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Effects of morbidity, age, gender and region on percutaneous transluminal coronary angioplasty (PTCA) utilisation

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Objectives: To investigate changes in the use of PTCA application in respect to morbidity, gender, region and age, and to investigate the morbidity as related to geographical variation.
Study design: Retrospective record linkage study.
Setting: All hospitals and cardiological centres ($n = 156$) which performed the Minimum Basic Data Set (MBDS).
Patients: All Austrian residents who were diagnosed for myocardial infarction, coronary heart disease or angina pectoris in 1993–1995 (1993: $n = 73.077$; 1994: $n = 80.173$; 1995: $n = 84.896$).
Measurements and main results: The intervention rate (IR = PTCA/indication) increased from 0.03–0.04 (33%) between 1993 and 1995 with differences in genders (males: 24%, females: 27.7%) and regions (Vorarlberg: − 7.5%, Burgenland: 65.3%). Male morbidity started to increase at about 60 y and female morbidity at about 70 y. Morbidity as a demand factor did not correlate with PTCA application. The intervention rate was significantly lower for females in Austria in general ($P < 0.001$) as it was in every Federal State ($P < 0.001$). This pattern was constant during 1993–1995 with the highest difference in Salzburg and the lowest in Styria. Austrian men were about three times more likely to have received PTCA application than women (crude Odds Ratio = 2.8, 95% CI = 2.6–3, P-value < 0.001). Logistic regression modelling revealed age as main confounder (adjusted Odds Ratio = 1.36, 95% CI = 1.31–1.42, $P < 0.001$). The $\geq 5\%$ intervention rate peak was between 30–75 y for males and between 30–65 y for females whereas morbidity of $\geq 1\%$ started for males at about 50 y and for females at about 60 y. Marked geographical differences of the intervention rate were observed (Upper Austria, Salzburg IR = 0.07, Styria IR = 0.02) but could not be explained by the demand factor morbidity (Pearson's correlation coefficients 1993: 0.039, $P = 0.71$; 1994: 0.155, $P = 0.133$; 1995: 0.087, $P = 0.399$).
Conclusions: The highest intervention rates were in the age groups with the lowest morbidity. Women received significantly fewer interventions than men by age and region. The demographic strata with lowest use rate were women aged 64 y and more. Marked geographical differences of PTCA application were stated but could not be explained by the demand factor morbidity. Further studies on supply factors as well as on economic and social factors are needed in order to develop public health strategies to guarantee equal utilisation rates for the whole Austrian population.

Keywords: angina pectoris; coronary heart disease; myocardial infarction; percutaneous transluminal coronary angioplasty; (PTCA)

Introduction

The first percutaneous transluminal coronary angioplasty (PTCA) was performed by Grüntzig[1] exactly twenty years ago. During the following years it developed to be a standard procedure in cardiology. Angina pectoris and myocardial infarction are the outstanding indications for PTCA. Two aspects have to be considered: what are the advantages when compared to other procedures and is it a cost-effective method?

Angioplasty vs pharmacological therapy

Comparisons of angioplasty *vs* pharmacological treatment in patients more severely affected by angina pectoris showed positive results for PTCA.[2] It offered a combined therapy approach for prevention of myocardial infarction in variant angina pectoris by establishing early re-vascularisation.[3] Several small studies suggested that immediate angioplasty in cases of acute myocardial infarction established reperfusion more quickly and more effectively than thrombolysis and was associated with lower mortality.[4]

Of course, the initial costs of PTCA are higher when compared to pharmacological treatment.[5] However, since the duration of hospital stay and the need for further hospitalisation is reduced after PTCA, it might be the long term more cost effective method when viewed over several years. Undoubtedly PTCA offers earlier and more complete relief of angina than medical therapy, which nevertheless has to be considered seriously in the cost effectiveness debate.[6]

Angioplasty vs coronary artery bypass grafting (CABG)

PTCA represents a valid alternative to coronary bypass grafting (CABG) and, moreover, might be performed even in patients in whom CABG is contraindicated.[7] Promising results can be achieved in the therapy of acute myocardial infarction.[8,9] However, in general there are no significant differences in the incidence of subsequent myocardial infarction and mortality, and differences between the two methods such as recovery rate or long term return to work diminish over a 5 y follow-up period.[10] In a recent study Corr[11] considered direct comparison of the two methods as inappropriate, since the pattern of the disease and patient's

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factors determine the outcome. Neither mode of treatment cures the underlying disease and long-term treatment strategies have to use both angioplasty and coronary bypass grafting as complementary procedures.

