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Original Contribution

# Day-of-the-week variations in myocardial infarction onset over a 27-year period: the importance of age and other risk factors ☆

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ABSTRACT

*Introduction:* The aim of this study was to analyze the day-of-the-week variations of acute myocardial infarction (AMI) over a 27-year period. The effects of sex, age, history of AMI, hypertension, fatality, and temporal changes over the 27-year period were also investigated.

*Methods:* The Charleroi register of ischemic cardiopathies is the oldest register of infarctions in the French-speaking community of Belgium and is one of the very rare registers that can track trends over 27 years. The analyses presented in our study relate only to patients in the 25- to 69-year age range over time from 1983 to 2009. The $\chi^2$ test for goodness of fit was used to test the difference among the frequencies of AMI events over 7 days during the week.

*Results:* Data from 9732 cases of AMI were analyzed. Overall, there was a significant day-of-the-week variation ($P < .001$), with an excess of AMI observed on Mondays (n = 1495) and a minimum on Saturdays (n = 1259), corresponding to a relative increase in AMI of 18.2% over the 2 days. The Monday peak is more pronounced for the 35- to 44-year ($P = .045$) age bracket than for the 45- to 54-year ($P = .27$) and the 55- to 64-year ($P = .032$) brackets. The cases with (n = 2713) and without (n = 4931) arterial hypertension exhibited the same day-of-the-week variation. In contrast, the cases with antecedent AMI (n = 1888) exhibited a less pronounced excess of MI incidence on Mondays compared with the cases without antecedent (n = 5970).

*Conclusions:* The present study demonstrates that there is a marked incidence peak in AMI on Mondays. This peak is similar for men and women but varies according to age. The Monday peak is not observed in subjects previously admitted for AMI or in fatal cases. The organization of the emergency medical services could take into account the day-of-the-week pattern of AMI to adapt emergency medical service capacity to needs.

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## 1. Introduction

Cardiovascular diseases are the primary causes of mortality in Belgium [1]. To monitor these important and problematic health aspects, in 1983, Belgium set up a register of acute coronary events in the region of Charleroi. This register is part of the international project "Monitoring Trends and Determinants in Cardiovascular Disease" (MONICA) coordinated by the World Health Organization. The standardized register has been operating for 27 years. The register collects all suspected cases of acute myocardial infarction (AMI) through a system involving all hospitals. Additionally, the register enables the analysis of death certificates. The aim of the register is (1) to contribute to the promotion of the quality in medical care provided by generalist and specialist health professionals, (2) to improve health system management, and (3) to plan prevention programs.

The incidences of AMI vary according to the day, the week, the season, and the year [2-4]. The increased incidence in the morning is attributable to increased blood pressure and heart rate [4]. An increase in AMI is also observed in winter compared with summer [5]. The increase in the incidence of AMI in the cold months is a consequence of a variety of causes, such as increased C-reactive protein, vasoconstriction, and increased blood pressure [5]. The incidence of AMI and the mortality attributed to this disease have declined markedly in Northern and Western Europe over the past 35 to 40 years [2].

Numerous studies reveal a day-of-the-week variation in the incidence of AMI, with a peak on Mondays [2,6-8]. However, only a few studies have investigated age and risk factor effects. None of the studies have reported long-term trends. Most of the articles refer to stress from commencing work week activity and a relative increase in inactivity as triggers of AMI [2]. Many studies have also reported that heavy alcohol consumption or binge drinking might trigger AMI [9-11].

The aim of this study was to analyze the day-of-the-week variations of AMI over a 27-year period. The effects of sex, age, history of AMI, hypertension, fatality, and temporal changes over the 27-year period were investigated. The day-of-the-week variations in the fatality rate associated with AMI were also investigated.

☆ Conflict of interests: The authors declare that they have no conflicts of interest.

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## 2. Methods

Full details of the design and methods used in our have been previously published [12]. Briefly, the defined geographic entity for the collection of coronary events, MONICA, is composed of 15 municipalities in Charleroi. Analyses presented hereafter relate only patients in the 25- to 69-year age range between 1983 and 2009.

The data sources for hospitalized patients are the 7 hospitals located in the study region. A physician reviews the documents of all suspected fatal and nonfatal cases of coronary thrombosis hospitalized in the intensive care unit of all hospitals in the city. Since 1998, the Minimum Clinical Summary permits an extra validation of every suspected case using the following codes of the *International Classification of Diseases*: 410 to 414 (ischemic heart disease). An event was considered new if its apparent date of onset was more than 28 days after any previous coronary heart disease event.

For fatal cases, the death certificates are collected by the Ministry of Health of the French-speaking community. All death certificates are validated and checked against the hospital file of hospitalized subjects and the documents from the ambulance and intensive care unit. Events are considered fatal if they result in a person's death within 28 days of the onset of the first symptom. The register includes both extrahospital as well as hospital events.

