

8.2.2.1 Trends of Overall Stroke Hospitalization

Table 8.2 showed the absolute number of stroke hospitalization in IP from 1995 to 2004. Figure 8.2 to 8.4 illustrated the trends of stroke admission cases that identified from hospital discharge abstract.

Table 8.2 Number of Stroke Admission in IP

Year	stroke	Stroke Excl. Q	Stroke Excl. I64	Stroke Excl. Q & I64
1995	989	969	805	794
1996	967	956	810	803
1997	879	857	729	710
1998	1027	999	858	837
1999	1095	1036	916	871
2000	1025	955	918	865
2001	1076	1027	988	949
2002	1208	1178	1102	1077
2003	1225	1193	1161	1136
2004	1242	1201	1153	1123

Note: Excl.Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query and unspecified stroke.

The number of stroke hospitalization increased 25.6% from 989 in year1995 to 1242 in 2004 with a sharp upward trend ($p = 0.001$) (Figure 8.1 & 8.2). It seems that stroke hospitalization dropped from year 1995 to 1997, then increased until1999, then decreased in 2000, and increased continuously afterwards from 1025 stroke cases to 1242 in 2004.

The trend of stroke hospitalization did not change when query diagnoses, unspecified stroke or both were excluded (Figure 8.2 – 8.3).

Figure 8.1 Number of Stroke Admission in IP, 1995-2004

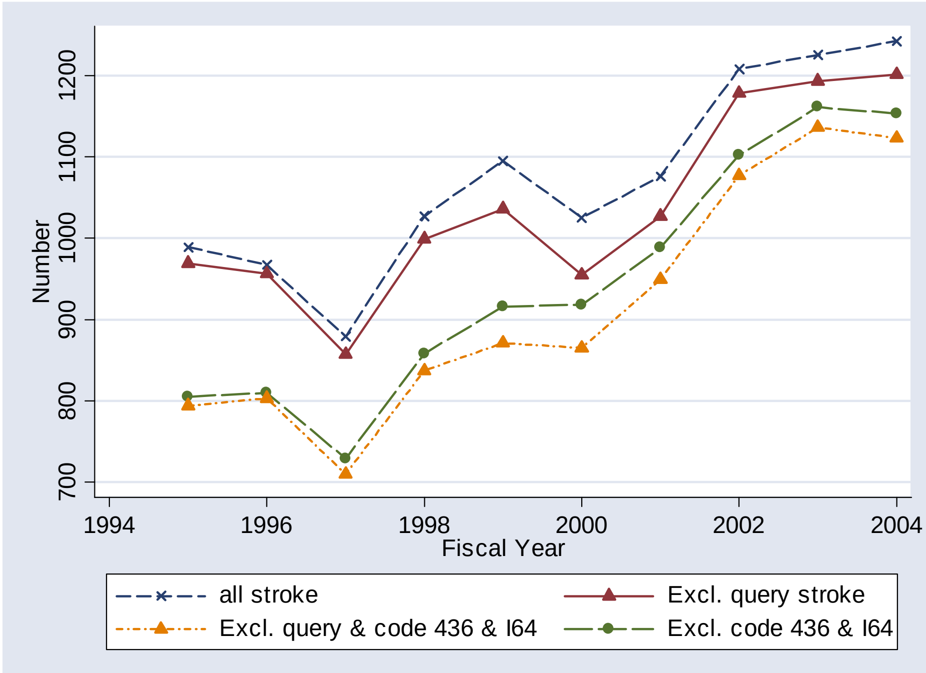


Figure 8.2 Trend of Stroke Admission in IP, 1995-2004 (1)

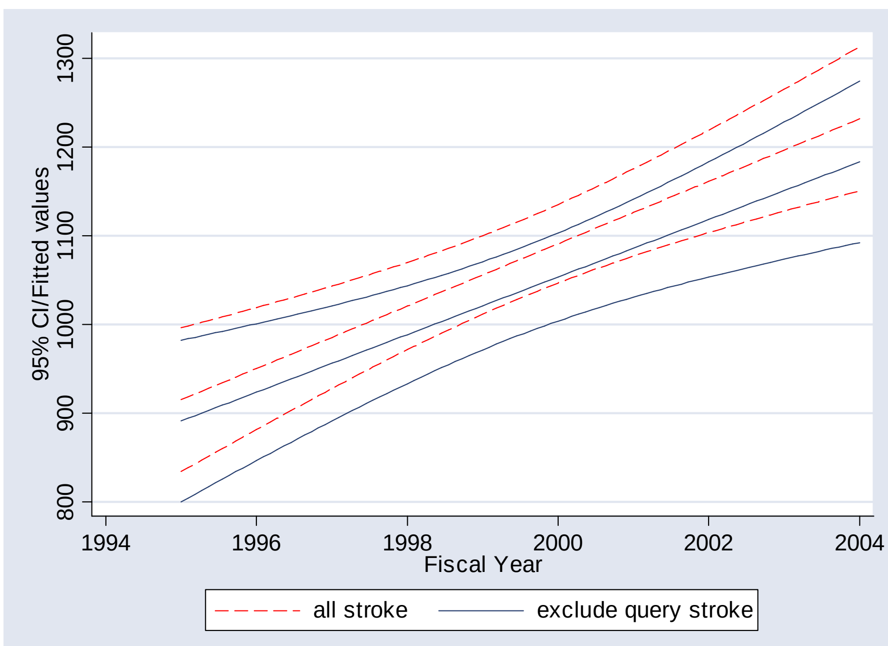
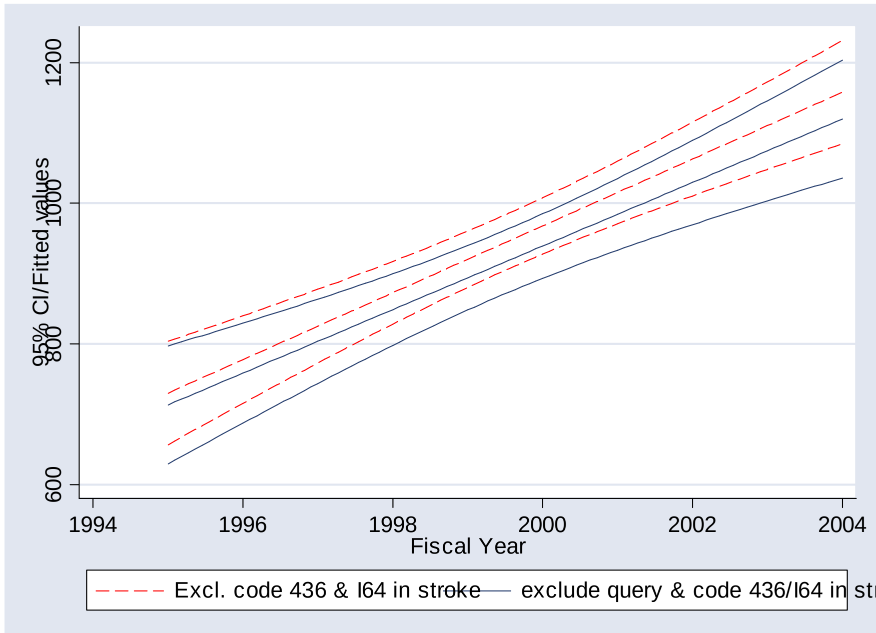


Figure 8.3 Trend of Stroke Admission in IP, 1995-2004 (2)



Linear projections of the stroke hospitalization into the future imply an average increase of 35 strokes per year (95%CI: 20 to 50) with differing rates when query diagnoses, unspecified stroke, or both were excluded from the projection, (Table 8.3)

Table 8.3 Projection of Increased Stroke Cases in Future in IP (per year)

	All stroke *	Excl. query stroke *	Excl. unspecified stroke *	Excl. both query & unspecified stroke *
Number of increased stroke (per year)	35	32	48	45
95% CI	20-50	15-50	34-61	29-61

* Linear projection is significant with p value < 0.003.

8.2.2.2 Trends of Stroke Hospitalization by Stroke Type

Table 8.4 below presents the detailed number of stroke hospitalizations by stroke type from 1995 to 2004.

Table 8.4 Number of Stroke Admission by Stroke Type in IP

Year	AIS	TIA	ICH	SAH	AIS Excl.Q	TIA Excl.Q	ICH Excl.Q	SAH Excl.Q	AIS Excl.I64	AIS Excl. Q&I64
1995	661	155	101	72	645	151	101	72	477	470
1996	633	146	109	79	627	142	108	79	476	474
1997	569	149	96	65	560	136	96	65	419	413
1998	679	157	105	86	663	146	105	85	510	501
1999	720	169	118	88	683	150	117	86	541	518
2000	715	142	97	71	680	107	97	71	608	590
2001	737	144	121	74	712	122	119	74	649	634
2002	783	245	117	63	769	231	116	62	677	668
2003	756	288	115	66	739	273	115	66	692	682
2004	758	296	104	84	733	280	104	84	669	655

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q&I64 = Exclude query & unspecified stroke

Figure 8.4 & 8.6 indicated that the number of ICH admission was stable during last decade with not much change from 101 to 104 cases whether query diagnoses were excluded or not ($p > 0.2$). The number of SAH increased slightly from 72 in 1995 to 84 in year 2004 but with a flat trend ($p > 0.2$ in regression line) whether query diagnoses was excluded or not (Figure 8.4 & 8.6).

The number of AIS hospitalization increased 14.7% from 661 in 1995 to 758 in 2004 in IP (Figure 8.4). The number of AIS hospitalizations declined at first to year 1997, then increased continuously ($p = 0.003$) whether query or unspecified stroke was included or not (Figure 8.5, 8.7 & 8.8).

Figure 8.4 Number of Stroke Hospitalization by Type in IP, 1995-2004

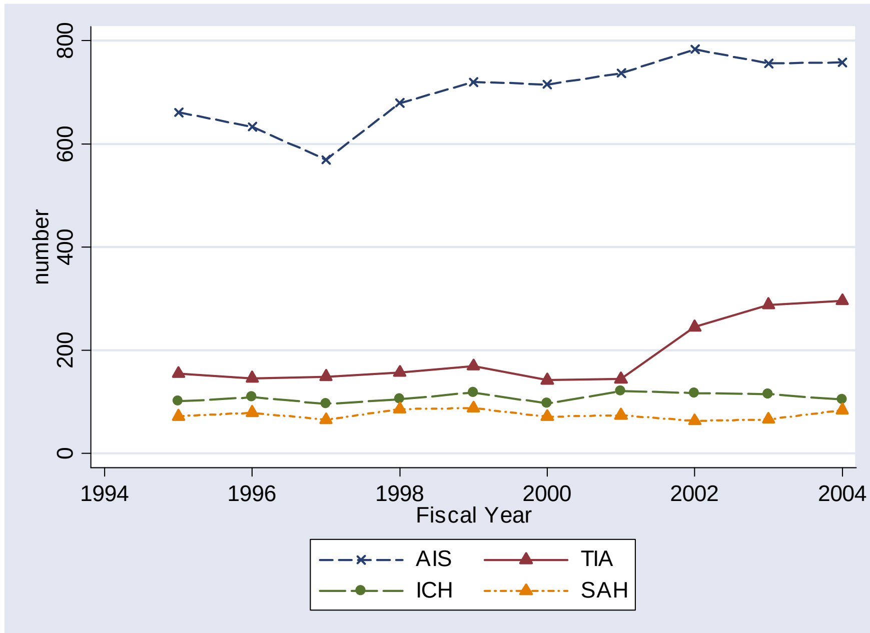


Figure 8.5 Number of AIS Exclude Query & Unspecified Stroke in IP, 1995-2004

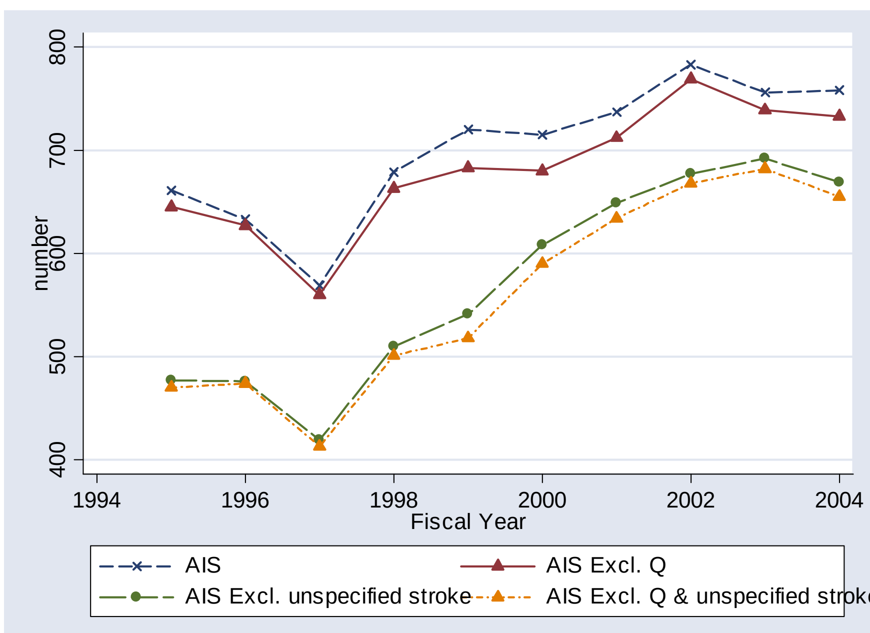


Figure 8.6 Number of Stroke by Type Excl. Query Stroke in IP Data, 1995-2004

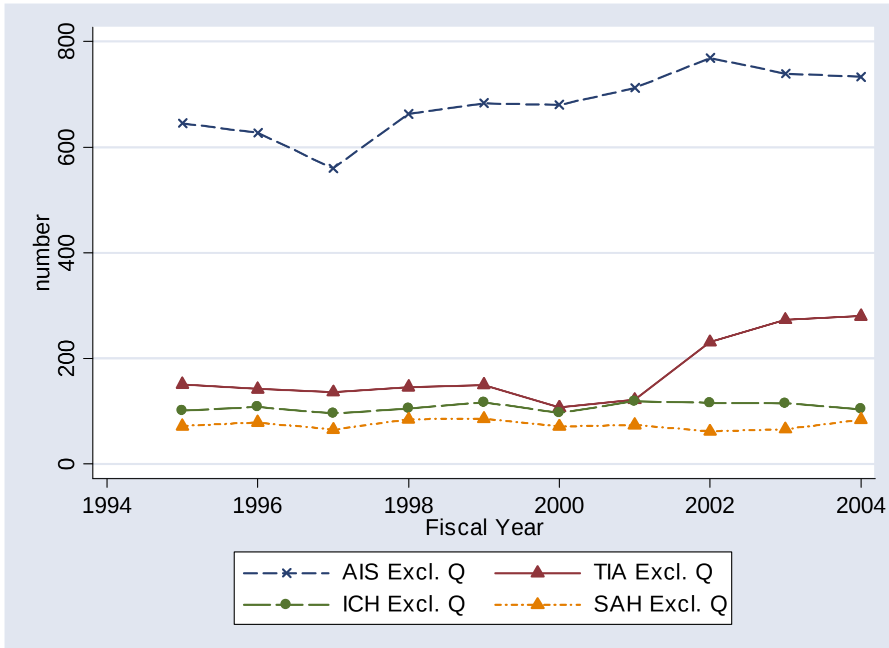


Figure 8.7 Trend of AIS Admission in IP, 1997-2004 (1)

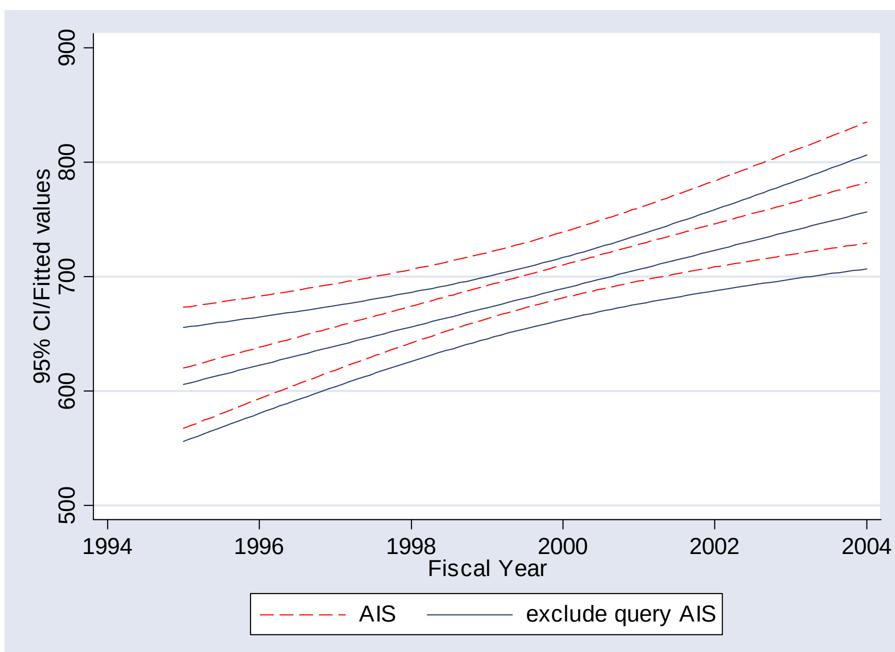
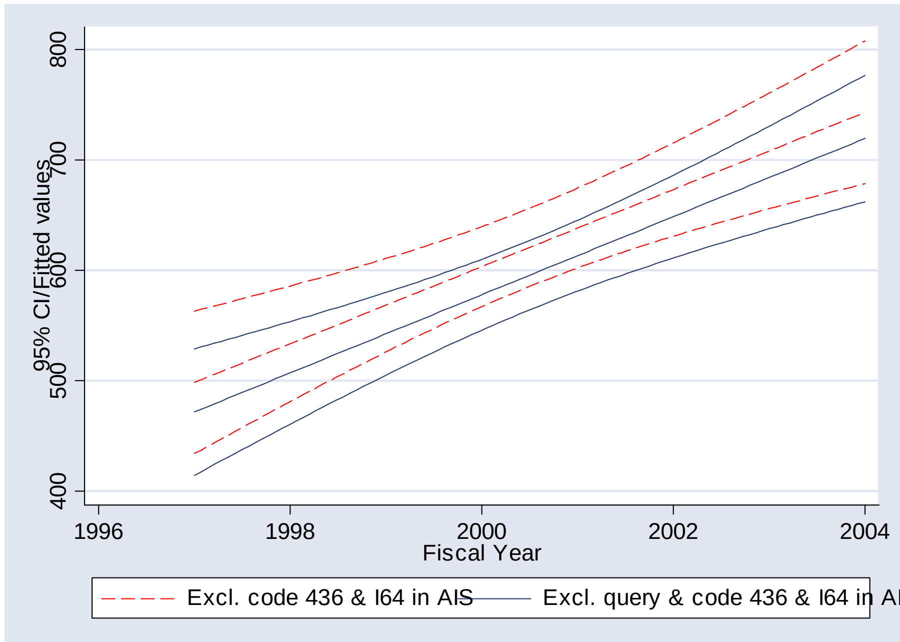
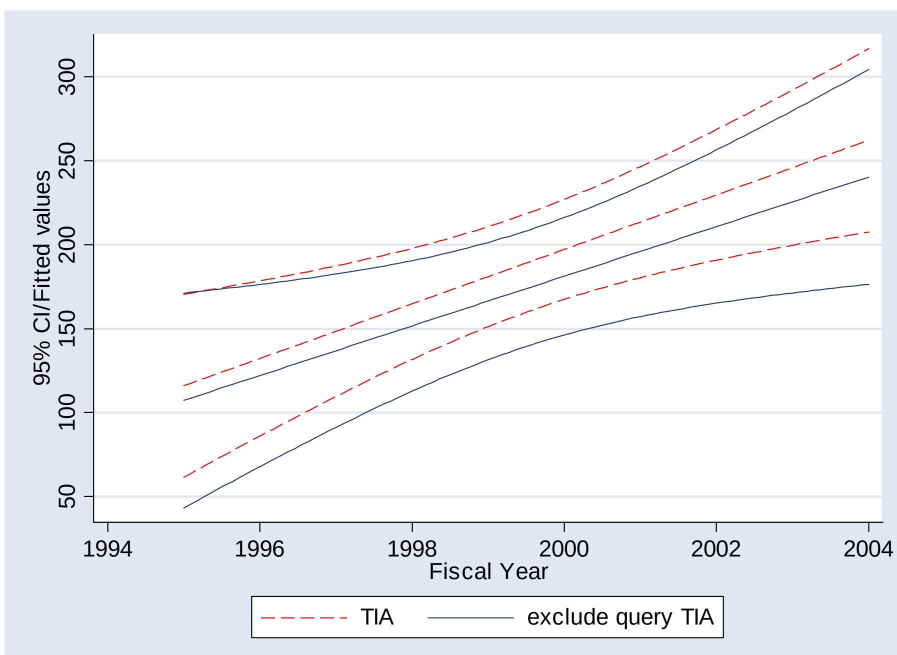


Figure 8.8 Trend of AIS Admission in IP, 1997-2004 (2)



The number of TIA admission was stable until 2001, then rose dramatically more than 1 fold from 144 in 2001 to 296 in year 2004, ($p < 0.02$) (Figure 8.4, 8.6 & 8.9) no matter whether query diagnoses was counted or not.

Figure 8.9 Trend of TIA Admission in IP, 1995-2004



8.2.2.3 Trends of Stroke Hospitalization by Sex

In stratified analysis by sex, we plotted the trend of overall stroke admission as well as trend for each stroke type by sex during 1995 to 2004.

8.2.2.3.1 Trends of Overall Stroke Admission by Sex

Table 8.5 Number of Stroke Hospitalization by Sex in IP

Year	Stroke-Female	Stroke – Male	Stroke Excl. Q-F	Stroke Excl. Q-M	Stroke Excl. I64-F	Stroke Excl. I64-M	Stroke Excl. Q & I64 - F	Stroke Excl. Q & I64 - M
1995	490	499	480	489	395	410	390	404
1996	461	506	456	500	388	422	385	418
1997	473	406	459	398	396	333	383	327
1998	530	497	517	482	442	416	431	406
1999	563	532	535	501	463	453	441	430
2000	534	491	488	467	465	453	432	433
2001	551	525	527	500	493	495	475	474
2002	642	566	656	552	574	528	559	518
2003	567	658	550	643	541	620	528	608
2004	613	629	590	611	563	590	547	576

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query & unspecified stroke; F = Female; M = Male

The number of stroke hospitalization in women started to decrease at the first two years till 1996, then increased, yet not stable with some decreasing in 2000 and 2003 (Figure 8.10 – 8.11). The number of stroke hospitalization in men rose a little bit in 1996, then declined sharply to 1997, and then began to increase almost continuously with one drop in 2000 and another drop in 2004. We observed the slightly higher number of stroke admission in women than in men before 2002. Then, the number of stroke in men surpassed women in 2003, and started to decline, while trend of stroke in women began to rise again. The increasing trends of number of stroke in both sexes were significant over time (both $p < 0.01$) no matter query diagnoses counted or not (Figure 8.10 & 8.12). The number of stroke hospitalization were close in men and women when unspecified stroke or both query and unspecified stroke eliminated; neither did the rising trend change ($P < 0.001$) (Figure 8.13 & 8.14).

Figure 8.10 Number of Stroke Admission by Sex in IP, 1995-2004

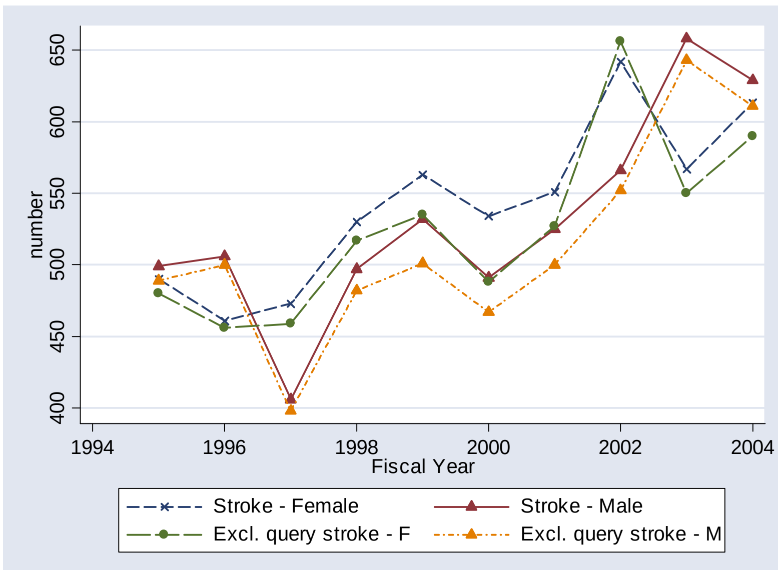


Figure 8.11 Trend of Stroke Admission by Sex in IP, 1995-2004 (1)

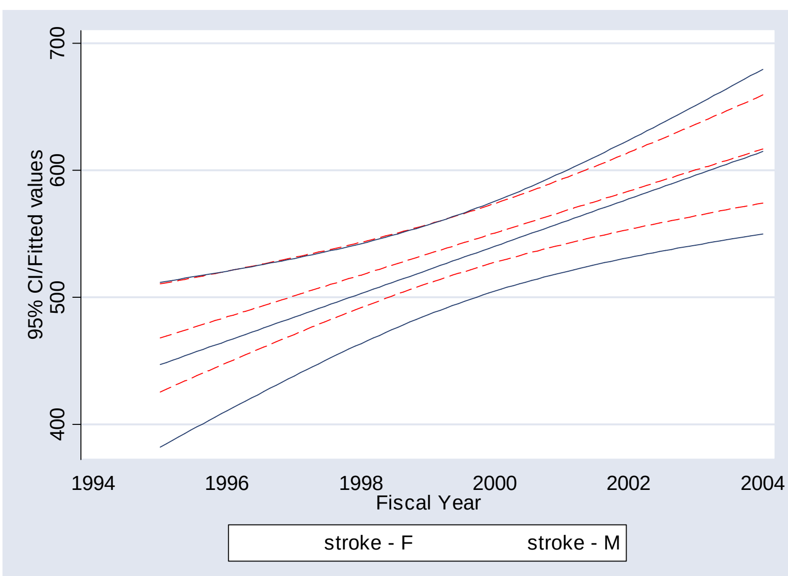


Figure 8.12 Trend of Stroke Admission by Sex in IP, 1995-2004 (2)

Figure 8.13 Number of Stroke by Sex in IP, 1995-2004

Figure 8.14 Trend of Stroke Exclude Unspecified Stroke in IP by Sex, 1995-2004

8.2.2.3.2 Trends of Stroke Admission by Stroke Type

Table 8.6& 8.7 showed the detailed number of stroke admission by stroke type and sex in IP data.

Table 8.6 Number of Stroke Admission by Stroke Type & Sex in IP (1)

Year	AIS_F	AIS_M	TIA_F	TIA_M	ICH_F	ICH_M	SAH_F	SAH_M	AIS Excl.Q-F	AIS Excl.Q-M
1995	315	346	84	71	51	50	40	32	308	337
1996	289	344	80	76	49	60	53	26	287	340
1997	305	264	84	65	49	47	35	30	300	260
1998	345	334	82	75	50	55	53	33	338	325
1999	373	347	84	85	49	69	5357	31	355	328
2000	357	358	84	58	48	49	45	26	336	344
2001	370	367	71	73	59	62	51	23	359	353
2002	408	375	135	110	62	55	37	26	402	367
2003	342	414	131	157	49	66	45	21	332	407
2004	351	407	155	141	52	52	55	29	337	396

Note: Excl. Q = Exclude query diagnoses; F = Female; M = Male

Table 8.7 Number of Stroke by Stroke Type & Sex in IP (2)

Year	AIS Excl. Q & I64-F	AIS Excl. Q & I64-M	AIS Excl. I64 - F	AIS Excl. I64 - M	TIA Excl. Q - F	TIA Excl. Q - M	ICH Excl. Q - F	ICH Excl. Q - M	SAH Excl. Q - F	SAH Excl. Q - M
1995	218	252	220	257	81	70	51	50	40	32
1996	216	258	216	260	67	75	49	59	53	26
1997	224	189	228	191	75	61	49	47	35	30
1998	252	249	257	253	76	70	50	55	53	32
1999	261	257	273	268	77	73	48	69	55	31
2000	280	310	288	320	59	48	48	49	45	26
2001	307	327	312	337	59	63	58	61	51	23
2002	335	333	340	337	125	106	62	54	37	25
2003	310	372	316	376	124	149	49	66	45	21
2004	294	361	301	368	146	134	52	52	55	29

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query & unspecified stroke; F = Female; M = Male

The number of AIS hospitalization in women was a bit higher than that in men before 2002 showing a slight rising trend (Figure 8.15, 8.18). Then the hospitalization of AIS in women declined to 2003, and increased afterwards; while hospitalization of AIS in men increased after 2002 and turned to steady in 2004. The trend of AIS in men went up continuously to 2000, then declined until 2002, and then rose again, surpassing the number of stroke in women in 2003, and finally dropped a little bit in 2004. The overall increasing trends of AIS in both sexes were significant ($p < 0.03$) whether query diagnoses, unspecified stroke or both of them included or not (Figure 8.16 – 8.21).

The number of TIA for both sexes were close and stable before 2001, and then increased dramatically with significant difference ($p < 0.03$) (Figure 8.22 – 8.23) no matter query diagnoses excluded or not.

Figure 8.15 Number of Ischemic Stroke in IP by Sex, 1995-2004

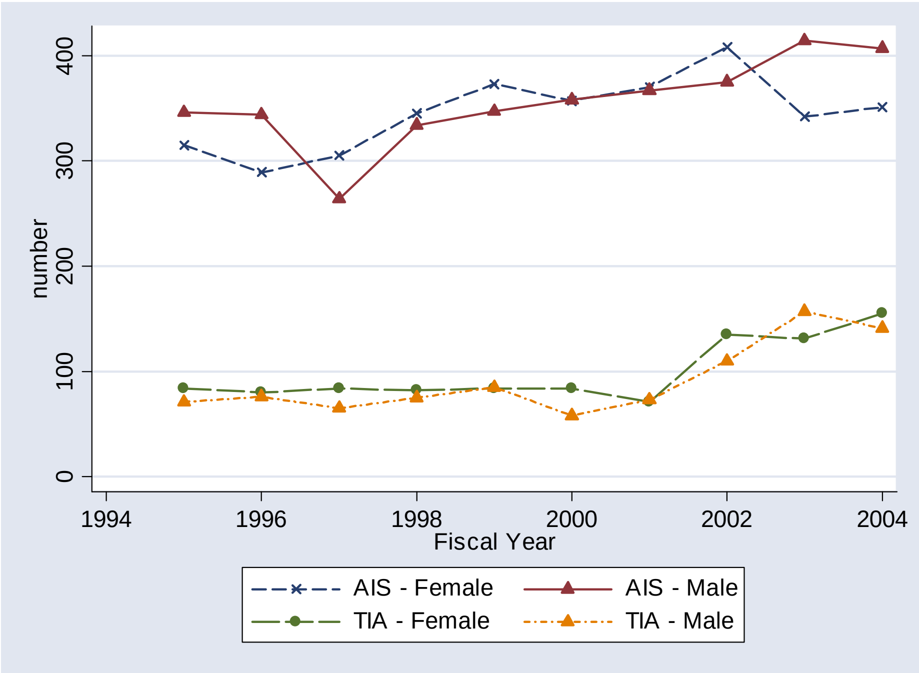
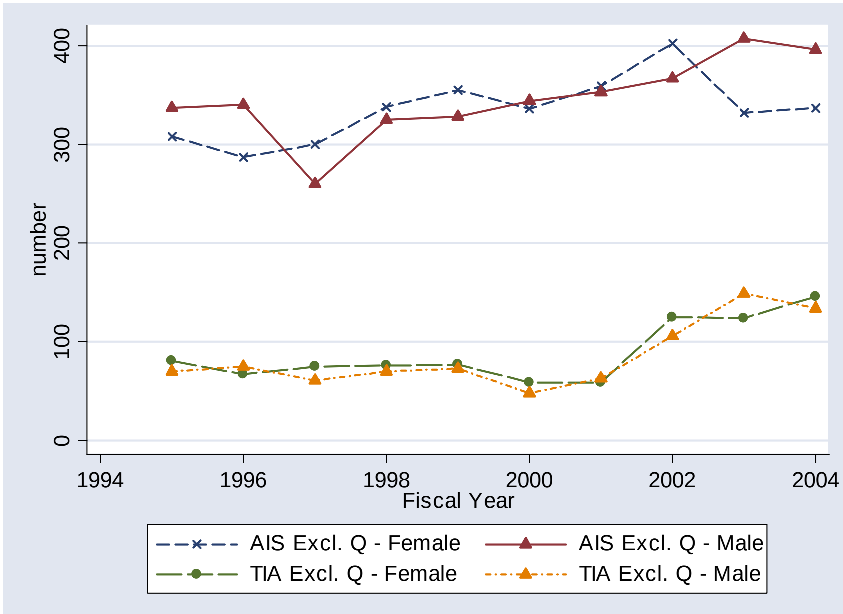
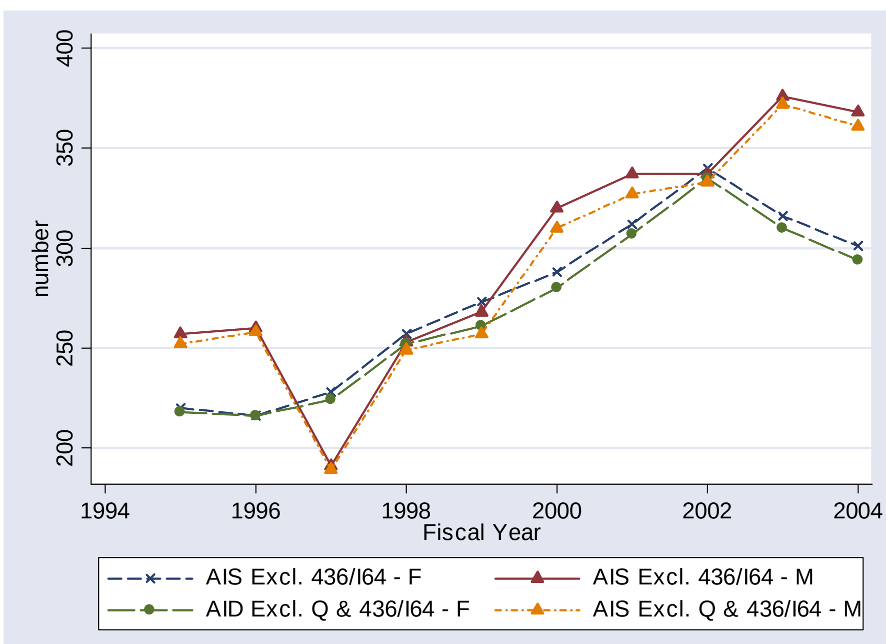


Figure 8.16 Number of Ischemic Stroke Excl. Query diagnoses in IP by Sex, 1995-2004



Note: Q = query diagnoses

Figure 8.17 Number of Ischemic Stroke Excl. Unspecified Stroke & Query diagnoses in IP by Sex, 1995-2004



