Trends and forecasts of hospital admissions for acute and chronic pancreatitis in the Netherlands

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Abstract

**BACKGROUND** The incidence and prevalence of acute and chronic pancreatitis have increased in the Western countries. Most likely, the number of hospital admissions has increased correspondingly.

**AIMS** To analyze the trends in hospital admissions in the Netherlands for acute and chronic pancreatitis from 1992 to 2004 and to forecast the number of admissions up to 2010.

**METHODS** Analysis of hospital admissions for acute and chronic pancreatitis accumulated in a nationwide database. Curve fitting regression models were used to explore future trends.

**RESULTS** The number of acute pancreatitis admissions rose in 1992-2004 from 1785 to 3120 (74.8% increase). The overall annual number of acute pancreatitis admissions increased from 11.8 to 19.2 per 100.000 person-years. The linear regression model predicted 3205 (95% CI: 3111-3299) and 3537 (95% CI: 3429-3645) admissions for 2007 and 2010 respectively, a further increase by at least 9.9% in 2010 compared to 2004. In the 12 year time period, chronic pancreatitis admissions showed an increase of 75.4% (from 790 to 1386). The overall annual number of chronic pancreatitis admissions increased from 5.2 to 8.5 per 100.000 person-years. The cubic regression model predicted 1868 (95% CI: 1619-2117) and 3173 (95% CI: 2456-3890) admissions for 2007 and 2010 respectively, an additional increase of 77.2% in 2010 compared to 2004.

**CONCLUSION** Hospital admissions for acute and chronic pancreatitis have increased substantially from 1992-2004. This trend will most likely continue for the near future and the burden and costs to the Dutch health care system will increase accordingly.
CHAPTER 3

Introduction

Over the past decades the incidence and prevalence of respectively acute and chronic pancreatitis in the Western countries have increased. It has been suggested that this could be explained by an increase in alcohol intake, a higher incidence of gallstone-related pancreatitis, and by improvements of diagnostic tests and imaging techniques.

The disease spectrum of acute pancreatitis ranges from mild and self limiting (80%) to a rapidly progressive fulminate illness with morbidity rates up to 30-50%. Its clinical course varies from a short period of hospitalization with supportive care (pain, fluid, and nutritional management) to prolonged hospitalization with admittance to an Intensive Care Unit because of the development of multi organ failure, systemic inflammatory response syndrome and septic complications.

Chronic pancreatitis is characterized by recurrent episodes of abdominal pain accompanied by progressive pancreatic exocrine and endocrine insufficiency. Hospitalization is required in case of an exacerbation to control pain (e.g. opioid medication, pancreaticojejunostomy) and for the treatment of complications such as pseudocysts. We analyzed the trends in hospital admissions for acute and chronic pancreatitis in the Netherlands in the period 1992-2004 and explored the predicted number of admissions up to 2010.

Methods

Study population

In the Netherlands hospitalization data are collected in the National Information System on Hospital Care (NISHC). This nationwide, automated database collects anonymous hospital discharge data from academic and general hospitals. The NISHC database is maintained by Prismant, the research and advisory agency for the Dutch Health Care Service. Since 1992 almost all (98%) Dutch hospitals are linked to the NISHC. The recorded discharge data are periodically verified and matched with the original hospital data to ensure an optimal data quality.

We retrospectively retrieved all hospital admissions (>1 day of hospital stay) with acute or chronic pancreatitis as the primary discharge diagnosis for the period from 1 January 1992 to 31 December 2004. The discharge codes are coded in accordance with the International Classification of Diseases coding system (ICD-9CM, 577.0 and 577.1). Data were retrieved grouped by sex and by age.
Statistics
The annual number of hospital admissions for acute and chronic pancreatitis per 100,000 person-years was calculated. The general population numbers within specified time frames were derived from the online statistical resource StatLine of the CBS (Central Commission for Statistics) of the Dutch Ministry of Economy Affairs (www.cbs.nl). Annual number of admissions was standardized for age and sex based on the distribution of the total number of person-years in the period 1992-2004, assuming that a person alive during the year generates one full person-year.

Future trends in hospital admissions up to 2010 were forecasted with curve fitting regression models while using the numbers of admissions for acute and chronic pancreatitis from the period 1992-2004 for historical validation. Principally, the regression model that best fitted the historical data as indicated by the explained variance estimate (highest $R^2$) was chosen. However, with a time horizon of 6 years, regression models may easily over- or underestimate future numbers of admissions the closer one gets to 2010, particularly in case of overfitting of historical data. To prevent possibly spurious estimates by merely taking the model with the highest $R^2$, the forecasts by the other models were visually inspected and a simpler regression model was selected instead, in case it explained at least 90% of the variance in historical data. In addition, the model selection process was repeated using smoothed historical data. Smoothing data directly reduces the risk of overfitting and leads to shrinked parameter estimates in regression models. Upper and lower 95% confidence intervals of the forecasted numbers of admissions are reported for the primary analysis as well as for the analysis based on smoothed data.

