POPULATION-BASED REGISTER OF
ACUTE MYOCARDIAL INFARCTION:
MANUAL OF OPERATIONS

Mette Madsen[1], Vilmundur Gudnason[2], Andrzej Paj k[3], Luigi Palmieri[4], Evangelista C Rocha[5], Veikko Salomaa[6], Susana Sans[7], Konrad Steinbach[8], Diego Vanuzzo[9] on behalf of the EUROCISS Research Group

1 Institute of Public Health, University of Copenhagen, Copenhagen, Denmark

2 Icelandic Heart Association Research Institute, Kopavogur, Iceland

3 Jagellonian University Medical College, Krakow, Poland

4 Istituto Superiore di Sanità, Rome, Italy

5 Instituto de Medicina Preventiva, Lisbon, Portugal

6 National Public Health Institute, Helsinki, Finland

7 Institut d'Estudis de la Salut, Barcelona, Spain

8 Austrian Heart Foundation, Ven, Austria

9 Azienda per i Servizi Sanitari 4 Medio Friuli, Udine, Italy

EUROCISS Project Research Group:

The EUROCISS Project (European Cardiovascular Indicators Surveillance Set http://www.cuore.iss.it/eurociss/eurociss.asp) was set up in 2000 by a partnership of 18 European Union countries under the coordination of the Istituto Superiore di Sanità, Rome, Italy.

S. Giampaoli (Project coordinator), P. Ciccarelli, L. Palmieri, S. Panico, D. Vanuzzo, ITALY

K. Steinbach AUSTRIA

M. Kornitzer/G. de Backer BELGIUM

J. Holub CZECH REPUBLIC

M. Madsen DENMARK

V. Salomaa FINLAND

J. Bloch/C. De Peretti FRANCE

A. Doring GERMANY

D. Trichopoulos/A. Trichopoulou GREECE

R. Adany HUNGARY

V. Gudnason ICELAND

M. Verschuren THE NETHERLANDS

S. Graff-Iversen NORWAY

A. Paj k POLAND

E. Rocha PORTUGAL

S. Sans SPAIN

N. Hammar SWEDEN

P. Primatesta UNITED KINGDOM

S. Allender EUROPEAN HEART NETWORK

CONTENTS

ABBREVIATIONS

ACC = American College of Cardiology
AMI = Acute Myocardial Infarction
ACS = Acute Coronary Syndrome
AHA = American Heart Association
BCS = British Cardiac Society
CABG = Coronary Artery Bypass Graft
CK-MB = Creatine-Kinase
CVD = Cardiovascular Disease
DALY = Disability Adjusted Life Year
DRG = Diagnosis Related Groups
ECG = Electrocardiogram
ECHIM = European Community Health Indicators Monitoring
ESC = European Society of Cardiology
EU = European Union
EUROCISS = European Cardiovascular Indicators Surveillance Set
EUROSTAT = Statistical Office of the European Communities
GP = General Practitioner
HDR = Hospital Discharge Records
HES = Health Examination Survey
HIS = Health Interview Survey
ICD = International Classification of Disease
IHD = Ischaemic Heart Disease
MDC = Major Diagnostic Categories
MI = Myocardial Infarction
MONICA = MONItoring trends and determinants of CArdiovascular diseases
OECD = Organisation for Economic Cooperation and Development
PCI = Percutaneous Coronary Intervention
PIN = Personal Identification Number
PTCA = Percutaneous Transluminal Coronary Angioplasty
WHO = World Health Organization

1. INTRODUCTION AND RATIONALE

1.1 Burden of disease

Cardiovascular disease (CVD) is the leading cause of death and hospitalisation in both genders in nearly all countries of Europe. In the European Union (EU)[1] 46% of women and 39% of men die from CVD (Figures 1 and 2) [1].

CVD clinically manifests itself in middle life and older age after many years of exposure to unhealthy lifestyles (smoking habit, unhealthy diet, physical inactivity) and risk factors (total and low-density lipoprotein cholesterol, blood pressure, diabetes). Even though the clinical onset is mainly acute, CVD often evolves gradually. Contrary to common belief of a sudden death and hence of a death free of suffering, CVD causes substantial loss of quality of life, disability, and life long dependence on health services and medications.

For many years CVD mortality has been decreasing in the majority of Western European countries and during recent years this decrease has occurred also in Eastern Europe [2]. However, the absolute number of patients in need of using health services for CVD conditions does not decrease to the same extent because prevalence tends to increase, and this is due to an increase in survival and an increasing proportion of older people in the population. In particular, coronary heart disease is bound to become a more frequent disease of older women [3]. CVD has major economical consequences as well as human costs. CVD alone accounts for 20% of global total DALYs (Disability Adjusted Life Years) in persons older than 30 years [4]. In terms of health, acute events may mean an increasing number of dependent, chronically ill and disabled people: this may cause increasing costs of healthcare and strain the healthcare system.

Among CVD, Ischaemic Heart Disease (IHD) by itself is the single most common cause of death in the EU accounting for 744,000 deaths each year: around one in six men (17%) and over one in seven women (16%) die from the disease [1].

---

[1]Data refer to the following 25 member States: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

In the last decade innovations in diagnostic technologies have facilitated diagnosis at earlier phases in the course of the natural history of disease or in presence of less severe tissue damage. The use of new biomarkers, such as the routine introduction of new myocite damage markers (troponins), has required a rethink of the concept of myocardial necrosis and has led to a new and more exhaustive definition of acute coronary syndrome (ACS) [5,6,7].

Coding changes in international disease classification have also posed new challenges for the comparability of disease indicators. All these factors may produce spurious trends in disease frequency, severity, prognosis and subsequent variations in medical practice if not properly controlled with the adoption of updated and valid epidemiological methods.

The magnitude of the CVD contrasts with the usual paucity and poor quality of data available on the incidence and prevalence of CVD, except for few rigorous but limited studies carried out in certain geographical areas.

According to the Organisation for Economic Cooperation and Development (OECD), it does not appear inevitable that longer life leads to higher healthcare costs. This is one of the reasons why the health system should be largely oriented toward work on preventive actions. Epidemiological studies have shown that IHD is preventable to a large extent. Different preventive strategies can be implemented to reduce the occurrence and impact of IHD, such as the identification of individuals at high risk, and to intensify treatment in those people who have already experienced a coronary event.

At the European level, the World Health Organization (WHO), OECD and the Statistical Office of the European Communities (EUROSTAT) collect simple CVD indicators (mortality, hospital discharge rates) and process them into tables available on web-site (www.euro.who.int/hfadb; www.oecd.org; www.europa.eu.int/comm/eurostat). These data are rarely comparable due to the different methodology and the peculiar health system of each country.

1.2 Disease register

The objectives of a AMI/ACS population-based register is to (a) evaluate the frequency, distribution and prognosis of the disease providing indicators, such as

attack rate, incidence rate, prevalence and case-fatality rate; (b) evaluate trends and changing pattern, outcomes and treatment effectiveness; and (c) monitor CVD prevention programmes. If survival rates are assumed to be known, prevalence can also be estimated.

Focusing on general population, a AMI/ACS register may provide a comprehensive picture of this disease in the community, highlight problem areas and suggest where treatment facilities are most in need of improvement. This register may also provide information system needed to plan healthcare services and to develop and test which methods are most useful as a basis for preventive actions.

A population-based register includes all cases in a defined population, whether treated at home or in hospital, in whichever season of the year or time of the day they may occur, and would also include rapidly fatal cases unable to reach the medical service.

Therefore, it is desirable that collection of information on suspected events and application of diagnostic criteria follow a standardised methodology in order to enable data comparison in different areas or between different countries.

To summarise, a population-based register is intended for health professionals and policy makers and provides the means to understand the characteristics, the burden and the consequences of the disease in the population through:

- the monitoring of the occurrence of the disease (i.e. to assess population differences and trends in attack and incidence rates and in mortality over time);
- the understanding of the differences and changes in the natural disease dynamics between genders, age groups, social classes, ethnic groups etc.;
- the identification of vulnerable groups;
- the monitoring of in- and out-of-hospital case fatality;
- the assessment of relations between disease incidence, case-fatality and mortality;
- the monitoring of the consequences of disease in the community in terms of drug prescriptions and rehabilitation;
- the monitoring of the utilisation of new diagnostic tools and treatments and

their impact.

This is crucial in order to:

- develop health strategies and policies;
- plan health services and health expenditures;
- improve appropriate allocation of resources;
- evaluate the effectiveness of interventions.

A register must be validated. Validation provides the means to:

- take into account bias from diagnostic practices and changes in coding systems;
- trace the impact of new diagnostic tools and re-definition of events;
- ensure data comparability within the register (i.e. different sub-populations, different time points, etc);
- ensure data comparability with other registers within and between countries.

1.3 Historical background

The first experience of population-based registers in the field of cardiovascular disease were the *WHO Myocardial Infarction Community Registers* in 1967 [8]; they were implemented by a group of experts convened by the WHO Regional office for Europe to (a) evaluate the extent of AMI in the community; (b) monitor the effect of changes in the management of AMI and different kinds of intervention; (c) provide an assessment of the validity of mortality statistics; (d) select a pool of patients who could be studied in detail and focus attention on specific problem areas. The register examined the incidence of myocardial infarction (MI) and the influence of smoking, obesity and hypertension on MI to show which people in the community were specifically at risk.