Excl. 436/I64 = Exclude unspecified stroke

Figure 8.18 Trend of AIS in IP by Sex, 1995-2004

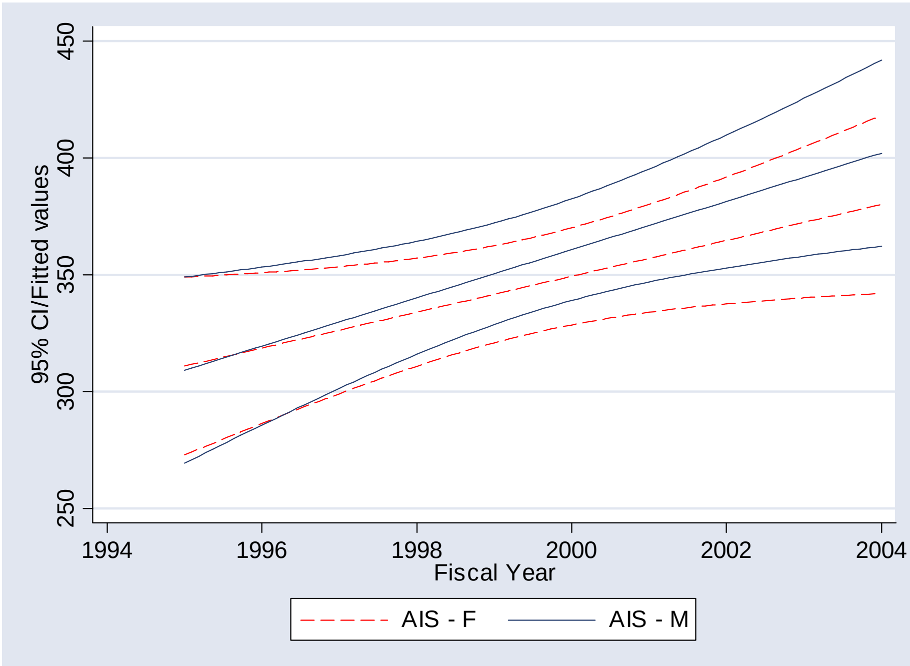


Figure 8.19 Trend of AIS Excl. Query Diagnoses in IP by Sex, 1995-2004

Figure 8.20 Trend of AIS Excl. Unspecified Diagnoses in IP by Sex, 1995-2004

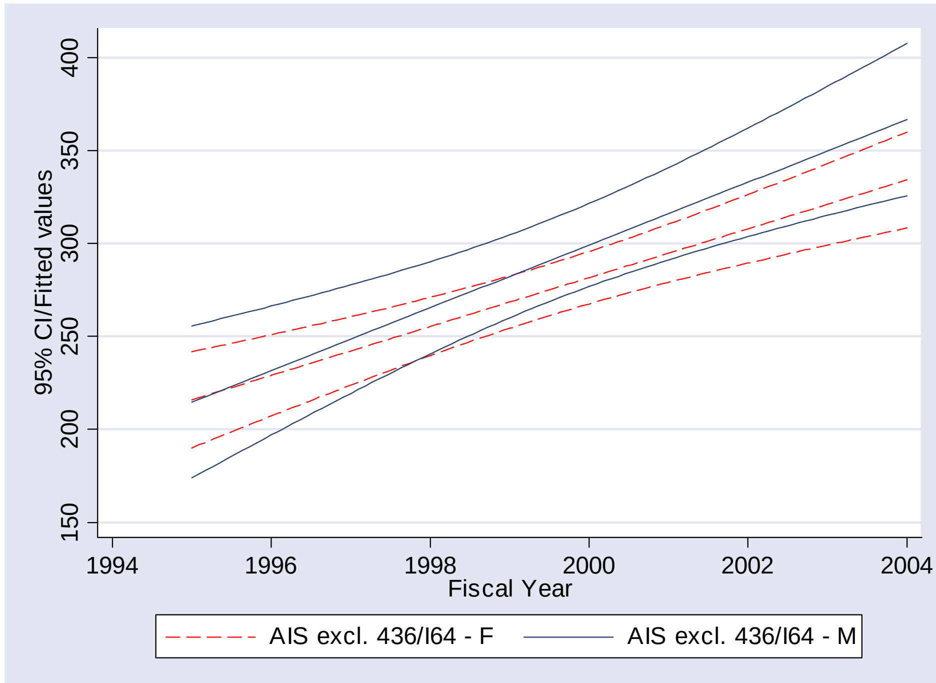


Figure 8.21 Trend of AIS Excl. Query & Unspecified Stroke in IP by Sex, 1995-2004

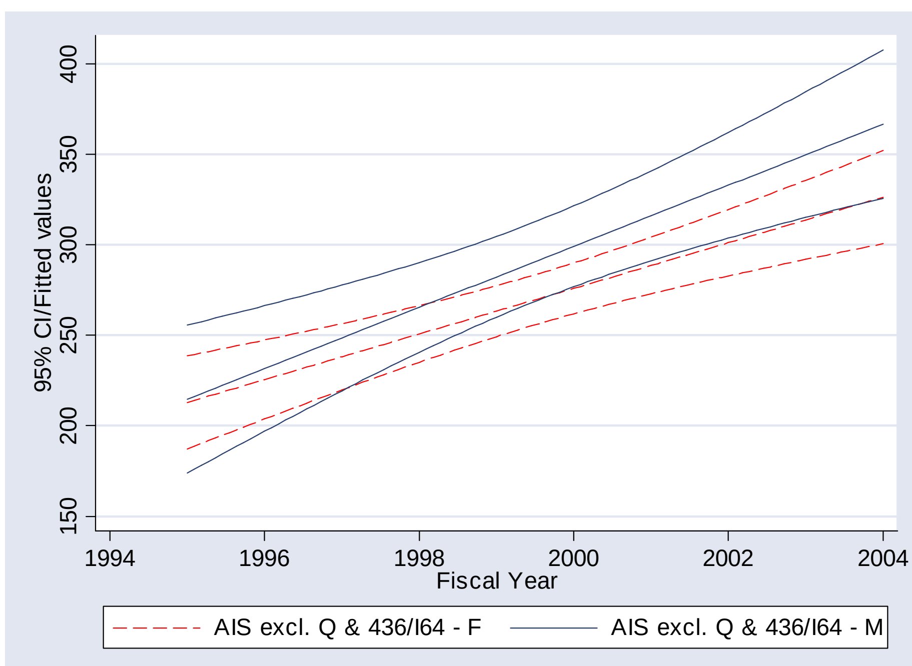


Figure 8.22 Trend of TIA in IP by Sex, 1995-2004

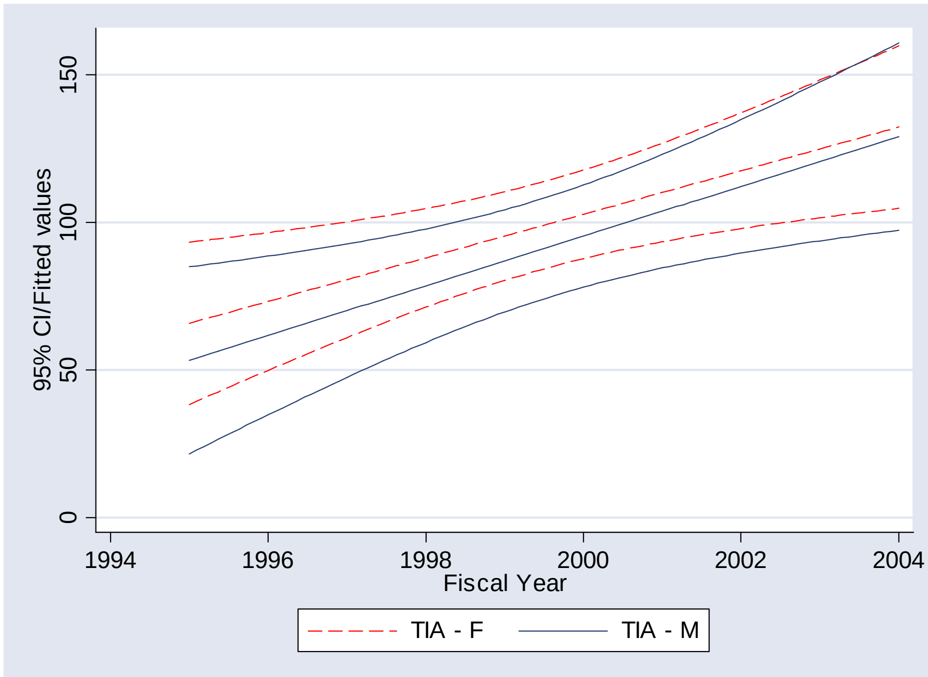


Figure 8.23 Trend of TIA Excl. Query Diagnoses in IP by Sex, 1995-2004

Higher numbers of ICH admissions were found in men than in women over time, with stable trends of ICH admissions in both sexes (p > 0.4) whether query diagnoses were included or not (Figure 8.24 – 8.25). The number of SAH was much higher in women than in men (Figure 8.26). We noticed a continuous stable trend for the number of SAH hospitalization in both sexes whether query diagnosis counted out or not (p > 0.1) (Figure 8.26 & 8.27).

Figure 8.24 Number of ICH Hospitalization in IP by Sex, 1995-2004

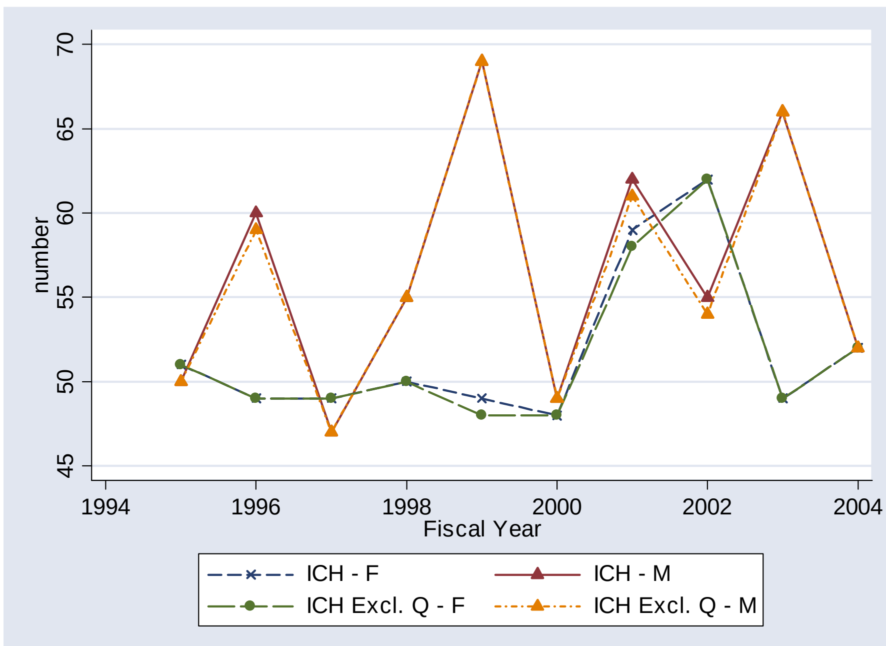


Figure 8.25 Trend of ICH in IP by Sex, 1995-2004

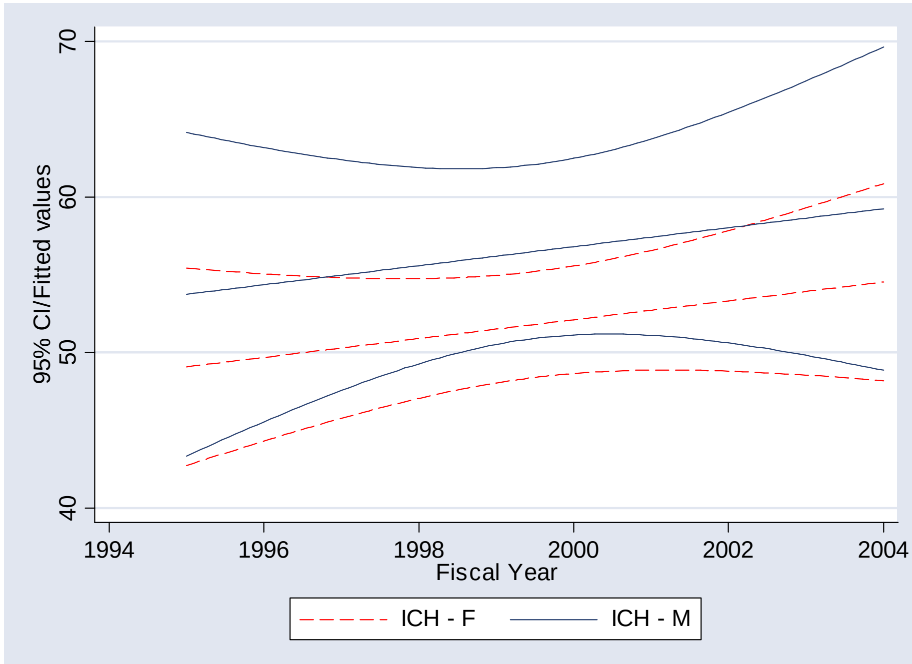


Figure 8.26 Number of SAH in IP by Sex, 1995-2004

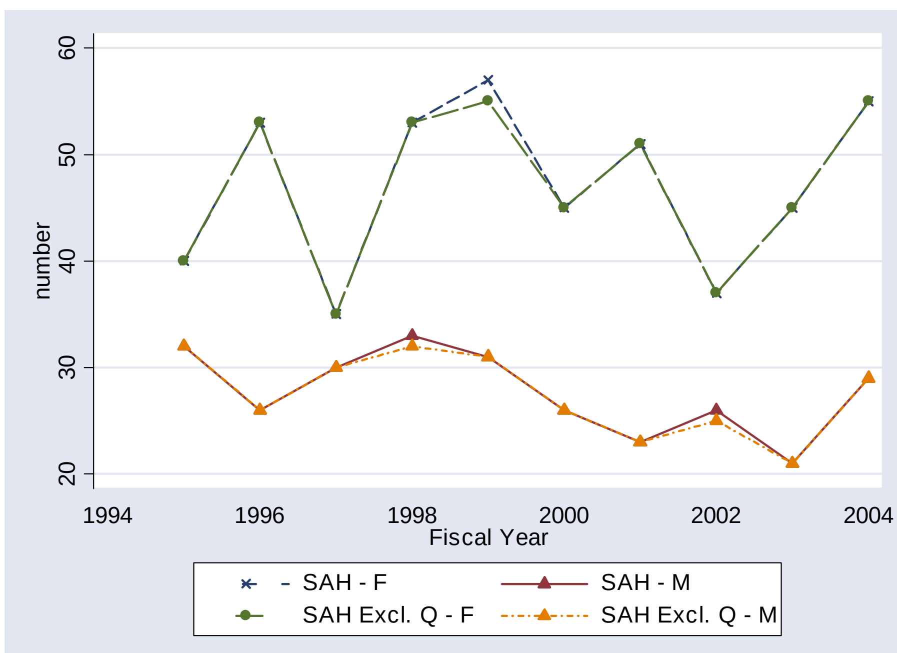
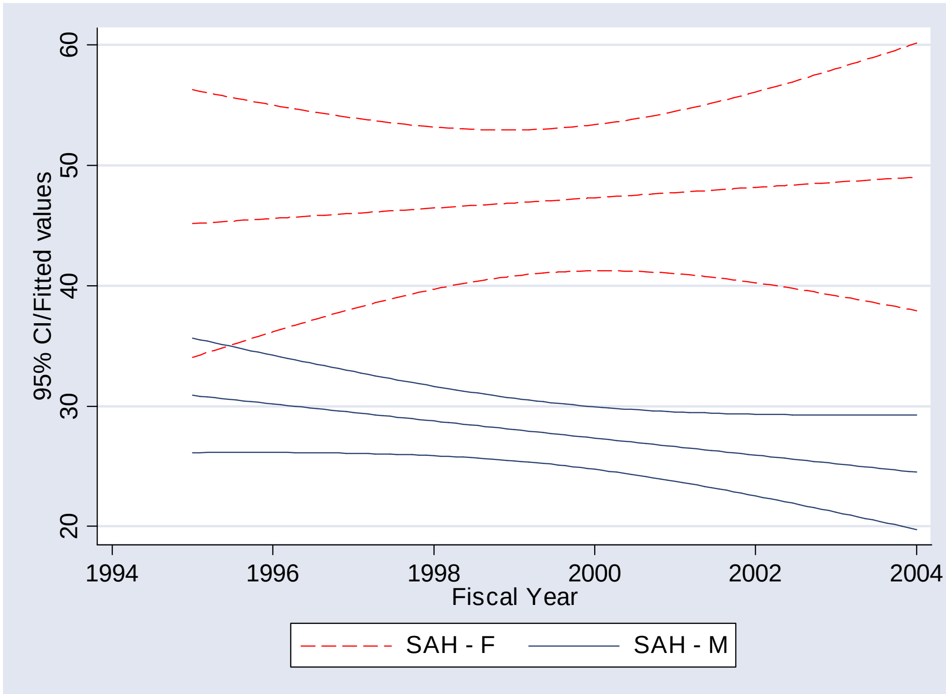


Figure 8.27 Trend of SAH in IP by Sex, 1995-2004



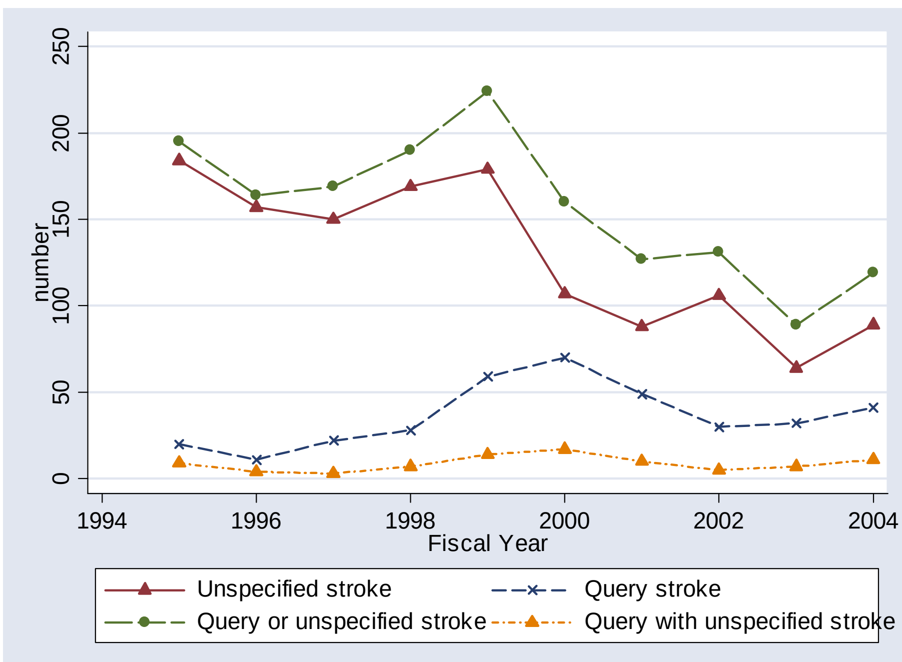
8.2.2.3.3 Trends for Query Stroke & Unspecified Stroke in IP Data

A few query stroke were found in IP (from 1% to 6.8%) and few query with unspecified stroke were identified (around 1%) over time. We notified the obviously downward trends in numbers of unspecified stroke (p=0.001), and those with query and unspecified stroke from 1995 to 2004 (Table 8.8 & Figure 8.28), though they once increased in 1999. The distribution of unspecified stroke, and query with unspecified stroke declined from 18.6% to 7.2% and 19.7% to 9.6% with substantial difference (both $p < 0.01$) over the last decade (Table 8.8). It appears that unspecified stroke accounted for fewer stroke in ICD-10 period compared to ICD-9 period.

Table 8.8 Number & Distribution of Query / Unspecified Stroke in IP

Year	Number of stroke	Query stroke (n, %)	Unspecified stroke (n, %)	Query or unspecified stroke (n, %)	Query with unspecified stroke (n, %)
1995	989	20 (2)	184 (18.6)	195 (19.7)	9 (0.9)
1996	967	11 (1)	157 (16.2)	164 (17)	4 (0.4)
1997	879	22 (2.5)	150 (17.1)	169 (19.2)	3 (0.3)
1998	1027	28 (2.7)	169 (16.5)	190 (18.5)	7 (0.7)
1999	1095	59 (5.4)	179 (16.3)	224 (20.5)	14 (1.3)
2000	1025	70 (6.8)	107 (10.4)	160 (15.6)	17 (1.7)
2001	1076	49 (4.6)	88 (8.2)	127 (11.8)	10 (0.9)
2002	1208	30 (2.5)	106 (8.8)	131 (10.8)	5 (0.4)
2003	1225	32 (2.6)	64 (5.2)	89 (7.3)	7 (0.6)
2004	1242	41 (3.3)	89 (7.2)	119 (9.6)	11 (0.9)

Figure 8.28 Number of Query Stroke & Unspecified Stroke in IP, 1995 -2004



8.2.3 Trends of Stroke Hospitalization Rate in IP Data

8.2.3.1 Trends of Hospitalization Rate for Overall Stroke in IP Data

The age-adjusted rates of overall stroke were higher than corresponding crude rates, as shown in Table 8.9 (all rates presented here are with the unit of per 100,000 per year). From 1995 to 2004, crude and age-adjusted stroke hospitalization rates for overall stroke were stable ($p > 0.2$) (Figure 8.29 – 8.31), though stroke hospitalization number increased over time (see section 8.2.2.1). There was no significant change for the trends of age-adjusted hospitalization rates when query diagnoses were excluded ($p > 0.23$), yet rates increased significantly when unspecified stroke excluded ($p = 0.04$) (Figure 8.32 – 8.34).

Table 8.9 Crude vs. Age-adjusted Stroke Occurrence Rate in IP

Year	C_stroke	A_stroke	C_stroke Excl. Q	A_stroke Excl. Q	C_stroke Excl. I64	A_stroke Excl. I64	C_stroke Excl.Q & i64	A_stroke Excl. Q & I64
1995	99.7	132.87	97.62	130.03	80.93	107.34	79.78	105.76
1996	97.04	127.69	95.92	126.2	81.1	106.19	80.39	105.23
1997	85.67	112.58	83.61	109.81	71.27	93.39	69.41	90.89
1998	97.96	127.45	95.21	123.97	81.94	106.15	79.94	103.66
1999	101.06	129.94	95.68	123.1	84.56	108.32	80.48	103.18
2000	92.19	116.43	86.21	108.81	82.41	103.61	77.7	97.66
2001	94.49	116.81	89.81	111.17	86.72	106.94	83.19	102.69
2002	106.2	128.85	103.62	125.87	96.63	117.05	94.38	114.52
2003	103.27	123.1	100.57	119.83	98.03	116.62	96	114.23
2004	106.67	124.77	103.17	120.84	98.93	115.46	96.35	112.58

Note: C = Crude rate; A = Age-adjusted rate; Excl. Q = Exclude Query diagnoses; Excl. I64 = Exclude unspecified stroke; Excl. Q & I64 = Exclude query & unspecified stroke

Figure 8.29 Crude Hospitalization Rate for Stroke, 1995-2004

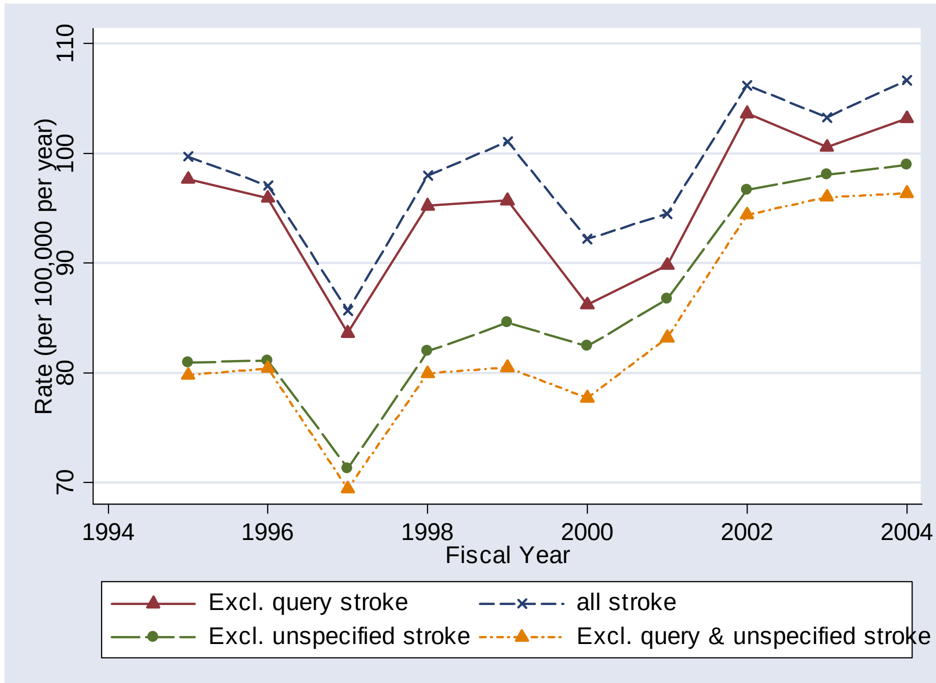


Figure 8.30 Age-adjusted Hospitalization Rate for Stroke, 1995-2004

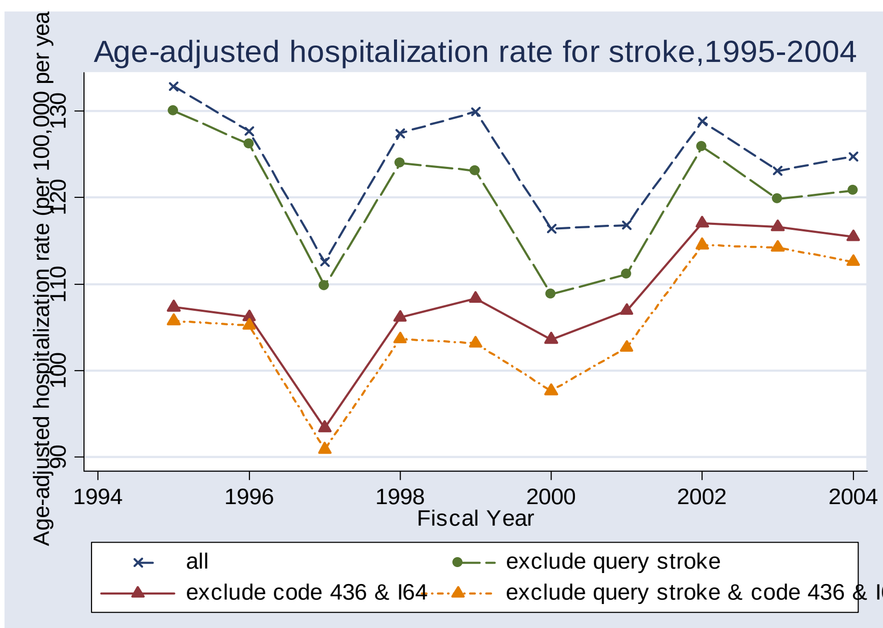


Figure 8.31 Trend of Age-adjusted Stroke Hospitalization Rate in IP, 1995-2004 (1)

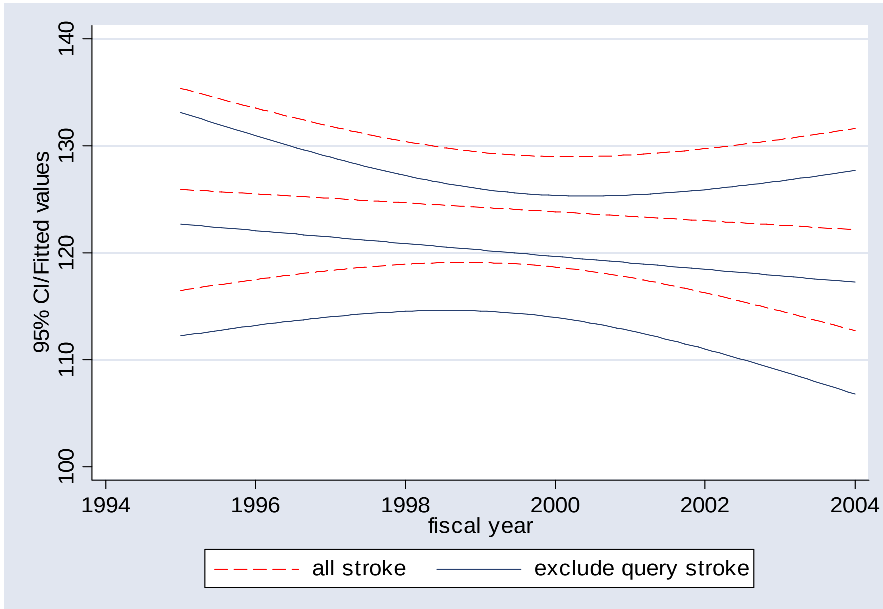


Figure 8.32 Trend of Age-adjusted Stroke Hospitalization Rate in IP, 1995-2004 (2)

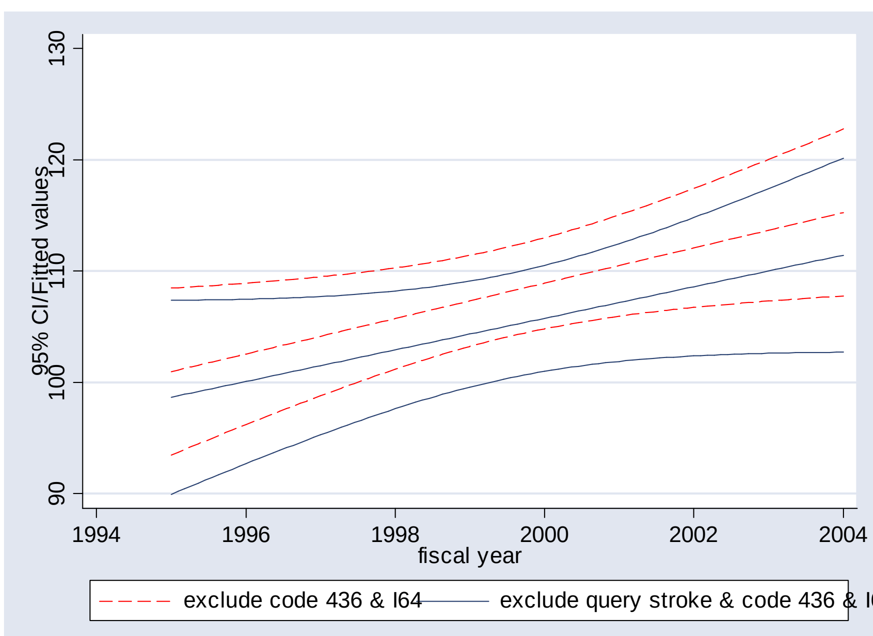


Figure 8.33 Trend of Crude Hospitalization Rate for Stroke in IP, 1995-2004 (1)

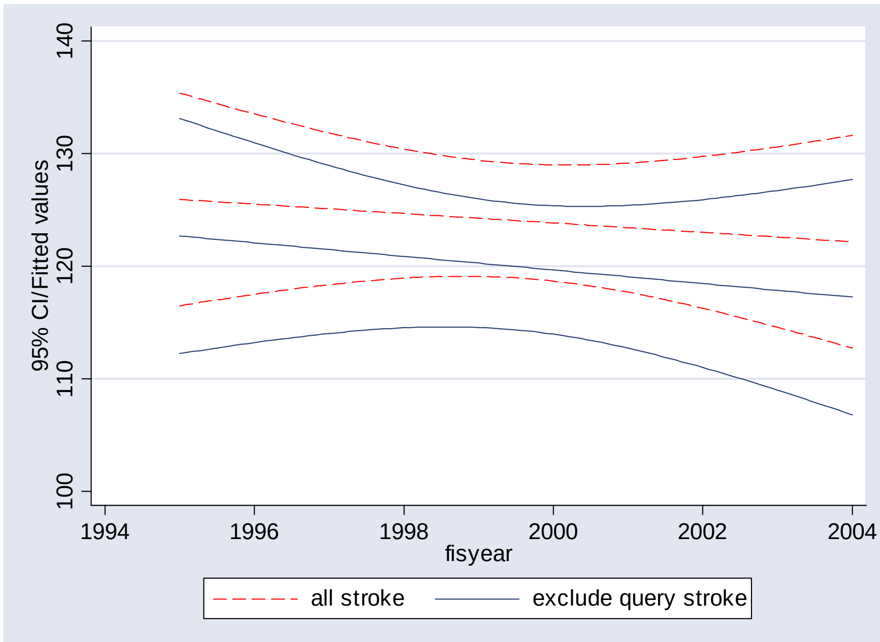
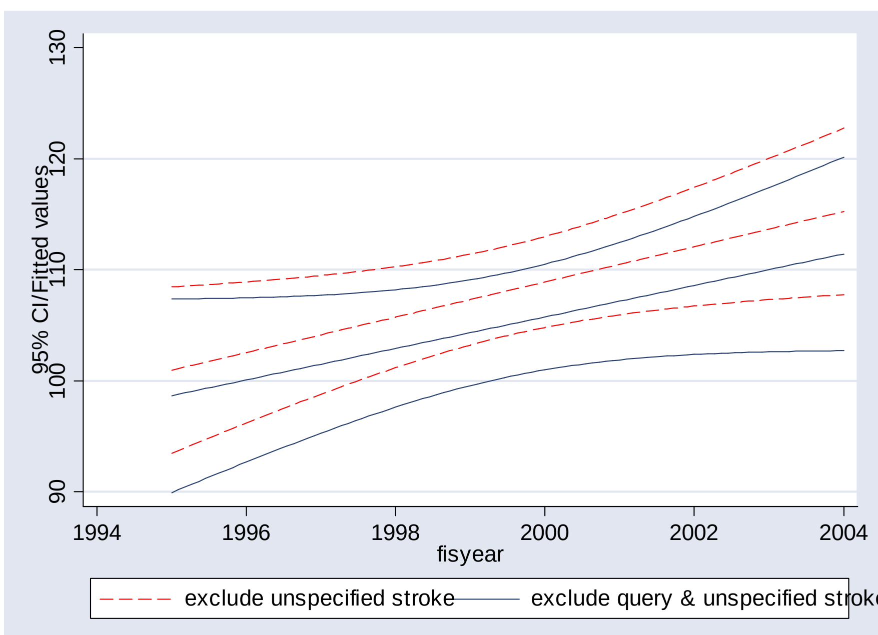


Figure 8.34 Trend of Crude Hospitalization Rate for Stroke in IP, 1995-2004 (2)



8.2.3.2 Trends of Age-adjusted Hospitalization Rate for Stroke Type in IP

Table 8.10 illustrated that age-adjusted hospitalization rates for each stroke type were higher than corresponding crude hospitalization rates.

Table 8.10 Age - adjusted Hospitalization Rate for Stroke Type, 1995 - 2004

Year	AIS	TIA	ICH	SAH	AIS Excl.I64	AIS Excl. Q	TIA Excl. Q	ICH Excl. Q	SAH Excl. Q	AIS Excl. Q & I64
1995	88.5	22	13.8	8.87	63	86.29	21.04	13.83	8.87	62.02
1996	85.3	20	13.8	9.08	63.75	84.45	18.98	13.69	9.08	63.48
1997	73.6	19	12.6	6.95	54.4	72.5	17.73	12.62	6.95	53.59
1998	84.6	20	13.7	9.17	63.34	82.6	18.66	13.66	9.05	62.3
1999	86.3	20	13.7	9.64	64.7	81.91	18.19	13.56	9.43	61.99
2000	82.2	16	11.1	7.28	69.34	78.37	12.06	11.11	7.28	67.22
2001	81.4	16	12.5	6.95	71.54	78.38	13.51	12.33	6.95	69.9
2002	84.4	26	12.7	5.77	72.61	82.95	24.63	12.6	5.69	71.59
2003	76.9	29	11.1	5.93	70.43	75.08	27.76	11.05	5.93	69.48
2004	77	29	10.9	7.58	67.68	74.58	27.74	10.93	7.58	66.32

Figure 8.35 – 8.37 indicate that the crude and age-adjusted AIS hospitalization rates for AIS are stable ($p= 0.46$) with or without query diagnoses counted. However, the trend of age-adjusted AIS hospitalization rates turned to upward when unspecified stroke were excluded ($p= 0.03$). Trend of age-adjusted hospitalization for TIA is also stable since 2001 ($p = 0.2$) (Figure 8.35 & 8.37), presenting slight upward curvilinear trend (Figure 8.38). Figure 8.35 & 8.39 showed slight downward trends for ICH and SAH (both $p > 0.35$); similar trends were found with query diagnoses excluded. Age-adjusted hospitalization rates for AIS excluding unspecified stroke codes show slight increasing trends ($p = 0.16$) (Figure 8.40 – 8.41).