The Statistical Package for the Social Sciences (SPSS) version 12.0.1 (SPSS, Chicago, IL) was used for statistical analysis.

Results
Acute pancreatitis
In 1992 a total of 1785 hospital admissions for acute pancreatitis were registered. In 2004 this number rose to 3120, representing an increase of 74.8% over a twelve year time period. Males were slightly overrepresented with 58.8% and 56.3%, respectively [Figure 1]. The growth rate of the number of admissions for women (85.3%) was higher than for men (67.4%).The overall annual number of primary acute pancreatitis admissions increased in the period 1992-2004 from 11.8 to 19.2 per 100,000 person-years.

After standardization for age and sex the annual number increased from 12.3 to 18.5 per 100,000 person-years [Figure 2]. This represents an increase of 50.4% between 1992-2004. The sex-standardized number per 100,000 person-years increased from 14.0 to 21.8 for men (55.7% increase) and from 9.6 to 16.6 for women (73.0% increase).
The linear regression model was selected to forecast the number of admissions for the years 2007 and 2010. The model explained 97.1% of the variance in the unstandardized historical data (against 98.2% for the more complex cubic model). The linear model forecasted 3344 (95% CI: 3130-3557) and 3680 (95% CI: 3444-3916) admissions for 2007 and 2010, respectively, suggesting an increase of 17.9% compared to the 2004 level.
After smoothing the historical data for acute pancreatitis, the $R^2$ of the linear model increased to 99.3% and the model forecasted 3205 (95% CI: 3111-3299) and 3537 (95% CI: 3429-3645) admissions for 2007 and 2010 respectively [Figure 3], suggesting an increase of at least 9.9% compared to the 2004 level.

**Chronic pancreatitis**
A total of 790 hospital admissions for chronic pancreatitis were registered in 1992. In 2004 the number of admissions rose to 1386, representing an increase of 75.4%. The increase of the number of chronic pancreatitis related admissions was more prominent in the years 2003 and 2004 (21.7% and 15.8%, respectively). Males were overrepresented with 67.8% and 66.4%, respectively [Figure 4]. The growth rate of the number of admissions for women (83.5%) was somewhat higher than for men (71.6%). The overall annual number of primary chronic pancreatitis related admissions increased in the period 1992-2004 from 5.2 to 8.5 per 100,000 person-years.

After standardization for age and sex the annual number increased from 5.5 to 8.2 per 100,000 person-years [Figure 5]. This represents an increase of 49.1% between
1992-2004. Moreover, the increase in number was most explicit in the years 2003 and 2004. The sex-standardized number per 100,000 person-years increased from 7.2 to 11.4 for men (58.3% increase) and from 3.3 to 5.7 for women (72.7% increase).

Only the cubic regression model explained more than 90% of the variance of the unstandardized historical data ($R^2$ 91.3%) and was selected to forecast the number
of admissions up to 2010. The cubic model forecasted 2246 (95% CI: 1708-2785) and 3830 (95% CI: 2446-5234) admissions in 2007 and 2010, respectively, suggesting an increase of 176% compared to the 2004 level. Smoothing the historical data prior to model selection did not reveal a simpler regression model exceeding the 90% prerequisite. By smoothing, the $R^2$ of the cubic model increased to 97.8% and the model forecasted 1868 (95% CI: 1619-2117) and 3173 (95% CI: 2456-3890) admissions for 2007 and 2010 respectively, suggesting an increase of at least 77.2% compared to the 2004 level [Figure 6].

**Discussion**

In this study we show that the number of hospital admissions in the Netherlands with acute or chronic pancreatitis as the primary discharge diagnosis has increased substan-
tially over the last 12 years up to 2004, by 74.8% and 75.4% respectively, with a higher growth rate for women than for men. After standardization for age and sex the annual number for both acute and chronic pancreatitis related admissions increased by at least 50%. This increase in admissions is in line with an earlier observation that the incidence of first attacks of acute pancreatitis in the Netherlands increased between 1985-1995.²³

Curve fitting regression models based on these trends show that the yearly number of admissions up to the year 2010 may further increase considerably. The historical trend in admissions for acute pancreatitis was best described by a linear model. The resulting forecasts suggested increasing yearly number of admissions of at least 9.9%, presumably 17.9%.