The WHO Myocardial Infarction Community Registers were followed by the *WHO MONICA Project* (MONItoring trends and determinants in CArdiovascular diseases) [9] which was indeed designed to answer key questions on decline in coronary heart disease mortality, in particular which part was attributable to survival improvement and coronary-event decline as a consequence of risk factors reductions and improving coronary care.

During 10 years of surveillance of 37 populations in 21 countries 166,000 events

were registered. The mean annual decrease in official coronary mortality rates (based on death certification) was -4% in men and -4% in women. By MONICA criteria, IHD mortality rates were higher but fell less (-3% and -2%). Changes in non-fatal rates were smaller (-2% and -1%). MONICA coronary-event rates (fatal and non-fatal combined) fell more (-2% and -1%) than case fatality (-1% and -1%). Contribution to changing IHD mortality varied, but in populations in which mortality decreased, coronary event rates contributed two thirds and case fatality one third [10].

1.4 Existing registers in Europe – an overview

The data collection for the international MONICA study ended in 1994/95. Some countries continued to collect data every year, while others only periodically (usually every 5 years).

Presently, the existing registers in Europe adopt different data collection procedures: some registers are based on the procedures used in the MONICA study, others on administrative databases with or without record linkage, some are national and some are regional. Different age groups are covered, the degree of validation of the diagnostic information varies and in most registers is much less intensive than in the MONICA study [11].

Tables 1, 2 and 3 give a brief overview of the existing AMI/ACS registers in Europe. Table 1 shows the national registers in the Northern countries, which are all based on record linkage between routine databases (hospital discharge records and cause of death registers).

Table 2A and 2B show regional population-based registers: most of them are based on a disease specific data collection comparable to the MONICA registers, while the others are based on different data collection methods.

Table 3 shows registers based on data from healthcare institutions such as General Practitioner (GP) and hospitals. These registers do not include out-of-hospital fatal events (sudden death), therefore they are not intended to assess disease occurrence but rather to evaluate outcome and survival of patients.

2. OBJECTIVES

The purpose of the EUROCISS Project is to provide a general guide and updated methods for the surveillance of AMI/ACS to those EU countries which lack appropriate surveillance systems and therefore wish to implement a population-based register in order to produce comparable and reliable indicators.

Taking into account developments in new diagnostic criteria, treatment and information technologies in recent years, this manual provides a standardised and simple model for the implementation of a population-based register. It recommends to start from a minimum data set and follow a step-wise procedure based on standardised data collection, appropriate record linkage and validation methods.

This manual is intended for investigators, health professionals, policy makers and data collection staff interested in the surveillance of AMI/ACS.

Although in many countries data extracted from some sources of information (mortality and hospital discharge records [HDR]) are now available thanks to the continuing process of computerisation, they are rarely reliable and comparable. These data can produce reliable indicators only if properly processed and validated by independent epidemiological sources.

This manual represents a valid tool to build the core indicators (attack rate, incidence, case fatality) recommended by the EUROCISS Project Research Group for inclusion in the short list of health indicators set up by the European Community Health Indicators Monitoring (ECHIM) Project. This Project was launched in 2005 with the aim of implementing health monitoring in EU [12].

3. STRATEGY FOR SURVEILLANCE

3.1 Surveillance methods and types of registers

Surveillance is the ongoing, systematic collection, analysis, interpretation and dissemination of health information to health professionals and policy makers. Surveillance, defined as a continuous, and not episodic or intermittent activity, differs from monitoring [13,14].

Disease surveillance in a population can be done using many different data sources (Table 4). Most countries have national databases on causes of death and discharge diagnoses for hospitalised patients. Mortality statistics have for many years been the main tool for comparing health and disease patterns among countries and today still remain the only source of information for some countries. Since the 1950s, the cause of death has been registered according to the International Classification of Disease (ICD). Different classification of disease within versions and different methods of ascertainment have led to problems in comparison between different revisions of ICD and/or similar versions among countries. In recent years routine statistics have also included discharge diagnoses from hospitalisation and visits to outpatient clinics coded according to the same international classifications as the mortality data.

Some countries have also some kind of Health Interview Survey/Health Examination Survey (HIS/HES). These surveys are primarily used for monitoring prevalence of disease (including IHD, effort angina, old MI), prevalence of risk factors (health behaviour, social network, environmental risk factors) and of disease consequences (disability, reduced physical function, unemployment).

Population-based registers ensure a more precise and valid monitoring of this disease. This register derives from a variety of currently available sources but requires a further level of processing to ensure accuracy.

A population-based register is usually formed through linkage of various sources of information (mortality data, hospital discharge and GP's records) and covers a defined population (entire municipalities, regions or whole country) and a specific age group (35 to74 or 35 to 64 years or all ages).

A population-based register is the best data source for the surveillance of AMI/ACS morbidity and mortality since it considers both fatal and non-fatal

events occurring in-and out-of hospital; therefore it provides estimates of key indicators such as attack rate and case fatality. Incidence can be assessed if information on first event is available. If survival rates are available, prevalence can be assessed as well.

Case findings and validation procedures depend on data collection methods, healthcare system, financing system (Diagnosis Related Group, [DRG]) and diagnostic criteria applied in the definition of events. The accuracy of rates produced using a population-based register is related to the completeness and quality control of data collected for numerator (death and hospital discharge registers) and denominator (census or population register). Completeness also depends on tracing subjects treated outside hospital (nursing home, clinic, etc.). A valid population-based register should also collect events in the target population which occur outside the area of surveillance.

The definition of the event must take into account both the ICD codes reported in the hospital discharge diagnoses (main or secondary) or causes of death (underlying or secondary) and the duration of event. This definition is of particular importance since AMI/ACS event may occur more than once and it is therefore necessary to consider both first and recurrent events. In this context, hospital admissions and deaths occurring within 28 days (onset is day 1) are considered to reflect the same event [15] (see definition of event in paragraph 4.1).

A personal identification number (PIN) for each subject is a strong tool in linkage procedures between hospital discharge diagnoses, GP's records and death certificates; alternatively, multiple variables (e.g. name, date and place of birth, gender, residence) may be used for record linkage.

Specific AMI/ACS register

The strength of this register lies in the possibility of validating each single event according to standardised diagnostic criteria and collecting disease-specific clinical and paraclinical data [16,17]. The weakness lies in the fact that data collection is expensive and this kind of registers can usually be maintained only for a limited period of time in a defined population of reasonable size. Another

limitation is that local or regional registers may not be representative for the whole country.

Identification of events can be obtained by *hot pursuit or cold pursuit. Hot pursuit* means identifying case admissions to hospital usually within one or two days from event onset and acquiring relevant information by visiting the ward or interviewing the patient. Information bias is minimised by the *hot pursuit* approach as information is collected immediately after the event. The process is very expensive.

Cold pursuit implies the use of routine and delayed procedures, by means of hospital discharge, review of medical and death records. The process is easier and less expensive than *hot pursuit*; the number of cases studied is typically smaller because discharge diagnoses are more precise and specific than those on admission, but there is a possibility of missing important information. Both methods are used to identify suspected events, which are subsequently validated using specific diagnostic criteria.

A specific AMI/ACS register provides the most valuable epidemiological measures for public health initiatives aimed at preventing the disease. It has been used in the WHO/MONICA Project, where uniform criteria for recording CVD have been applied to 37 population in 21 countries for a period of 10 years [10].

Register based on routine databases

Events are identified using mortality data and HDR. This register has existed for many years in the Northern countries, where all individuals are identified by a PIN which allows record linkage between different information sources. It is economical, covers the whole country, all age groups and collects large numbers of events. The main objective of administrative databases is to produce relevant statistics in order to plan health services and healthcare expenditure and to give internationally data on mortality, causes of death and hospital admissions. The register is not primarily planned for research purposes but is increasingly used in epidemiological research. Its strength lies in the fact that it covers the whole country and the completeness is close to 100%. The weakness lies in the fact that data are not standardised to the same degree as in the disease specific data

collection and clinical and paraclinical data available are limited. If used in research, the register based on routine databases needs to be carefully validated. AMI/ACS registers based on administrative data, such as hospital discharges and death certificates, have been employed in Denmark, Sweden and Finland in order to obtain national rates of AMI/ACS incidence, mortality and case fatality [17-24].

Hospital-based register

A hospital-based register provides the number of hospitalisations but do not provide data on less severe events and out-of-hospital mortality. Hence, it cannot directly be used to estimate incidence or prevalence in a defined population.

Even so, case series from hospital-based register present important clinical information about AMI/ACS.

A hospital-based register collects information about hospital patients through surveillance of admission and discharge records. In particular, it provides detailed information on diagnostic and therapeutic procedures and on risk factor levels prior to admission to hospital. One primary objective of this type of register is to assess length of stay, in-hospital treatment and outcome.

3.2 Target population

A population-based AMI/ACS register may cover a whole country; where this is not feasible, the population under surveillance would typically be residents of a defined region in the country. The target population should preferably cover a well defined geographical and administrative area or region for which population data and vital statistics are routinely collected and easily available each year. Both urban and rural areas should be monitored: differences often exist with regard to exposure to risk factors, treatment of predisposing disease and access to facilities.

It is important that all cases among those with residence in the area are recorded even if the case occurs outside the area (*completeness*). In the same way, all cases treated at hospitals within the area but with residence outside the area must be excluded. If this is not possible, it is important to give an estimate of the magnitude of the loss of cases and establish whether it could be changing and

interfering with the validity of the observed trends in the rates over a period of years.