Figure 8.35 Age-adjusted Hospitalization Rate by Stroke Type in IP, 1995-2004

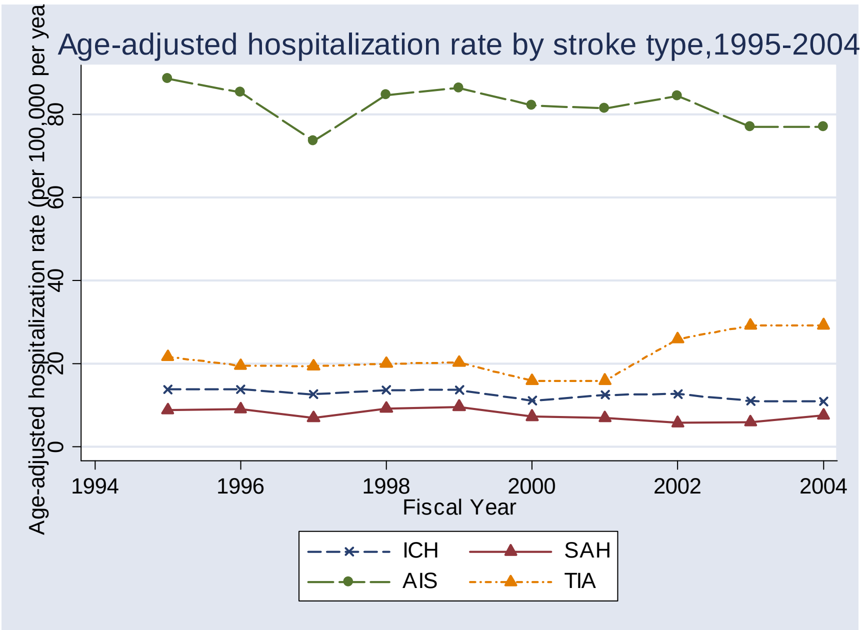


Figure 8.36 Crude Hospitalization Rate by Stroke Type in IP, 1995-2004

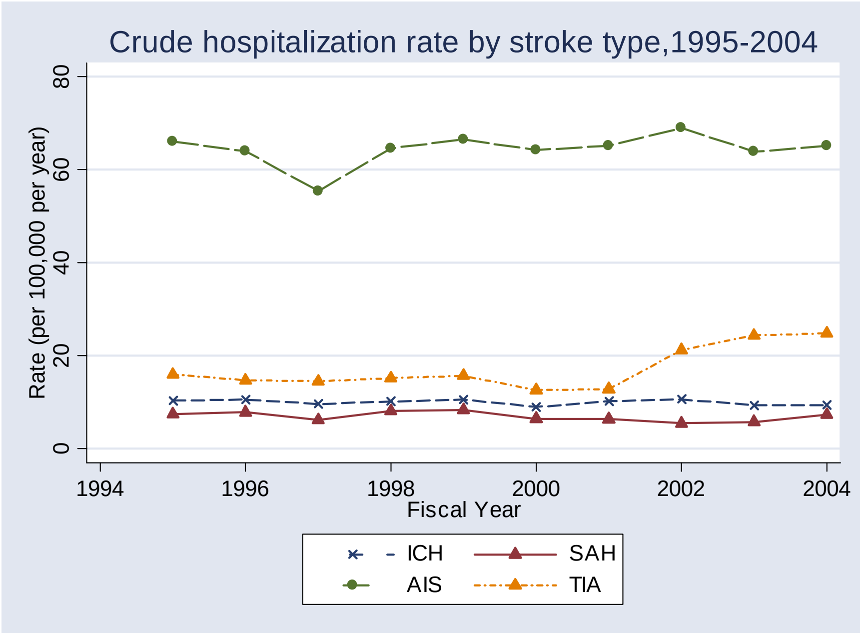


Figure 8.37 Trend of Age-adjusted Hospitalization Rate for Ischemic Stroke, 1995-2004 (1)

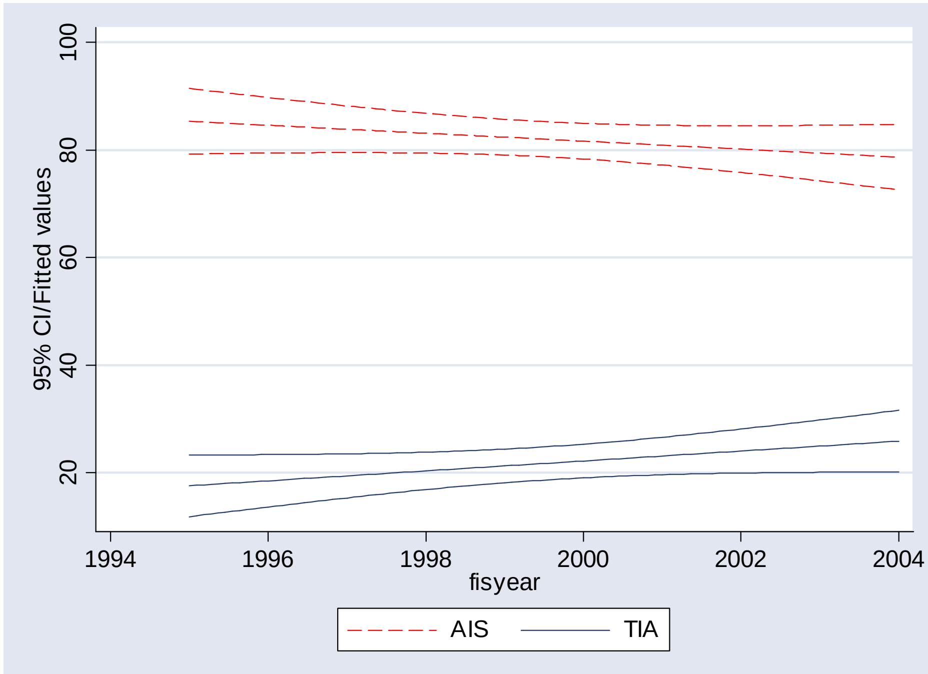


Figure 8.38 Curvilinear Trend for Age-adjusted TIA in IP

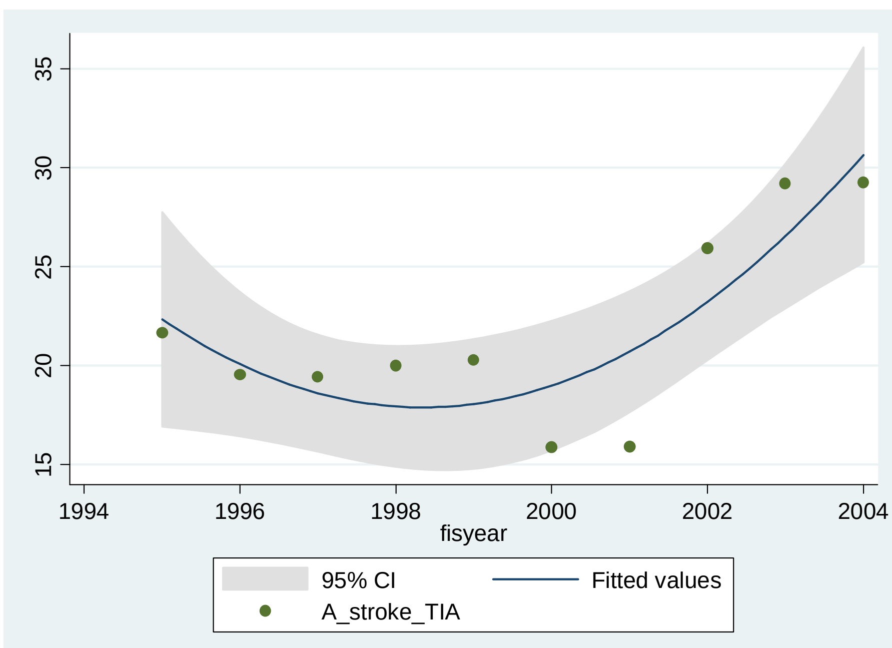


Figure 8.39 Trend of Age-adjusted Hospitalization Rate for Hemorrhagic Stroke, 1995-2004 (1)

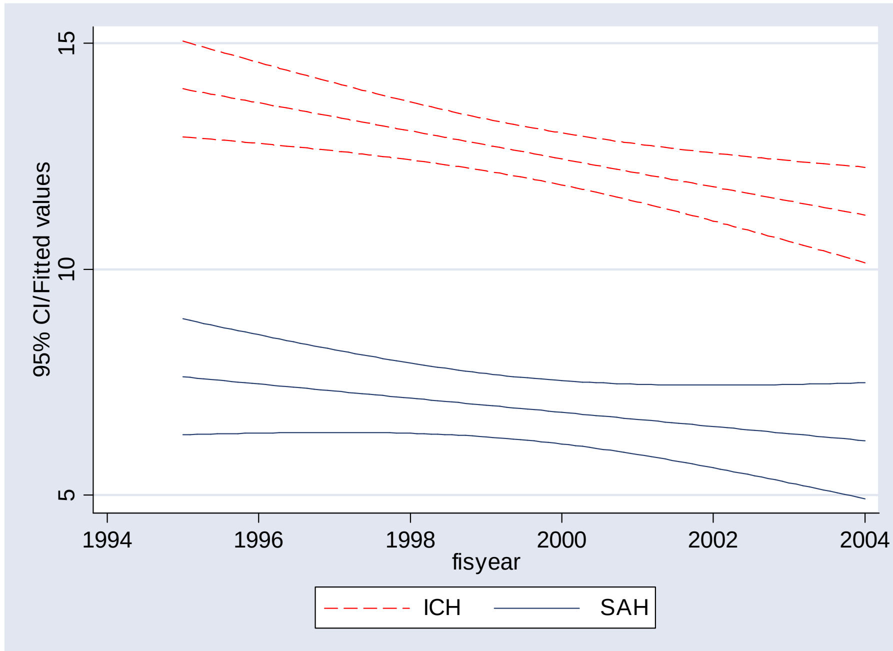


Figure 8.40 Age-adjusted Hospitalization Rate for AIS in IP, 1995-2004

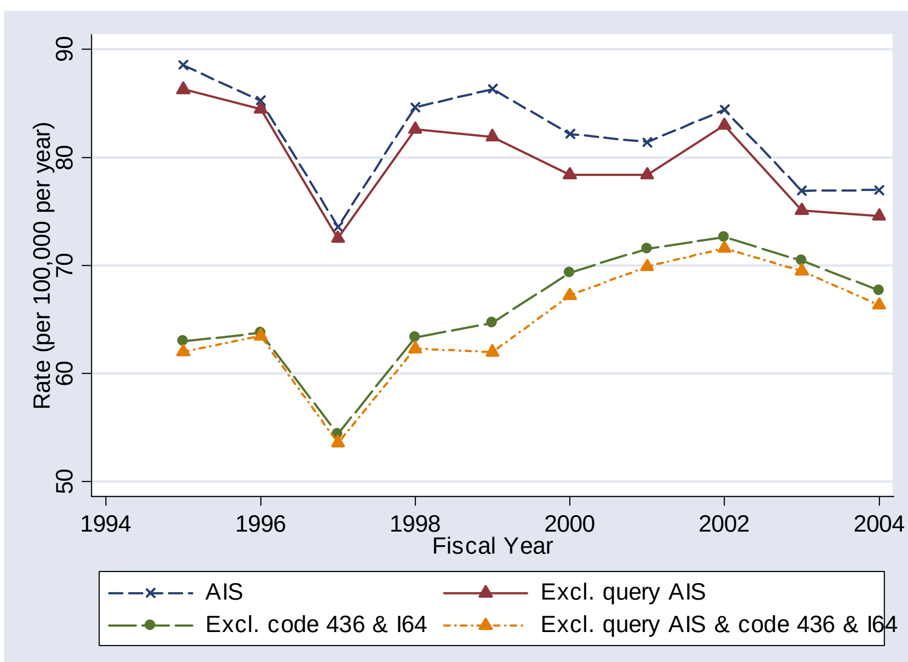
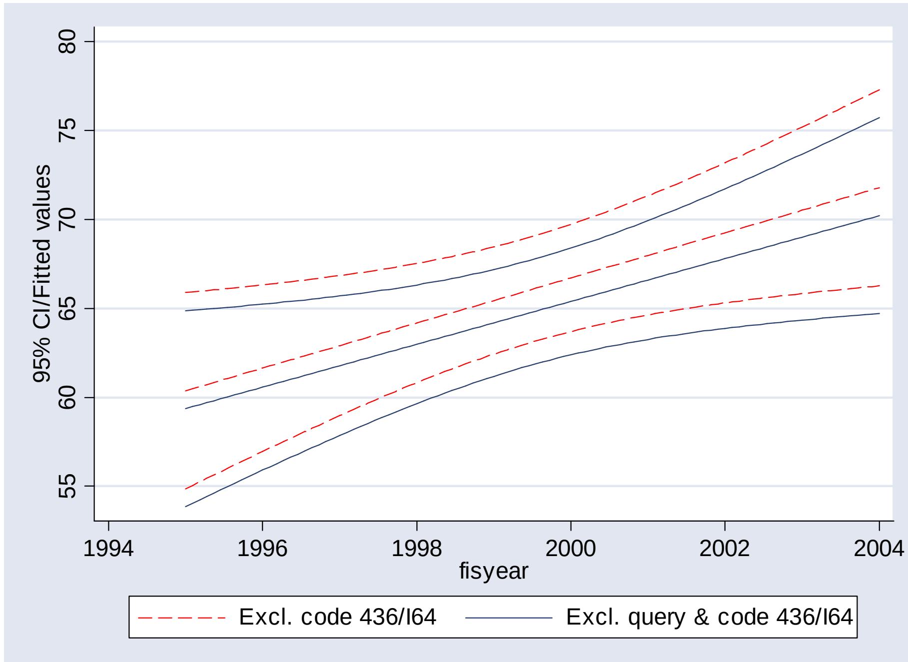


Figure 8.41 Trend of Age-adjusted Hospitalization Rate for AIS Excl. Unspecified Stroke in IP, 1995-2004



8.2.3.3 Trends of Age-gender Adjusted Hospitalization Rate for Stroke in IP

Table 8.11 – 8.13 list detailed age-gender adjusted hospitalization rates for stroke and stroke type in IP. We noticed higher age-gender adjusted stroke hospitalization rates in women than in men whether query diagnoses or unspecified stroke were included or not. Age-gender adjusted hospitalization rate for stroke in both sexes were stable around 124 per 100,000 person per year ($p > 0.6$), and did not change with query diagnoses or unspecified stroke excluded (Figure 8.42 – 8.44).

Table 8.11 Age-gender Adjusted Hospitalization Rate for Stroke in IP, 1995 - 2004

Year	Stroke		AIS		TIA		ICH		SAH	
	F	M	F	M	F	M	F	M	F	M
1995	135.86	129.62	86.84	89.83	24.12	19.25	14.6	13.03	10.29	7.51
1996	126.64	128.16	81.13	88.75	19.97	18.98	13.06	14.53	12.48	5.89
1997	124.96	100.49	80.52	66.73	22.88	16.09	13.66	11.58	7.9	6.09
1998	136.54	118.27	90.04	79.08	21.28	18.68	13.82	13.44	11.4	7.08
1999	140.42	119.37	93.83	78.77	21.39	19.12	12.11	15.06	13.1	6.42
2000	125.72	107.03	85.92	78	19.09	12.83	11.17	11.01	9.54	5.19
2001	126.33	107.09	86.09	76.43	17.06	14.71	12.8	12.14	10.37	3.81
2002	144.59	113.46	93.6	75.38	29.86	22.15	14.27	11.17	6.85	4.77
2003	119.89	124.49	74.11	78.51	27.33	30.46	9.8	12.07	8.66	3.46
2004	130.3	118.44	75.39	77.49	32.37	26.19	11.92	9.91	10.62	4.85

Table 8.12 Age-gender Adjusted Stroke Hospitalization Rate in Different Strata in IP, 1995 - 2004 (1)

Fiscal Year	Stroke Excl. I64		Stroke Excl. Q		Stroke Excl. Q & I64		AIS Excl. I64		AIS Excl. Q & I64	
	F	M	F	M	F	M	F	M	F	M
1995	108.63	105.73	132.93	126.87	107.18	104.03	59.62	65.95	59.09	64.54
1996	106.02	105.93	125.18	126.66	105.15	104.88	60.51	66.52	60.51	65.99
1997	105.31	81.86	121.39	98.46	101.74	80.37	60.87	48.1	59.73	47.61
1998	113.19	99.06	133.13	114.73	110.54	96.72	66.68	59.86	65.49	58.96
1999	115.36	101.11	133.55	112.62	109.95	96.26	68.76	60.51	65.66	58.19
2000	108.71	98.18	115.88	101.51	101.32	93.6	68.92	69.14	67.14	66.71
2001	112.59	100.83	119.96	102.18	108.16	96.79	72.35	70.16	70.99	68.28
2002	128.87	105.33	141.47	110.63	125.75	103.34	77.88	67.25	76.79	66.3
2003	113.9	117.69	116.14	121.67	111.33	115.5	68.12	71.71	66.98	70.94
2004	119.64	110.47	125.47	115.34	116.15	108.12	64.72	69.52	63.06	68.42

Note: Excl. I64 = Exclude unspecified stroke; Excl. Q = Exclude query diagnoses;

Excl. Q & I64 = Exclude query & unspecified stroke

Table 8.13 Age-gender Adjusted Stroke Hospitalization Rate in Different Strata in IP, 1995 - 2004 (2)

Fiscal Year	AIS Excl. Q		TIA Excl. Q		ICH Excl. Q		SAH Excl. Q	
	F	M	F	M	F	M	F	M
1995	84.84	87.37	23.2	18.95	14.6	13.03	10.29	7.51
1996	80.53	87.78	19.1	18.73	13.06	14.25	12.48	5.89
1997	79.38	65.7	20.45	15.09	13.66	11.58	7.9	6.09
1998	88.09	76.97	19.82	17.46	13.82	13.44	11.4	6.86
1999	89.26	74.55	19.78	16.59	11.84	15.06	12.67	6.42
2000	81.7	74.62	13.47	10.69	11.17	11.01	9.54	5.19
2001	82.78	73.67	14.17	12.78	12.63	11.93	10.37	3.81
2002	92.52	73.59	27.83	21.48	14.27	10.95	6.85	4.62
2003	71.79	77.12	25.89	29.03	9.8	12.07	8.66	3.46
2004	72.38	75.64	30.54	24.94	11.92	9.91	10.62	4.85

Note: Excl. Q = Exclude query diagnoses

Figure 8.42 Age-gender Adjusted Hospitalization Rate for Stroke in IP, 1995-2004 (1)

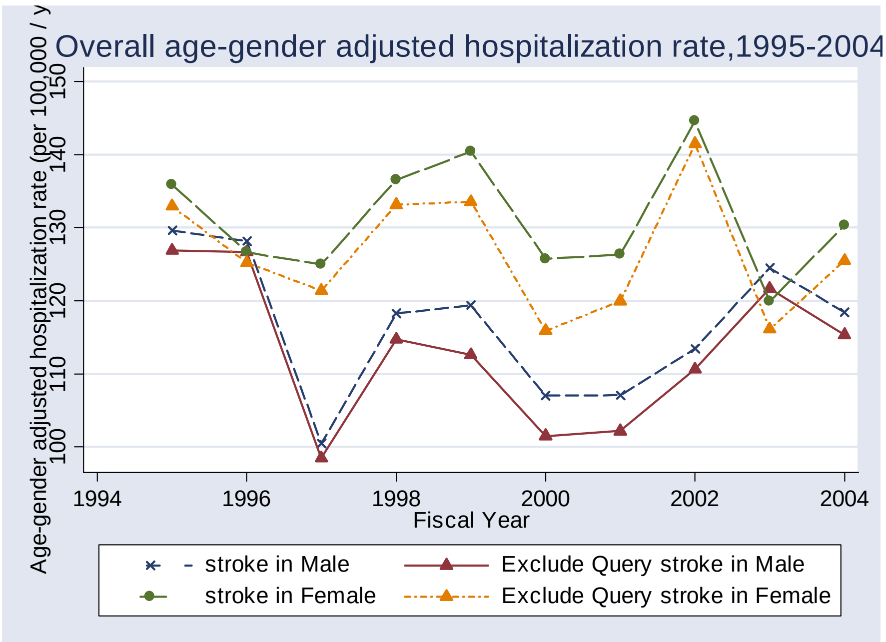


Figure 8.43 Age-gender Adjusted Hospitalization Rate for Stroke in IP, 1995-2004 (2)

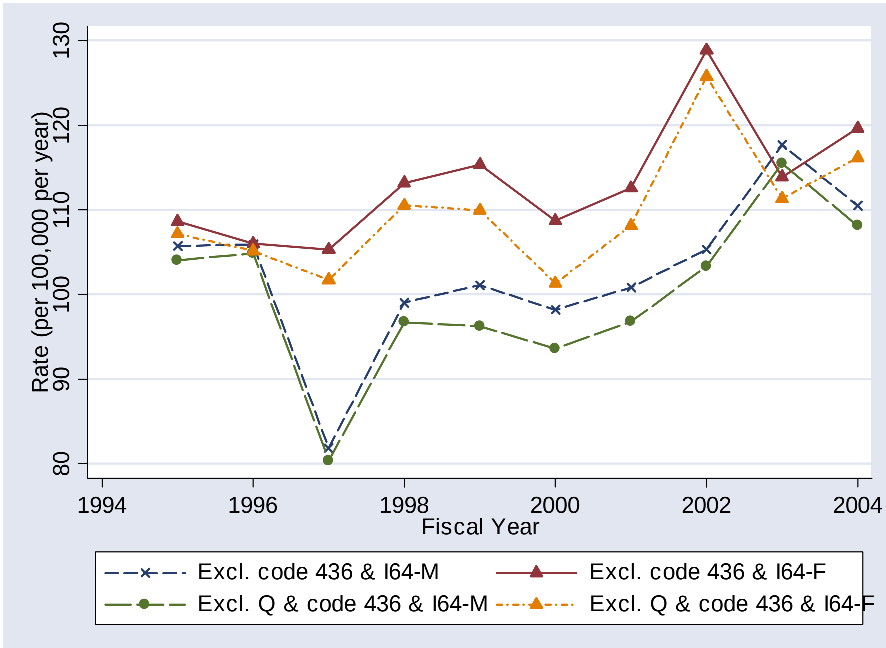
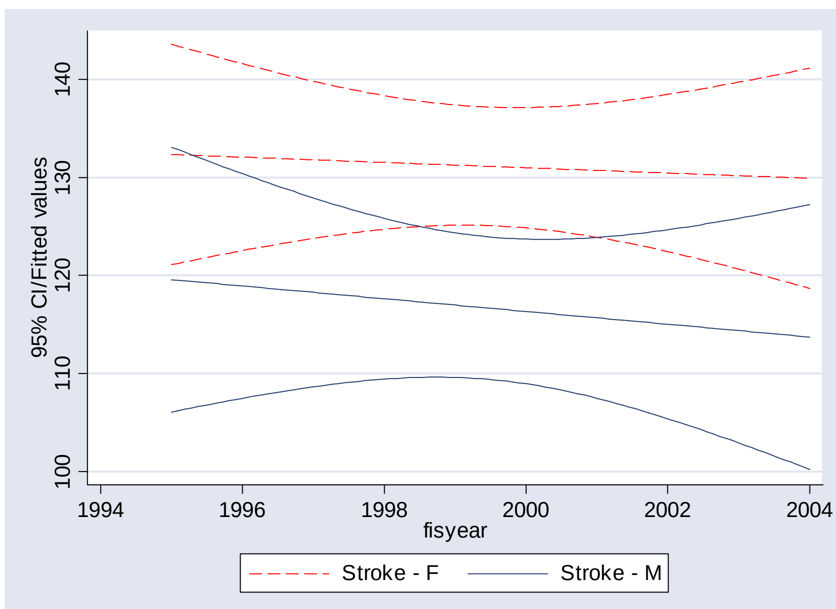


Figure 8.44 Trend of Age-gender Adjusted Hospitalization Rate for Stroke in IP, 1995-2004



Age-gender adjusted hospitalization rates for AIS in women and men were similar to those for all stroke. Both trends were stable whether query diagnosis or unspecified stroke excluded or not (all of p>0.27) (Fig 8.45 – 8.47).

Figure 8.45 Age-gender Adjusted Hospitalization Rate for AIS, 1995-2004

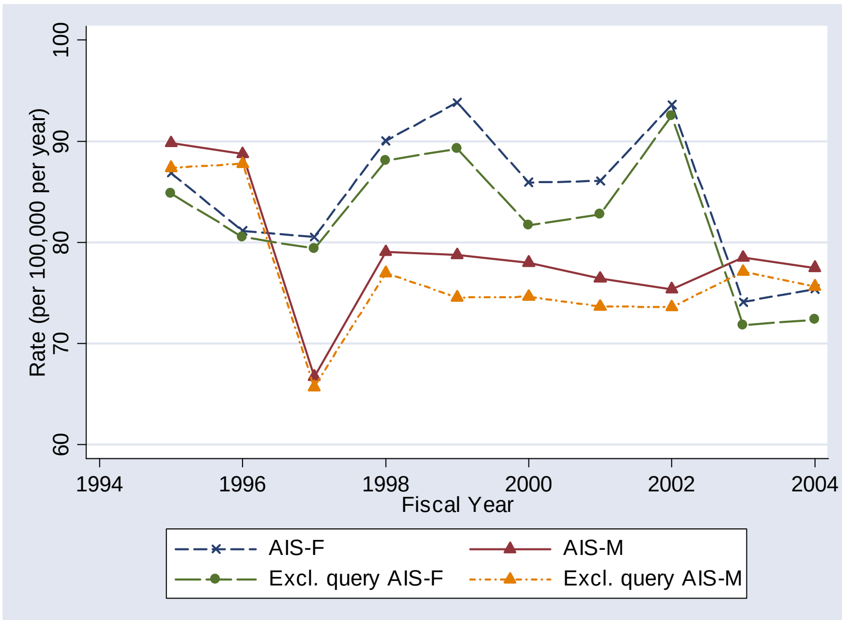


Figure 8.46 Age-gender Adjusted Hospitalization Rate for AIS in Different Strata, 1995-2004

Figure 8.47 Trend of Age-gender Adjusted Hospitalization Rate for AIS by Sex, 1995-2004 (1)

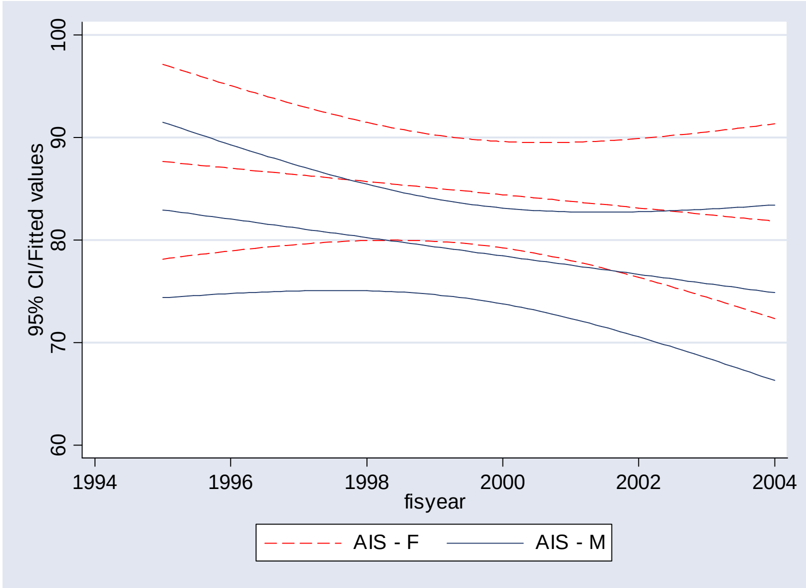


Figure 8.48 & 8.49 indicated that age-gender adjusted hospitalization rates for TIA were close for both sexes with a stable trend in women ($p > 0.10$), and a significantly rising trend in men ($p = 0.05$). The trends did not change when query diagnoses were excluded, yet with no significant difference in men.

Figure 8.48 Age-gender Adjusted Hospitalization Rate for TIA, 1995-2004

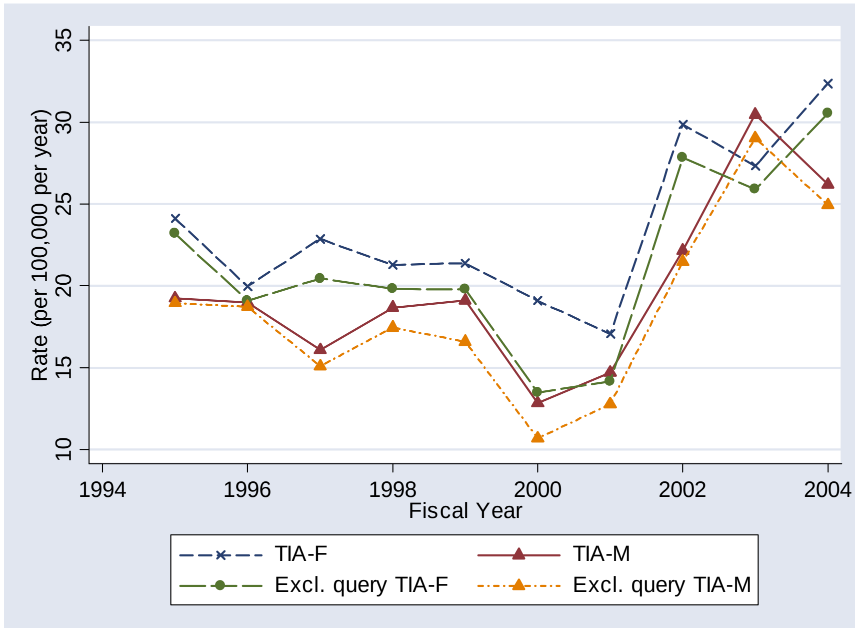
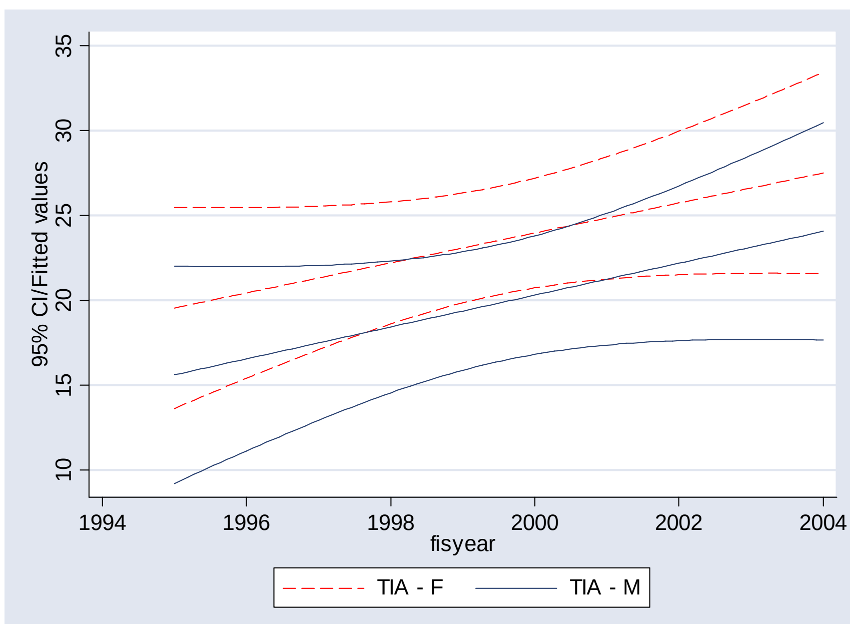


Figure 8.49 Trend of Age-gender Adjusted Hospitalization Rate for TIA, 1995-2004



Age-gender adjusted hospitalization rates for ICH fluctuated for both sexes over time but were stable ($p > 0.46$) whether query diagnoses were excluded or not (see Figure 8.50 – 8.51).

Figure 8.50 Age-gender Adjusted Hospitalization Rate for ICH in Different Strata, 1995-2004

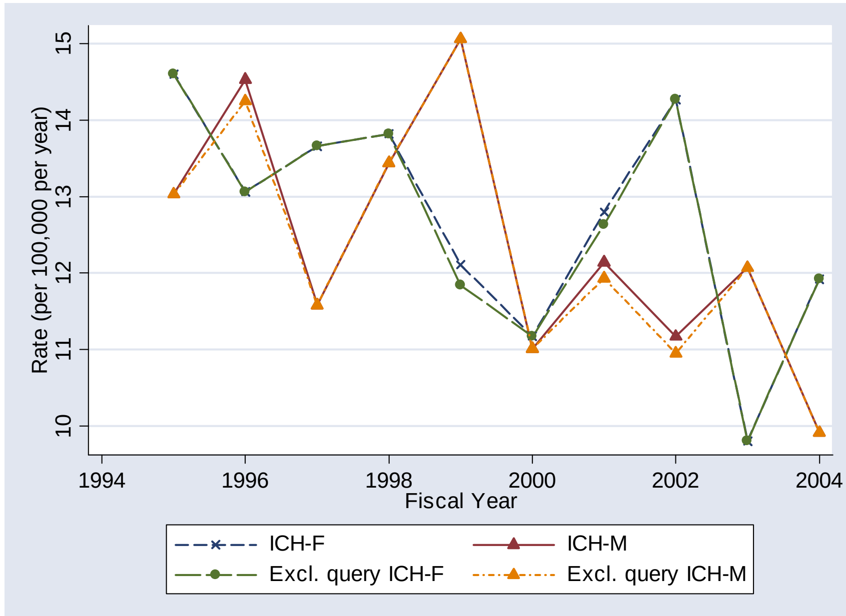
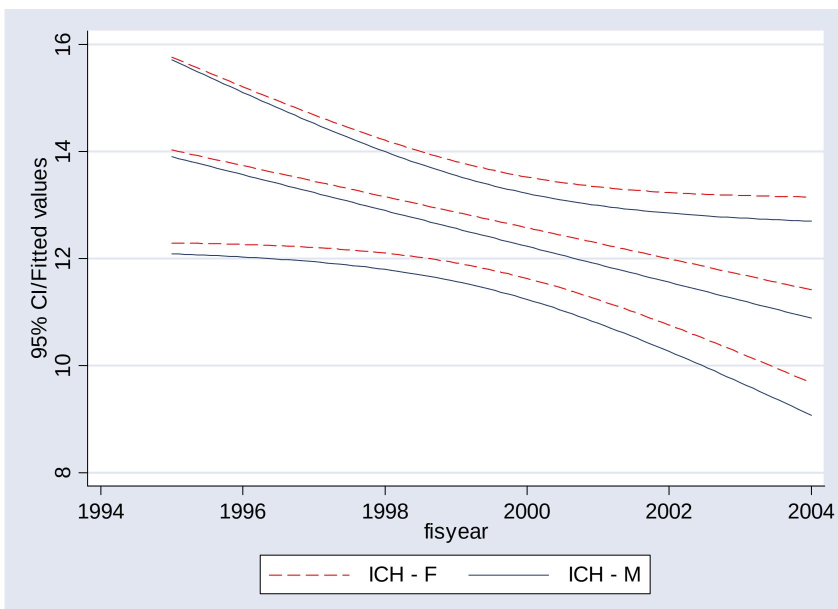


Figure 8.51 Trend of Age-gender Adjusted Hospitalization Rate for ICH, 1995-2004



Age-gender adjusted hospitalization rates for SAH were higher in women than in man, but stable ($p > 0.5$), and the trends did not change when query diagnoses were excluded in both sexes (Figure 8.52 – 8.53).