The average cost of treating a patient with PTCA are about 52% that of CABG increasing to about 80% during the following 2 y because of the greater need for subsequent interventions.[12] The decrease of the cost advantage over time led Gunnell *et al*[13] to the conclusion, that the rapid expansion of PTCA should be limited. No results on follow-ups more than 5 y are available these days, therefore no valid conclusions can be drawn.[14]

However, PTCA continues to have two main limitations: the relatively high acute complication rate mainly due to uncontrolled vessel dissection (4–7%) and the long-term re-stenosis rate (20–40%).[7] Stents seem to be the ideal adjunct to PTCA since they seal dissection and prevent vessel recoil. But up to now there are no long-term results on efficacy and safety available. Therefore careful case selection for angioplasty remains an important issue. To aid case selection the American College of Cardiology and the American Heart Association has developed guidelines.[15]

In Austria the first PTCA was performed in 1979 in the University Hospital for Cardiology, Vienna.[16] According to WHO[17] 1000 PTCAs per 1 million inhabitants should be performed. Whereas the USA reached this aim by 1990, Austria fulfilled this guideline only in part (1995: 0.5/1000). According to the European Survey on Cardiac Interventions.[18] Austria is in seventh position after Iceland, Germany, Belgium, the Netherlands, Switzerland and France and lies above the European mean for 1993 (343/million).

The aim of this study was to investigate changes in PTCA application in Austria between 1993 and 1995 in respect to the factors: morbidity, gender, region and age by the means of the intervention rate (PTCA/indications) and the standardized morbidity rate. Furthermore we were interested in the demand factor morbidity as reason for differences in geographical distribution.

Methods

Data sets

We used three different data sets: the *census of 1991* for calculation of the SMRs on district level, the *prospected demographic data*[19,20] for the years 1993–1995 for calculation of morbidity and intervention ratios on regional (Federal State) level and the *Minimum Basic Data Set* (MBDS), (In 1997 the federal financing system for hospitals based on service was invested. Until then several Austrian hospitals received financial aid from the Ministry for Social Affairs according the sum of days of hospitalisation for all patients. In order to obtain this financial aid the responsible authorities of the hospitals had to perform the Minimum Basis Data Set) for patients data on age, sex,

Table 1 Top Ten diagnoses in the context of PTCA in Austria between 1993–1995

		1993	1994	1995
414	other chronic ischaemic heart disease	2114	2335	3153
414.0	coronary heart disease			
MI[a]		298	288	389
AP[b]		235	222	167
412	old myocardial infarction	65	72	46
414.1	myocardial aneurysm	30	13	8
440.2	diseases of peripheral arteries of limbs	18	23	11
401	essential hypertony	17	9	29
429.2	cardiovascular disease	11	1	3
424.1	diseases of the aortal valve	7	0	3
272.0	hypercholesterinaemia	6	3	0

[a]410 acute myocardial infarction, .0 ventral, .1 dorsal, .2 subendocardial, .3 multilocalized, .5 not localized; .6 right heart; 411 other acute or subacute forms of iscaemic heart diseases, .0 unstable angina pectoris, .1 postinfarction syndrome (Dressler), .3 cardiogenic shock.
[b]413 angina pectoris, .0 de-novo, .1 chronic stabil, .2 post infarction.

Table 2 Changes of morbidity and intervention rate in Austria between 1993 and 1995, region/gender comparison

	1993						1995					
	Morbidity			Intervention rate			Morbidity			Intervention rate		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Burgenland	1.02	0.98	1.05	0.026	0.041	0.012	1.13	1.18	1.09	0.043	0.058	0.027
Carynthia	0.75	0.77	0.73	0.040	0.058	0.022	0.93	0.96	0.89	0.040	0.053	0.026
Lower Austria	0.84	0.87	0.81	0.029	0.043	0.014	0.97	1.03	0.91	0.036	0.051	0.020
Upper Austria	0.90	0.92	0.87	0.053	0.069	0.036	0.97	1.03	0.91	0.071	0.095	0.046
Salzburg	0.56	0.65	0.47	0.066	0.085	0.042	0.67	0.75	0.60	0.068	0.097	0.033
Styria	1.16	1.06	1.25	0.021	0.036	0.009	1.27	1.19	1.33	0.022	0.035	0.011
Tyrol	0.67	0.73	0.62	0.030	0.045	0.013	0.89	0.91	0.88	0.035	0.055	0.015
Vorarlberg	0.83	0.88	0.79	0.040	0.056	0.022	1.22	1.28	1.16	0.037	0.057	0.015
Vienna	1.09	1.07	1.10	0.029	0.044	0.015	1.23	1.25	1.22	0.042	0.064	0.021
total	0.91	0.92	0.91	0.034	0.050	0.018	1.06	1.08	1.03	0.042	0.062	0.023