It is also important to consider to what extent an area is representative for the whole country (*representativeness*): it should be representative according to the CVD mortality rate, distribution of risk factors (socioeconomic status and health behaviour) and distribution of health services (specialised hospital, GP).

The population to be monitored should be selected in order to produce estimates of disease rates that are sufficiently robust from a statistical point of view, so that trends can be established and data comparability ensured. In general, it is necessary to select more than one area in order to have a comprehensive picture for the whole country. In such cases, a coordination between the areas is recommended to ensure comparability. The target population should be selected taking the following parameters into account:

Age: the age range covered by the MONICA Project was 35 to 64 years. The EUROCISS Project suggests the wider age-range 35 to 74 years or even up to 84 years of age when possible, considering that more than half of the events occur in patients above 65 years of age. The age groups recommended from EUROCISS Project to present morbidity and mortality are decennia, in particular the age ranges 35 to 44, 45 to 54, 55 to 64, 65 to 74 and, if possible, 75 to 84. If administrative routine data are used, all ages will automatically be included, but for patients above the age of 85 the diagnostic information tends to be less reliable.

Age-standardised rates (35 to 74 and 35 to 84) are recommended using the European Standard Population as reference.

Gender: the differences in AMI/ACS incidence and mortality between men and women are well documented in literature. Therefore, it is important that the same high quality data collection methods are applied to both women and men.

Population size: the size of the population under surveillance is determined by the number of events. The number of events is determined by the definition of the event and the event rate in the age groups included. In most cases the population size has to be determined on the basis of mortality statistics. Notably, the mortality rate for 'IHD' is greater than that for 'ACS' which is greater than

mortality rate for 'AMI'; in addition, the age-specific mortality rate for men is greater than that for women.

This means that in order to estimate attack rates in middle-age subjects with the same degree of precision, the population should be larger for women than for men.

To estimate the size of the population under surveillance for the register, the age range 45-74 years, instead of 35-44 years where few events occur, is taken into consideration. To be eligible to participate to an AMI/ACS population-based register, a minimum of 300 coronary events (fatal and non fatal, men and women together) per year in the population ages 45-74 years is necessary. The minimum of 300 fatal events has been established in order to detect a decrease by 2% in attack rate per year, taking into account that the population to be under surveillance could range between approximately 1.800.000 (all ages) in a low incidence country like Italy and 200.000 (all ages) in a high incidence country like Finland, basing the calculation on female attack rates usually lower than male attack rates.

If more areas are enrolled, it would be desirable that the same number of 300 total events is considered for each single area.

Patient eligibility: a patient is considered eligible for inclusion in a population-based AMI/ACS register only if he/she is resident in the area under surveillance, meets the selected age and had a AMI/ACS event within the defined time period.

3.3 Data sources

To monitor AMI/ACS in the general population, the following sources of information should be available at a minimum: mortality records with death certificates; and, HDR with clinical information.

Some events occur suddenly and are not able to reach the hospital and some non-fatal cases may not be referred to hospital for treatment. Therefore, additional sources are usually needed to achieve complete information on all fatal and non-fatal events: clinical pathology laboratory (autopsy register), nursing home, clinic, emergency or ambulance service, GP, drug dispensing register.

Death certificate

The death certificate provides complete data on fatal events and is collected in a systematic and continuous way in all EU countries. Mortality statistics are easily accessible in all countries but are usually published in a detailed and complete form after 2-4 years.

The format of the death certificate varies from country to country but generally includes personal identification data, date and place of death (i.e. municipality, nursing home, hospital or other) and causes of death (underlying, immediate and contributing). CVD causes of death are coded according to the ICD. Problems of temporal and geographic comparisons derive from the different versions of the ICD adopted over time (7th, 8th, 9th, 10th revision) and from different coding practices in each country. Furthermore, diagnostic criteria for coding death certificates are not defined at international level and ICD versions are updated every 10 years by WHO.

Some countries code the underlying cause of death only.

The reliability of mortality data depends on the completeness and accuracy of the vital registration system of the country as well as the registration and coding of causes of death. When the proportion of deaths coded as "unknown cause of death" is higher than 5%, cause specific mortality data should be used with caution. The accuracy of the recorded causes of death depends on the autopsy rate. This rate varies largely between countries and over time. In some countries the autopsy rate has declined in recent years, which is a problem for the use of mortality statistics in disease surveillance.

Hospital Discharge Records

HDR give the number of hospitalisations for AMI/ACS, which are absolutely necessary to monitor CVD. Moreover, clinical information and medical care reported in hospital documents are important for validation of events. Hospital discharge data are available in most EU countries, but in some countries only as aggregated tables without detailed information on age and gender distribution and without AMI/ACS as separate diagnostic categories.

HDR include personal data, admission date, type of hospitalisation (urgent, ordinary or transfer to other structure) and discharge diagnoses. Hospital

discharge diagnoses are coded by ICD codes (currently ICD-9 or ICD-10). For some countries, only a limited number of diagnoses is coded.

Problems in assessment of a specific coronary event may arise when an acute event is followed by a period of rehabilitation or transfer to other wards and the event could be counted more than once.

Discharge diagnoses are not validated on a routine basis and validation studies are necessary to check the diagnostic quality. The validity of a hospital discharge diagnosis may vary on the basis of patient characteristics, geographical region and type of hospital or clinic.

Hospital admission policies vary over time and place; the registration of the most severe cases dying shortly after the arrival to the hospital differs between hospitals, depending on the administrative procedures connected to hospital admissions. HDR may also include patients not resident in the area under surveillance.

The adoption of new diagnostic techniques, such as troponin, may cause major changes in event rates estimated from hospital discharge data.

A further problem may derive from the use of DRG. In some countries, hospital reimbursement is based on the DRG tariff system, which is built on equal-resources criteria and aggregates events in major diagnostic categories (MDC).

Countries using the DRG system are: Denmark, Finland, France, Germany, Italy, Norway, Portugal, Spain and Sweden. In order to assess the occurrence of AMI/ACS, HDR from all hospital departments should be used. If this is not possible, then at minimum, the following departments must be taken into consideration:

- cardiology;
- heart surgery;
- intensive care (an intensive care unit, including any type of acute medical unit);
- medical (a general medical ward, including a geriatric unit);
- rehabilitation (a specialised rehabilitation unit);
- other (other units, e.g. outliers or patients on surgical wards).

Autopsy register

Not all countries perform autopsy on suspected or sudden deaths on a routine basis. Autopsy is performed on violent deaths or on deaths occurring in hospital when clinical diagnosis is undetermined. The first one is performed by a forensic medicine specialist, the second one by a pathologist of the hospital where death occurred. Data from autopsy register refer therefore to a low percentage of deaths but provide a more valid diagnosis to complement the information reported on the death certificate.

Nursing home and clinic

Nursing home and clinic mainly provide data on cases among elderly patients who sometimes get care from these institutions without being admitted to hospital. Therefore, information on events occurring in the nursing home can be critical, especially if the register covers elderly patient up to 84 years of age.

In some countries rehabilitation after an acute event is provided by the rehabilitation clinic which may give information on patients who have received the acute care outside the region.

Emergency and ambulance services

Data provided by emergency and ambulance services are useful to integrate information for register implementation since patients dying from sudden death or experiencing fatal AMI/ACS are not always able to reach the hospital. These services are able to provide data otherwise not obtainable, such as Electrocardiogram (ECG) during the acute phase of the event, blood pressure measurement, level of consciousness and muscular deficit at the time of event occurrence in paucisymptomatic patients recurring to emergency services. The need of very urgent medical treatment often makes information partial but the integration of these data with those from other sources of information contributes to the implementation of the register and event validation.

General Practitioner register

A GP register gives information on those events which do not reach the hospital and for those patients who are hospitalised outside the area of usual residence.

This register may also provide an adequate coverage for prevalence of old MI. This network operates in a few countries (e.g. the Netherlands and UK).

GPs network may be affected by selection bias as usually only volunteer GPs participate in studies. For this reason data from GPs network requires validation.

Drug dispensing register

In some member countries, patients may receive comprehensive drug reimbursement under their national sanitary system, and so drug prescriptions can serve as a proxy for disease. Prescribing guidelines for CVD indicate prescription of anti-hypertensives, low-dose aspirin, antiplatelet, antidiabetic and statins. The administration of thrombolytic therapy can also be used as a proxy for disease.

4. METHODS

4.1 Definition of events

The disease under surveillance is *acute myocardial infarction* (AMI: ICD-9 410; ICD-10 I21, I22) and the broader diagnostic group is *acute coronary syndrome* (ACS: ICD-9 410-411; ICD-10 I20.0, I21, I22). *Acute myocardial infarction* is defined as myocardial cell death due to prolonged ischaemia [5,25].

Criteria for AMI/ACS events

The diagnosis of AMI/ACS events is based on symptoms, ECG changes, elevation of biomarkers, and in fatal cases, autopsy findings. Since the early 1980s, the MONICA definition has been used for standardised diagnostic classification of suspected cases of AMI and IHD death (Table 5) [9]. The situation changed with the adoption of more sensitive and specific biomarkers of myocardial injury, first creatine kinase MB mass (CK-MBm) and then the introduction of cardiac troponins (troponin T and troponin I). In the year 2000 the Joint European Society of Cardiology (ESC) and the American College of Cardiology (ACC) created a new consensus document redefining AMI (Table 6) [5].