Figure 8.52 Age-gender Adjusted Hospitalization Rate for SAH in Different Strata, 1995-2004

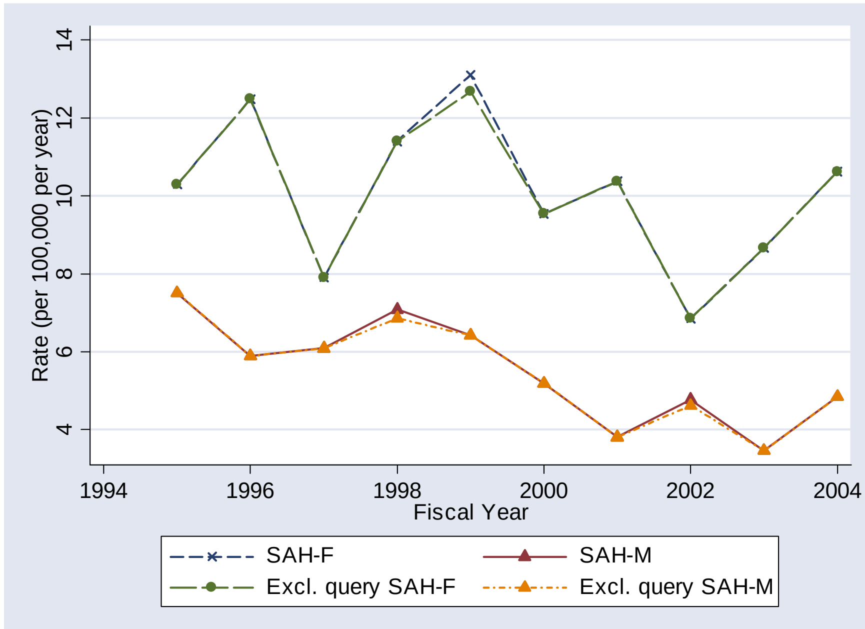
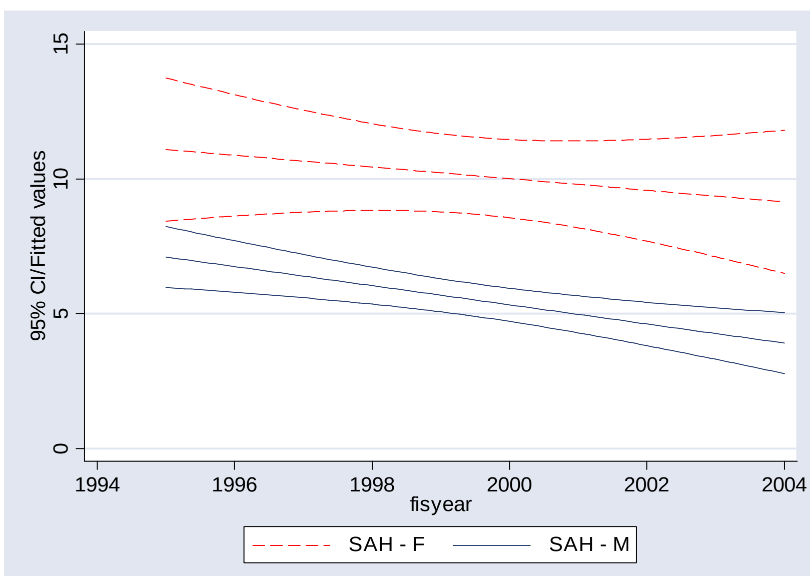


Figure 8.53 Trend of Age-gender Adjusted Hospitalization Rate for SAH, 1995-2004



8.2.4 Study of In-hospital Case-Fatality During 1995 – 2004

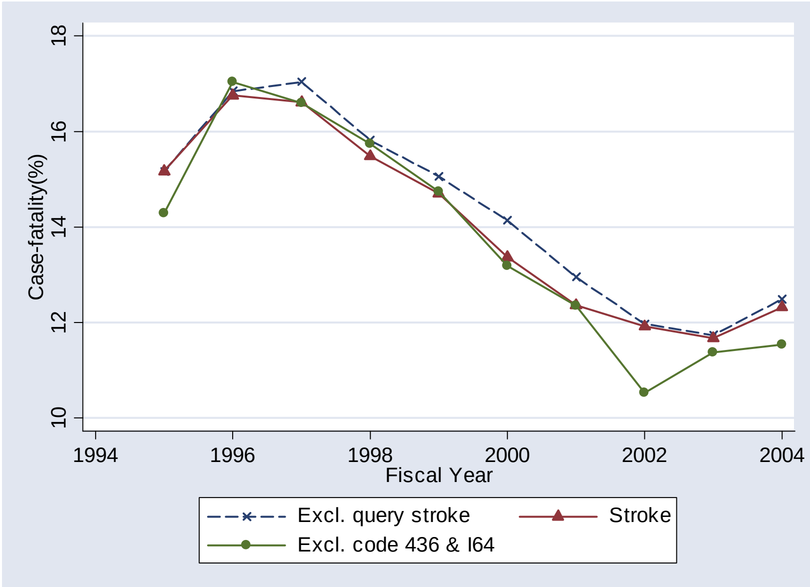
8.2.4.1 Trends of In-hospital Case-Fatality for Stroke

Table 8.14 presented the in-hospital case-fatality for stroke during 1995-2004 for different situation. Figure 8.54 illustrated continuous decline since 1996 for all stroke with significant difference ($p < 0.002$) whether query stroke or unspecified stroke was excluded or not.

Table 8.14 In-hospital Case-Fatality for Stroke, 1995 – 2004 (%)

Year	Case_fatality	Case_fatality Excl. Unspecified Stroke	Case_fatality Excl. Query Stroke
1995	15.16	14.28	15.17
1996	16.75	17.03	16.84
1997	16.60	16.59	17.03
1998	15.48	15.73	15.81
1999	14.70	14.73	15.05
2000	13.36	13.18	14.13
2001	12.36	12.34	12.95
2002	11.92	10.52	11.96
2003	11.67	11.36	11.73
2004	12.31	11.53	12.48

Figure 8.54 In-hospital Case-Fatality for Stroke, 1995-2004



8.2.4.2 Trends of In-hospital Case-Fatality by Stroke Type

1,488 deaths were found from 1995 to 2004 with higher death and case-fatality in hemorrhagic stroke (the highest in ICH), and lower death and case-fatality in ischemic stroke (the lowest in TIA). Table 8.15 listed detailed number of in-hospital case-fatality by stroke type. In-hospital AIS case-fatality has experienced a sharp decline whether unspecified stroke is counted or not ($p < 0.003$) (Table 8.15, Figure 8.55 & 8.56). A total of eight deaths were found in ten years, and case-fatality for TIA was quite low (close to 0) and stable over time as shown in Figure 8.57. Case-fatality for hemorrhagic forms of stroke (ICH and SAH) was stable (Figure 8.58). A curvilinear trend for SAH case-fatality was detected in IP data set (Figure 8.59).

Table 8.15 In-hospital Case-Fatality by Stroke Type, 1995 – 2004 (%)

Year	AIS	TIA	ICH	SAH	AIS Excl. Unspecified Stroke
1995	14.22	0	32.67	31.94	12.36
1996	15.79	0.68	31.192	34.17	15.96
1997	14.05	0.67	51.04	24.61	13.12
1998	13.99	0.63	37.14	27.90	13.92
1999	13.47	0.59	31.35	29.54	13.12
2000	12.86	0	32.98	18.30	12.5
2001	10.58	0.69	27.27	28.37	10.32
2002	12.26	0.40	28.20	22.22	10.04
2003	10.58	0	37.39	30.30	9.97
2004	11.21	0.67	33.65	36.90	9.29

Figure 8.55 In-hospital Case-Fatality by Stroke Type, 1995-2004

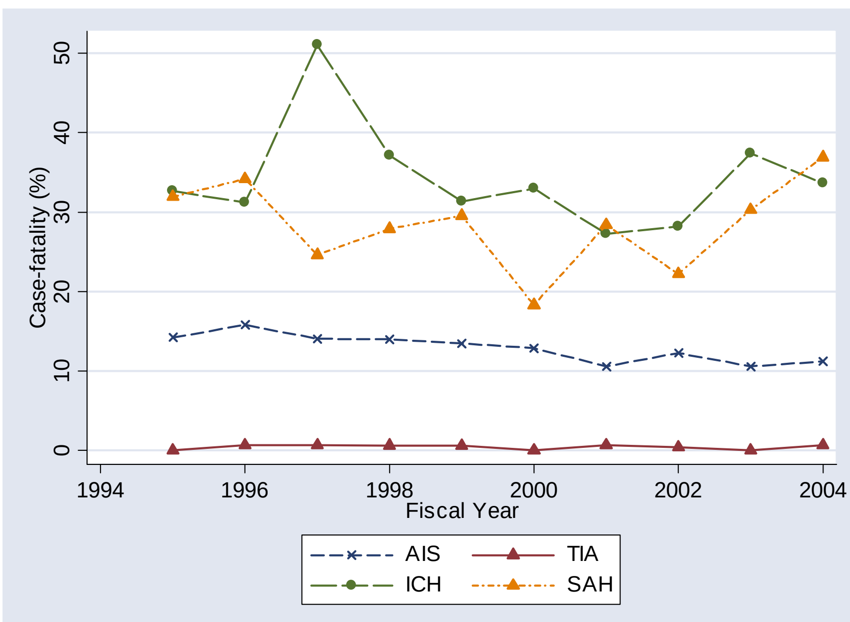


Figure 8.56 Trend of In-hospital Case-Fatality for AIS, 1995-2004

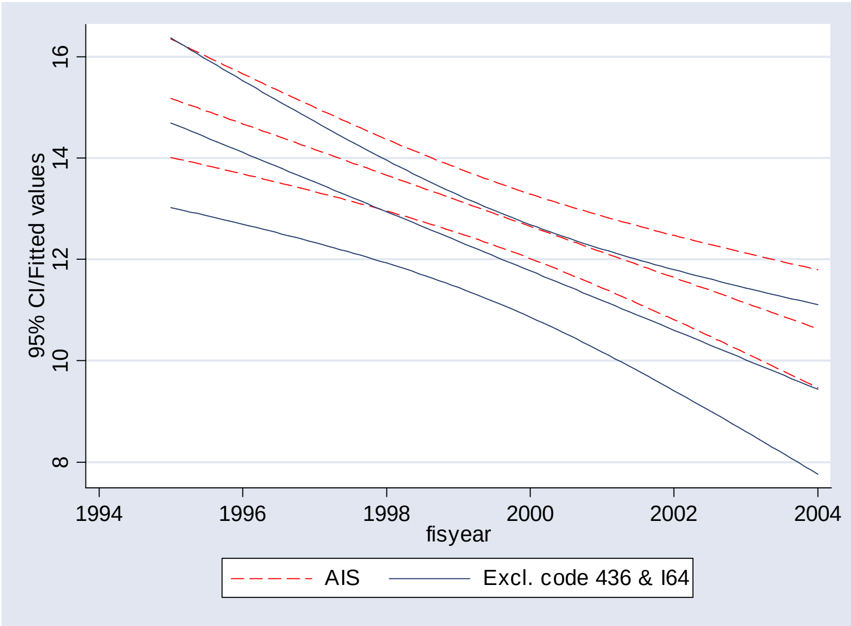


Figure 8.57 Trend of In-hospital Case-Fatality for Ischemic Stroke, 1995-2004

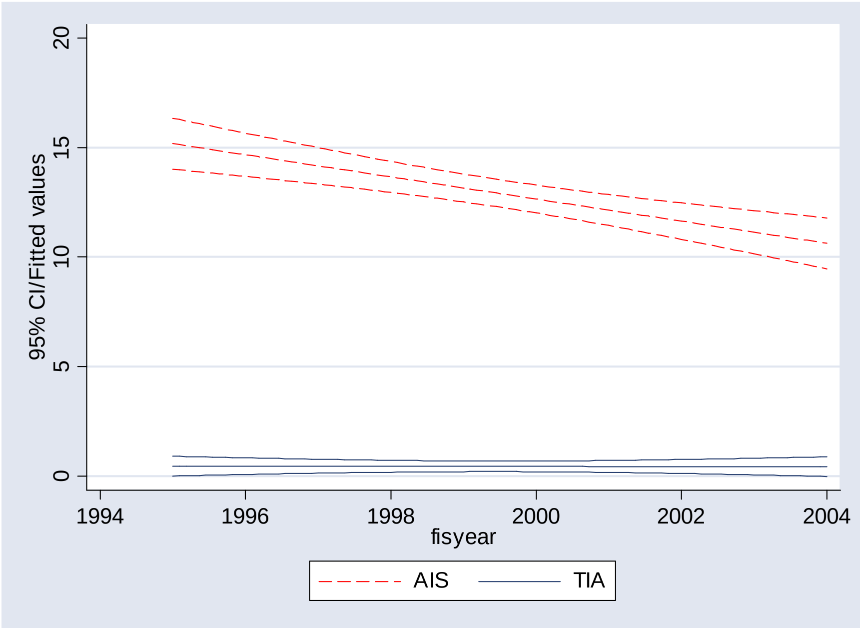


Figure 8.58 Trend of In-hospital Case-Fatality for Hemorrhagic Stroke, 1995-2004

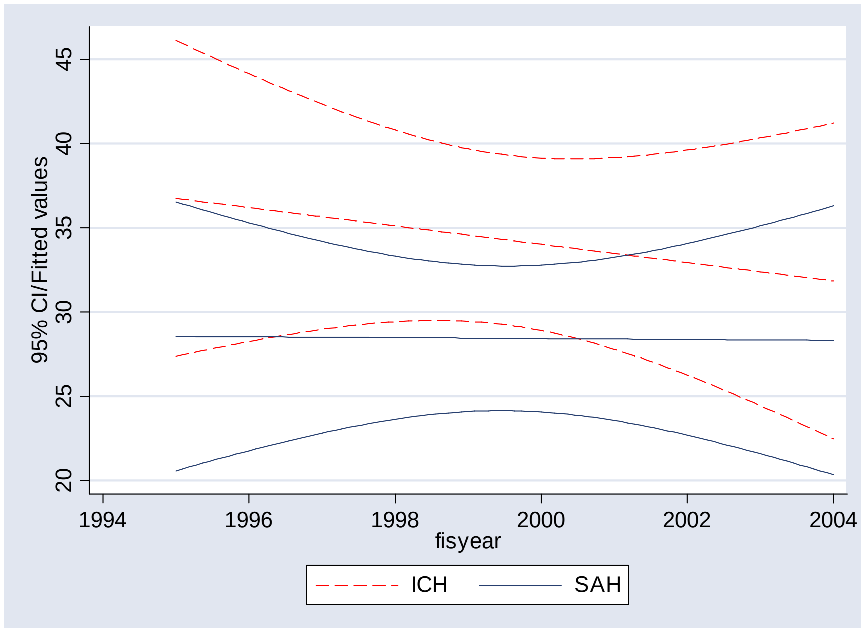
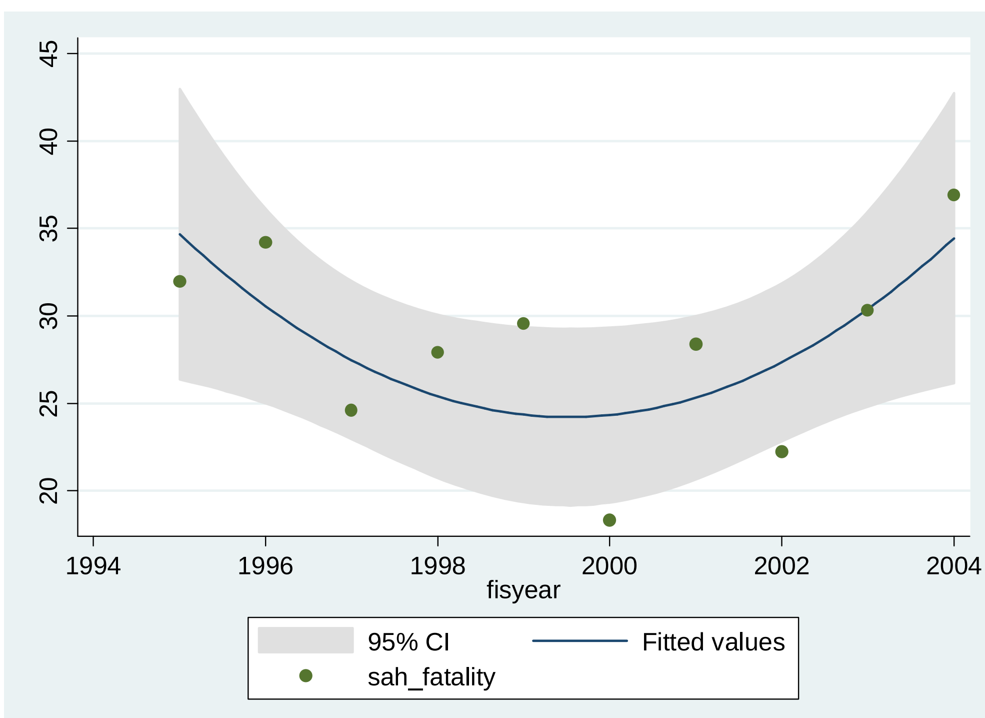


Figure 8.59 Curvilinear Trend for In-hospital Case-fatality of SAH in IP



8.2.4.3 Trends of In-hospital Case-Fatality for Stroke and Stroke Type by Sex

A secondary analysis was developed to show the trends of in-hospital case-fatality for stroke and stroke type by sex. Table 8.16 & 8.17 summarize the in-hospital case-fatality in each stratum. We observed higher in-hospital case-fatality in women than in men for overall stroke, and declining trends of in-hospital case-fatality in both sexes whenever unspecified stroke was excluded ($p < 0.002$) (Figure 8.60 – 8.62). The in-hospital case-fatality for AIS in both sexes show an overall decreasing trends for both sexes ($p < 0.038$) (Figure 8.63 & 8.64). Figure 8.65 to 8.68 indicate the fluctuation of in-hospital case-fatality for ICH and SAH, likely due to the relatively small number of annual cases.

Table 8.16 In-hospital Case-Fatality for Stroke by Sex, 1995 – 2004 (%)

Year	F	M	M Excl. Q	F Excl. Q	F Excl. I64	M Excl. I64
1995	15.91837	14.42886	14.31493	16.04167	13.41772	15.12195
1996	19.08894	14.62451	14.6	19.29824	19.84536	14.45498
1997	18.18182	14.77833	15.07538	18.73638	17.92929	15.01501
1998	16.60377	14.28572	14.52282	17.02128	16.96833	14.42308
1999	16.69627	12.59398	12.97405	17.00935	16.84665	12.58278
2000	11.98502	14.86762	15.41756	12.90984	11.6129	14.79029
2001	13.43013	11.2381	11.8	14.04175	13.59026	11.11111
2002	12.14953	11.66078	11.5942	12.30032	9.756097	11.36364
2003	14.46208	9.270516	9.33126	14.54545	13.86322	9.193548
2004	14.02936	10.65183	10.6383	14.40678	12.61101	10.50847

Note: F = Female; M = Male; Excl. Q = Exclude query diagnoses; Excl. I64 = Exclude unspecified stroke

Table 8.17 In-hospital Case-Fatality by Stroke Type & Sex, 1995 - 2004

Year	AIS - F	AIS - M	ICH - F	ICH - M	SAH - F	SAH - M
1995	16.8254	11.84971	27.45098	38	27.5	37.5
1996	17.64706	14.24419	36.7347	26.66667	35.84906	30.76923
1997	17.37705	10.22727	51.02041	51.06383	22.85714	26.66667
1998	15.36232	12.57485	34	40	32.07547	21.21212
1999	15.5496	11.23919	34.69388	28.98551	31.57895	25.80645
2000	12.04482	13.68715	33.33334	32.65306	11.11111	30.76923
2001	11.89189	9.264305	23.72881	30.64516	29.41177	26.08696
2002	14.21569	10.13333	17.74194	40	24.32433	19.23077
2003	13.74269	7.971015	40.81633	34.84848	33.33334	23.80952
2004	13.10541	9.58231	36.53846	30.76923	36.36364	37.93103

Note: F = Female; M = Male

Figure 8.60 In-hospital Case-Fatality for Stroke by Sex, 1995-2004 (1)

Figure 8.61 In-hospital Case-Fatality for Stroke by Sex, 1995-2004 (2)

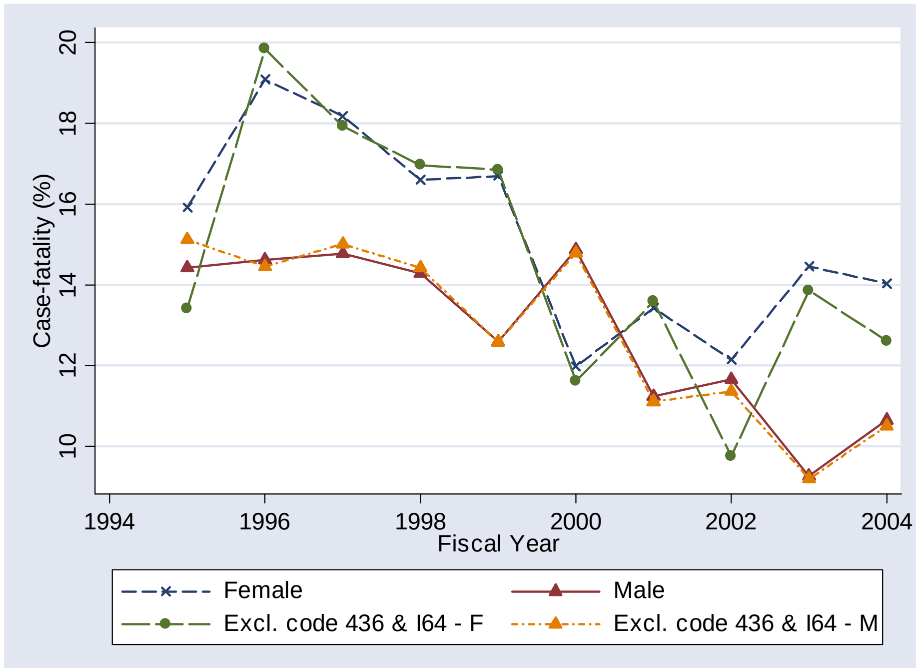


Figure 8.62 Trend of In-hospital Case-Fatality for Stroke by Sex (1)

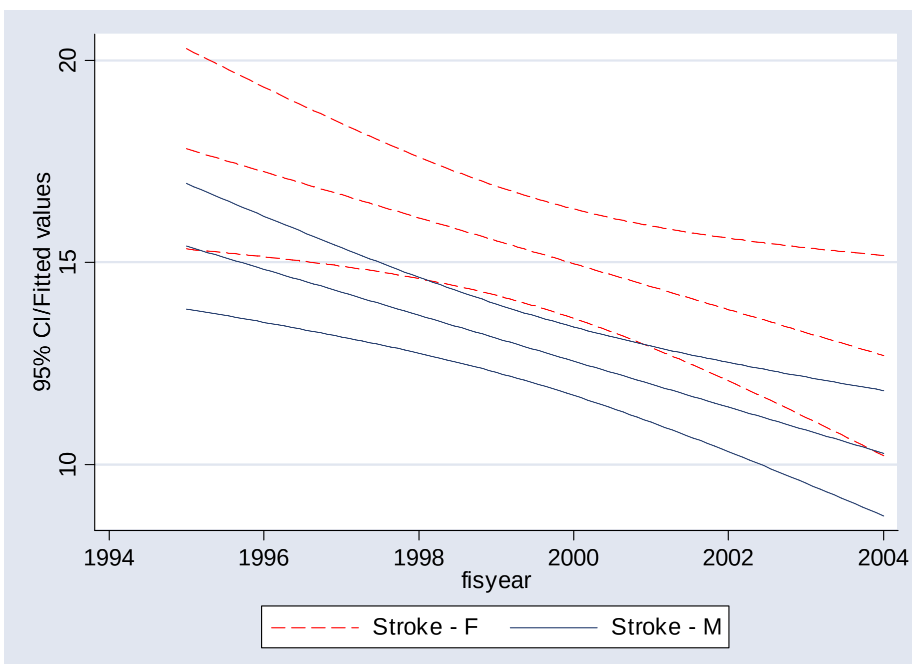


Figure 8.63 In-hospital Case-Fatality for AIS by Sex, 1995-2004

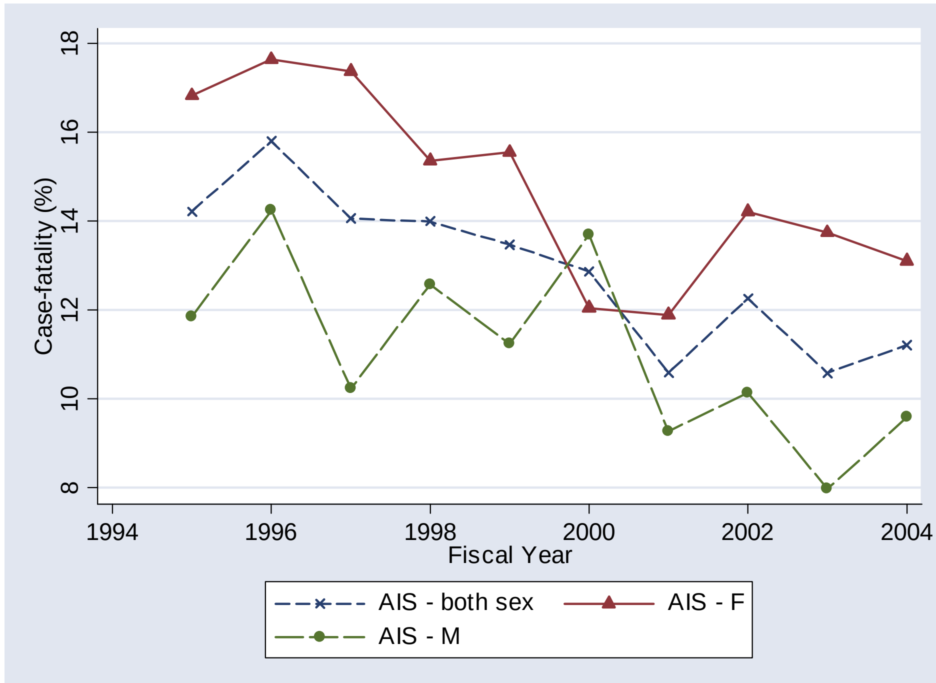


Figure 8.64 Trend of In-hospital Case-Fatality for AIS by Sex, 1995-2004

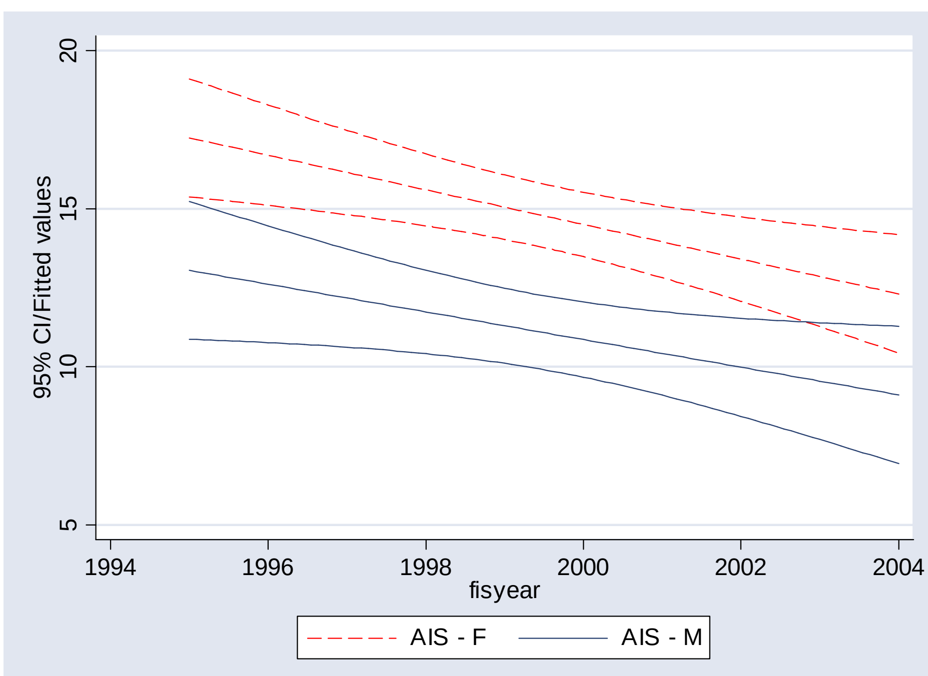


Figure 8.65 Trend of In-hospital Case-Fatality for ICH by Sex, 1995-2004

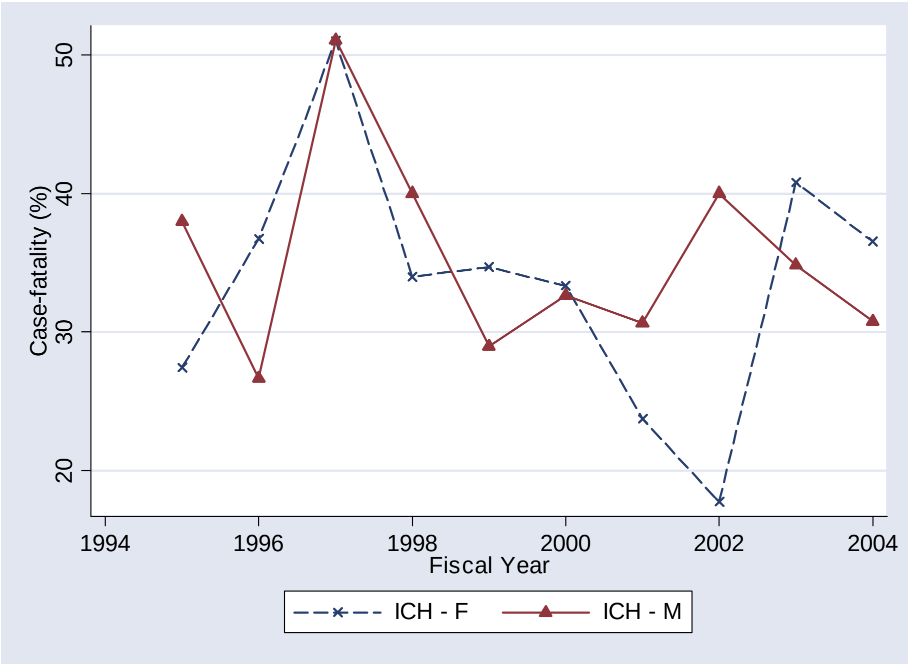


Figure 8.66 Trend of In-hospital Case-Fatality for ICH by Sex, 1995-2004

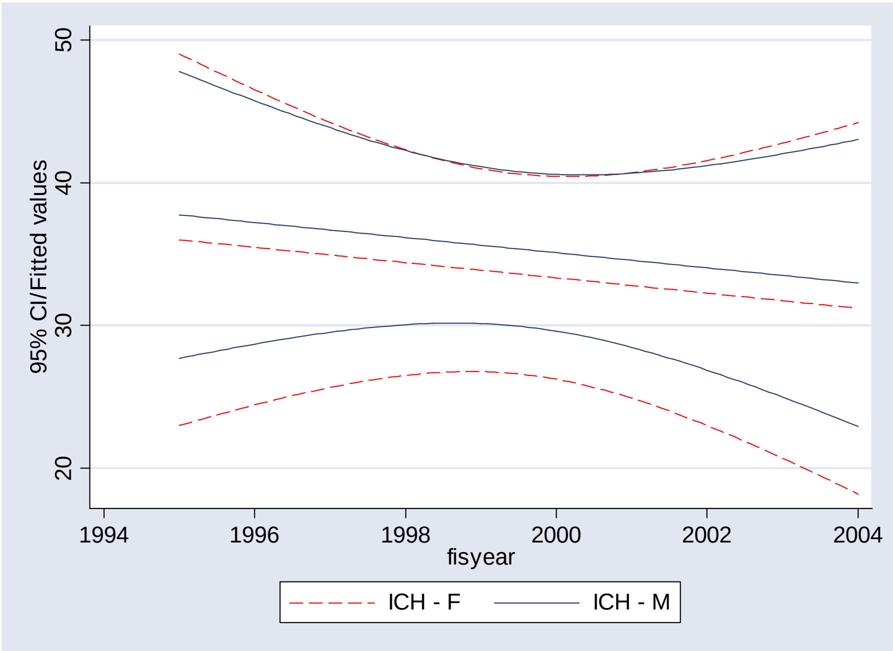


Figure 8.67 Trend of In-hospital Case-Fatality for SAH by Sex, 1995-2004

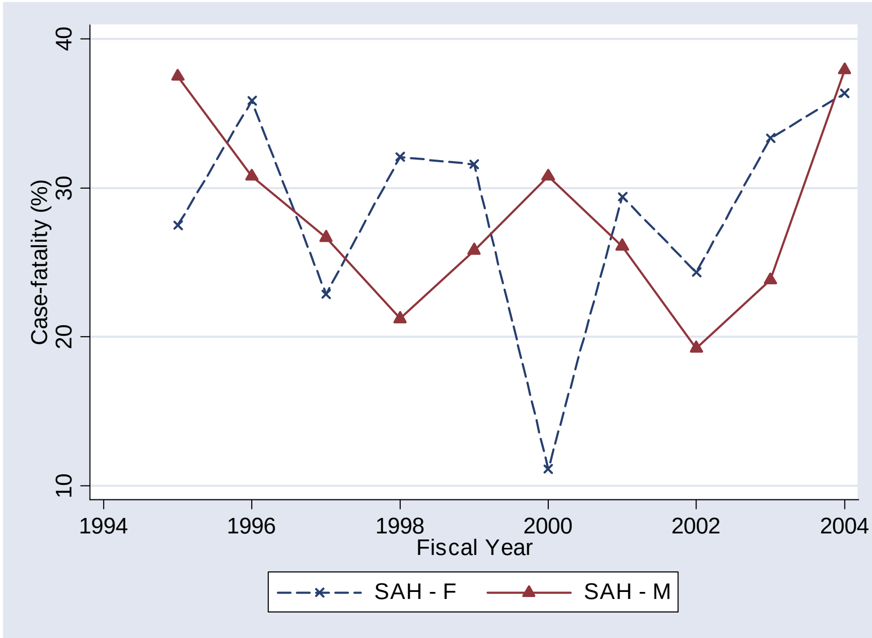
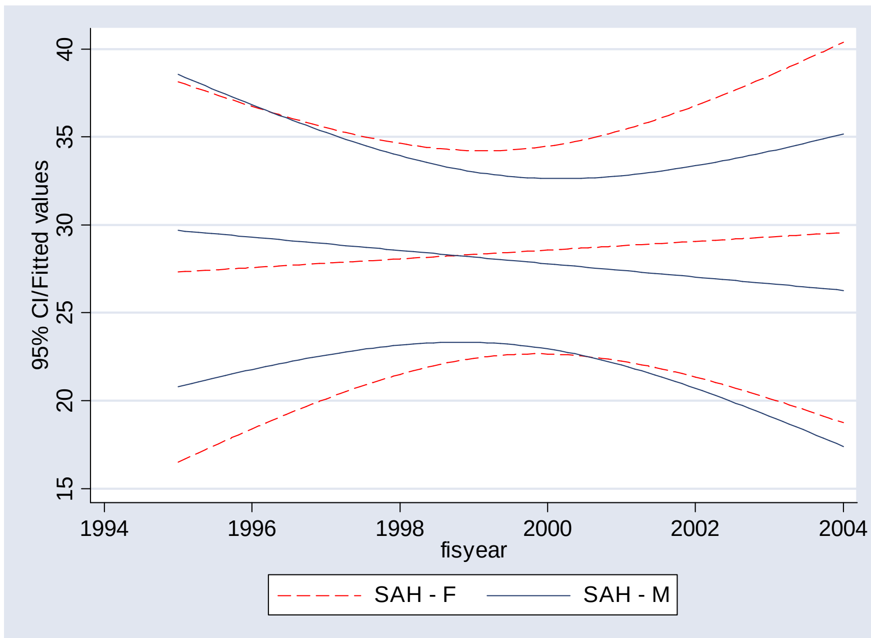


Figure 8.68 Trend of In-hospital Case-Fatality for SAH by Sex, 1995-2004



CHAPTER NINE: RESULTS FOR TRENDS OF STROKE IN EMERGENCY ROOM (ER)

9.1 Study Population in Emergency Room (ER)

We identified 16,251 stroke subjects who visited emergency room between 1996 and 2004 from ER data (see Figure 7.1 flow chart), and developed the analysis on trends of stroke in emergency room during this period.