The excess of the relative risk of events on each day of the week was calculated. The effects of sex, age, history of AMI, hypertension, fatality, and temporal changes over the 27-year period were investigated. For age effects, patients were analyzed after conventional stratification into 4 age groups of 10 years (25-34, 35-44, 45-54, 55-64) and 1 age group of 5 years (65-69). Differences from the expected value from each age group were calculated. The temporal trend was analyzed according to 2 periods of 6 years (1983-1988 and 1989-1994) and 3 periods of 5 years (1995-1999, 2000-2004, and 2005-2009). This stratification was created arbitrarily before analyzing the data.

The $\chi^2$ test for goodness of fit was used to test the difference between the frequencies of AMI events on the 7 days of the week. For AMI history (MI+), hypertension (HTA+), and fatality (F) effects as well as for temporal trend analysis, percentage increases (Monday vs Saturday) were calculated. Pearson $\chi^2$ and $\chi^2$ for trends were also used when applicable. Statistical analyses were performed using R version 2.15.2 (R Foundation for Statistical Computing, Vienna, Austria).

## 3. Results

### 3.1. Characteristics of the study population

Data from 9732 cases of AMI were analyzed between 1983 and 2009. The average age was 57.1 years. Women represent only 25.8% (n = 2514) of all AMI events, and this percentage remained stable over the 27-year period. Women were, on average, older than men (59.7 vs 56.9 years, $P < .001$).

### 3.2. Overall effect

Overall, there was a significant day-of-the-week variation ($P < .001$), with an excess of AMI cases observed on Mondays (n = 1495) and a minimum on Saturdays (n = 1259), corresponding to a relative increase in AMI of 18.2 between the 2 days.

### 3.3. Sex profile

The day-of-the-week distribution was confirmed after sex stratification (Fig. 1). However, women exhibited a nonsignificant day-of-the-week variation ($P = .220$), with a 20.4% relative increase in events between the 2 days (n = 377 on Mondays vs n = 313 on Saturdays). For men, the day-of-the-week variations are significant, with a relative increase in events of 18.3% (n = 1188 on Mondays vs n = 945 on Saturdays).

### 3.4. Age profile

There were 177, 961, 2221, 3753, and 2616 patients in the groups 25 to 35, 35 to 44, 45 to 54, 55 to 64, and 65 to 69 years, respectively. In the subanalysis for the different age groups, differences were observed (Fig. 2). The Monday peak is more pronounced for the 35- to 44-year age range than for the 45- to 54- and the 55- to 64-year ranges. In contrast, for the 25- to 34-year age range, Friday and Saturday peaks were observed, with a trough on Mondays. The day-of-the-week variations are significant for the 35- to 44-year ($P = .045$) and the 55- to 64-year age range ($P = .032$) but not for the other groups. Younger patients were less likely to exhibit hypertension (23.8% for the 25- to 34-year range vs 40.4% for the 65- to 69-year range, $P < .001$) or history of myocardial infarction hypertension (15.4% for the 25- to 34-year range vs 28.7% for the 65- to 69-year range, $P < .001$). The prevalence of hypertension and the history of myocardial infarction hypertension increased linearly according to age.

Overall, the age effect on the weekly distribution of AMI was confirmed after sex stratification. Younger women exhibit a slightly different pattern with a Wednesday peak.

### 3.5. Risk factors

The cases with (n = 2713) and without (n = 4931) HTA exhibit the same day-of-the-week variation (Fig. 3). In contrast, the cases with a medical history of myocardial infarction (n = 1888) exhibit a less pronounced Monday peak than the cases with antecedent AMI (n = 5970). With the exception of the cases with a medical history of AMI, these results are significant ($P < .025$).

### 3.6. Fatal vs nonfatal cases

There was a marked decrease in fatality over the 27-year period. Case fatality rates were 52.9%, 46.3%, 33.3%, 35.9%, and 19.2% for the 1983-1988, 1989-1994, 1995-1999, 2000-2004, and 2005-2009 periods, respectively. There was a significant ($P = .011$) day-of-the-week variation of 28-day fatality, with an excess of fatal cases observed on the weekend (fatality of 43.5% and 43.2% for Saturdays and Sundays, respectively) and a minimum on Mondays (fatality of 37.1%). The difference in fatality between the weekends and weekdays was stable over the 27-year period of analysis. The majority of deaths occurred up to 1 hour (21.6%) or between 1 and 24 hours (69.6%) after the onset of symptoms.

### 3.7. Trend analysis

The number of AMI cases decreased during the period of analysis, with an average of 452, 343, 287, and 231 events per year for the 1983-1994, 1995-1999, 2000-2004, and 2005-2009 periods, respectively.

The Monday peaks are more pronounced for the periods 2000-2004 and 2005-2009. These results are illustrated in Fig. 4. The day-of-the-week variations are significant for the periods 1983-1989 ($P = .012$) and 2005-2009 ($P = .007$) but not for the other periods.

## 4. Discussion

The incidences of AMI vary according to the day, the week, the season, and the year [2-4]. The increased incidence in the morning is attributable to increased blood pressure and heart rate [4]. The increase in the incidence of AMI in the cold months is a consequence

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