In 2003 new case definitions were published as American Heart Association (AHA) statement (Table 7) [6].

A more recent classification is proposed by the British Cardiac Society (BCS, Table 8) [7].

Identification of events

Fatal events include: ICD-9 codes 410-414 (ICD-10: I20-I25) as underlying cause of death as these codes include the majority of definite and possible events.

Non-fatal events include ICD-9 codes 410-411 (ICD-10: I20.0, I21,I22) as primary or secondary hospital discharge diagnosis.

Fatal events

Version	Codes	Disease
ICD 8	410	Acute myocardial infarction
ICD 9	411	Other acute and subacute forms of ischemic heart disease
	412	Old myocardial infarction
	413	Angina pectoris
	414	Other forms of chronic ischemic heart disease
ICD 10	I 21, I 22	Acute myocardial infarction
	I 20.0	Other acute and subacute forms of ischemic heart disease
	I 25.2	Old myocardial infarction
	I 20	Angina pectoris
	I 25 (excluded I 25.2)	Other forms of chronic ischemic heart disease
Non-fatal events		
Version	Codes	Disease
ICD 8	410	Acute myocardial infarction
ICD 9	411	Other acute and subacute forms of ischemic heart disease
ICD 10	I 21, I 22	Acute myocardial infarction
	I 20.0	Other acute and subacute forms of ischemic heart disease

Onset and survival

AMI/ACS events are defined as *first ever, recurrent, non-fatal and fatal*:

- *First ever AMI/ACS event:* refers to people who have never had an AMI/ACS event before.

- *Recurrent AMI/ACS event*: for a new episode of symptoms to be counted as a new or recurrent AMI/ACS event, general AMI/ACS criteria must be met and either:
    - onset is day one (1);
    - a new AMI/ACS occurring after 28 days is a new event.

If a patient experiences further acute symptoms suggestive of AMI/ACS within 28 days (as stated above) of the onset of a first episode, this second episode is not counted as a new AMI/ACS event. Equally, if a patient experiences further acute symptoms suggestive of AMI/ACS after 28 days (as stated above) of the onset of a first episode, this second episode is counted as a new event.

- *Non-fatal AMI/ACS event*: refers to cases who survived at least 28 days from the onset of the AMI/ACS symptoms.

- *Fatal AMI/ACS event*: refers to cases who died within 28 days of AMI/ACS symptoms onset.

It should be noted that each event is registered separately.

4.2 Indicators

Attack rate

Attack rate is calculated identifying the events by using primary or secondary hospital discharge diagnoses or underlying cause of death for out-of-hospital deaths. Almost 32% of the patients die before they reach the hospital, and therefore a hospital discharge register alone is not sufficient [26].

Incidence rate

This indicator can be estimated only if information on first event is available.

In Northern countries an event is defined as first if there is no discharge with AMI as primary or secondary diagnosis in-hospital discharge records of the past 7 years.

Case-fatality

Case fatality is the proportion of events that are fatal by the 28th day.

The EUROCISS Project recommends 1 day and 28 day case fatality. All in- and out-of-hospital fatal and non-fatal events are to be considered as denominator.

4.3 Data collection methods

The different types of registers described in section 3.1 use different data collection methods. Registers with disease specific data collection can be divided into population-based registers using record linkage of administrative databases (mortality, HDR) and disease specific registers using hot and cold pursuit for the identification of events.

AMI/ACS population-based register based on routine administrative data

In recent years, the development of computerised record linkage has made it possible to overcome obstacles in linking existing administrative databases. Record linkage methods can be summarised into three broad categories: *manual*, *deterministic* and *probabilistic*.

Manual matching is the oldest, most time-consuming and most costly method. In general, it is not a feasible option when large databases are involved.

Deterministic linkage matches records from two data sets (or two records from different locations in a single data set) using a unique variable (e.g. PIN or hospital chart number) or by full agreement of a set of common variables (e.g. name, gender, birth date).

Probabilistic [27] linkage is used to identify and link records from one data set to corresponding records in another data set (or two records from different locations in a single data set) on the basis of a calculated statistical probability for a set of relevant variables (e.g. name, gender, date of birth). This type of linkage links records with a specified high probability of match. The method requires detailed prior knowledge about various measures of the relative importance of specific identifier values in both files that are to be linked.

The main limitations of record linkage are the difficulty in:

- obtaining administrative files for research purposes: mortality data files are usually available at the National Institute of Statistics, while hospital discharge data are available at the Ministry of Health. These kinds of data are anonymous and therefore do not allow record linkage. Nominal files of both mortality and hospital discharge are available at the regional level or at the sanitary units;

- combining data: missing events are mainly explained by errors in PIN or in name and they lead to unsuccessful record linkage;

- defining and obtaining minimal data set (for mortality: PIN; family and first name; date and place of birth; gender; residence; date and place of death; underlying and secondary causes of death. For hospital discharge diagnosis the same variables should be considered together with admission date and hospital discharge diagnoses);

- obtaining necessary funds for processing large administrative files.

The national AMI registers in the Northern countries use record linkage between Hospital Discharge Registers and Causes of Death Registers as the basis for the register. The linkage as such is easy because of the PIN attached to every citizen in the country.

However, the linkage has to be followed by many specific definitions on how to handle primary and secondary diagnoses, underlying and contributory causes of death, transfer between hospitals with difference in the diagnoses between the admitting hospital and the hospital where the patient is transferred, how to define date of attack, first time events, reinfarctions etc.

Practical suggestions on how to handle these problems has come from the work carried out in Northern countries [23,28,29].

Specific population-based register

Hot pursuit [15]

This method of detecting events involves identifying patients acutely in hospital and interviewing them directly whilst they are under acute care. The problem with this method is that data collection technique is very difficult to standardise (e.g. descriptions of symptoms may vary with the observer). Periods of staff shortages or holidays may lead to loss of cases that cannot be recovered and a large team is needed to search the wards for cases. However, some information may be more complete than that obtainable from case notes.

Notification of events should be instituted on a routine basis checking admission registers on the wards.

While the extreme forms of hot pursuit involve getting the information from the patient acutely, an alternative is to use the hot pursuit method to identify the patients of interest and to mark their notes or list them for review later. An efficient reliable routine is needed for picking up the case notes at an identifiable point in their processing.

A benefit of the hot pursuit method is that information on the diagnosis is collected soon after admission. This has its limitations, however, as initial diagnosis can sometimes be superseded by subsequent tests and other more detailed investigation.

Residents hospitalised outside the area will always have to be registered by cold pursuit, weeks or months later.

Cold pursuit [15]

Use of discharge diagnoses rather than hospital admissions is a more simple system of identifying events for the study. Its advantage is that it can be done months or years after the event but it is limited because the information in the case notes may not be complete and the notes themselves may not be accessible.

Once event has been identified, if validation is required, medical notes should be obtained in order to extract the necessary information from them.

When a register is launched for the first time, a plan for future evaluation of trends is recommended. This can be achieved by continuous surveillance as part of a broader health information system or annual register repeated at 5 to 10 year intervals. The minimum recommended period of observation is one complete calendar year because of possible seasonal variation.

Combined approach

A mix of hot and cold pursuit ensures the most complete identification of coronary events.

Some of the patients must have been identified as soon as possible after symptoms onset with the possibility of direct examination, while the remaining events are based on routine data.

It is difficult to check up on a hot pursuit system several months later, but discharge lists can be used as a backup method to ensure that the hot pursuit method had detected all the diagnosed cases. Residents hospitalised outside the area and other late-detected cases mean that a proportion of events will always have to be registered by cold pursuit, weeks or months later.

5. QUALITY CONTROL

Quality control of registers is extremely important for a valid monitoring and comparison between regions and countries. The quality of the register depends on:

- completeness of cases and completeness of information;
- iInternal validity;
- external validity (representativeness).

5.1 Completeness of cases and completeness of information

Completeness of cases means that all AMI/ACS cases in the target population have been included, i.e. both cases taking place within the region and cases taking place outside the region. The register has also to cover hospitalised cases whenever they occur during day/night or winter/summer as well as cases occurring outside hospital (e.g. sudden death among patients who never reach the hospital).

Completeness of information means that all relevant information has been registered (e.g. place of treatment, date of admission, date of discharge, PIN, gender, hospital discharge diagnostic codes, intervention/procedure codes, department/ward, date of birth).

The most important source of systematic bias in estimating incidence is related to the coverage of event registration. The registration system must attempt to identify all possible cases of the disease that have come to the attention of the existing medical and medico-legal sources. The completeness of event identification and the completeness and availability of information, obtainable for event recording and diagnosis, depend on the existing standard of medical care: if the medical care system misses or misdiagnoses cases, the register cannot remedy the omission.

When the event is defined (codes and duration), it may be easy to identify duplicate coding and to take out information for quality control purposes. Duplicate codes may include events transferred from one ward to another, e.g. for an acute PCI. In some cases the duration of the admission is very short (< 2 days) either because of transferral or because of diagnosis misclassification. These cases may also be picked up for validation.

Cases not admitted to general hospitals are a problem when the registration system is based only on hospital records. Another source of potential loss of identification is private practice: private physicians and hospitals may be less cooperative than those in the public system; in private hospitals the staff may be more sensitive to criticism and anxious to show how they register medical documents.