9.2 Trends of Stroke in Emergency Room (ER)

9.2.1 Description of Study Population in Emergency Room (ER)

The median age for stroke patients in ER ranged from 71 – 73 yr. Female accounted for almost 51% in stroke patients. The distributions of stroke type were comparable over time with an average of 51% for AIS, 36% for TIA, 6% for ICH and 7% for SAH (Table 9.1).

Table 9.1 Demographic Characteristics for the Study Population in ER, 1996- 2004

Fiscal year	1996*	1997	1998	1999	2000	2001	2002	2003	2004	Total
Number	1195	1642	1715	2001	1951	2030	1843	1900	1974	16,251
Mean age (SD), y	70 (15)	70 (15)	70 (15)	69 (15)	68 (16)	69 (16)	69 (15)	70 (16)	68 (16)	69 (16)
Median age (IQR), y	73 (62-80)	72 (62-80)	73 (62-81)	72 (60-80)	72 (58-81)	73 (60-81)	73 (60-81)	73 (60-81)	71 (58-81)	72 (60-81)
Female, n (%)	568 (48)	838 (51)	872 (51)	1034 (52)	1015 (52)	1067 (53)	976 (53)	940 (49)	1005 (51)	8315 (51)
Stroke Type, n (%)										
AIS	628 (53)	862 (53)	889 (52)	964 (48)	985 (50)	987 (49)	918 (50)	996 (52)	1014 (51)	8243 (51)
TIA	417 (35)	570 (35)	586 (34)	749 (37)	715 (37)	755 (37)	718 (39)	687 (36)	698 (35)	5895 (36)
ICH	78 (7)	97 (6)	101 (6)	129 (6)	99 (5)	110 (5)	97 (5)	103 (5)	119 (6)	933 (6)
SAH	72 (6)	113 (7)	139 (8)	159 (8)	152 (8)	178 (9)	110 (6)	114 (6)	143 (7)	1180 (7)

Note: * Three months ER data (from April to June) were not available for stroke patients in fiscal 1996. We only studied the trend of stroke in ER data from 1997 to 2004.

9.2.2 Trends of Stroke Occurrence in Emergency Room (ER)

9.2.2.1 Trends of Overall Stroke Occurrence in ER

Table 9.2 shows the absolute number of stroke occurrence in ER from 1997 to 2004. Figure 9.1 to 9.3 illustrates the trends of stroke admission cases that were identified from hospital discharge abstract.

Table 9.2 Number of Stroke Admission in IP

Year	Stroke	Stroke Excl. Q	Stroke Excl. I64	Stroke Excl. Q & I64
1997	1642	1103	879	542
1998	1715	1239	959	660
1999	2001	1453	1187	832
2000	1951	1379	1086	712
2001	2030	1571	1167	856
2002	1843	1503	1022	776
2003	1900	1511	1040	788
2004	1974	1556	1124	846

Note: Excl.Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query and unspecified stroke.

The number of strokes increased 20.2% from 1642 in year1997 to 1974 in 2004 with a stable trend ($p = 0.16$). Figure 9.1 & 9.2 illustrate a flat trend of stroke occurrence in ER whenever unspecified stroke excluded ($p = 0.27$), and a significant continuous rising trend of stroke when query diagnoses were excluded or both of query and unspecified stroke were excluded (both $p < 0.04$) (Figure 9.3).

Figure 9.1 Number of Stroke in ER, 1997-2004

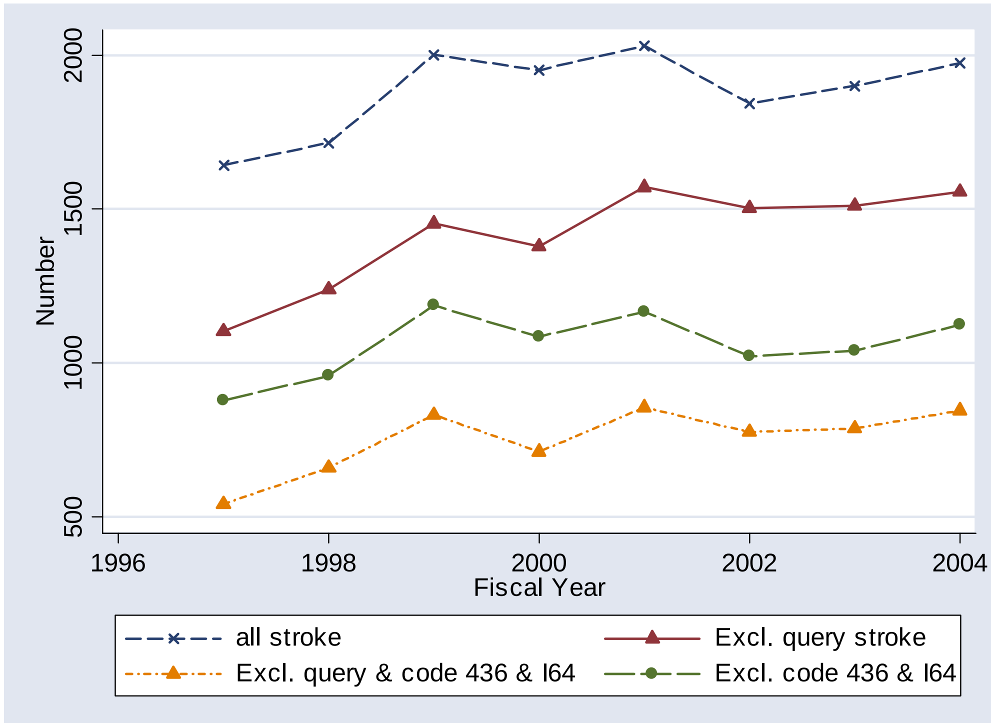


Figure 9.2 Trend of Stroke in ER, 1997-2004 (1)

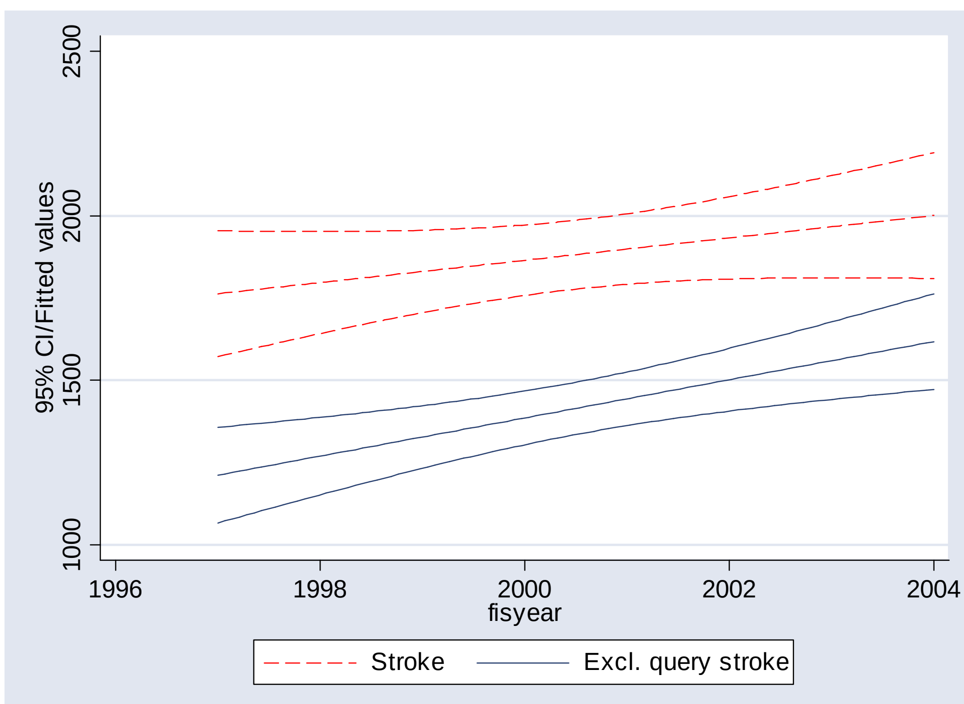
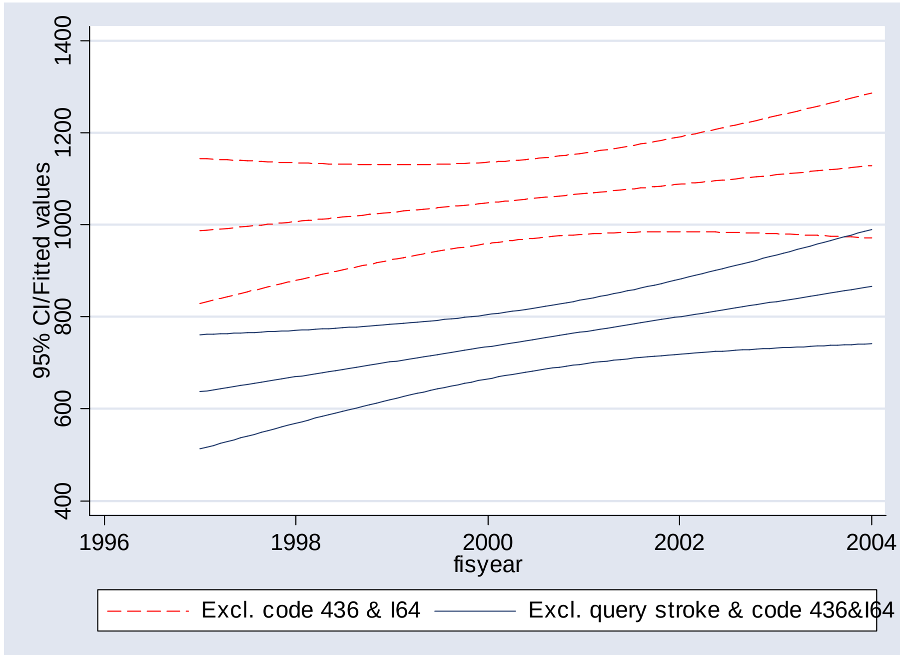


Figure 9.3 Trend of Stroke in ER, 1997-2004 (2)



Linear projections of the stroke occurrence into the future imply a stable rate (increase of 34 strokes per year (95%CI: -12 to 80)). However, the trend is increasing at 58 (95% CI: 23-93) or 33 (95% CI: 3-62) stroke per year if query diagnoses or both of query and unspecified stroke excluded in the projection, respectively (Table 9.3).

Table 9.3 Projection of Increased Stroke Cases in Future in ER (per year)

	All stroke	**Excl. query stroke ***	**Excl. unspecified stroke**	**Excl. both query & unspecified stroke ***
Number of increased stroke (per year)	34	58	20	33
95% CI	-12 - 80	23 - 93	-17 - 58	3 - 62

* Linear projection is significant with p value < 0.003.

9.2.2.2 Trends of Stroke Occurrence by Stroke Type

Table 9.4 below presented the detailed number of stroke occurrence by stroke type from 1997 to 2004.

Table 9.4 Number of Stroke Occurrence by Stroke Type in ER

Year	AIS	TIA	ICH	SAH	AIS Excl. Q	TIA Excl. Q	ICH Excl. Q	SAH Excl. Q	AIS Excl. I64	AIS Excl. Q&I64
1997	862	570	97	113	651	304	80	68	99	90
1998	889	586	101	139	694	370	97	78	133	115
1999	964	749	129	159	749	501	120	83	150	128
2000	985	715	99	152	755	453	90	81	120	88
2001	987	755	110	178	823	529	102	117	124	108
2002	918	718	97	110	812	505	97	89	97	85
2003	996	687	103	114	846	483	101	81	136	123
2004	1014	698	119	143	860	480	116	100	164	150

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q&I64 = Exclude query & unspecified stroke

The number of AIS occurrence increased 17.6% from 862 in 1997 to 1014 in 2004 in ER with a continuous significant increase ($p = 0.025$) (Figure 9.4 & 9.7). The number of AIS occurrence increased sharply ($p = 0.003$) if query diagnoses were excluded, yet not when unspecified stroke or both of query and unspecified stroke were excluded ($p > 0.27$) (Figure 9.5 – 9.8). We noticed a 15% - 25% reduced AIS occurrence when query diagnoses were excluded, and much higher reduction (around 90%) when unspecified stroke dropped.

Figure 9.4 Number of Stroke Occurrence by Type in ER, 1997-2004

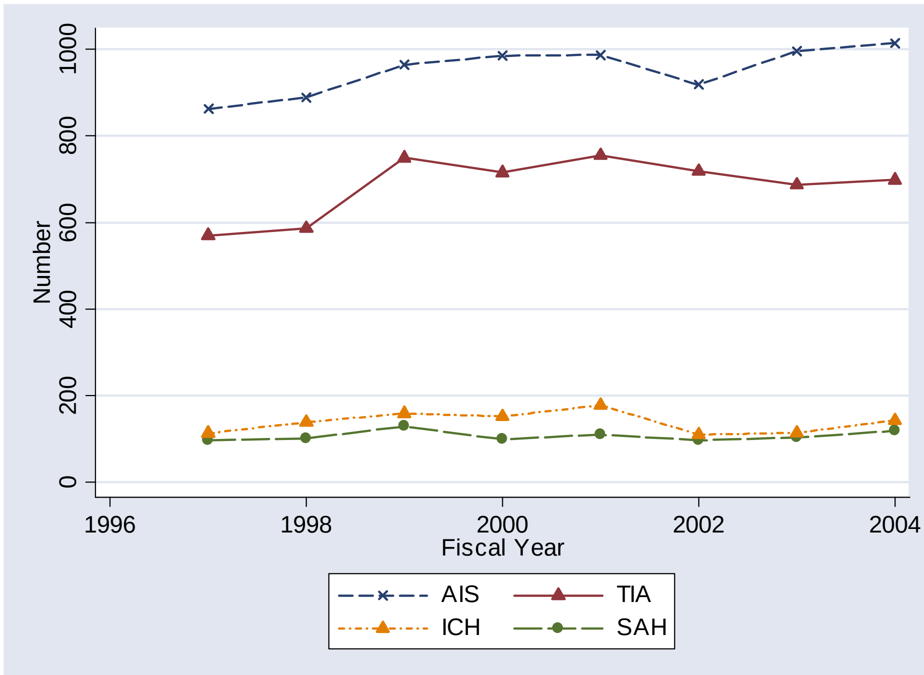


Figure 9.5 Number of AIS Exclude Query & Unspecified Stroke in ER, 1997-2004

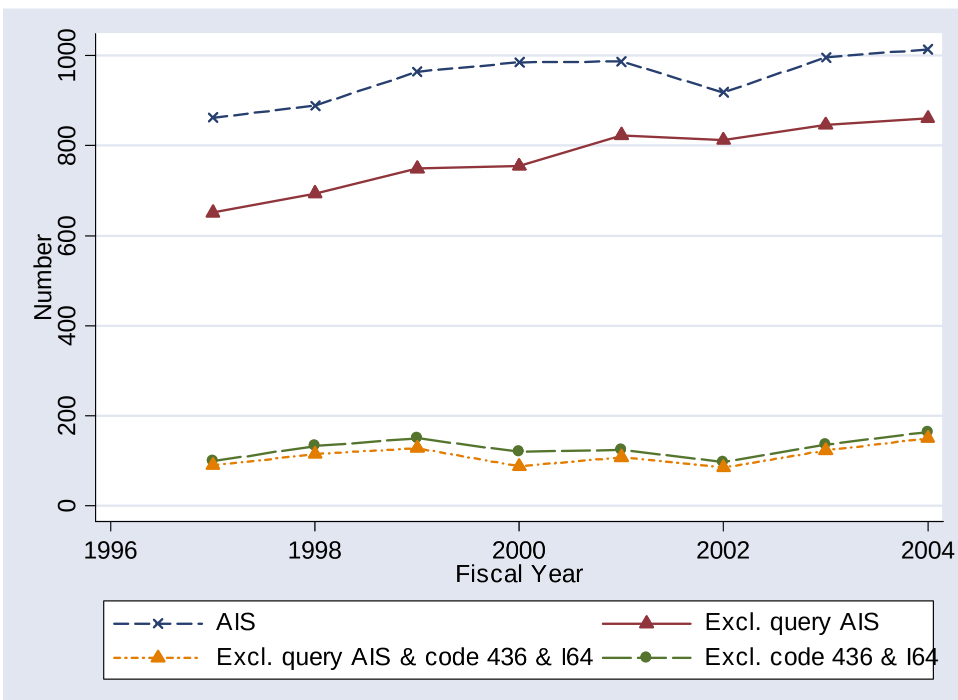


Figure 9.6 Number of Stroke by Type Excl. Query Stroke in ER Data,1997-2004

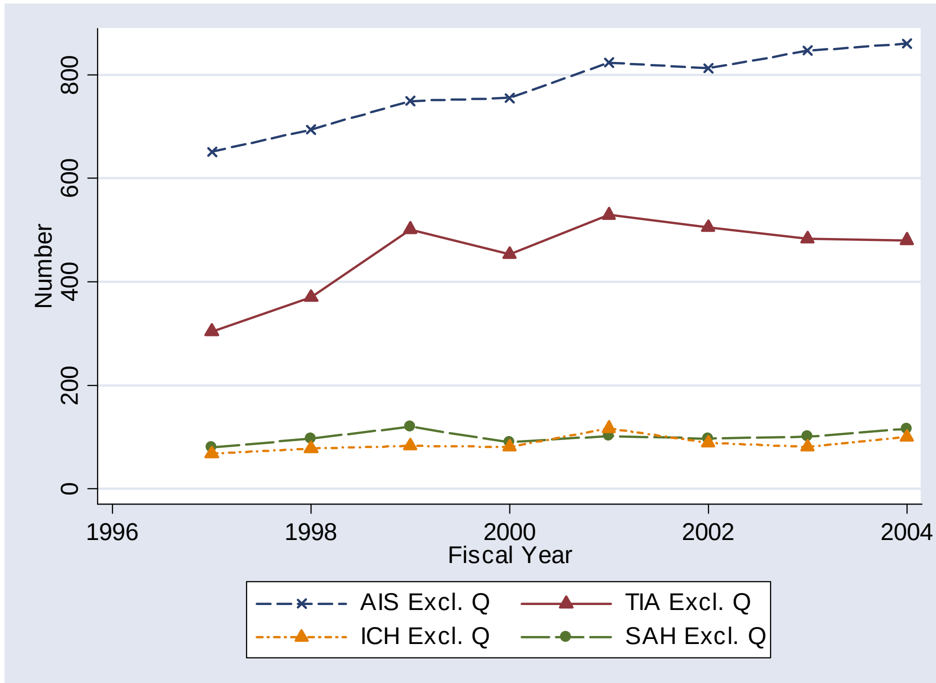


Figure 9.7 Trend of AIS Admission in ER, 1997-2004 (1)

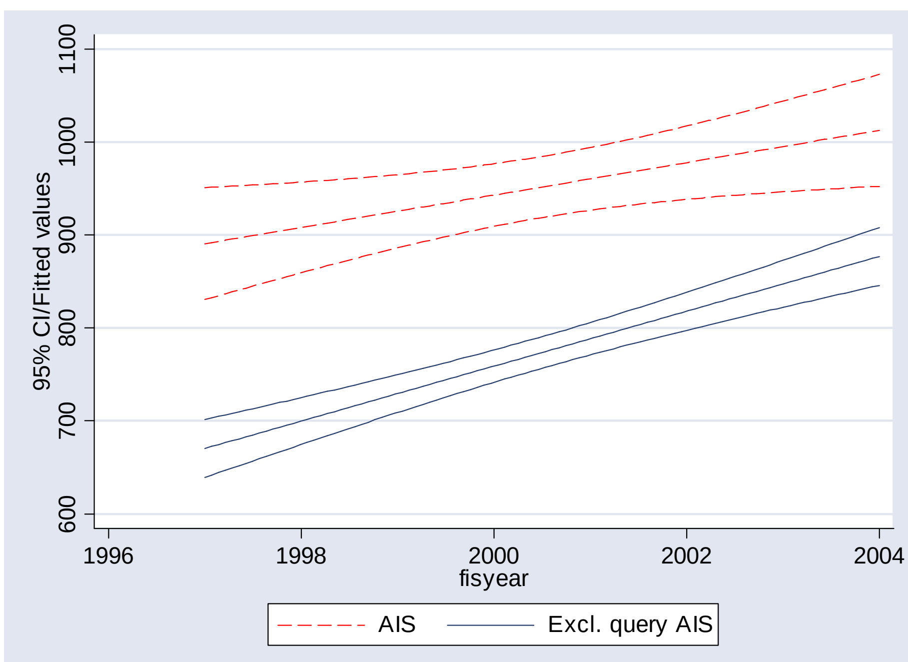
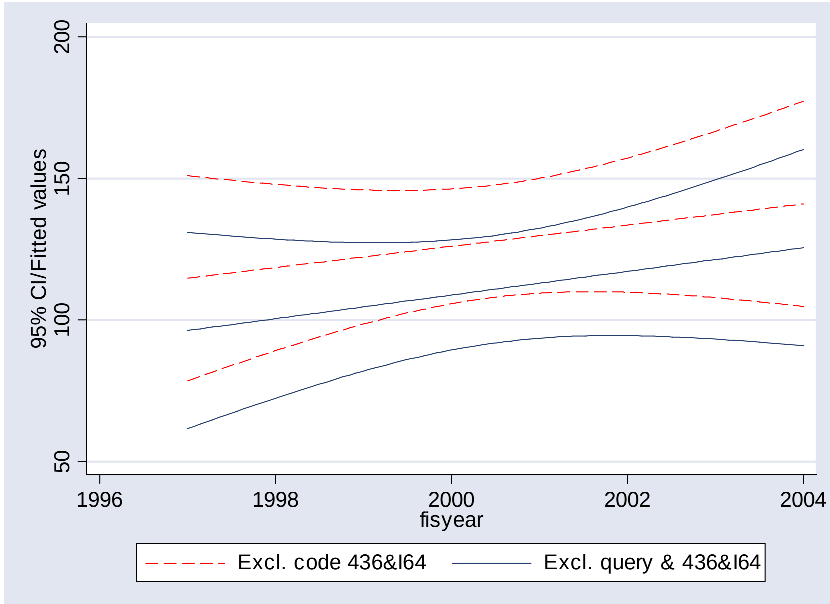


Figure 9.8 Trend of AIS Admission in ER, 1997-2004 (2)



The number of TIAs in ER was stable (p = 0.15) (Figure 9.4), yet substantially increased when query diagnoses were excluded (p = 0.04) (Figure 9.6 & 9.9). TIA occurrence was reduced 25% to 35% if query diagnoses were not considered in ER.

Figure 9.9 Trend of TIA Occurrence in ER, 1997-2004

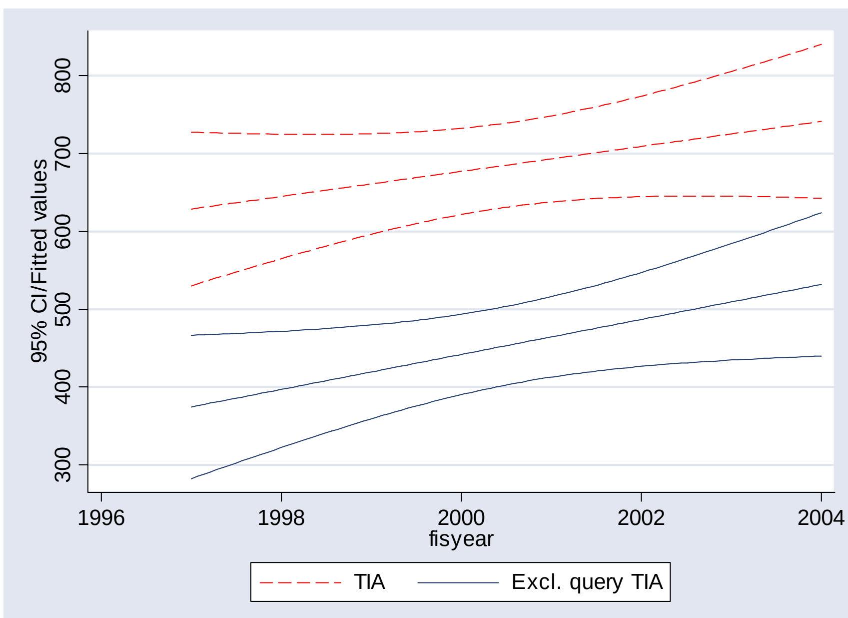
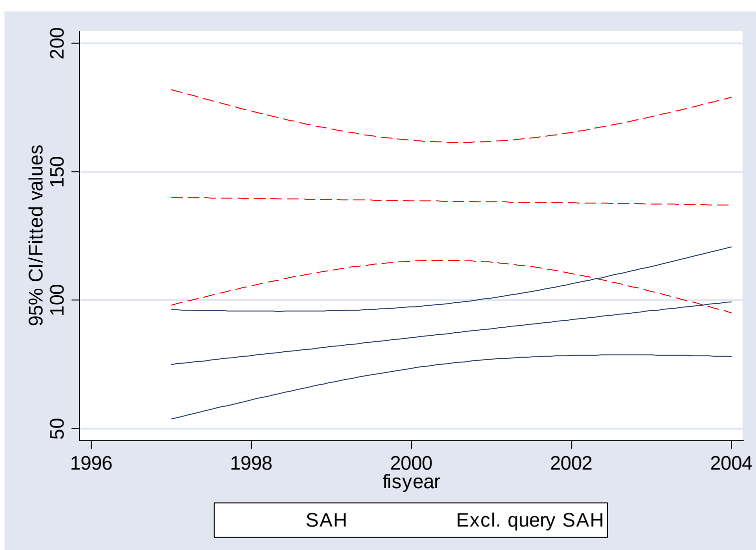


Figure 9.4 & 9.10 indicated that the number of ICH occurrence was stable during the last decade with no much change from 97 in year 1997 to 119 in 2004. ICH cases did not reduce when query diagnoses were excluded, and trend was stable (p=0.23).

Figure 9.10 Trend of ICH Occurrence in ER, 1997-2004

The number of SAH was quite stable over time (p = 0.9), yet reduced almost 40% when query diagnoses excluded with no change in trend (p = 0.14) (Figure 9.4 & 9.11).

Figure 9.11 Trend of SAH Admission in ER, 1997-2004



9.2.2.3 Trends of Stroke Occurrence by Sex

In stratified analysis by sex, we plotted the time trend of stroke and stroke by type between 1997 and 2004.

9.2.2.3.1 Trends of Overall Stroke Occurrence by Sex

Table 9.5 Number of Stroke Occurrence by Sex in ER

Year	Stroke-Female	Stroke – Male	Stroke Excl. Q-F	Stroke Excl. Q-M	Stroke Excl. I64-F	Stroke Excl. I64-M	Stroke Excl. Q & I64 - F	Stroke Excl. Q & I64 - M
1997	838	804	544	559	468	411	274	268
1998	872	843	616	623	493	466	331	329
1999	1034	967	720	733	626	561	421	411
2000	1015	936	696	683	575	511	368	344
2001	1067	963	801	770	632	535	452	404
2002	976	867	782	721	550	472	409	367
2003	940	960	763	748	526	514	405	383
2004	1005	969	775	781	590	534	431	415

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query & unspecified stroke; F = Female; M = Male

The number of stroke occurrence in ER were higher in women than in men (Table 9.5) with stable trends for both sexes whether unspecified stroke excluded or not (all of $p > 0.6$) (Figure 9.12, 9.13). However the rising trends for both sexes were seen when query diagnoses were excluded ($p < 0.008$), (Figure 9.12 & 9.14).

Figure 9.12 Number of Stroke Occurrence in ER by Sex, 1997-2004 (1)

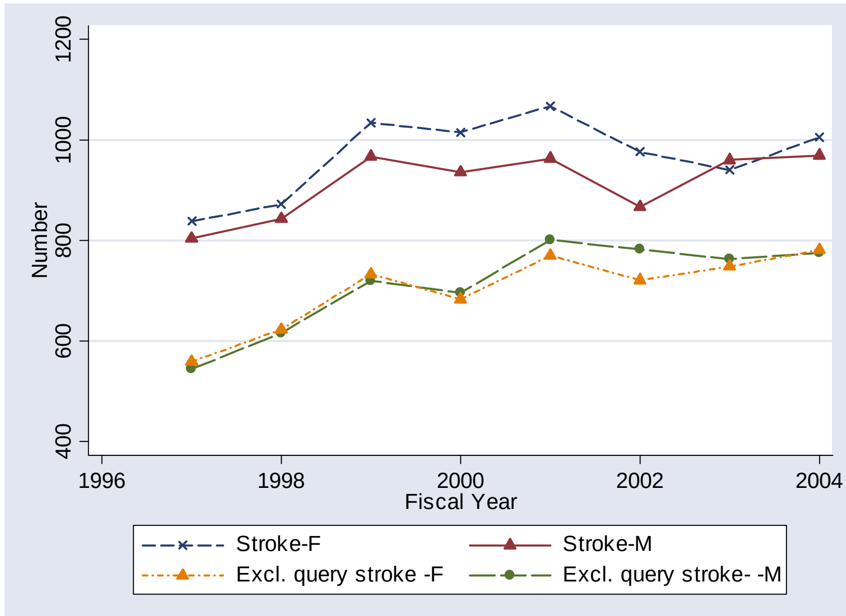


Figure 9.13 Number of Stroke Occurrence in ER by Sex, 1997-2004 (2)

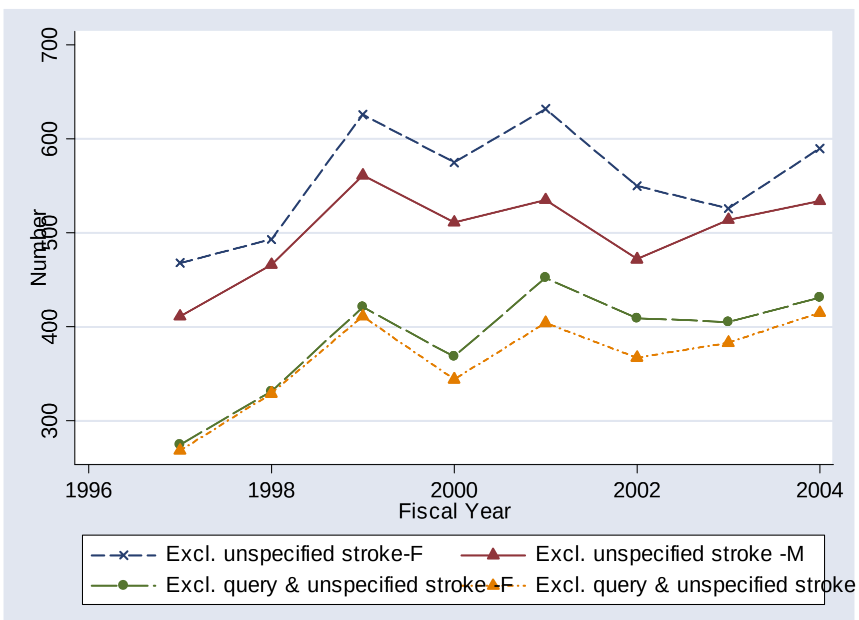
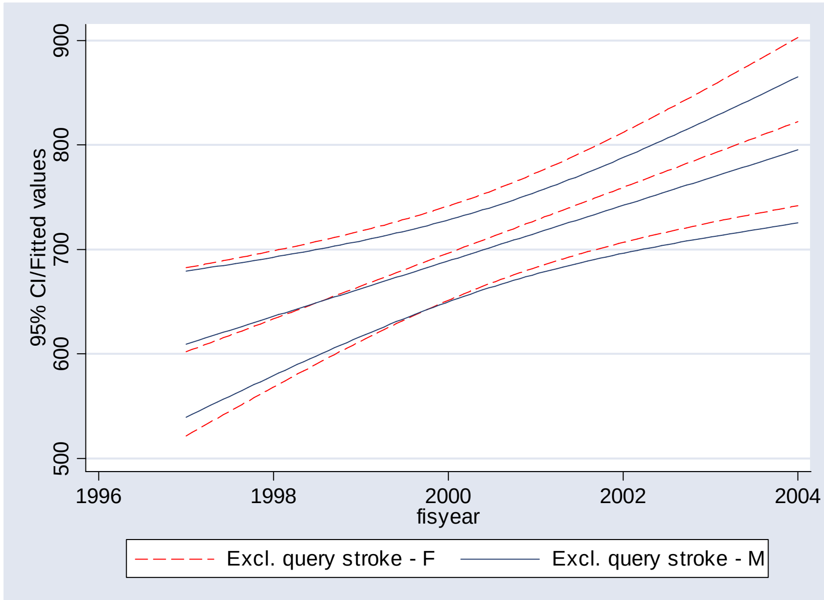


Figure 9.14 Trend of Stroke Exclude Query diagnoses by Sex in ER, 1997-2004



9.2.2.3.2 Trends of Stroke Occurrence by Stroke Type

Table 9.6& 9.7 showed the detailed number of stroke admission by stroke type and sex in IP data.

Table 9.6 Number of Stroke Occurrence by Stroke Type & Sex in ER (1)

Year	AIS_F	AIS_M	TIA_F	TIA_M	ICH_F	ICH_M	SAH_F	SAH_M	AIS Excl.Q-F	AIS Excl.Q-M
1995	424	438	312	258	44	53	58	55	318	333
1996	438	451	305	281	51	50	78	61	335	359
1997	481	483	393	356	67	62	93	66	365	384
1998	492	493	387	328	44	55	92	60	367	388
1999	501	486	402	353	56	54	108	70	407	416
2000	468	450	387	331	50	47	71	39	413	399
2001	483	513	337	350	47	56	73	41	424	422
2002	482	532	377	321	60	59	86	57	403	457
2003	424	438	312	258	44	53	58	55	318	333
2004	438	451	305	281	51	50	78	61	335	359

Note: Excl. Q = Exclude query diagnoses; F = Female; M = Male

Table 9.7 Number of Stroke by Stroke Type & Sex in ER (2)

Year	AIS Excl. Q & I64-F	AIS Excl. Q & I64-M	AIS Excl. I64 - F	AIS Excl. I64 - M	TIA Excl. Q - F	TIA Excl. Q - M	ICH Excl. Q - F	ICH Excl. Q - M	SAH Excl. Q - F	SAH Excl. Q - M
1997	48	42	54	45	152	152	40	40	34	34
1998	50	65	59	74	188	182	48	49	45	33
1999	66	62	73	77	240	261	62	58	53	30
2000	39	49	52	68	238	215	37	53	54	27
2001	58	50	66	58	273	256	51	51	70	47
2002	40	45	42	55	260	245	50	47	59	30
2003	66	57	69	67	238	245	46	55	55	26
2004	59	91	67	97	253	227	59	57	60	40

Note: Excl. Q = Exclude query diagnoses; Excl.I64 = Exclude unspecified stroke coded as 436 in ICD-9 or I64 in ICD-10; Excl. Q & I64 = Exclude query & unspecified stroke; F = Female; M = Male

Figure 9.15 to 9.18 indicate that the number of AIS occurrences show rising trends in both sexes whether query diagnoses were excluded or not ($p < 0.001$). However, rising rates of AIS became stable for both sexes when unspecified stroke was not counted ($p > 0.36$) (Figure 9.19, 9.20). The number of TIA for both sexes fluctuated but was stable ($p > 0.24$) (Figure 9.21 & 9.22).