In contrast, the cubic model best fitted the trend of admissions for chronic pancreatitis. The resulting forecasts suggested increases of at least 77.2%. Because of its ‘accelerating’ nature, it can be debated if this progressive cubic regression model truly forecasts the hospital admissions in the near future. The hospital admissions in 2003 en 2004 increased with respectively 21.7 and 15.8%. With these high yearly percentages in mind, the derived minimum estimate of a 77.2% increase over 6 years seems reasonably realistic and may set the target for health care service planning. Whether or not this growth rate will be even higher and will approximate the also suggested 176% increase over 6 years, remains uncertain. A regular update of curve-fitting based forecasts with additional, more recent data is advisable.

It can be speculated that the increase of hospital admissions for both acute and chronic pancreatitis from 1992-2004 in combination with the forecasted increase, puts a proportionally higher burden on the Dutch health care system, both in terms of labour efforts as well as costs. To substantiate this speculation, it would be interesting to assess the trend in length of stay. Regarding labour efforts, decreasing length of stay may partially compensate for increasing numbers of admissions. However, while the overall length of hospital stay for any indication reduced during the last decade in the Netherlands, actual data regarding the length of stay of admissions for acute and chronic pancreatitis were not retrieved from the NISHC.

The outcomes of the present study depend heavily on the validity of the NISHC as a reliable source for hospital discharge data for acute and chronic pancreatitis. Since 1992 the NISHC collects information on at least 98% of hospital admissions in the Netherlands. The accuracy and validity of the data is ensured by a thorough verification strategy by which collected data from pooled hospitals is rechecked and verified with its original source. Eland and co-workers performed, as a part of a retrospective study in which incidence rates of acute pancreatitis in the Netherlands were assessed, a restricted validation analysis. Data were retrieved from 101 patients who were reported to the NISHC with a discharge diagnosis code for acute pancreatitis NISHC.³ They report a positive predictive value (PPV) of 82.2% for acute pancreatitis discharge diagnosis codes. This percentage was similar for the years 1985, 1990, and 1995. On the other hand, only
76% of patients with an acute pancreatitis were notified to the NISHC. They concluded that as a consequence of the overreporting due to miscoding and the underreporting due to non-coding, the observed incidence rates seem to reflect true rates. Our group retrospectively analyzed the reliability of hospital discharge data (in total 483 admissions) for both acute and chronic pancreatitis collected in the NISHC. In this validation study we observed a substantial miscoding and non-coding of discharge diagnoses of acute and chronic pancreatitis on the level of individual hospital admissions, ultimately leading to an underestimation at group level of the total number of acute and chronic pancreatitis diagnoses of 15.8% and 6% respectively.

The observed prominent increase in hospital admissions for acute and chronic pancreatitis over the last twelve years deserves further attention. It has been suggested that the increase of the incidence and prevalence of respectively acute and chronic pancreatitis in the Western countries could be explained by an increase in alcohol intake and a higher incidence of gallstone-related pancreatitis. Unfortunately, the source data per admission that were used for the present study do not contain accurate information regarding the actual cause of the pancreatitis attack. However, to explicate and vindicate the observed trend some considerations come to mind. It is well known from epidemiological studies that the incidence of acute pancreatitis follows the changes in alcohol consumption. Also, a close relation has been described between the per person alcohol consumption and the numbers of discharges with chronic pancreatitis 6 years later. According to registry data of the Central Commission for Statistics the general alcohol consumption in the Netherlands only slightly increased in the period 1992-2000 (www.cbs.nl). Furthermore, there has only been a minimal change in alcohol consumption in the Netherlands. Therefore, the increase in hospital admissions for both acute and chronic pancreatitis seems not to be explained by a change in alcohol consumption.

As mentioned, another common cause of acute pancreatitis is gallstone disease. Our data show a slightly higher increase in admissions among women. Because gallstone disease is associated with the female gender, this increase may point to a contribution from gallstone-related pancreatitis. According to registry data of the Central Commission for Statistics the primary hospital admissions for gallstone disease are rising and most patients are women. Another well known observation is that obesity is linked to gallstone disease. Interestingly, in the Netherlands there has been a steady increase in the prevalence of obesity in the period from 1976-1997.

In conclusion, the number of hospital admissions for both acute and chronic pancreatitis have increased substantially from 1992-2004. This trend will most likely continue for the near future. Consequently, it can be anticipated that the burden and costs of acute and chronic pancreatitis admissions to the Dutch health care system will increase accordingly.
References