The identification of fatal events is in some way less difficult than that of non-fatal events. Whereas survivors may be lost in the totality of inhabitants of the surveillance area, death is unequivocal. However, registration of causes of death may be incorrect and needs to be validated and collection of information of deaths occurring outside the area of residence has to be ensured. It is to be expected that some events occur outside hospital. If the proportion of fatal events coded as hospitalised is very high it may indicate incomplete registration of out-of-hospital AMI/ACS deaths.

Identification of potential events may be based on many different data sources. This may involve a considerable amount of record linkage, which is facilitated if PIN is adopted.

Another problem relates to medical records whose quality may be variable: younger patients may have had no other illness episodes and the records may be restricted to the relevant coronary event. In older patient, the identification of the event is more complicated due to the existence of comorbidities.

5.2 Internal validity

The most important question regarding validity concerns the diagnostic information.

The diagnostic criteria for the event definition are valid if they measure the AMI/ACS they claim to measure. Validation evaluates the sensitivity, specificity and predictive value of the registered diagnosis compared to a golden standard. To validate coronary events, the MONICA diagnostic criteria [9], the New Criteria of the Joint ESC/ACC [5], the AHA criteria [6] or the BCS criteria [7] may be applied as golden standard.

Nowadays, the MONICA diagnostic criteria (see Table 2B) are the most widely used for the validation of events from population-based registers. The introduction of the new criteria ESC/ACC, based on biomarker findings (troponin, CK-MB), does not cover early and other fatal cases, and non-fatal cases where tests are partial, delayed, missing or curtailed [30]. The change in diagnostic criteria for AMI and the introduction of the new concept of ACS does not facilitate comparison and interpretation of trends. A comparison between MONICA diagnostic criteria and the different new criteria [31] has been made and published; it concludes that the AHA definition, when applied using troponins, identifies a sizeable new group of MI patients at high risk of a recurrent event among persons with suspected acute coronary syndrome.

Validation studies of routine statistics have been carried out over the years with heterogeneous results due to differences in methodology or reflecting true differences in the validity of the routinely collected data between countries [17,22,28,29]. Some studies have been carried out comparing community registers with national statistics and data from the MONICA project [23,32]. These findings stress the importance of validating routine mortality and hospital statistics against the national register to determine whether and how they can be used to reflect true attack rates and mortality. Consistency of coding with the diagnosis and consistency of coding/comparability of the information for different areas of the country and over time represent other issues for validation.

If it is not possible to validate all the events included in the disease register or in the mortality routine statistics, the objective for validation should be to evaluate a sample of events. The sample should be distributed along a full year in order to ensure that potential seasonal or other time related variations of diagnostic patterns are traced.

5.3 External validity (representativeness)

It is not essential that the whole country is covered by a surveillance system, but it is essential that the registration of events is complete with regard to events occurring in the target population. It is important to know how representative the register is for the whole country according to the IHD mortality rate, the

distribution of risk factors (socioeconomic status and health behaviour) and the distribution of health service (specialised hospital, GP).

For the population chosen there must be good demographic data subject to at least annual revision; inaccuracy may become apparent years after the period being studied because of the results of a decennial national census.

A careful description of the population characteristics may help to describe how representative the target population is for the whole country.

5.4 Methods to evaluate diagnostic quality

Register validation can include examination of each single case or validation based on random samples for diagnostic information, name, age, residence.

Validation has to be carried out by an epidemiological team not involved in the treatment of patients. For local registers with a limited number of cases it may be possible to validate each single event, but registers covering wider areas, for practical reasons, can only validate data based on random samples of suspected cases recorded during a selected period or during some days each month. A selection method consists of choosing some days each month and recording all events, extracted either from hospital discharge or mortality records, which occur in those days. In this way seasonal variation can be traced.

In order to produce validated indicators, a conditio sine qua non is to allow access to personal relevant medical records and routine raw data of health statistics.

In some cases it is possible to validate a register by linking the routine register to an independent data source, e.g. a high quality register for a small area within the region.

Validation of diagnosis in fatal events

A register of AMI/ACS is meant to produce frequency indicators of the acute forms of coronary events and of coronary death. These correspond to ICD-10 codes I 20-25 in the underlying cause of death. However, IHD is often associated to other comorbidities, which might produce occasional miscoding of IHD in national mortality registers, in spite of the ICD coding rules. The percentage of such misclassification varies by country, age and gender. It is necessary to ensure

that no true cases are hidden under other diagnoses (false negatives) and hence missed in AMI/ACS registration. In the validation process it is therefore necessary to review and validate the diagnosis in at least a sample of cases for the following diseases, against the standard chosen, in particular when they are followed by IHD as secondary cause of death: sudden death; heart failure; pulmonary thromboembolism; acute pulmonary oedema; aortic aneurisms; arrythmias; diabetes; hypertension.

Some countries only code the underlying cause of death, while others code all four causes of death. Those who rely on underlying cause of death only should perform validation at least twice in every ten years period and for a full year or on a sufficiently sized sample for a full year. Depending on the percentage of false negative diagnoses for IHD death found in the first validation, decisions should be taken about the intensity and duration of the validation exercise for fatal cases throughout the registration period. A false negative rate above 10-15% should in principle be an indication to perform diagnostic validation of deaths certificates on a continuous basis rather than on a periodic or a sample basis.

Validation of diagnosis in non-fatal events

Registration of non-fatal events are based on both primary and secondary hospital discharge diagnoses. In those countries which register the primary diagnosis only, particular attention should be given to this type of validation. Manual coding of the secondary diagnosis may be necessary during the validation to ensure comparability with other countries and completeness of registration.

There are also elective treatment procedures that might hide ACS.

Many AMI cases are treated during the acute phase with PCI and some of these cases may be identified by the ICD-9CM codes for the interventions: code 36.1 for CABG (Coronary Artery Bypass Graft) and codes 36.01, 36.02, 36.05, 36.06 (stent) for PTCA (Percutaneous Transluminal Coronary Angioplasty). Revascularisation procedures alone are not sufficient to define the acute event.

6. ETHICAL ISSUES

The Helsinki Declaration requires that biomedical research with human subjects must conform to generally accepted scientific principles.

The *"Recommendation n. R (97)5 of the committee of ministers to EU member states on the protection of medical data"* [33] gives guidelines to how medical data can be registered, stored and used in a way that ensure the rights and the fundamental freedoms of the individual and in particular the right to privacy. *(Adopted by the Committee of Ministers on 13 February 1997 at the 584th meeting of the Ministers' Deputies).*

In the following the most important recommendations are presented.

"*Medical data should be collected and processed only by health-care professionals, or by individuals or bodies working on behalf of health-care professionals. Individuals or bodies working on behalf of health-care professionals who collect and process medical data should be subject to the same rules of confidentiality incumbent on health-care professionals, or to comparable rules of confidentiality.*"

Therefore it is essential that a cardiologist or physician (or study nurse) with proven experience in the field of cardiovascular disease is involved in the coordination of the AMI register.

"*Medical data shall be collected and processed fairly and lawfully and only for specified purposes.*"

"*Medical data may be collected and processed:*

a. *if provided for by law for:*
   i. *public health reasons; or*
   ii. *subject to Principle 4.8[*], the prevention of a real danger or the suppression of a specific criminal offence; or*
   iii. *another important public interest; or*

b. *if permitted by law:*

---

[*] Processing of genetic data for the purpose of a judicial procedure or a criminal investigation should be the subject of a specific law offering appropriate safeguards.

      i. *for preventive medical purposes or for diagnostic or for therapeutic purposes with regard to the data subject or a relative in the genetic line; or*

      ii. *to safeguard the vital interests of the data subject or of a third person; or*

      iii. *for the fulfilment of specific contractual obligations; or*

      iv. *to establish, exercise or defend a legal claim; or*

c. *if the data subject or his/her legal representative or an authority or any person or body provided for by law has given his/her consent for one or more purposes, and in so far as domestic law does not provide otherwise."*

Whenever possible, medical data used for scientific research purposes should be anonymous. Professional and scientific organisations as well as public authorities should promote the development of techniques and procedures securing anonymity. However, if such anonymisation would make a scientific research project impossible, and the project is to be carried out for legitimate purposes, it could be carried out with personal data on condition that:

a. *the data subject has given his/her informed consent for one or more research purposes; or*

b. *when the data subject is a legally incapacitated person incapable of free decision, and domestic law does not permit the data subject to act on his/her own behalf, his/her legal representative or an authority, or any person or body provided for by law, has given his/her consent in the framework of a research project related to the medical condition or illness of the data subject; or*

c. *disclosure of data for the purpose of a defined scientific research project concerning an important public interest has been authorised by the body or bodies designated by domestic law, but only if:*

      i. *the data subject has not expressly opposed disclosure; and*

      ii. *despite reasonable efforts, it would be impracticable to contact the data subject to seek his consent; and*

      iii. *the interests of the research project justify the authorisation; or*

d.   *the scientific research is provided for by law and constitutes a necessary measure for public health reasons."*

Record linkage between mortality and hospital discharge records is possible in countries which have adopted a PIN on a national level. Other nominal data (such as name, gender, date and place of birth) are usually available at a regional level. Record linkage permits to identify the event by matching admissions and discharges or admissions and deaths, thus avoiding double counting, which may occur when, for example, the same patient transferred to another ward (e.g. from cardiology to cardiovascular surgery and then to rehabilitation) is registered in the HDR more than once.

Moreover, the identification of patient is essential for the event validation when it is necessary to collect and examine the history and clinical documentation and to assess case fatality at different intervals (28 days, 6 months, 1 year). Before starting any study, it is recommended to seek approval from the local ethics committee.