Figure 9.15 Number of Ischemic Stroke in ER by Sex, 1997-2004

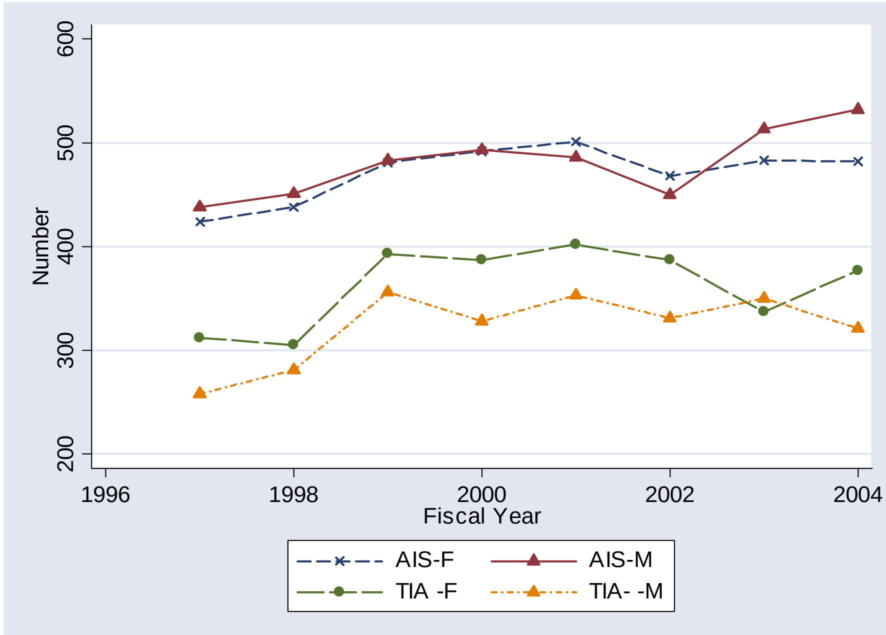
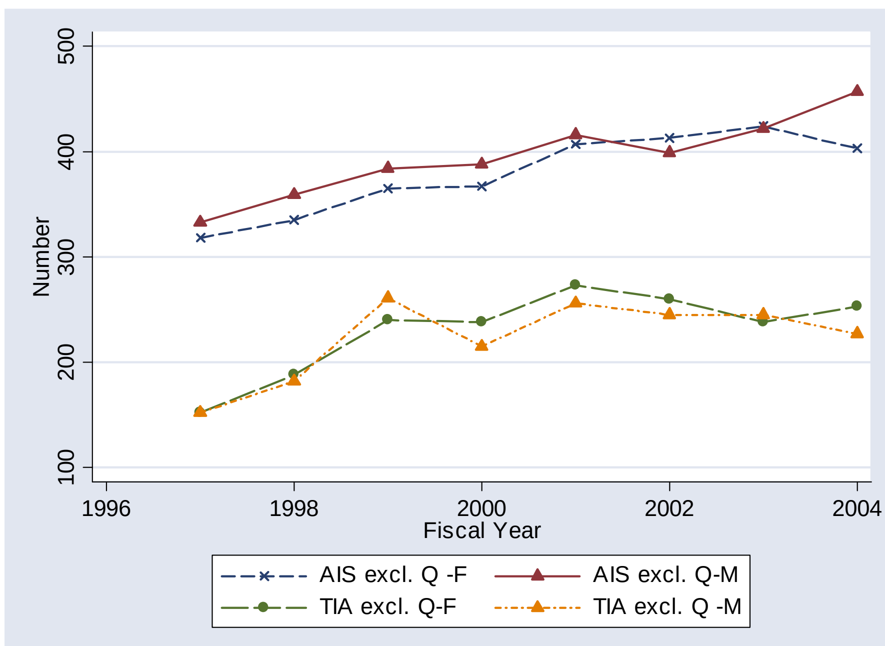


Figure 9.16 Number of Ischemic Stroke Excl. Query diagnoses in ER by Sex, 1997-2004



Q = query diagnoses

Figure 9.17 Trend of AIS in ER by Sex, 1997-2004

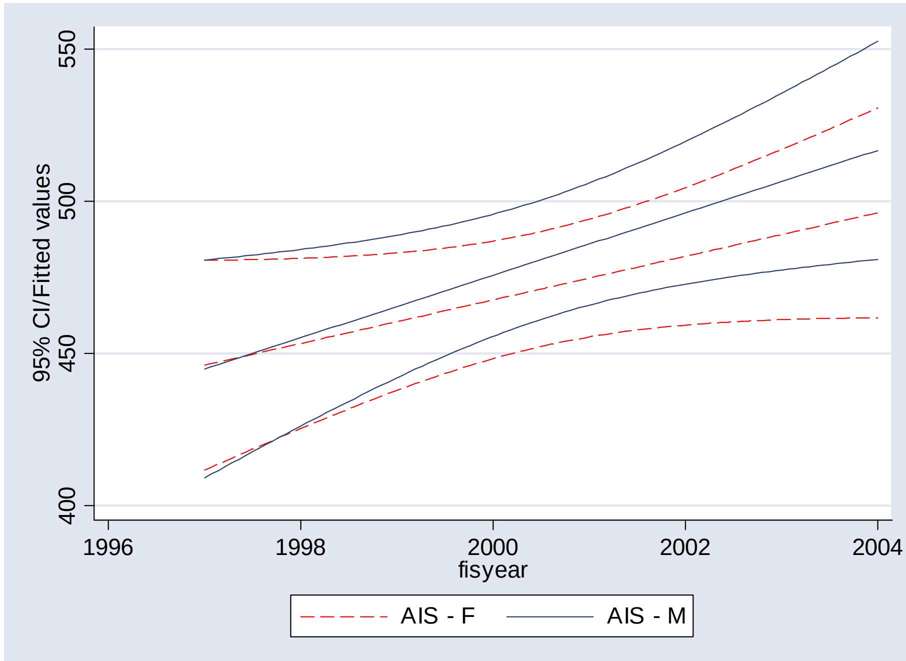


Figure 9.18 Trend of AIS Excl. Query diagnoses in ER by Sex, 1997-2004

Figure 9.19 Trend of AIS Excl. Unspecified Diagnosis in ER by Sex, 1997-2004

Figure 9.20 Trend of AIS Excl. Query & Unspecified Diagnosis in ER by Sex, 1997-2004

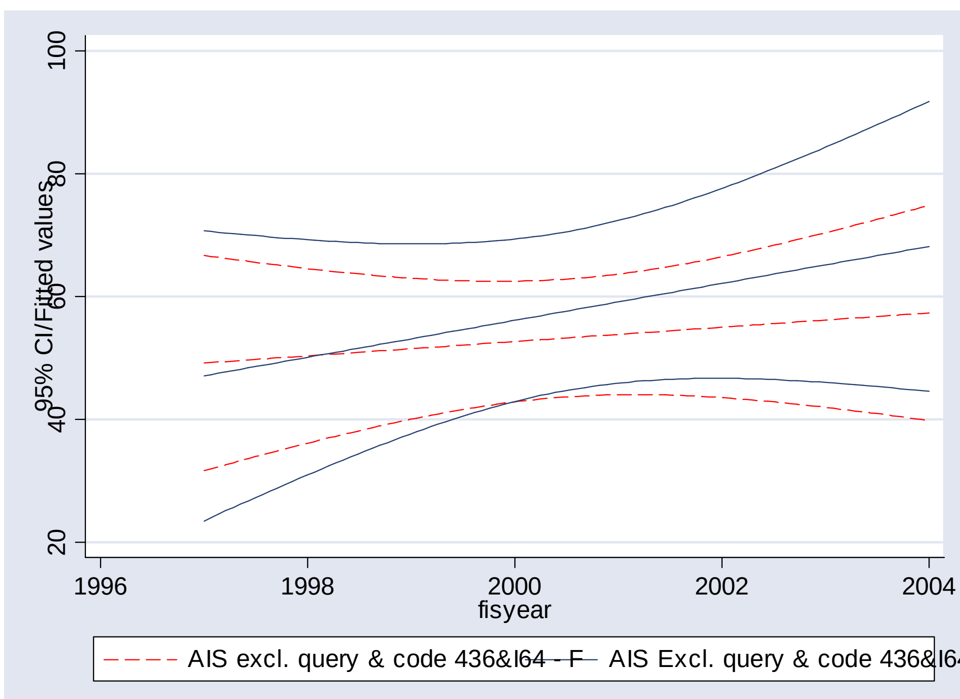


Figure 9.21 Trend of TIA in ER by Sex, 1997-2004

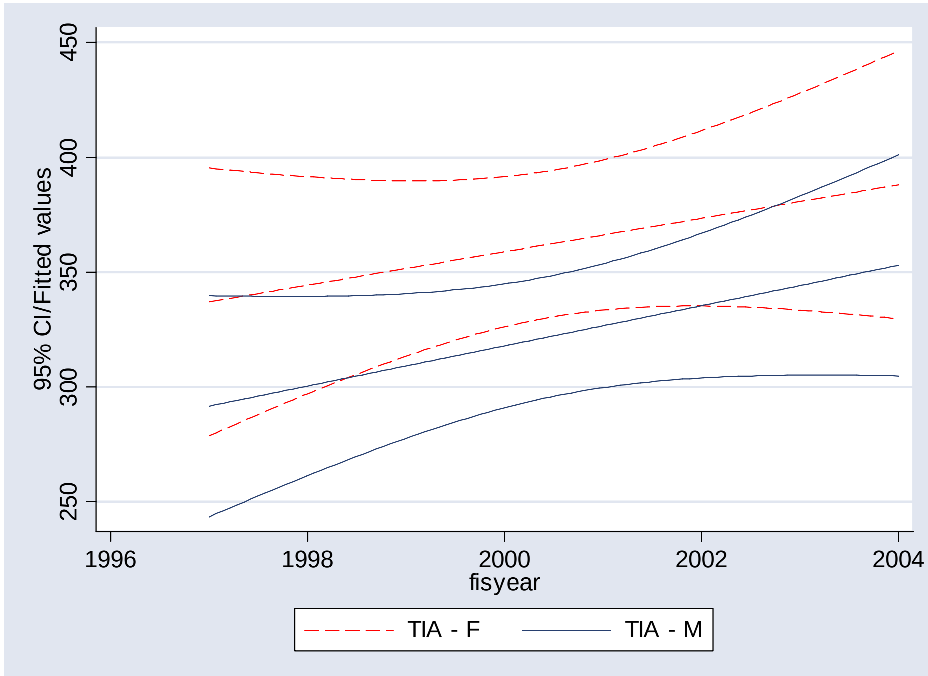
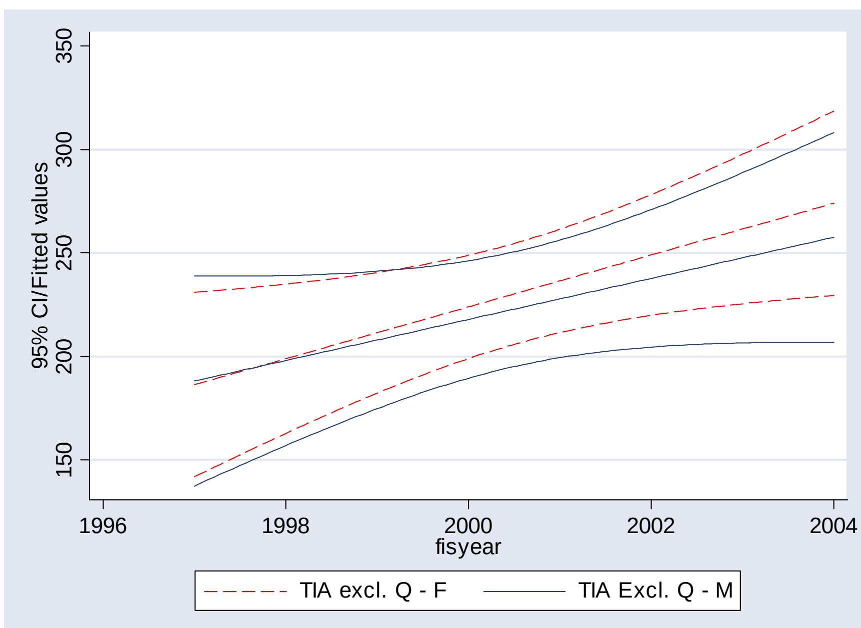


Figure 9.22 Trend of TIA Excl. Query diagnoses in ER by Sex, 1997-2004



Number of ICH occurrence in women and men was stable whether query diagnoses were excluded or not (p > 0.4) (Figure 9.23 – 9.25). The number of SAH was much higher in women than in men with both stable trends (Figure 9.26). The rising trend of SAH in women became clear (p = 0.04), while trend in men did not change when query diagnoses were excluded (p = 0.3) (Figure 9.26 – 9.28).

Figure 9.23 Number of ICH Occurrence in ER by Sex, 1997-2004

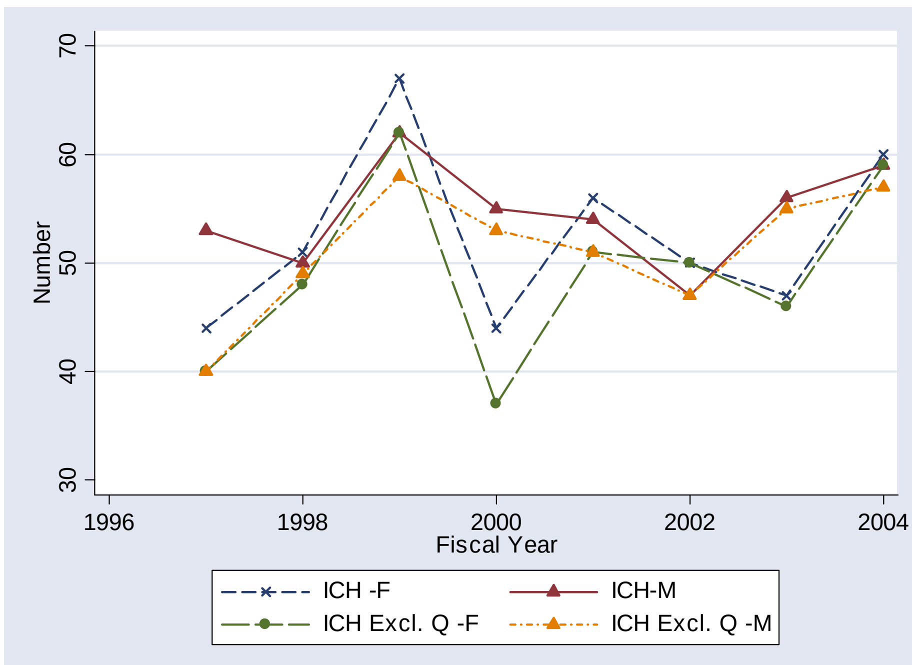


Figure 9.24 Trend of ICH in ER by Sex, 1997-2004

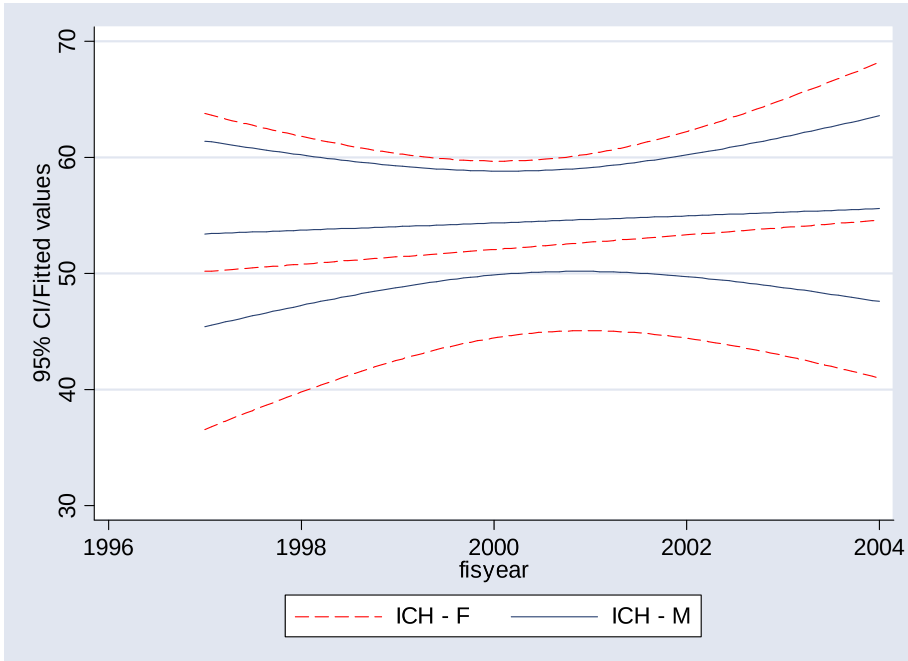


Figure 9.25 Trend of ICH Exclude Query diagnoses in ER by Sex, 1997-2004

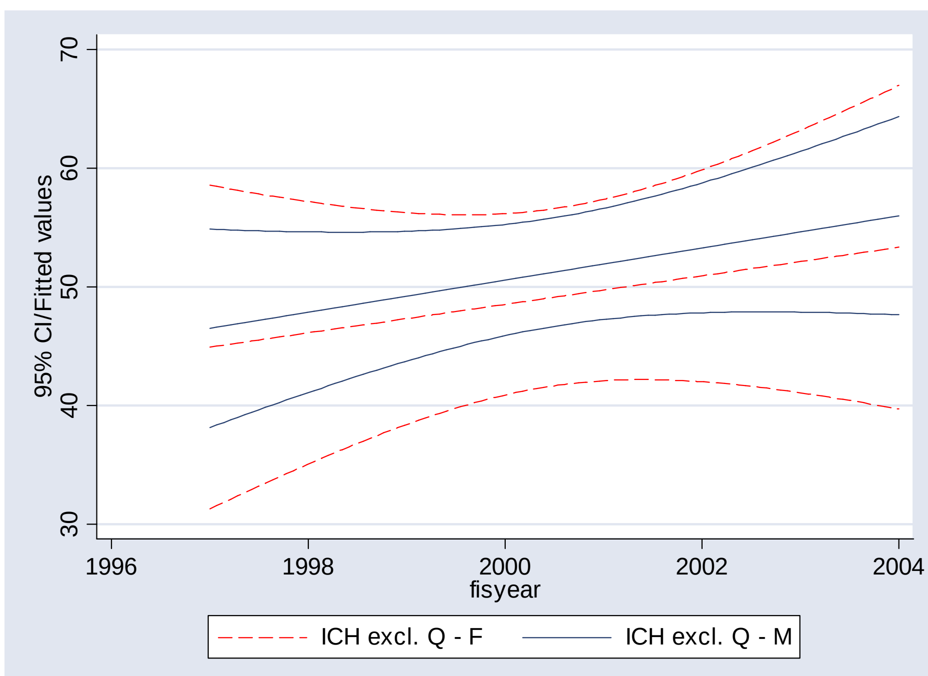


Figure 9.26 Number of SAH in ER by Sex, 1997-2004

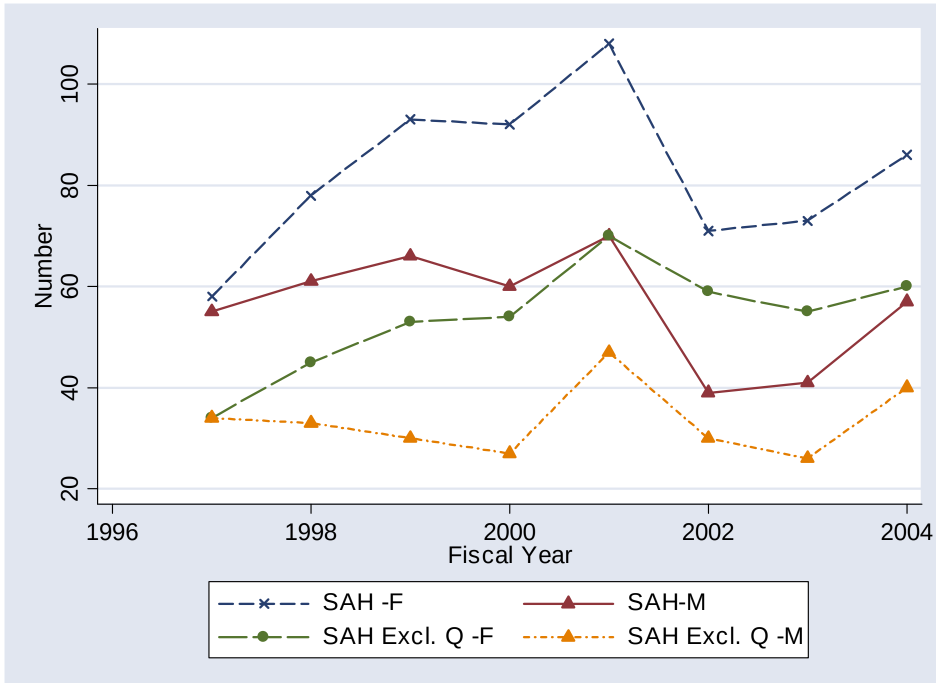


Figure 9.27 Trend of SAH in ER by Sex, 1997-2004

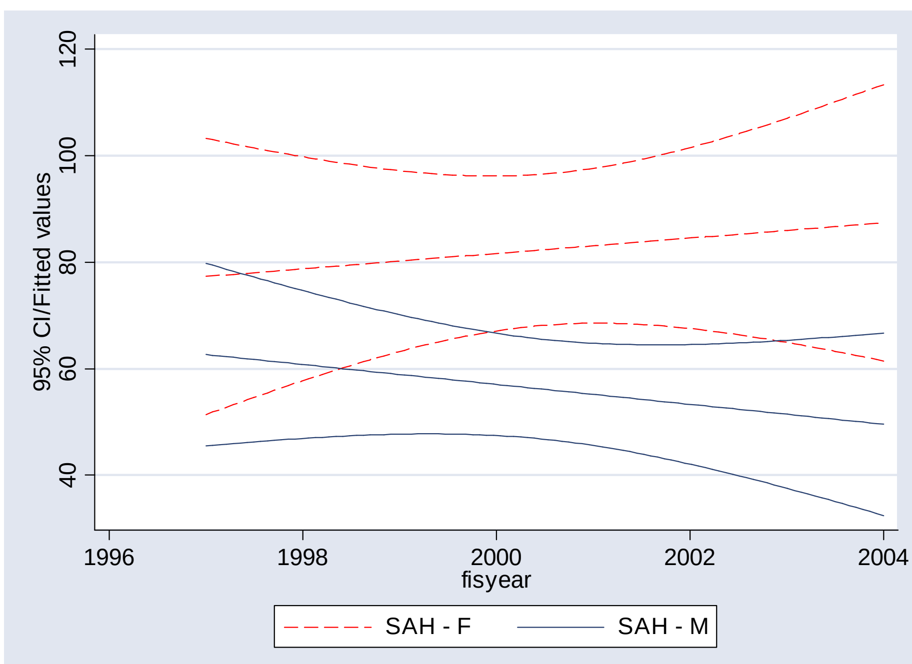
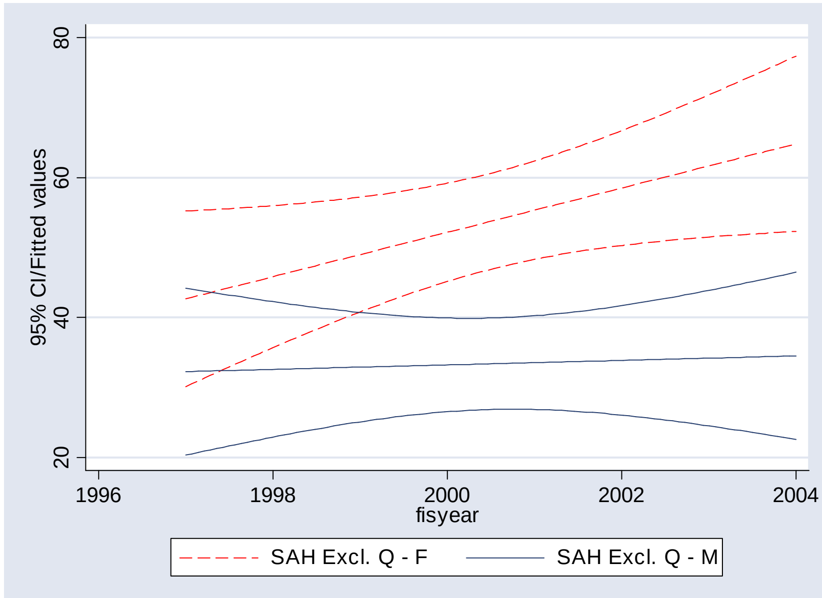


Figure 9.28 Trend of SAH Exclude Query diagnoses in ER by Sex, 1997-2004



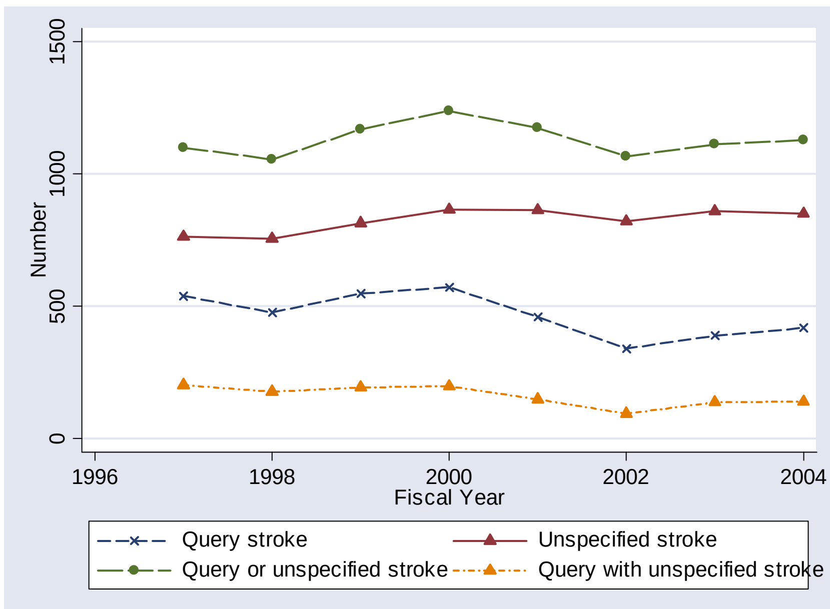
9.2.2.3.3 Trends for Query Stroke & Unspecified Stroke in ER Data

Table 9.8 & Figure 9.29 illustrate that query stroke reduced from 33% to 21% among total stroke, with a significant downward trend over time (p = 0.04). The distribution of unspecified stroke was stable (around 45%) over the last decade (p = 0.03) though the absolute number of unspecified stroke increased obviously (p = 0.03). There were significant declining trends (p=0.007) for the distribution of query or unspecified stroke (reduced from 67% to 57%), and query with unspecified stroke (12% to 7%) between year 1997 and 2004.

Table 9.8 Number & Distribution of Query / Unspecified Stroke in ER

Year	Number of stroke	Query stroke (n, %)	Unspecified stroke (n, %)	Query or unspecified stroke (n, %)	Query with unspecified stroke (n, %)
1997	1642	539 (32.8)	763 (46.5)	1100 (67)	202 (12.3)
1998	1715	476 (27.8)	756 (44.1)	1055 (61.5)	177 (10.3)
1999	2001	548 (27.4)	814 (40.7)	1169 (58.4)	193 (9.6)
2000	1951	572 (29.3)	865 (44.3)	1239 (63.5)	198 (10.1)
2001	2030	459 (22.6)	863 (42.5)	1174 (57.8)	148 (7.3)
2002	1843	340 (18.4)	821 (44.5)	1067 (57.9)	94 (5.1)
2003	1900	389 (20.5)	860 (45.3)	1112 (58.5)	137 (7.2)
2004	1974	418 (21.2)	850 (43.2)	1128 (57.1)	140 (7.1)

Figure 9.29 Number of Query Stroke & Unspecified Stroke in ER, 1997 -2004



9.2.3 Trends of Stroke Occurrence Rate in ER Data

9.2.3.1 Trends of Occurrence Rate for Overall Stroke in ER Data

The age-adjusted rates of overall stroke were higher than corresponding crude rates, (Table 9.9) (all rates were presented with a unit of per 100,000 per year). From 1997 to 2004, crude and age-adjusted stroke occurrence rates slightly declined over time (p =

0.08) (Figure 9.30 – 9.32), though stroke number increased slightly (see section 9.2.2.1). The trends of crude and age-adjusted occurrence rates for stroke appeared to be stable when query diagnoses or unspecified stroke were excluded ($p > 0.9$) (Figure 9.32 & 9.33).

Table 9.9 Crude vs. Age-adjusted Stroke Occurrence Rate in ER

Year	C_stroke	A_stroke	C_stroke Excl. Q	A_stroke Excl. Q	C_stroke Excl. I64	A_stroke Excl. I64	C_stroke Excl.Q & i64	A_stroke Excl. Q & I64
1997	160.66	208.95	107.89	141.71	85.96	110.26	52.97	68.77
1998	162.54	210.42	117.5	154.08	90.85	115.86	62.59	80.98
1999	185.53	236.08	134.72	173.88	110.05	138.23	77.14	98.72
2000	176.68	219.43	124.88	157.45	98.35	120.31	64.48	80.37
2001	179.09	219.08	138.6	171.16	102.96	124.26	75.52	92.11
2002	159	191.33	129.67	156.99	88.17	105.28	66.95	80.36
2003	160.7	189.46	127.8	151.92	87.96	102.69	66.65	78.55
2004	164.25	188.96	129.47	150.02	93.52	106.99	70.39	80.95

Note: C = Crude rate; A = Age-adjusted rate; Excl. Q = Exclude Query diagnoses; Excl. I64 = Exclude unspecified stroke; Excl. Q & I64 = Exclude query & unspecified stroke

Figure 9.30 Crude Occurrence Rate for Stroke in ER, 1997-2004

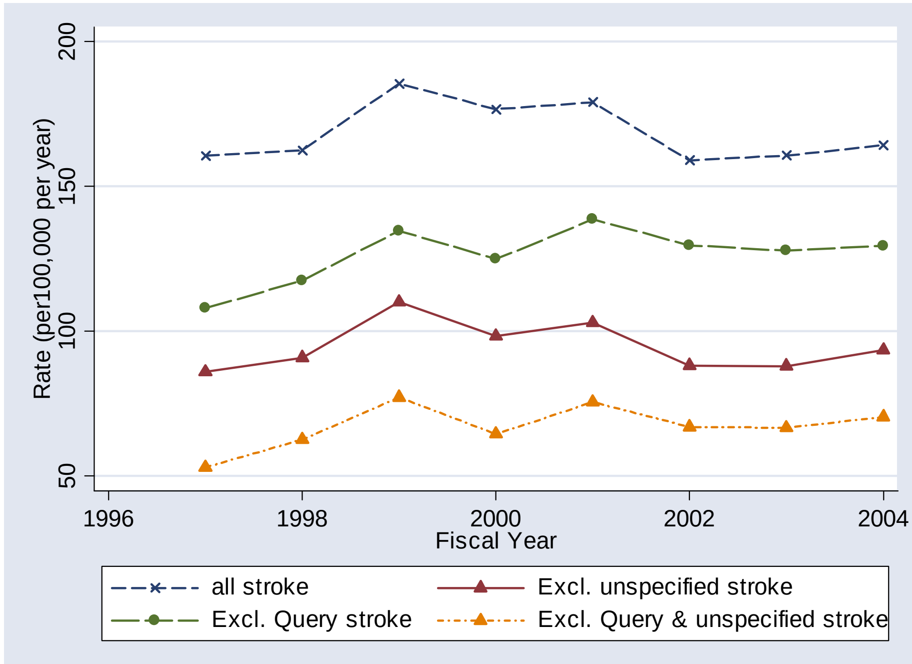


Figure 9.31 Age-adjusted Occurrence Rate for Stroke in ER, 1997-2004

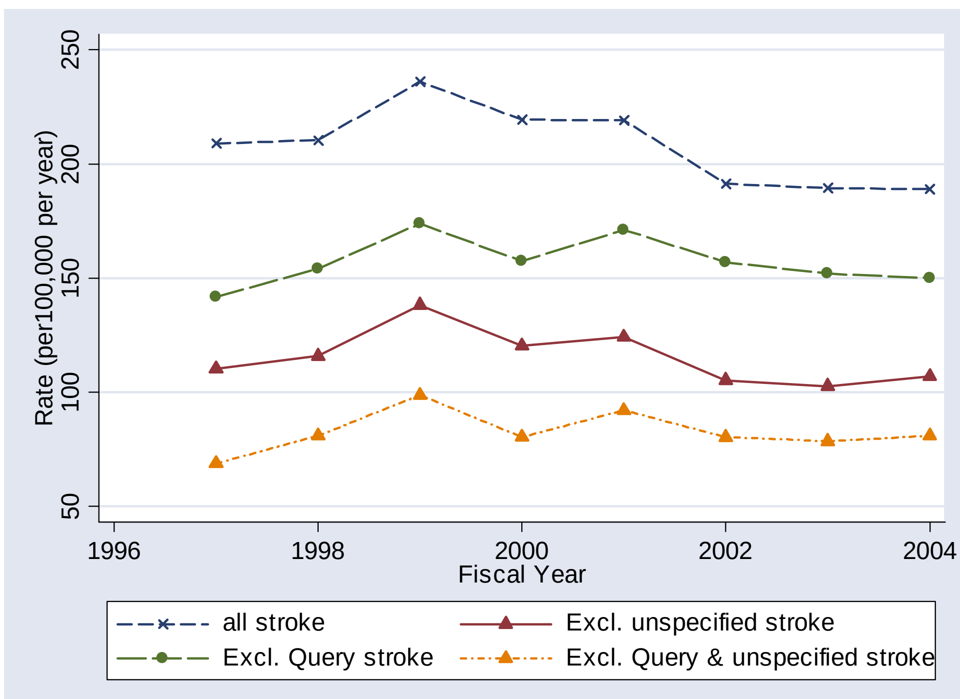


Figure 9.32 Trend of Age-adjusted Stroke Occurrence Rate in ER, 1997-2004 (1)

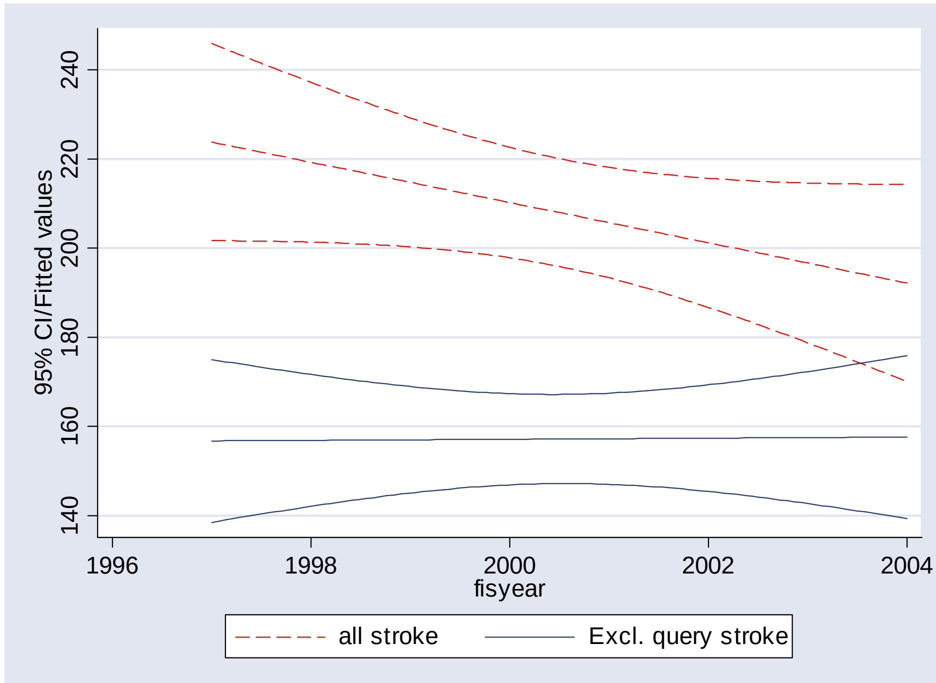
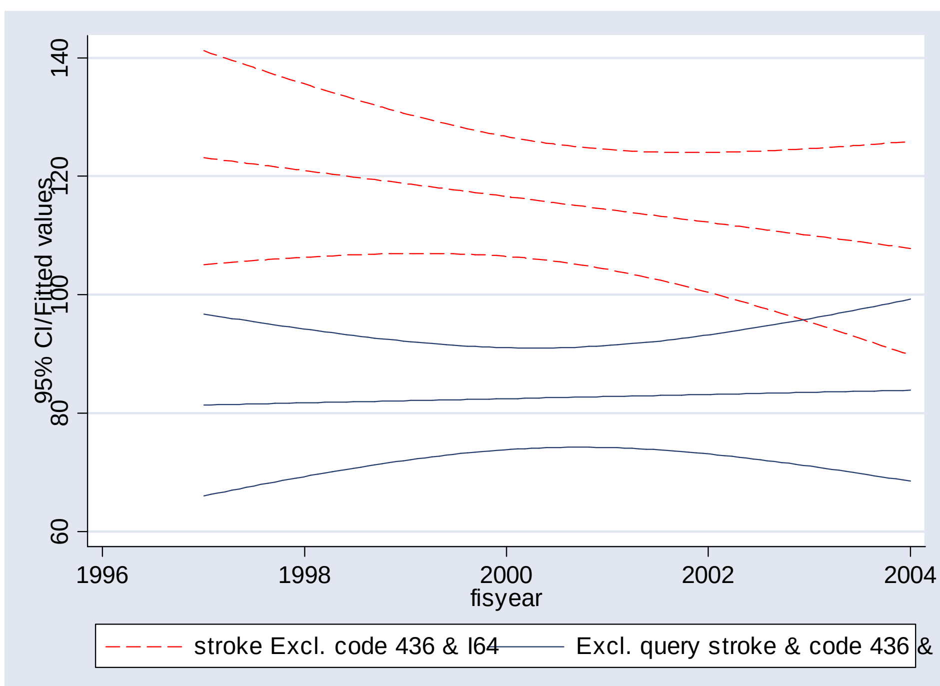


Figure 9.33 Trend of Age-adjusted Stroke Occurrence Rate in ER, 1997-2004 (2)



9.2.3.2 Trend of Age-adjusted Occurrence Rate for Stroke Type in ER

Table 9.10 illustrates that age-adjusted occurrence rates for each stroke type were higher than corresponding crude hospitalization rates.