7. ECONOMIC CONSIDERATION

Overall IHD is estimated to cost the EU economy over 45 billion euro a year. Of the total cost of IHD, 51% is due to direct healthcare costs, 34% to productivity loses and 15% to the informal care of people with IHD [1]. Cost considerations are essential before implementing a population-based register.

Without a valid surveillance system, it is not possible to plan and evaluate health services for populations, implement interventions for prevention and identify "vulnerable" subgroups in terms of burden of disease such as the elderly, the young, the poor, the unemployed. Surveillance and evaluation mean a systematic way of learning from experience and using it to improve current activities and promote better planning by careful selection of alternatives for future actions and allocation of resources. The economic benefit of a good surveillance system clearly exceeds the cost of the registers.

A population-based register may be costly and to produce meaningful data it needs to be in operation for at least one year, but preferably for some years or continuously. However, the importance of a valid and efficient AMI/ACS register justifies the high implementation costs and the consequent need to find adequate financing.

The register based on record linkage between administrative databases is the most cost-effective, but this register depends on the data quality of the Hospital Discharge Register and the Cause of Death Register and also on the possibility of a valid record linkage. In addition, methods need further evaluation and implementation. Notably, if the hospital discharge and mortality registers are available for record linkage, the costs for the linkage and dissemination of results are low. The main costs for using this methodology for assessment of incidence in a defined population concerns the need to perform regular validations of the diagnostic information. It may be recommended to include a basic epidemiologic research in the costs, which may include analysis of risk factors by linkage to health interview surveys and of treatment effect by linking the register to other data sources (e.g. data on drugs and on invasive procedures). Sometimes access to data produces separate costs.

The register based on a disease specific data collection is more expensive especially if hot pursuit is used. Beside the cost mentioned above, this type of register also needs funding for the detailed prospective data collection and for validation of diagnostic information. The data collection includes: identification of patients, reading medical records, making inquiries to additional data sources, filing and validation of the data. This means that a team of epidemiologists, nurse, medical doctors and informatics dedicated to this work full time is absolutely necessary. It should be recognised that this type of register usually collects information that permits analyses of research questions beyond the monitoring of AMI/ACS incidence, mortality and case fatality. This may concern the role of risk factors for disease occurrence or the role of treatment for survival in patients.

8. IMPLEMENTATION - STEPWISE PROCEDURE

This section describes the procedures required to implement an AMI/ACS register taking into account the recommendations reported in this manual of operations. The flow chart summarises these procedures (Figure 3).

STEP 1. Define target population and routine data

- Select a geographical administrative area with a population big enough to provide stable estimates. This means that a stable population in a representative area of the country with 300 fatal and non-fatal coronary events in the age range 45 to 74 should be chosen.

- Characterise population from a demographic point of view through a detailed description of the characteristics of the population under surveillance, in particular: demographic characteristics (age and gender distribution); socio-cultural characteristics (educational level, occupation, social group, unemployment rate, migration, immigrants with or without citizenship); characteristics of the healthcare system (specialised hospital, GP, rehabilitation clinic); macro and micro areas (urban and rural). Disease frequency is often different in macro areas of the country; a description of difference in mortality and risk factors allows to select those areas to be included in the surveillance system. Within the population-based surveillance study, the phenomenon of immigration plays an important role, therefore immigrants coming from European and extra-European countries resident in the study area must be enrolled. Geographical or administrative borders of the surveillance areas must be clearly defined.

- Analyse existing Hospital Discharge and Mortality data. Events in non-residents occurring in the study area or admitted to hospital in the study area do not qualify. Events of residents occurring out of the area do qualify. Efforts must be made to find them or to estimate the potential loss and whether or not it could be changing and interfering with the validity of the observed trends in rates over a period of years.

- Identify problems with these data: coverage, ICD version, identification of events, procedures, unit of analysis (number of events or discharges and/or number of patients), PIN, coherence with previous studies, etc. Data files are

usually available at the regional level in detailed forms.

When a register is launched for the first time, a plan for future follow-up to measure trends is recommended. This can be achieved by a continuous surveillance as part of a broader health information system or by annual register repeated at 5 to 10 years intervals.

STEP 2. Perform a pilot study and validate routine data

Before starting an AMI/ACS register or a large scale use of linked administrative data, a pilot study on available hospital discharge and mortality data in a small area is recommended in order to study the feasibility and to estimate internal validity.

Validation studies on available data include:

- estimation of coverage: comparison of different routine data sets (electronic or manual), number of patients treated in- and out-of-area, hospital/mortality ratios, age and gender ratios, principal vs. secondary and/or procedure diagnoses;
- validation of discharge diagnoses according to a standard method (including revision and abstraction of medical records) in a random sample or in all cases;
- validation of mortality causes according to a standard method in a random sample or in all cases;
- analysis of demography and representativeness of the area in comparison with the region or country;
- selection of age range of interest (35 to 74 or 35 to 84).

STEP 3. Carry out record linkage of administrative data

In the Northern countries, where every citizen has a PIN included in national registers of hospital discharges and deaths, record linkage for the identification of AMI/ACS events is efficient and reliable. For countries which have not adopted the PIN it may be much more difficult to perform this step. Files have to be organised with the same format and include the same variables (family name, name, date of birth, residency and place of birth).

It is recommended to:

- explore the feasibility of record linkage within hospital records - probabilistic or deterministic approach or using PIN (within the same hospital, among hospitals of the area, among hospitals at regional or national level). When hospital records are collected at regional or national level, it is possible to collect events that occur out-of-hospital;

- explore the feasibility of record linkage between hospital records and mortality register (probabilistic or deterministic approach or using PIN);

- explore the feasibility of linkage with other sources of information (e.g. GP, drug dispensing register). Not all GPs are organised in networks, with computerised documentation of patient history; when they are, the definition of events rarely uses the same diagnostic criteria.

STEP 4. Set up an AMI/ACS population-based register

After performing STEP 2 and 3 it is possible to set up an AMI/ACS population-based register following A (record linkage between administrative registers) or B (disease specific data collection).

A. Register based on record linkage between routine administrative data:

- when the linkage procedure between hospital discharge and mortality records is feasible, it is important to define the event, the duration, how to handle transfer between hospitals with difference in the diagnoses between the admitting hospital and the hospital where the patient is transferred, how to define first time events, recurrent events, fatal and non-fatal events etc. (see paragraph 4.1). A linkage system and a control for duplicate records should be set up;

- validation of diagnostic information is recommended in a random sample of sufficient size of the identified events, with the estimation of sensitivity and specificity and positive predictive value of the defined events;

- population data by age and gender of the area under surveillance are needed to estimate incidence, recurrence, attack rate, case fatality and mortality rates;

- periodic validations should be performed.

B. Register based on disease specific data collection:

- set up a pilot population-based register with proven standardised protocol for AMI/ACS and evaluate pilot study results (coverage, completeness of information and diagnostic validity);

- based on the results of the pilot study, set up, if feasible, a full scale register and decide whether to use hot or cold pursuit;

- then, if feasible, design the full-scale register (target population, data collection methods and validation procedures).

To set up a full scale register:

- select one or more populations representative for the region or the country;

- for each selected population set up a population-based register with approved standardised protocol for AMI/ACS;

- write a detailed protocol for the data collection including validation procedures;

- evaluate the coverage and representativeness and completeness of information;

- if relevant, use the results from the register to validate administrative data.

STEP 5 Disseminate results

- Set up a strategy for analysis of data and for dissemination of results to decision-makers, politician and broader population.

- Publish yearly on a web-site indicators of attack rate, incidence, case fatality according to gender and age-standardised with European population as reference (35 to 74 and 35 to 84);

- Use data for research. This is very important to ensure a high quality of the register over time. And a high quality register can be the basis for good research.

Figure1. Deaths by cause, men, latest available year, EU
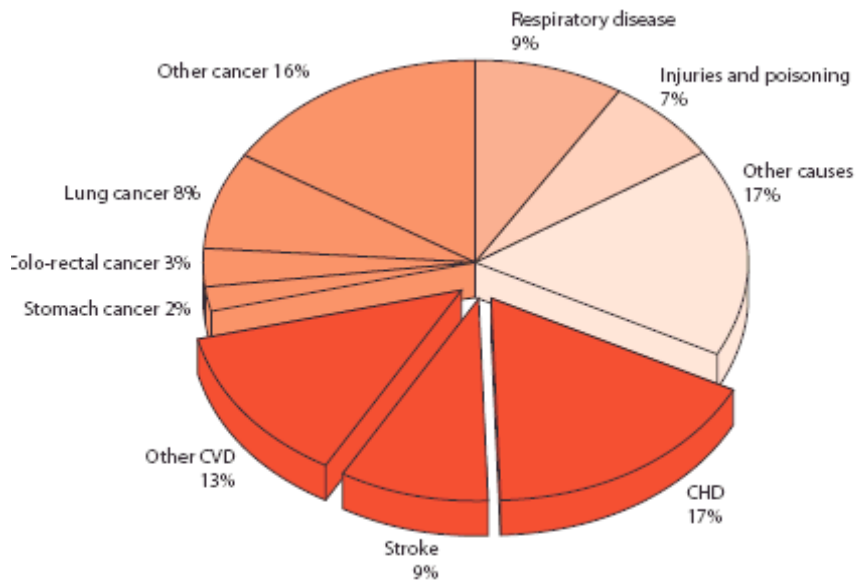
Figure 2. Deaths by cause, women, latest available year, EU
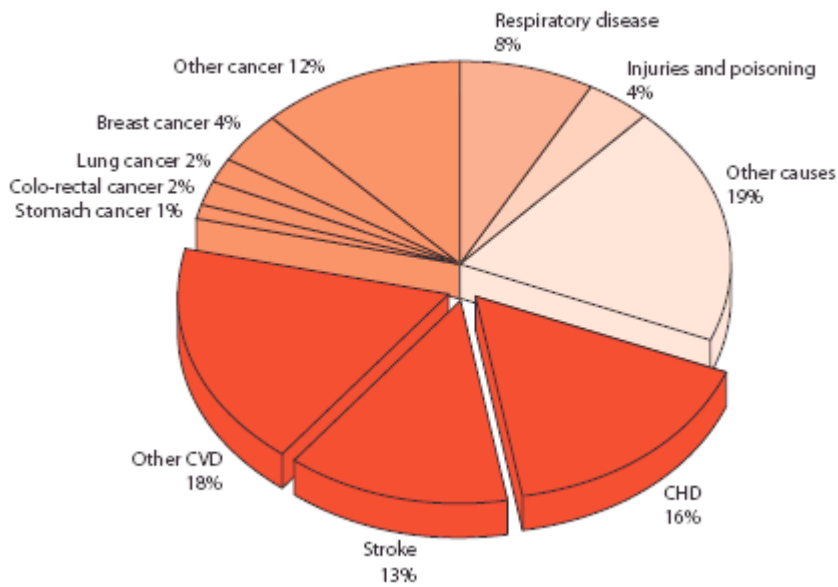
Petersen S, Peto V, Rayner M, Leal J, Luengo-Fernandez R and Gray A (2005). European cardiovascular disease statistics. BHF:London

Figure 3. DESCRIPTION OF STEPWISE PROCEDURE

1° STEP | **Define population**
⇒ Description of population characteristics
⇒ Availability of Hospital Discharge Records (HDR) and mortality
⇒ Check 300 coronary events in 45 -74 years age group

2° STEP | **Pilot Study**
⇒ Validation of mortality
⇒ Validation of morbidity
⇒ Check representativity of area

3° STEP | **Explore possibility of record linkage**
⇒ HDR
⇒ Mortality
⇒ GP

4° STEP | **Register**

Mortality   HDR

Linkage

Fatal events   Non fatal events

5° STEP | **Analyses**

Dissemination of results
⇒ Attack rate
⇒ Case fatality

TABLE 1. NATIONAL POPULATION-BASED AMI/ACS REGISTERS

Country	First year available	Last year available	Ongoing registration	Age range	Population (x 1,000)		Access data
					Men	Women	
Denmark	*1978*	*2001*	yes	all	2,677	2,734	NIPH
Finland	*1991*	*2003*	yes	all	2,600	2,600	NIPH
Iceland	*1981*	*2002*	yes	25 to 74	170		NIPH; Icelandic Heart Association
Sweden	1987	2001	yes	all	4,545	4,466	NBHW

NIPH, National Institute of Public Health
NBHW, National Board of Health and Welfare

Source: European J of Public Health 2003; 13 (Suppl 3): 55-60 (updated 2006)

TABLE 2A. REGIONAL POPULATION-BASED AMI/ACS REGISTERS: POPULATION CHARACTERISTICS

Country	First year available	Last year available	Ongoing registration	Age range	Population (x 1,000)		Access data
					Men	**Women**	
Belgium Charleroi	1983	2003	yes	25 to 69	50	50	School of Public Health
Belgium Ghent	1983	2003	yes	25 to 74	71	71	University of Ghent
Belgium Bruges	1999	2003	yes	25 to 74	75	75	University of Ghent
Denmark Northern Jutland	*1978*	*2001*	yes	all	247	247	Aarhus University
Finland FINAMI	*1993*	*2002*	yes	all	90	103	NIPH
France Lille, Strasbourg, Toulouse	*1985*	*2004*	yes	25 to 64 (until '96); 35 to 74 (from '97)	752	767	INSERM U780
Germany Ausburg	*1985*	*2002*	yes	25 to 74	203	204	National Institute of Statistics
Italy 7 areas	*1998*	*2003*	yes	35 to 74	3,600		Istituto Superiore di Sanità
Norway	1972	2002	yes	all	1,000		Health Region West
Spain 5 areas	1985	1998	no	25 to 74	234	246	Institute of Health Studies
Sweden Northern Sweden	1985	2005	yes	35 to 74	160	162	MONICA

NIPH, National Institute of Public Health

INSERM, Institut National de la Sante et de la Recherche Medicale

MONICA, MONItoring of trends and determinants in CArdiovascular diseases

Source: European J of Public Health 2003; 13 (Suppl 3): 55-60 (updated 2006)

TABLE 2B. REGIONAL POPULATION-BASED AMI/ACS REGISTERS: CASE DEFINITION

Country	ICD version	Sources of information		Linkage mortality / HDR	Validation
		Mortality ICD codes (*)	HDR ICD codes (*)		
Belgium Charleroi, Ghent, Bruges	IX, X	410-414, 428, 798, 799	410-414, 428, PTCA, CAGB	name, date of birth	*ECG, enzymes, symptoms, MONICA*
Denmark	VIII,X	410	410	ID	no validation
Finland	X	410, 411, 428, 798, 799	410, 411, PTCA, CABG	ID	MONICA, ESC/ACC
France	IX, X	410-414, 428, 798, 799, others	410-414, 428	name, date of birth	MONICA
Germany	X	410-414, 798, 799	410, 411, PTCA, CAGB	name, date of birth	MONICA, ESC/ACC
Italy	IX	410-414, 798, 799, others	410-414	name, date of birth	MONICA
Norway	X	410	410, PTCA, CABG	ID	no validation
Spain	IX	410-414, 428, 798, 799, others	410-414	name, date of birth	MONICA
Sweden	X	410, 411	410, 411	ID	MONICA

(*) all codes are presented in the ICD-9 revision to facilitate comparison

TABLE 3. INSTITUTIONAL-BASED REGISTERS

NIPH, National Institute of Public Health

Country	Area Coverage	1st Year	Age range	Population (x 1000)		Access data
				Men	**Women**	
Austria	National	1990	all	1,600		Austrian Health Foundation
Greece	Regional	2003	all	n.a.		Hippokrrateion Hospital, University of Athens Medical School
Hungary	National	1996	all	4,800	5,300	The Centre for Health Information, National Health Insurance Fund, Department of Financial Informatics
Hungary (GP)	Regional	1998	all	125	139	School of Public Health, University of Debrecen
The Netherlands (GP)	Regional	1971	all	12		NIPH - University Nijmegen
Poland	National	2003	all	n.a.		Silesian Centre for Heart Disease
Spain (IBERICA)	Several provinces		35 to 74			Municipal Institute of Medical Research

TABLE 4. METHODS OF SURVEILLANCE OF AMI/ACS

Data sources	Type of registers/health surveys	Data collection	Main indicators
Routine databases	Mortality Hospital registers Drug dispensing registers	National routine databases	Mortality/Hospital Discharges Length of stay Prescribed medications
Surveys	Health interview and health examination	Questionnaire and medical examination of random samples of the population	Prevalence Disability Risk factors
Acute Myocardial Infarction/Acute Coronary Syndrome registers	Population-based	Record linkage between routine databases including cases outside hospital (mortality+hospital discharge records)	Attack rate (Incidence rate) (Prevalence) Case fatality rate Treatment Procedures
		Disease-specific collection of data including fatal and non-fatal cases in and outside hospital by hot/cold pursuit	Attack rate Incidence rate Prevalence Case fatality rate Treatment Procedures Years of life lived with disability Estimate of long-term care needs

Table 5. Criteria for definition of acute myocardial infarction, MONICA Project

a) <u>*Definite AMI*</u>: definite ECG; probable ECG with abnormal enzymes and symptoms (typical/ atypical); ischemic, uncodable or not available ECG, with abnormal enzymes and typical symptoms. Fatal cases with definite findings in autopsy – recent acute myocardial infarction or recent coronary occlusion.
b) <u>*Possible AMI*</u>: non-fatal events with typical symptoms whose ECG and enzyme results do not place them in the category 'definite' and in whom there is no good evidence for another diagnosis of the attack. Fatal events with no evidence for another cause of death (clinically or at autopsy), with typical/atypical symptoms or with evidence of chronic IHD at necropsy, or with a good history of chronic IHD.
d) <u>*Insufficient data (unclassifiable):*</u> fatal events with no autopsy, no history of typical, atypical or inadequately described symptoms, no previous history of chronic IHD and no other cause of death.

For further information, http/www.ktl.fi/publications/monica/manual

TABLE 6. CRITERIA FOR DEFINITION OF ACUTE, EVOLVING OR RECENT MYOCARDIAL INFARCTION – ESC/ACC CRITERIA

Either one of the following criteria satisfies the diagnosis for an acute, evolving or recent myocardial infarction:

(1) Typical rise and gradual fall (troponin) or more rapid rise and fall (CK-MB) of biochemical markers of myocardial necrosis with at least one of the following: *(a) ischemic symptoms*   *(b) development of pathologic Q waves on the ECG*   *c) ECG changes indicative of ischemia (ST segment elevation or depression); or*   *(d) coronary artery intervention (e.g., coronary angioplasty*
(2) Pathologic findings of an acute MI.