Table 9.10 Age - adjusted Occurrence Rate for Stroke Type in ER, 1997 - 2004

Year	AIS	TIA	ICH	SAH	AIS Excl.I64	AIS Excl. Q	TIA Excl. Q	ICH Excl. Q	SAH Excl. Q	AIS Excl. Q & I64
1997	111.25	73.52	12.07	12.11	12.56	84.34	39.65	10.15	7.56	11.4
1998	110.97	72.93	12.31	14.22	16.41	87.4	46.49	11.88	8.32	14.29
1999	115.37	89.68	15.37	15.67	17.52	90.14	60.45	14.4	8.88	14.98
2000	112.69	81.76	10.74	14.23	13.58	87.16	52.41	9.85	8.02	10.08
2001	108.21	82.47	11.94	16.46	13.39	90.77	58.01	11.06	11.32	11.72
2002	96.08	75.41	9.8	10.03	10.03	85.5	53.39	9.8	8.3	8.86
2003	100.55	69.3	9.91	9.7	13.79	85.82	49.35	9.75	7	12.45
2004	98	67.46	11.26	12.24	16.03	83.66	46.67	10.99	8.68	14.6

Figure 9.34 & 9.35 show that the crude and age-adjusted occurrence rates for AIS declined over time ($p = 0.012$). In contrast, the trends for age-adjusted occurrence rates for AIS were stable when query diagnoses or unspecified stroke were dropped ($p > 0.53$) (Figure 9.36 & 9.38). The trend of age-adjusted TIA occurrence was stable whether query diagnoses were counted or not ($p > 0.5$) (Figure 9.39). Figure 9.40 & 9.41 illustrate stable ICH and SAH rates, as well as similar trends when query diagnoses were excluded ($p > 0.2$).

Figure 9.34 Age-adjusted Occurrence Rate by Stroke Type in ER, 1997-2004

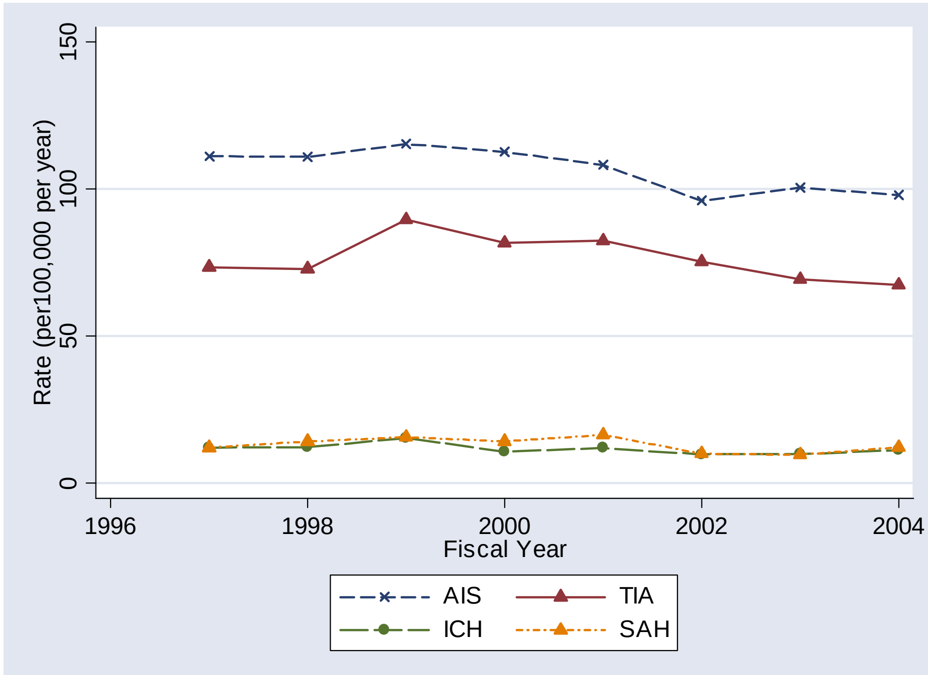


Figure 9.35 Crude Occurrence Rate by Stroke Type in ER, 1997-2004

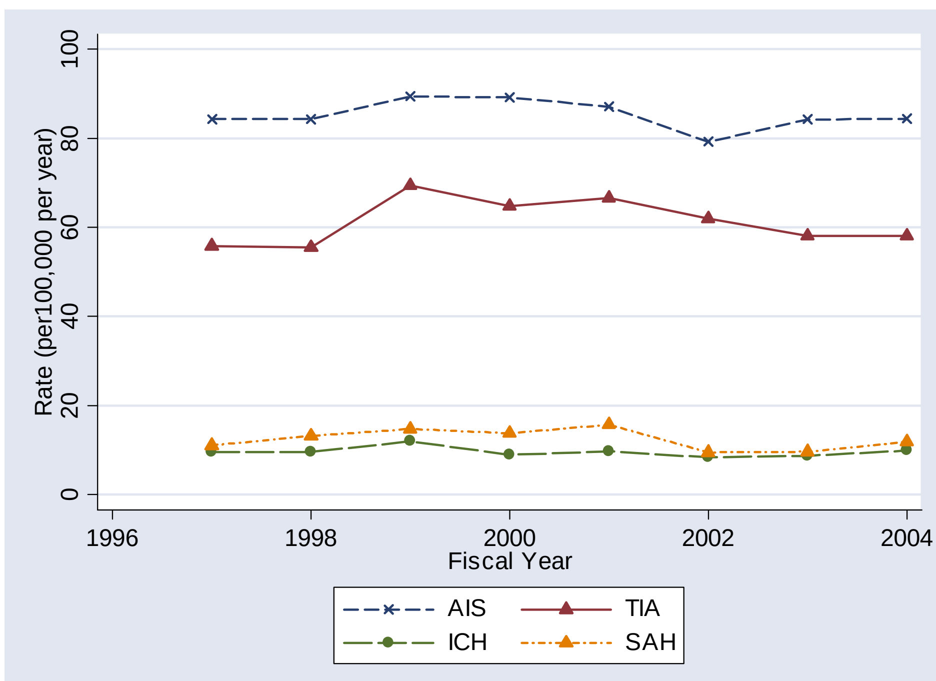


Figure 9.36 Age-adjusted Occurrence Rate for AIS, 1997-2004

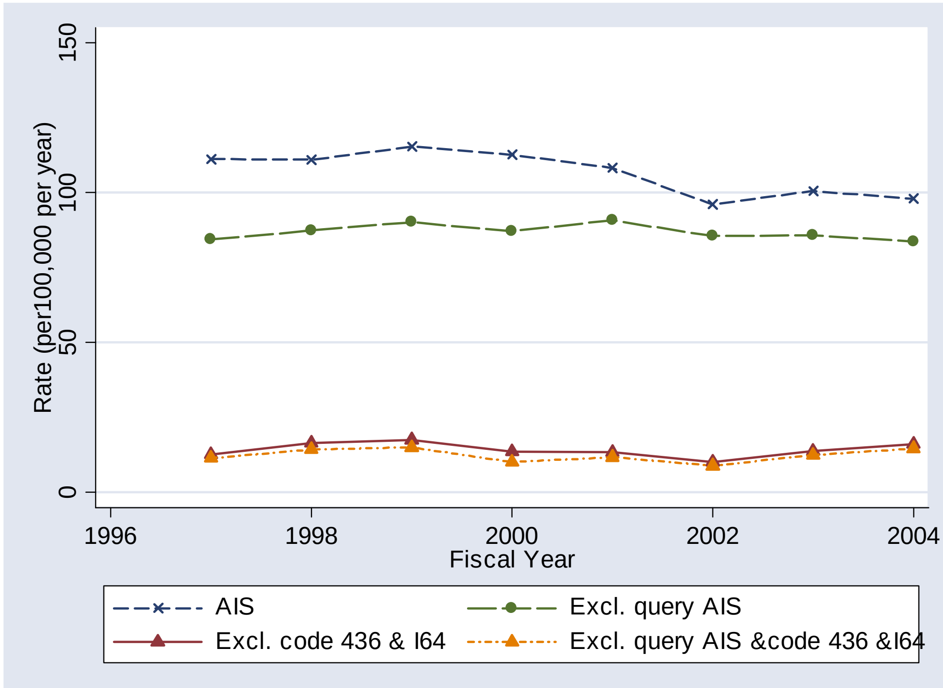


Figure 9.37 Trend of Age-adjusted Occurrence Rate for AIS, 1997-2004 (1)

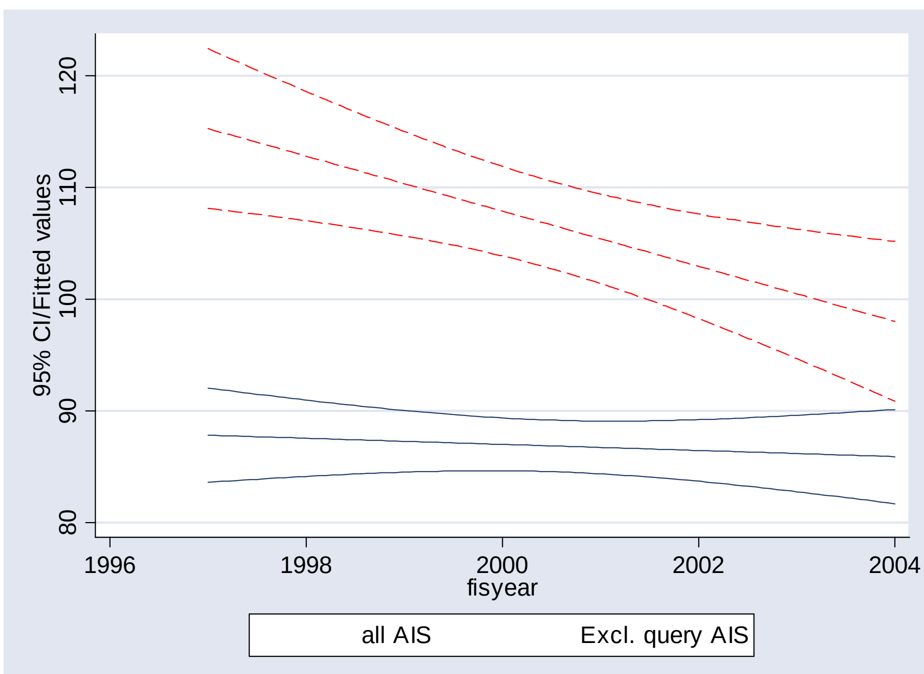


Figure 9.38 Trend of Age-adjusted Occurrence Rate for AIS, 1997-2004 (2)

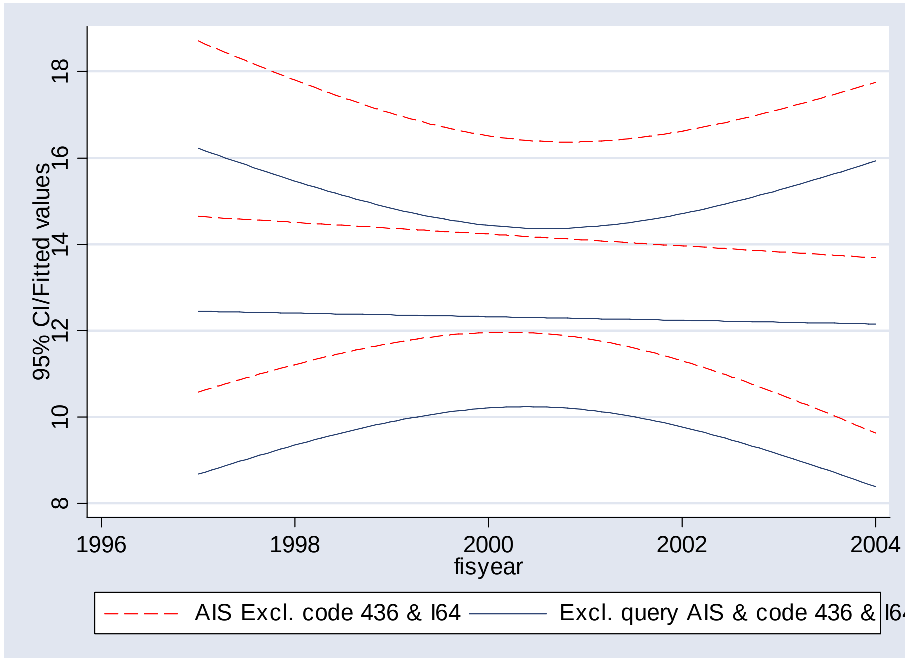


Figure 9.39 Trend of Age-adjusted Occurrence Rate for TIA, 1997-2004

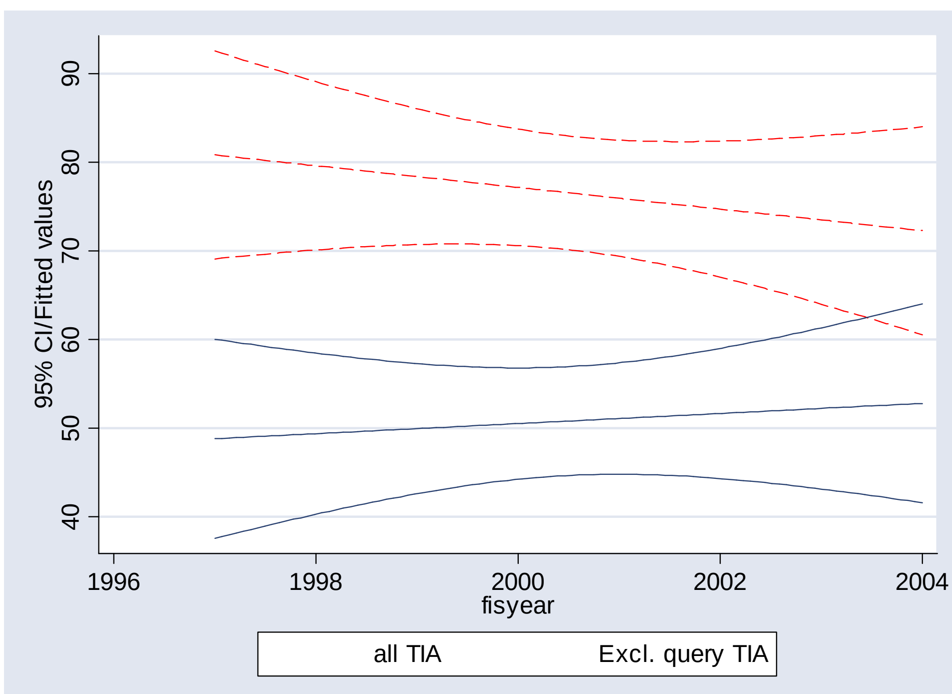


Figure 9.40 Trend of Age-adjusted Occurrence Rate for ICH in ER, 1997-2004

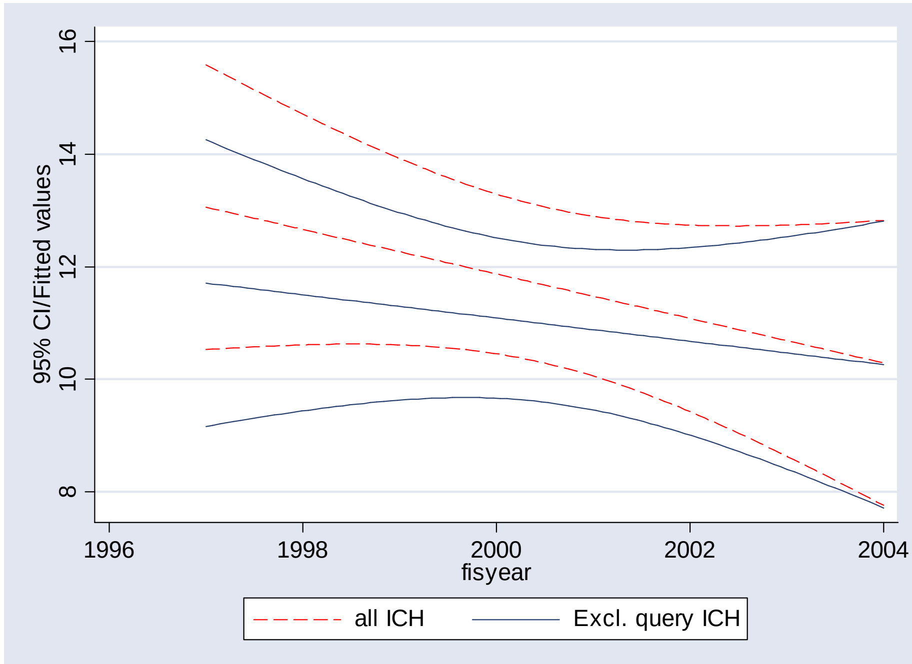
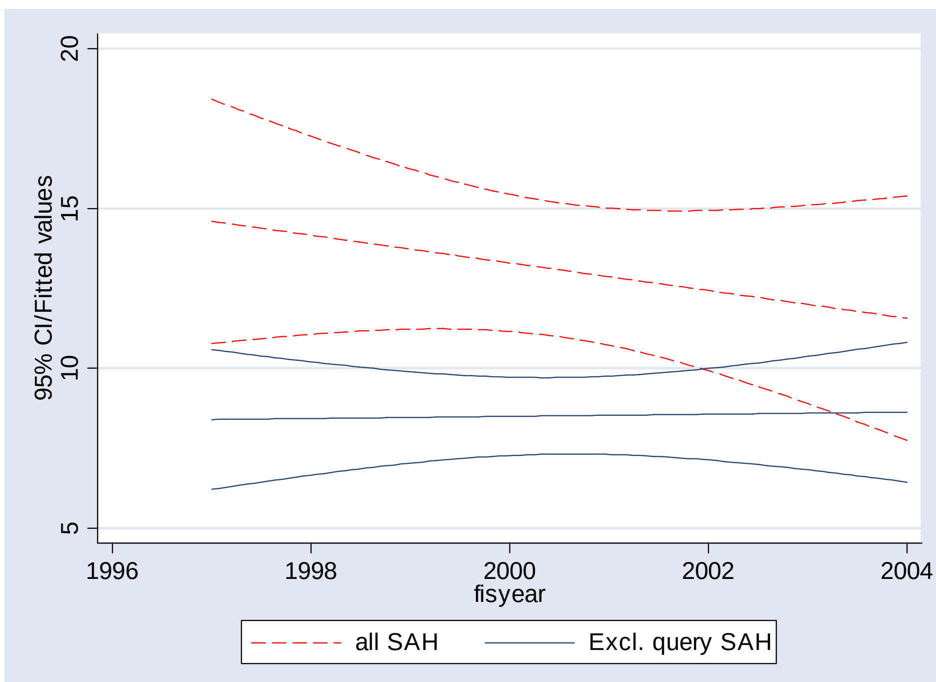


Figure 9.41 Trend of Age-adjusted Occurrence Rate for SAH in ER, 1997-2004



9.2.3.3 Trends of Age-gender Adjusted Stroke Occurrence Rate in ER

Table 9.11 – 9.13 listed detailed age-gender adjusted occurrence rates for stroke and stroke type in emergency room (ER). We notice higher age-gender adjusted stroke occurrence rates in women than in men whether query diagnoses or unspecified stroke excluded or not. Age-gender adjusted occurrence rates of stroke for both sexes show significant declining rates over time ($p < 0.05$) (Figure 9.42 & 9.44). However, both decreasing trends were less clear with unspecified stroke eliminated ($p > 0.17$), or when query diagnoses were excluded ($p > 0.65$) (Figure 9.42 & 9.43, 9.45 & 9.46).

Table 9.11 Age-gender Adjusted Occurrence Rate for Stroke in ER, 1997 - 2004

Year	Stroke		AIS		TIA		ICH		SAH	
	F	M	F	M	F	M	F	M	F	M
1997	222	195.78	113.62	108.45	83.75	63.6	11.54	12.52	13.08	11.22
1998	222.66	197.89	113.72	107.7	78.96	66.94	13.44	11.18	16.53	12.07
1999	254.89	217.31	120.62	109.79	98.23	81.19	16.7	14.05	19.34	12.27
2000	239.3	199.7	118.24	106.81	92.74	71.04	10.18	11.19	18.14	10.66
2001	241.11	197.21	115.39	100.65	91.88	73.25	13.09	10.82	20.74	12.49
2002	214.53	168.84	104.29	87.92	86	65.21	10.72	8.87	13.52	6.84
2003	197.33	180.23	102.58	97.57	71.93	66.14	9.62	10.02	13.2	6.5
2004	203.77	173.87	98.86	96.23	77.27	58.04	12.03	10.43	15.61	9.17

Table 9.12 Age-gender Adjusted Stroke Occurrence Rate in Different Strata in ER, 1997 - 2004 (1)

Fiscal Year	Stroke Excl. I64		Stroke Excl. Q		Stroke Excl. Q & I64		AIS Excl. I64		AIS Excl. Q & I64	
	F	M	F	M	F	M	F	M	F	M
1997	122.62	98.25	145.1	137.88	72.21	65.29	14.24	10.92	12.66	10.15
1998	124.16	107.61	159.89	147.78	84.8	76.98	15.22	17.42	13	15.4
1999	152.08	124.66	179.85	167.26	103.78	93.44	17.81	17.15	16.19	13.79
2000	133.56	107.35	166.87	147.63	87.14	73.54	12.51	14.46	9.55	10.49
2001	140.84	108.24	182.88	158.96	101.8	82.55	15.13	11.68	13.24	10.22
2002	119.64	91.45	172.92	141.35	89.36	71.56	9.4	10.54	8.94	8.73
2003	109.63	95.33	161.53	141.58	85.22	71.71	14.88	12.67	14.18	10.78
2004	119.12	95.2	158.16	141.12	87.49	74.3	14.21	17.56	12.48	16.38

Note: Excl. I64 = Exclude unspecified stroke; Excl. Q = Exclude query diagnoses;

Excl. Q & I64 = Exclude query & unspecified stroke

Table 9.13 Age-gender Adjusted Stroke Occurrence Rate in Different Strata in ER (2)

Fiscal Year	AIS Excl. Q		TIA Excl. Q		ICH Excl. Q		SAH Excl. Q	
	F	M	F	M	F	M	F	M
1995	85.56	82.74	41.06	38.16	10.6	9.69	7.88	7.28
1996	88.08	86.2	49.23	43.65	12.75	11	9.83	6.93
1997	92.26	87.61	60.3	60.14	15.55	13.26	11.74	6.24
1998	89.28	84.58	57.6	47.19	8.77	10.78	11.22	5.08
1999	94.32	86.63	62.53	53.4	11.85	10.26	14.17	8.67
2000	92.5	78.51	58.22	48.58	10.72	8.87	11.49	5.39
2001	90.48	80.65	51.49	46.87	9.47	9.87	10.08	4.19
2002	83.14	83.21	52.2	41.22	11.79	10.15	11.03	6.56
2003	85.56	82.74	41.06	38.16	10.6	9.69	7.88	7.28
2004	88.08	86.2	49.23	43.65	12.75	11	9.83	6.93

Note: Excl. Q = Exclude query diagnoses

Figure 9.42 Age-gender Adjusted Occurrence Rate for Stroke by Sex in ER, 1997-2004 (1)

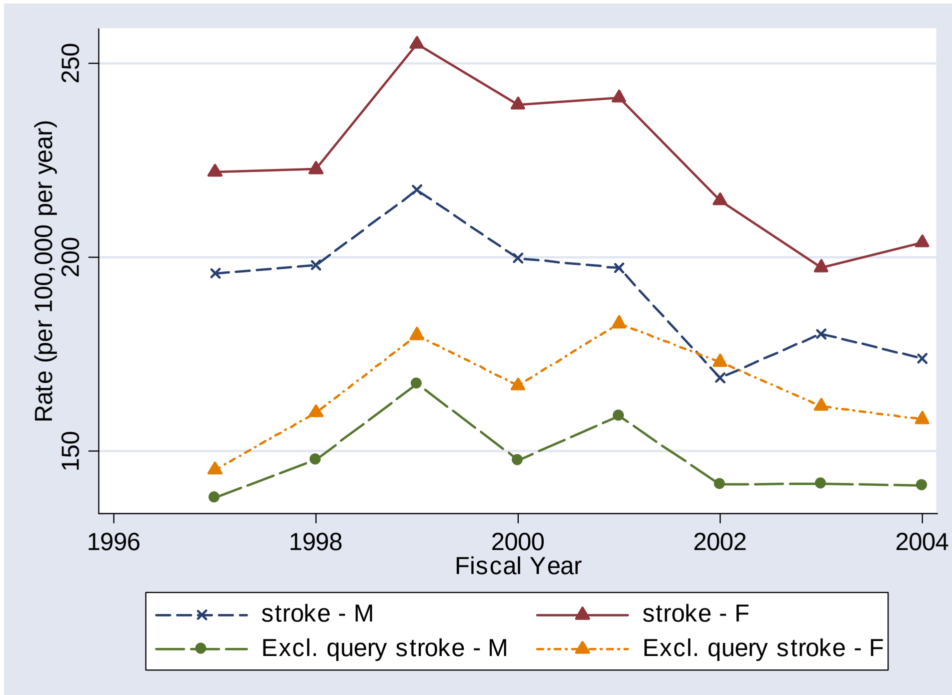


Figure 9.43 Age-gender Adjusted Occurrence Rate for Stroke by Sex in ER, 1997-2004 (2)

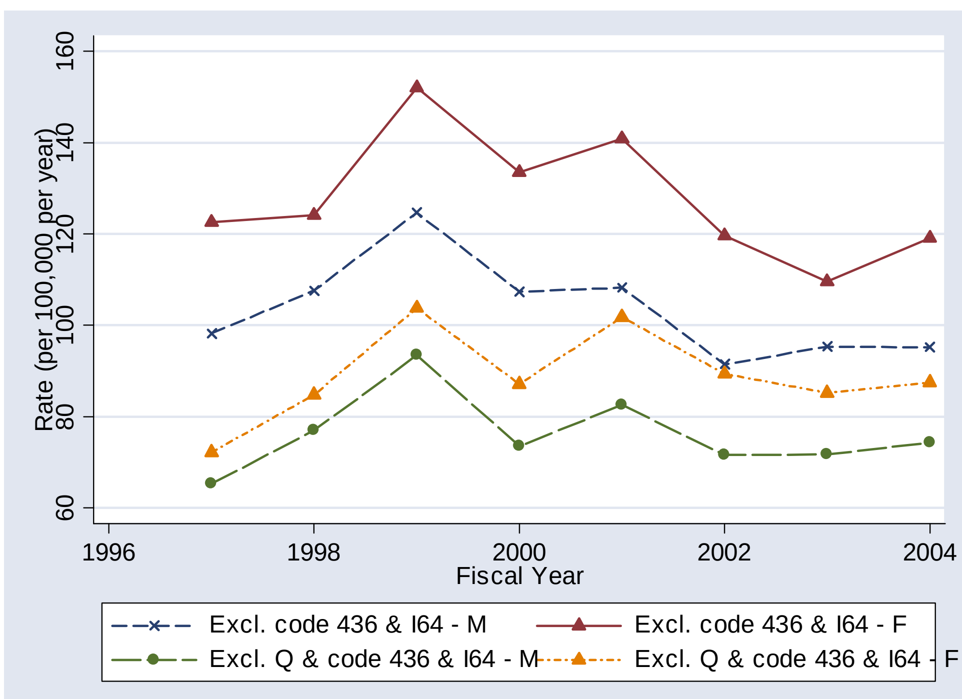


Figure 9.44 Trend of Age-gender Adjusted Occurrence Rate for Stroke by Sex in ER, 1997-2004

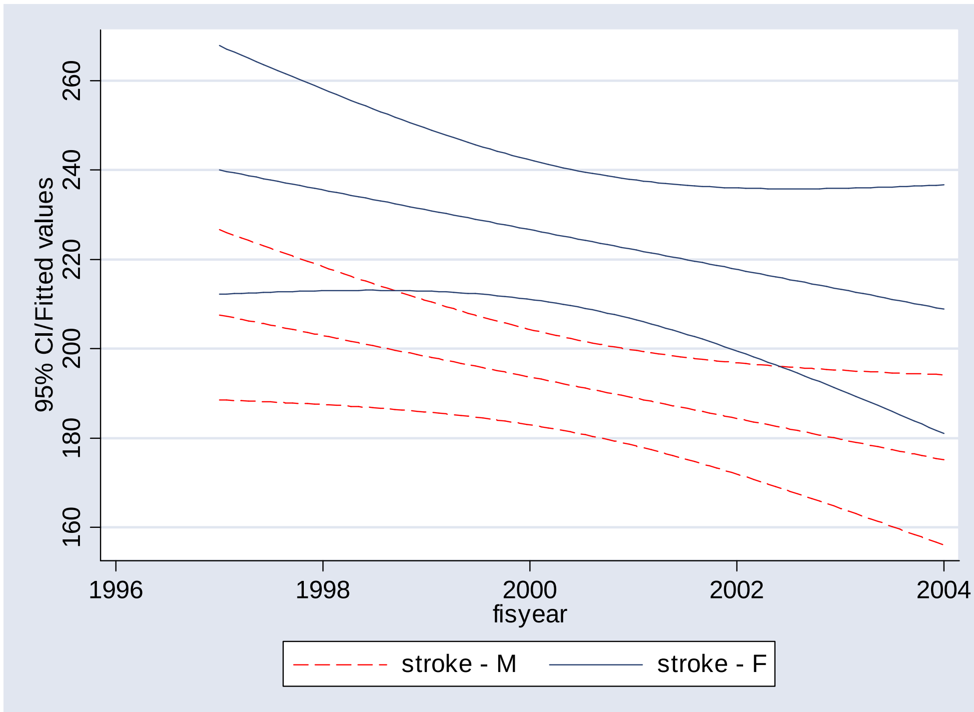


Figure 9.45 Trend of Age-gender Adjusted Occurrence Rate for Stroke Exclude Query diagnoses by Sex in ER, 1997 - 2004

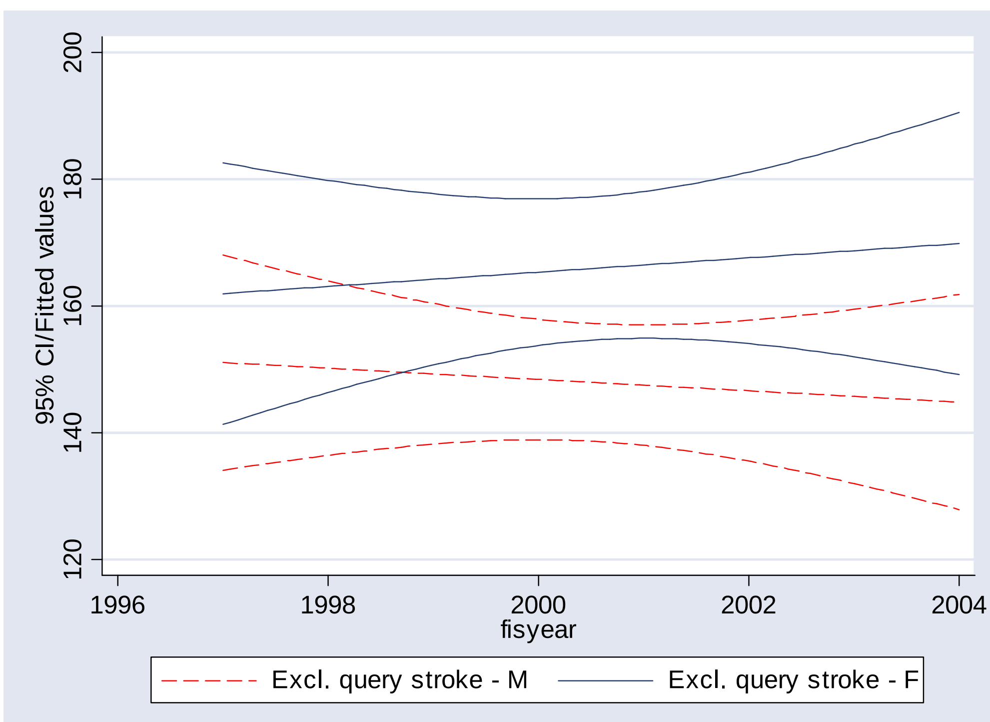


Figure 9.46 Trend of Age-gender Adjusted Occurrence Rate for Stroke by Sex Exclude Unspecified Stroke in ER, 1997-2004

Age-gender adjusted occurrence rates for AIS in both sexes were similar, with stable trends (p > 0.11) (Figure 9.47 & 9.49). However, age-adjusted occurrence rates decreased dramatically from averagely 110 per 100,000 per year to 14 per 100,000 per year if unspecified stroke was excluded with a stable trend (p > 0.45) (Figure 9.48 & 9.51) over time. Age-adjusted occurrence rates declined to 83 per 100,000 per year when query diagnoses were excluded with overall stable trends over time (p > 0.9) (Figure 9.47 & 9.50).