Source: Eur Heart J 2000; 21: 1502-1513

TABLE 7. CASE DEFINITION FOR AMI/ACS IN EPIDEMIOLOGY AND CLINICAL RESEARCH STUDIES – AHA CRITERIA

ECG Findings	Biomarker Findings							
	Cardiac Symptoms or Signs Present				*Cardiac Symptoms or Signs Absent*			
	Diagnostic	Equivocal	Missing	Normal	Diagnostic	Equivocal	Missing	Normal
Evolving diagnostic	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite
Positive	Definite	Probable	Probable	No	Definite	Probable	Possible	No
Non specific	Definite	Possible	No	No	Definite*	Possible	No	No
Normal or other ECG findings	Definite	Possible	No	No	Definite*	No	No	No

Classification of case is at highest level allowed by combinations of 3 characteristics (cardiac signs and symptoms, ECG findings, biomarkers).
In absence of diagnostic troponin, downgrade to possible.

Source: Circulation 2003;108: 2543-2549.

TABLE 8. SPECTRUM OF ACUTE CORONARY SYNDROME (ACS) – BCS

	Markers	ECG	Pathology
ACS with unstable angina	TnT and CK-MB undetectable	ST or T non- elevation or transient ST elevation or normal	Partial coronary occlusion (plaque disruption, intra-coronary thrombus, micro-emboli)
ACS with myocite necrosis	TnT elevation, < 1.0 ng/ml (or AccuTnI<0.5 ng/ml)	ST o T elevation or transient ST elevation or normal	Partial coronary occlusion (plaque disruption, intra-coronary thrombus, micro-emboli), more extended than that provoked by angina
ACS with clinical myocardial infarction	TnT elevation, > 1.0 ng/ml (or AccuTnI>0.5 ng/ml) +/- CK-MB elevation	ST elevation or ST non-elevation or T inversion: may evolve Q waves	Complete coronary occlusion (plaque disruption, intra-coronary thrombus, micro-emboli)

ACS, Acute Coronary Syndrome
TnT, Troponine T
CK-MB, Creatine-Kinase
BSC recommends systematic measurement of TnT after Percutaneous Coronary Intervention (> 6 hours)

Source: Heart 2004; 90: 603-609.

REFERENCES

1. Petersen S, Peto V, Rayner M, Leal J, Luengo-Fernandez R and Gray A. European cardiovascular disease statistics 2005. BHF: London.

2. Kesteloot H, Sans S, and Kromhout D. Dynamics of cardiovascular and all-cause mortality in western and Eastern Union between 1970 and 2000. Eur Heart J 2006; 27: 107-113.

3. Kattainen A, Salomaa V, Harkanen T, Jula A, Kaaja R, Kesaniemi YA, et al. Coronary heart disease: from a disease of middle-aged men in the late 1970s to a disease of elderly women in the 2000s. Eur Heart J 2006; 27(Suppl 3): 296-301.

4. Strong K, Mathers C, Leeder S, Beaglehole R. Preventing chronic diseases: how many lives can we save? Lancet 2005; 366: 1578-82.

5. The Joint European Society of Cardiology/American College of Cardiology Committee. Myocardial infarction redefined. A consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the Redefinition of Myocardial Infarction. Eur Heart J 2000; 21: 1502-1513.

6. Luepker VR, Apple FS, Chistenson RH, Crow RS, Fortmann SP, Goff D, Goldberg RJ, Hand MM, Jaffe AS, Julian DG, Levy D, Manolio T, Mendis S, Mensah G, Paj k A, Prineas R, Reddy S, Roger V, Rosamond WO, Shahar E, Sharrett R, Sorlie P, Tunsall-Pedoe H. Case definitions for acute coronary heart disease in epidemiology and clinical research studies. Circulation 2003;108: 2543-2549.

7. Fox KAA, Birkhead J, Wilcox R, Knight C, Barth J. British Cardiac Society Working Group on the definition of myocardial infarction. Heart 2004; 90: 603-609.

8. World Health Organisation Regional Office for Europe. Myocardial Infarction Community Registers. Copenhagen: WHO, 1976 (Public Health in Europe report No 5).

9. Tunstall-Pedoe H, Kuulasmaa K, Tolonen H, Davidson M, Mendis S with 64 other contributors for The WHO MONICA Project. MONICA Monograph and Multimedia Sourcebook. Geneva: World Health Organization; 2003.

10. Tunstall-Pedoe H, Kuulasmaa K, Mahonen M, Tolonen H, Ruokokoski E, Amouyel P. Contribution of trends in survival and coronary-event rates to changes in coronary

heart disease mortality: 10-year results from 37 WHO MONICA project populations. Monitoring trends and determinants in cardiovascular disease. Lancet 1999; 353:1547-57.

11. The EUROCISS Working Group. Coronary and Cerebrovascular Population-based Registers in Europe: are morbidity indicators comparable? Results from the EUROCISS Project. European J of Public Health 2003; 13 (Suppl 3): 55-60.

12. European Community Health Indicators Monitoring (ECHIM) Project. http://www.echim.org/ (accessed 16.05.07).

13. WHO STEPS Stroke Manual: the WHO STEPwise approach to stroke surveillance. http://www.who.int/chp/steps/Manual.pdf (accessed 16.05.07).

14. Federici A. Le parole della nuova Sanità. Il Pensiero Scientifico Editore 2002.

15. Tunstall-Pedoe H. Diagnosis, measurements and Surveillance of Coronary Events. Int J Epidemiol 1989; 18 (suppl 1): 169-173.

16. Tunstall-Pedoe H. Problems with Criteria and Quality Control in the Registration of Coronary Events in the MONICA Study. Acta Med Scand Supplementum 1998; 728:17-25.

17. A. Mahonen M, Salomaa V, Keskimaki I et al. The feasibility of routine mortality and morbidity register data linkage to study the occurrence of acute coronary heart disease events in Finland. The Finnish Cardiovascular Diseases Registers (CVDR) Project. Eur J Epidemiol 2000; 16: 701-711.

18. B. Abildstrøm S, Rasmussen S, Rosén M, Madsen M. Trends in incidence and case-fatality after acute myocardial infarction in Denmark and Sweden. Heart 2003; 89: 507-511.

19. C. Rosén M, Alfredsson L, Hammar N, et al. Incidence, mortality and case fatality for acute myocardial infarction in Sweden 1987-1995. Results from the Swedish National AMI Register. J Intern Med 2000; 248: 159-64.

20. D Hammar N, Alfredsson L, Rosén M, et al. A national record linkage to study acute myocardial infarction incidence and case fatality in Sweden. Int J Epidemiol 2001; 30: S30-S34.

21. E Videbæk J, Madsen M. Heart Statistics Denmark 2000-2001. Danish Heart Foundation and National Institute of Public Health, Copenhagen; 2001.

22. F Pajunen P, Koukkunen H, Ketonen M, Jerkkola T, Immonen-Raiha P, et. al. The validity of the Finnish Hospital Discharge Register and the Causes of Death Register data on coronary heart disease. Eur J Cardiovasc Prev Rehabil 2005; 12 (Suppl 2):132-7.

23. G Madsen M, Davidsen M, Rasmussen S, Abildstrøm SZ, Osler M. The validity of the diagnosis acute myocardial infarction in routine statistics. A comparison of mortality data and hospital discharge data with the Danish MONICA registration. J Clin Epidemiol 2003;56:124-13.

24. D Hammar N, Alfredsson L, Rosén M, Spetz C-L, Kahan T, Ysberg A-S. A national record linkage to study acute myocardial infarction incidence and case fatality in Sweden. Int J Epidemiol 2001; 30; S30-S34.

25. Braunwald E. Heart Disease. Philadelphia: Saunders Company, 2005 http://www.ktl.fi/publications/monica/manual (accessed 16.05.07).

26. Chambless L, Keil U, Dobson A et al. Population versus Clinical View of Case Fatality From Acute Coronary Heart Disease. Results from the WHO MONICA Project 1985-1990. Circulation 1997; 96:3849-3859.

27. Fellegi IP, Sunter AB. A Theory for Record Linkage. J Am Stat Ass, 1969; 64: 1183-1210.

28. Mahonen M, Salomaa V, Brommels M, Molarius A, Miettinen H, Pyorala K, et al. The validity of hospital discharge register data on coronary heart disease in Finland. Eur J Epidemiol 1997; 13: 403-15.

29. Hammar N, Nerbrand C, Ahlmark A, et al. Identification of cases of myocardial infarction: Hospital discharge data and mortality data compared to myocardial infarction community registers. Int J Epidemiol 1991; 20:114-20.

30. Tunstall-Pedoe H. Comment on the ESC/ACC redefinition of myocardial infarction by a consensus dissenter. Eur Heart J 2001; 22: 613-615.

31. Salomaa V, Koukkunen H, Ketonen M et al. A new definition for myocardial infarction: what difference does it make? Eur Heart J 2005; 26:1719-1725.

32. Mahonen M, Salomaa V, Torppa J, et al. The Validity of the Routine Mortality Statistics on Coronary Heart Disease in Finland: Comparison with the FINMONICA MI Register Data for the Years 1983-1992. J Clin Epidemiol 1999; 15: 157-166.

33. Recommendation no. R (97) 5 of the Committee of Ministers to Member States on the protection of medical data (Adopted by the Committee of Ministers on 13 February 1997 at the 584th meeting)