Figure 9.47 Age-gender Adjusted Occurrence Rate for AIS in ER, 1997-2004

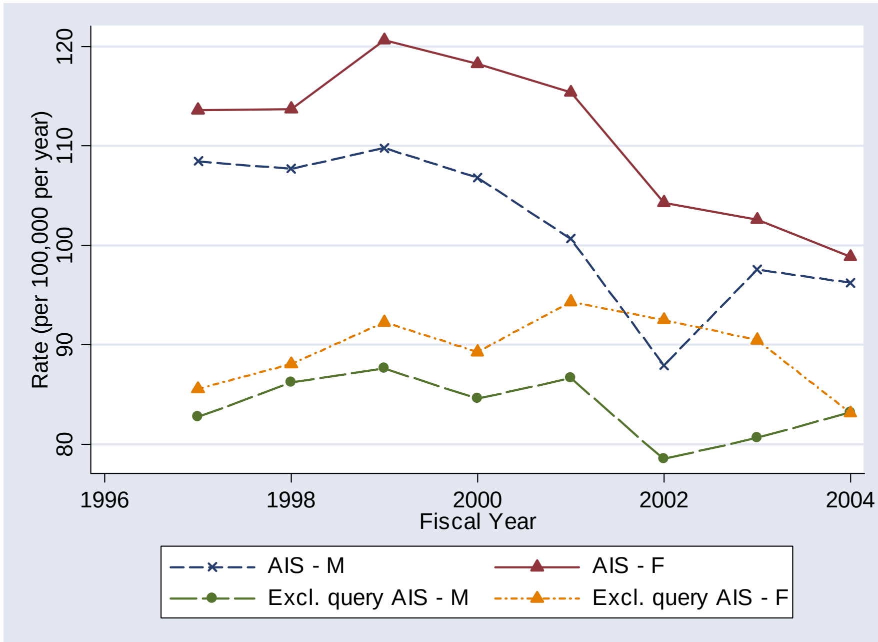


Figure 9.48 Age-gender Adjusted Occurrence Rate for AIS Excl. Unspecified Stroke in ER, 1997-2004

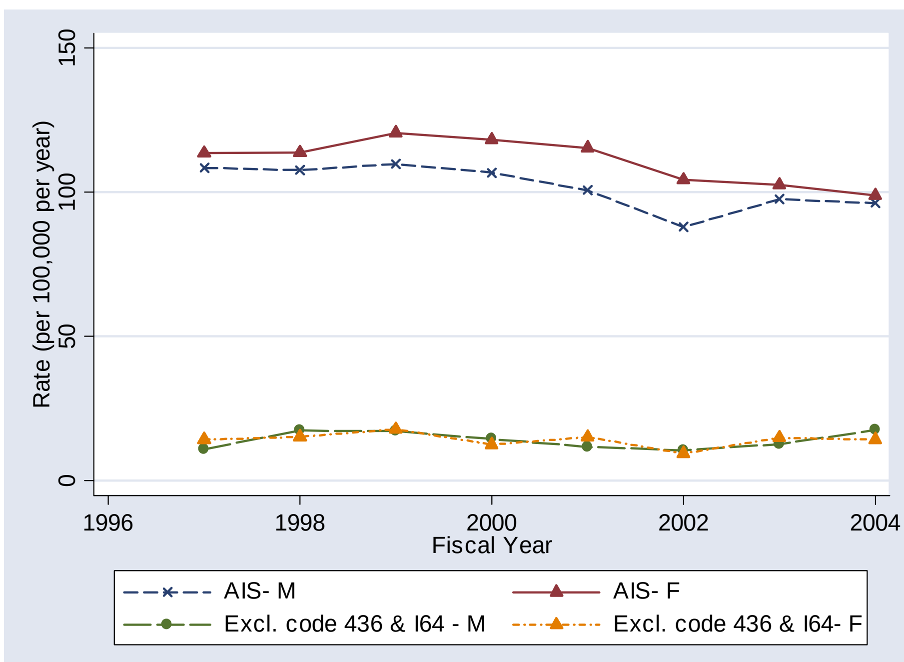


Figure 9.49 Trend of Age-gender Adjusted Occurrence Rate for AIS by Sex, 1997-2004 (1)

Figure 9.50 Trend of Age-gender Adjusted Occurrence Rate for AIS by Sex, 1997-2004 (2)

Figure 9.51 Trend of Age-gender Adjusted Hospitalization Rate for AIS Exclude Unspecified Stroke, 1995 - 2004

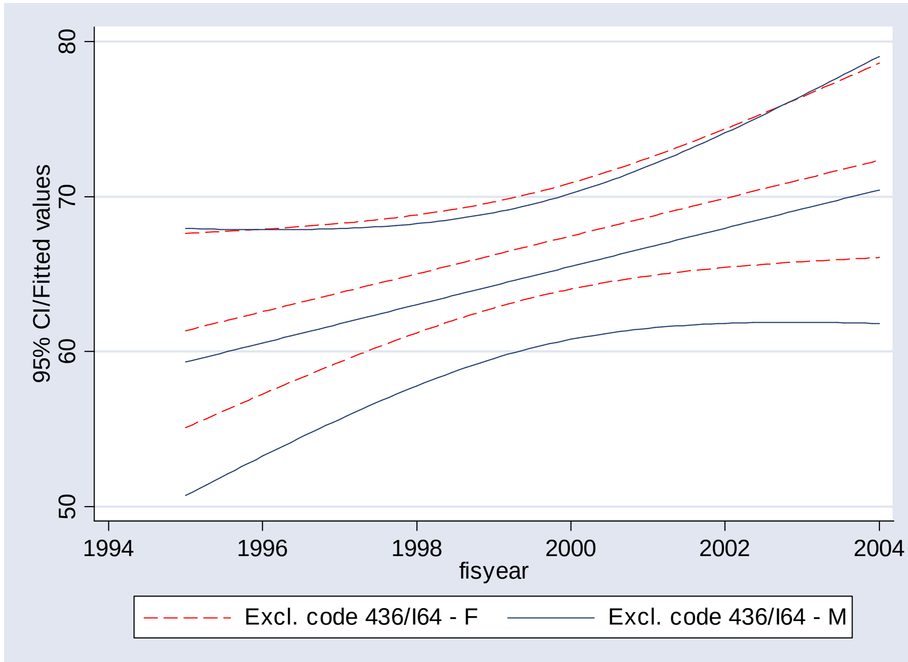


Figure 9.52 & 9.53 indicate that age-gender adjusted occurrence rates for TIA were higher in women than men, with stable rates whether query diagnoses were counted or not ($p > 0.35$). Age-gender adjusted occurrence rates for TIA decreased almost half when query diagnoses were excluded.

Figure 9.52 Age-gender Adjusted Occurrence Rates for TIA in ER, 1997-2004

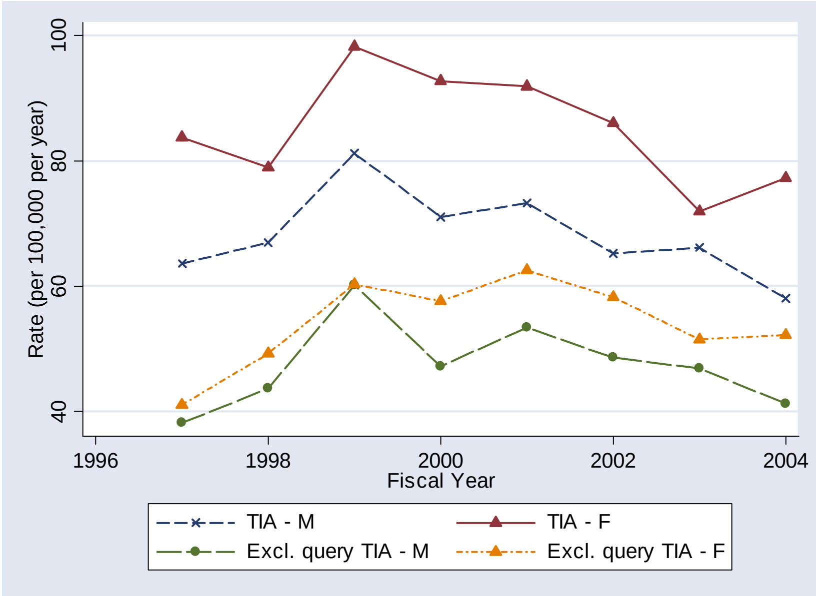
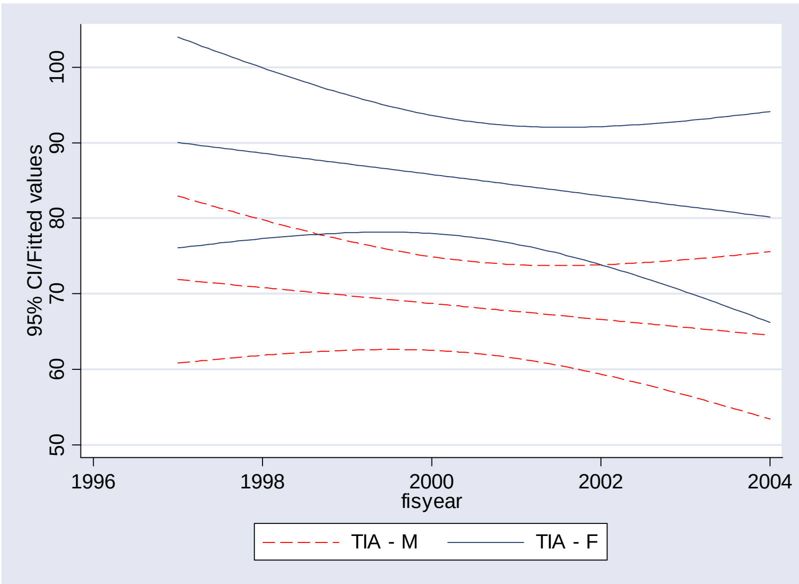


Figure 9.53 Trend of Age-gender Adjusted Occurrence Rate for TIA, 1997-2004



Age-gender adjusted occurrence rates for ICH in ER were similar, yet fluctuating for both sexes over time with stable rates (p > 0.65) whether query diagnoses were excluded or not (see Figure 9.54 - 9.55).

Figure 9.54 Age-gender Adjusted Occurrence Rate for ICH in ER in Different Strata, 1997-2004

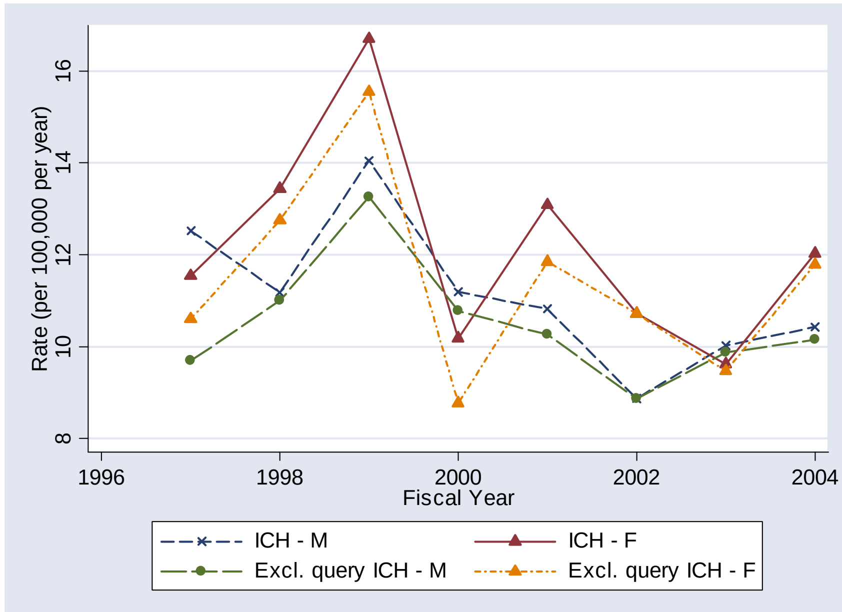


Figure 9.55 Trend of Age-gender Adjusted Occurrence Rate for ICH in ER, 1997-2004

Age-gender adjusted hospitalization rates for SAH were higher in women than in men, with stable trends (p > 0.59) with or without query diagnoses excluded. (p = 0.55) (Figure 9.56 & 9.57).

Figure 9.56 Age-gender Adjusted Occurrence Rate for SAH in ER in Different Strata, 1995-2004

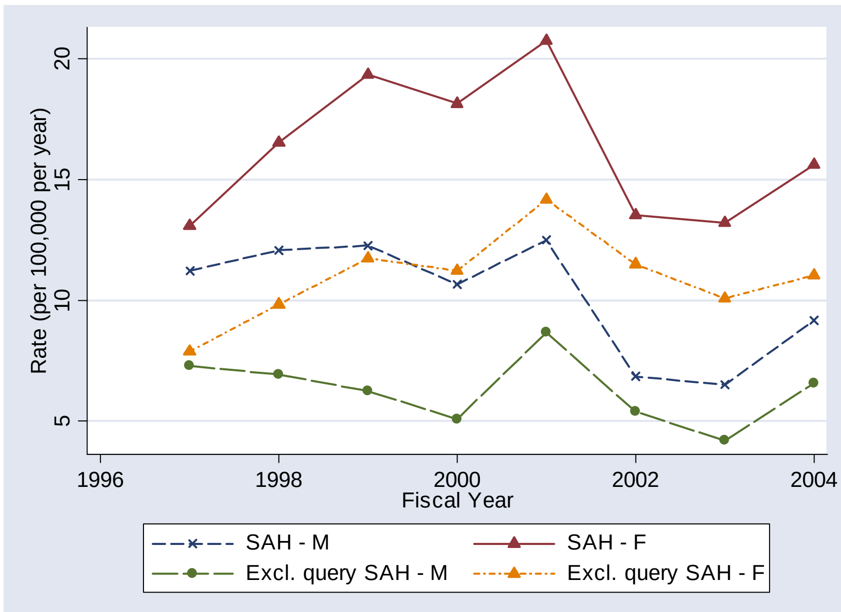
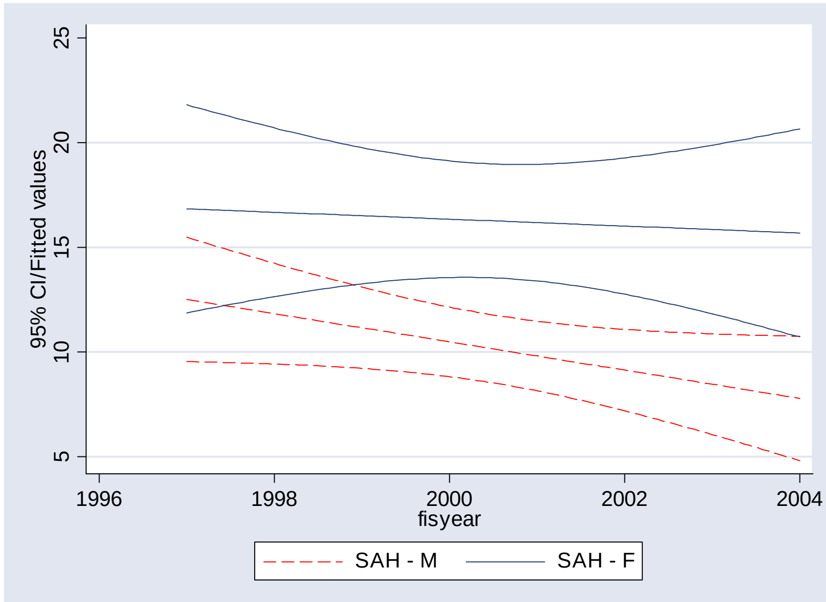


Figure 9.57 Trend of Age-gender Adjusted Occurrence Rate for SAH in ER, 1997-2004



CHAPTER TEN: DISCUSSION ON TRENDS OF STROKE

10.1 Comparison of Trends of Stroke among Three Databases

Overall, age-adjusted occurrence rates have been declining for total strokes and for AIS in both men and women, yet have remained steady for TIA, ICH and SAH in merged hospitalization and emergency visits from 1997 to 2004. Although trends for absolute number of AIS and TIA in women were stable, the absolute number of AIS and TIA in men has been increasing. We identified consistent increasing trends for the number of stroke, ICH, yet discrepant trends for the number of SAH in both sexes (increasing trend in women vs. declining trend in men). In IP, we observed rising trends for number of total stroke and ischemic stroke in both sexes compared to in merged IP-ER over the past ten years. However, most of the age-gender adjusted hospitalization rates were stable except for significantly upward trend in TIA among men. In emergency room visits, only the number of AIS appeared to have a significant upward trend, though age-adjusted AIS rates were declining over the same period. (See table 10.1 on page 237)

A strength of this study is the use of the merged inpatient and emergency room data. We detected about 10,000 more stroke cases in merged IP-ER (n = 20,220) compared to IP only (n = 10,733) over the past ten years, with an average of 1000 more stroke cases annually. Although we do not have data on stroke severity we suspect that, most of these cases were TIA and probably mild AIS. Table 10.2 shows that the number and age-adjusted rates of all strokes, AIS and SAH, in merged IP-ER data were 2-fold higher than those in IP data; while there were 4-fold magnitude differences for number of TIA between these two databases, as shown in Table 10.2. ICH increased about 50% in merged IP-ER compared to in IP only. If we conservatively assume 70% correct data in merged IP-ER (reduce 30% incorrect data due to lower PPV of AIS), there would be 700 strokes underestimated each year in the CHR if we only based our estimates upon IP data. Obviously, the burden of stroke, over the past ten years is much bigger than what has been reported using IP data alone, especially for ischemic stroke.

10.2 Effect of Query Diagnosis & Unspecified Stroke

Exclusion of "Q" or query diagnosis affects the reported numbers and rates of stroke occurrence. Given that there is no evidence or consensus on the accuracy of the "Q" code, it is uncertain whether these codes should be included or excluded in rate calculations. The age-adjusted hospitalization rates of overall stroke and AIS increased significantly over time when codes of unspecified stroke eliminated compared to original constant rates; while the downward pattern of age-adjusted stroke or AIS occurrence rate turned to stable after query or unspecified stroke were excluded in merged IP-ER data set.

Table 10.1 Comparison of Trend of Stroke Occurrence Using Different Database

	Merged IP-ER		IP		ER	
	Number	Rate	Number	Rate	Number	Rate
Stroke	–	↓	↑	–	–	–
Stroke Excl. Q	↑	–	↑	–	↑	–
Stroke Excl. I64	↑	–	↑	↑	–	–
Stroke Excl. Q & I64	↑	–	↑	–	↑	–
AIS	–	↓	↑	–	↑	↓
AIS Excl. Q	↑	–	↑	–	↑	–
AIS Excl. I64	↑	–	↑	↑	–	–
AIS Excl. Q & I64	↑	–	↑	–	–	–
TIA	↑	–	↑	–	–	–
TIA Excl. Q	↑	–	↑	–	↑	–
ICH	–	–	–	–	–	–
ICH Excl. Q	–	–	–	–	–	–
SAH	–	–	–	–	–	–
SAH Excl. Q	–	–	–	–	–	–
Stroke - F	–	↓	↑	–	–	↓
Stroke - M	↑	↓	↑	–	–	↓
Stroke Excl. Q - F	↑	–	↑	–	↑	–
Stroke Excl. Q - M	↑	–	↑	–	↑	–
Stroke Excl. I64 - F	↑	–	↑	–	–	–
Stroke Excl. I64 - M	↑	–	↑	–	–	–
Stroke Excl. Q & I64 -F	↑	–	↑	–	–	–
Stroke Excl. Q & I64 -M	↑	–	↑	–	–	–
AIS - F	–	↓	↑	–	↑	–
AIS - M	↑	–	↑	–	↑	–
AIS Excl. Q - F	↑	–	↑	–	↑	–
AIS Excl. Q - M	↑	–	↑	–	↑	–
AIS Excl. I64 - F	↑	–	↑	–	–	–
AIS Excl. I64 - M	↑	–	↑	–	–	–
AIS Excl. Q & I64 -F	↑	–	↑	–	–	–
AIS Excl. Q & I64 -M	↑	–	↑	–	–	–
TIA - F	–	–	↑	–	–	–
TIA - M	↑	–	↑	↑	–	–
TIA Excl. Q - F	↑	–	↑	–	↑	–
TIA Excl. Q - M	↑	–	↑	–	↑	–
ICH - F	↑	–	–	–	–	–
ICH - M	↑	–	–	–	–	–
ICH Excl. Q - F	↑	–	–	–	–	–
ICH Excl. Q - M	–	–	–	–	–	–
SAH - F	↑	–	–	–	–	–
SAH - M	↓	–	–	–	–	–
SAH Excl. Q - F	↑	–	–	–	↑	–
SAH Excl. Q - M	–	–	↓	–	–	–

Note: 'Rate' = Age-adjusted (or age-gender adjusted) rate; '↑' = rising trend with significant difference from 0 ($p < 0.05$ in regression analysis – linear regression was used to estimate number changes over time, while Poisson regression was applied to assess rate changes over time); '↓' = declining trend with significant difference from 0 ($p < 0.05$ in regression analysis); '–' = no statistically difference on changes over time

Table 10.2 Comparison of Average Number & Age-adjusted Rate (per 100,000 per year) for Stroke between Merged ER-IP & IP, 1997-2004

	Merged IP-ER		IP	
	Number	Age-adjusted Rate	Number	Age-adjusted Rate
Stroke	2198	243	1073	124
AIS	1144	128	700	82
TIA	743	83	189	22
ICH	157	17	108	13
SAH	154	15	75	8
Stroke- F	1133	263	542	131
Stroke- M	1065	223	531	117
AIS – F	570	134	346	85
AIS - M	575	122	356	79
TIA - F	397	93	98	24
TIA – M	346	73	91	20
ICH - F	75	17	52	13
ICH - M	82	17	57	12
SAH - F	91	18	47	10
SAH - M	63	11	28	6
Query Diagnosis	425	N/A	32	N/A
Unspecified Stroke	523	N/A	120	N/A

Note: F – Female; M - Male

10.3 Comparison with Other Literature

It is difficult to compare across studies due to differences in approaches – active surveillance or passive surveillance; different data source - registry data or hospital discharge data; different methods of case ascertainment – inconsistent codes used for stroke identification or stroke type classification; different time-trend analyses – using Poisson regression or not in the statistical evaluation of change across time; and different study period. Most studies in the world examined overall stroke, or just two main types of stroke – cerebral infarction (ischemic stroke) and hemorrhagic stroke [93, 94, 107, 115-118]. Five years ago, Hill et al [68] conducted a study in Calgary and reported the trend of in-hospital stroke including AIS and TIA. They found higher age-adjusted rate for stroke (around 160 per 100,000 per year) from 1994 to 2002 in Calgary compared to around 120 per 100, 000 per year from 1995 to 2004 in our study. The age-adjusted hospitalization rates for AIS, TIA, ICH and SAH in their study were about 30, 8, 5, and 3 per 100,000 higher per year than the present study. The reason for the lower rate in our study is that we excluded all those unclear PHN coded as '0', '1' or blank as we treated them as missing PHN which were not be able to link with ER data, though these patients were residents in the CHR. However, consistently, we all observed steady trends of stroke hospitalization rate, although the absolute numbers of stroke admission rose significantly due to the substantial increasing AIS. Unlike the increasing trend of the rate of ICH in Quebec addressed by Mayo et al [115]. We identified a stable pattern of the rate of ICH and a decreased trend of SAH in the CHR.

Our observation of increasing number of stroke is consistent with the released report in Canada from the Heart and Stroke Foundation of Canada (HSFC), and Public Health Agency of Canada (PHAC) [119] though both of their statements did not count TIA (code 435) in stroke. Interestingly, we observed a slightly higher number of strokes and stroke rates in women than in men with no significant difference, instead of lower number of stroke and stroke rates in women in whole Canada population reported by

PHAC. We noticed that PHAC include neither code 436 & I64 (for unspecified stroke), nor code 435 (for TIA) in their report. However, they included I65.x (occlusion and stenosis of precerebral arteries not resulting in cerebral infarction) and I66.x (occlusion and stenosis of cerebral arteries not resulting in cerebral infarction) in ICD-10 that we did not count. This is probably the reason why they used the term “Occlusive stroke” instead of “ischemic stroke” in the released statement, and found discrepant sex difference as our study. Whether these differences reflect gender attitudes of health professionals or biology, or both, requires further study.

Many projects investigated only first-ever stroke or say stroke incidence, while we reported all stroke occurrence including first-ever and recurrent stroke to provide more complete information. We included TIA due to the elevated risk of subsequently developing AIS, hemorrhagic stroke, or recurrent stroke.

We also detected concordant continuous decline of case-fatality for all stroke and AIS since 1997, and slight downward trends for ICH and SAH, as in Hill et al and other studies [68, 94, 116, 117]. The continuous drop in hospital case fatality rates is also consistent with downward trend of age-adjusted mortality for cardiovascular disease in Canada reported by the Heart and Stroke Foundation of Canada (HSFC) [120].

10.4 Causes for Increasing Stroke Number, Declining Stroke Rate & Case-Fatality

The increased use of computed tomography could have resulted in enhanced detection of stroke, especially the detection of mild strokes. The aging of the population will likely bring with it an increase in the number of seniors with stroke. The continuous drop in hospital case fatality rates, may be explained in part by a reduction in the prevalence of smoking, by other lifestyle changes such as dietary improvements, and increased physical activity, and by improved medical care of stroke patients [120]. In addition, stricter preventive measures of persons with TIA and ischemic heart disease, and better risk factor management have lately been implemented. Recently, evidence-based medicine and national and international guidelines have suggested more aggressive risk factor modification for both primary and secondary prevention of vascular events [121-127]. Antithrombotic agents, antihypertensive and lipid-lowering drugs, and more invasive interventions, play an important role not only in decreasing the rates of cerebral infarction, but possibly also in reducing the severity of stroke. This may partially explain the decline in case-fatality as well.

In addition, improved survival after acute stroke and improved health care, such as stroke unit in Calgary after 2001 contributed to the downward trend of case-fatality. Stroke unit care results in one less death for every 16 patients treated on a stroke unit [128]. It may be the key factor in the falling death rates. Prior to 2001, stroke patients in CHR were cared for on both the general neurology service and the general medical service, and about 50% of strokes were admitted to the general neurology service. In 2001, a multidisciplinary stroke unit was opened at Foothills Hospital, which serves as a tertiary stroke center for a referral population of approximately 1.5 million. A majority of patients diagnosed with stroke are admitted directly to the unit from the emergency department. The stroke unit is staffed by a multidisciplinary team consisting of nurse practitioners, nurses, neurologists, rehabilitation physicians, social workers, medical staff, and occupational, physical and speech therapists. This comprehensive, dedicated stroke unit also facilitates emergent therapies, such as thrombolysis.

We observed a sex difference in terms of higher stroke rates and in-hospital case-fatality in women. There is evidence that women have a different experience with stroke than men (more often worse), resulting in different presentation, response to treatment, and functional outcomes [75]. Future studies should be designed to capture sex differences.

10.5 Comparison with Other Chronic Disease Surveillance

Surveillance of stroke is not as same as surveillance of diabetes, or hypertension, or other chronic diseases. For many chronic diseases, such as hypertension, diabetes, renal disease and some cardiovascular diseases, those who already have these diseases are not at risk of developing them again. However stroke is an episodic disease with multiple underlying pathologies. Stroke is different because it can be recurrent. Typical terms in epidemiology, incidence and prevalence, to not apply well to the description of stroke. For many chronic diseases, if an individual has a first-ever stroke (incident) one year, they are also considered prevalent in that year and every subsequent year. We do not think it is appropriate to count stroke every year after first stroke occurred on a person.

10.6 Significance

This is a pilot novel study which is the first step on developing stroke surveillance system. These general epidemiological trends of stroke serve as a starting point for us to assess the burden of stroke in the Calgary Health Region. One big difference to note between this study and other research is that this study extends our knowledge about using only IP data for the evaluation of the burden of stroke occurrence, which has been widely reported by most literature. From a health surveillance perspective, we linked the emergency room visits of stroke (ER) with IP data in order to best evaluate the true burden of stroke occurrence in the CHR. Wielgosz et al have stated that hospital-based stroke surveillance was generally inadequate for population-based incidence estimations. Where computerized databases exist, record linkage can provide the means to develop a cost-effective surveillance system [1].

The results of this study are of public health significance and have implications for acute stroke management. The decline in in-hospital case-fatality over time is an encouraging observation. Ongoing improvements in pre-hospital care, emergency and neurocritical care are likely reasons for this observation [68]. The increasing number of stroke in Calgary will provide information for administrative planning, and result in increased utilization of health care resources over time. Plots of the stratum-specific rates of stroke occurrence in merged IP-ER over time indicated that the relation between some stroke rates and year was linear, which is possible for us to project the future trend of stroke.

Hospital discharge data, accompanied by emergency room data under the universal health care system in Canada, are valuable sources of information to monitor trends and to plan health care requirement.

However, implementation of correct codes on stroke ascertainment, specifically for ischemic stroke, should await more studies and consensus from expert panels to make stroke administrative data definition decisions. This study will inform that debate.

10.7 Limitation

If the large proportion of patients with stroke readmitted soon after a previous discharge or transferred from one hospital to another is not taken into account, the number of events could be overestimated, leading also to a spurious reduction in the percentage of subjects dying during hospitalization. The accuracy of the diagnosis codes are very good for overall stroke, TIA and ICH in merged IP-ER data and IP, as we demonstrated in the first part of this project. However, PPV for AIS and SAH diagnosis are poorer than when unspecified stroke excluded in merged IP-ER. Therefore, we should be cautious on reporting the trend of AIS and SAH occurrence. We wait for further discussion with epidemiologists and specialists on whether we should adjust for the results of AIS, and how to find an optimal way to deal with this issue. Otherwise, such diagnostic misclassification would probably tend to attenuate the rates.

10.7.1 Systematic Bias

A critical missing issue in the use of administrative data for stroke surveillance is an estimate of the stroke severity and the ultimate disability. This limits the assessment of outcomes and quality indicators, but not stroke occurrence rates. However, stroke severity is an important unmeasured confounder on our observation of declining case-fatality, because a fall in the average severity of stroke could partly or entirely explain the declining case-fatality [68].

Moreover, important difficulties in stroke recognition arise in passive surveillance techniques when stroke is not the most responsible diagnosis for a hospital stay and when stroke is mild and overlooked by a chart coder. However, multiple linked datasets, instead of only one, were utilized to maximize the validity of this approach.

10.7.2 Misclassification

This project assumes that the Calgary Health Region population is a closed population without immigration or emigration. Actually, the CHR population is an open population. Approximately, 3.7% of the population emigrated within Canada [72].

Patients who suffered stroke or other events in another province will not be captured by our methods. Similarly, patients who immigrated to CHR and suffered a stroke event in CHR may have been misclassified as incident cases when they had previously had events in another jurisdiction. However, it is not an issue for this study as we are interested in all stroke occurrences, not just incident cases, and the data we got have excluded those PHN out of CHR (so only CHR residents were included). Because emigration and immigration made up a small proportion of the total population and because there is no reason to believe that migration patterns differentially affect stroke patients, it is unlikely that this effect will significantly bias the results.

One of the biases that could distort the validity of this study would be the bias resulting from the misclassification of diagnosis of TIA with AIS, which could be caused by query diagnosis or incorrect coding of unspecified stroke. Although, the validation of merged IP-ER data for our study showed very good PPV for overall stroke, yet PPV for AIS is poor. We know that the accurate classification of stroke type is a major challenge to stroke surveillance. Otherwise, potential misclassification would exist, and the direction of the bias for AIS or TIA could be either over- or underestimation.

10.7.3 Generalization

The direct results from only CHR data will generally be only useful in the Calgary Health Region. Methodology proven in this project can be periodically repeated to assess stroke occurrence on an annual basis, and needs to allow generalization to the rest of province. Using merged data source to portrait the trends of stroke in this project can be tried as a first step in developing algorithms that would be potentially applied to the whole country for stroke surveillance establishment.

10.8 Conclusion

Stratification by sex, and type of stroke revealed an almost across-the-board decline in age-adjusted stroke occurrence rates in merged IP-ER and IP data during the past ten years. However, the declining trend of stroke is accompanied by continuously increasing number of stroke occurrence and decline in in-hospital case-fatality. Our data indicated that merged IP-ER data can provide a valuable source of information on the actual population-based burden of strokes, and is much bigger than hospital-based burden of stroke. Exclusion of query diagnosis and unspecified stroke affect the reported numbers and rates of stroke occurrence, though this did not have much effect on the trend of stroke. The downward trend of stroke rate is in association with increased use of preventive treatments and major reductions in pre-morbid risk factors.

While it appears that rates of stroke are stabilizing or even decreasing, the real burden is the actual number of people with stroke events. The merged IP-ER data presents a clear picture of the burden that stroke continues to place on the Calgary Health Region with over 2000 stroke cases identified each year. An aging population in the CHR will further drive the increasing occurrence of stroke over the coming years. Therefore, the increasing demand for health care resources for stroke is important when our findings are disseminated to health planners and decision makers. The information in our surveillance study also offers evidence for the need to enhance prevention efforts in order to stem the tidal wave of increasing stroke. Furthermore, the higher proportion of TIA patients (34%) in the merged IP-ER data compared to the percentage of 18% TIA in only IP data is a warning for health care professionals and managers to improve preventive treatments in high risk patients of stroke, and promote the education of TIA awareness in the public.

10.9 The Prospect for the Amelioration of the Project

Further study can be developed on rates of stroke occurrence by age group and geographic region. The longitudinal association between stroke occurrence and socioeconomic differences by stroke type in last decade can be portrayed as well. Moreover, it would also be good to develop and examine co-morbidity and risk factor, and length of stay in hospital annually. Besides, graphs of the temporal trends in stroke mortality among the socioeconomic groups by stroke type can be constructed to allow for visual evaluation of the patterns in level and rate of change of stroke mortality. The mortality rates among population with and without stroke need to be studied to examine the ratio between them, which reflects the significance of stroke mortality in the population.

In addition, linking with other data sources may provide more comprehensive information for the stroke surveillance. For instance, we could link the Practitioner Claims database by PHN to differentiate first-ever stroke compared to recurrent stroke events, as has been done for hypertension and diabetes mellitus. Information on the epidemiology recurrent stroke is valuable for planning stroke prevention and management. Further linking with Vital Statistics data would provide important survival information for 30-day or 3 or 5-year mortality of stroke patients, as an outcome measure for a stroke surveillance system.

We hope to use these strategies to develop internal algorithms at Alberta Health & Wellness that will provide automated quarterly and annual updates on stroke surveillance in the Alberta province. Finally, we hope that algorithms that are developed in Alberta can be generalized to the rest of the country and a complete national picture of stroke events can be derived on an annual basis. Our methodology could then be used on a periodic basis, by CIHI or others, to provide an update on the burden of stroke for policy-makers and stakeholders.

APPENDIX

FACULTY OF MEDICINE | UNIVERSITY OF CALGARY

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2007-06-12

Dr. Michael D. Hill
Department of Clinical Neurosciences
Room 1242A
Foothills Hospital
Calgary, Alberta

Dear Dr. Hill:

RE: Surveillance of Stroke Occurrence in Alberta During 1994-2003

Ethics ID: E-20823

Student: Ms. Haifeng Zhu

The above-named research, including the Proposal, and Thesis Proposal Approval dated November 8, 2006, has been granted ethical approval by the Conjoint Health Research Ethics Board of the Faculties of Medicine, Nursing and Kinesiology, University of Calgary, and the Affiliated Teaching Institutions. The Board conforms to the Tri-Council Guidelines, ICH Guidelines and amendments to regulations of the Food and Drugs Act re clinical trials, including membership and requirements for a quorum.

Dr. Michael Hill and Dr. Colleen Maxwell, two of the investigators for this study, are members of the CHREB but did not participate in the review, were not present during discussion and did not vote on this protocol
Please note that this approval is subject to the following conditions:
(1) access to personal identifiable health information was not requested in this submission;
(2) a copy of the informed consent form must have been given to each research subject, if required for this study,
(3) a Progress Report must be submitted by **June 12, 2008**, containing the following information:

- i) the number of subjects recruited;
- ii) a description of any protocol modification;
- iii) any unusual and/or severe complications, adverse events or unanticipated problems involving risks to subjects or others, withdrawal of subjects from the research, or complaints about the research;
- iv) a summary of any recent literature, finding, or other relevant information, especially information about risks associated with the research;
- v) a copy of the current informed consent form:
- vi) the expected date of termination of this project.

4) a Final Report must be submitted at the termination of the project.

Please accept the Board's best wishes for success in your research.
Yours sincerely,

Glenys Godlovitch, BA(Hons), LLB, PhD
Chair, Conjoint Health Research Ethics Board

GG/emcg
c.c. Adult Research Committee Dr. Marja Verhoef(information) Research Services Ms. Haifeng Zhu (Student) Office of Information & Privacy Commissioner

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June 18, 2007

Dr. Michael D. Hill
Department of Clinical Neurosciences
Room 1242A
Foothills Hospital
Calgary, Alberta

Dear Dr. Hill:

RE: E-20823 - Surveillance of Stroke Occurrence in Alberta During 1994-2003

Thank you for submitting an application regarding the above project for review by the Adult Research Committee of the Calgary Health Region (CHR). This will confirm that the committee has granted institutional approval for this project, and that the CHR has granted approval under Sections 53 and 54 of the Health Information Act. ***This approval is contingent on approval by the Conjoint Health Research Ethics Board.***

It is understood from your submission that your study will be entirely funded through external sources and that the CHR will be reimbursed for all research costs associated with this project. **To facilitate a smooth startup of your project, please notify affected departments in the Region well in advance of your intent to initiate this study.**

Please accept the committee's best wishes for success in your research.

Yours sincerely,

Elizabeth MacKay, MD
Acting Chair, Adult Research Committee

cc: Dr. T. Noseworthy (information), Conjoint Health Research Ethics Board, Ms. Haifeng Zhu (Student), Health Records

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