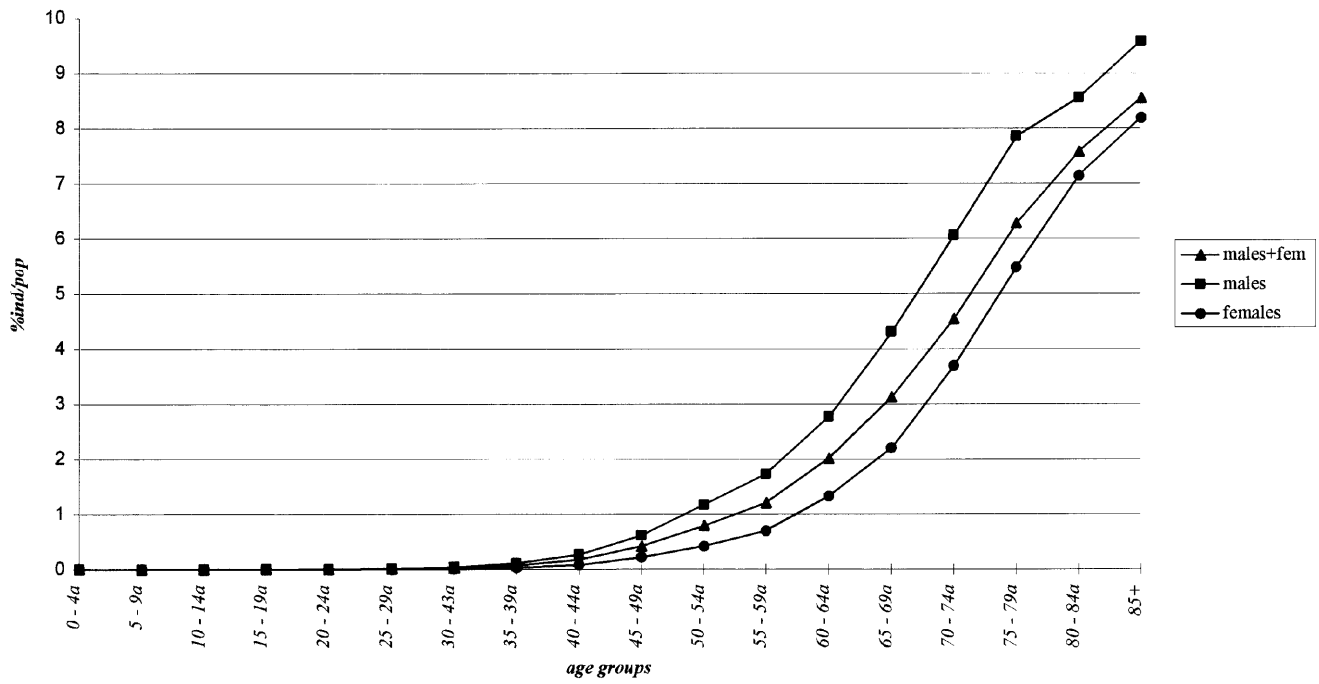


Figure 1 Morbidity in Austria in 1995, gender/age comparison.

postal code, state of residency, main and additional diagnoses as ICD-9 codes and therapy. Since the MBDS was not performed in every hospital we missed data from six cardiological intervention centres out of 23.

Study population

Our study population comprised all Austrian patients who (a) were referred to an Austrian hospital performing the Minimum Basic Data Set between 1993 and 1995 and (b) were diagnosed as suffering from angina pectoris and/or myocardial infarction.

The definitions of angina pectoris and myocardial infarction as used for this paper were created by comparison of the ICD-9 classifications[21] with the classifications of the Austrian guidelines for Coronary Angiography Referrals.[22] This was necessary for definition of more specified indicational diagnoses for PTCA than that provided by the ICD-9 coding. The ICD-9 codes summarised under the diagnoses under investigation are for AP: 413, 413.0, 413.1, 413.2, 414 and 414.0 (414 (other chronic ischaemic heart diseases) and 414.0 (coronary heart

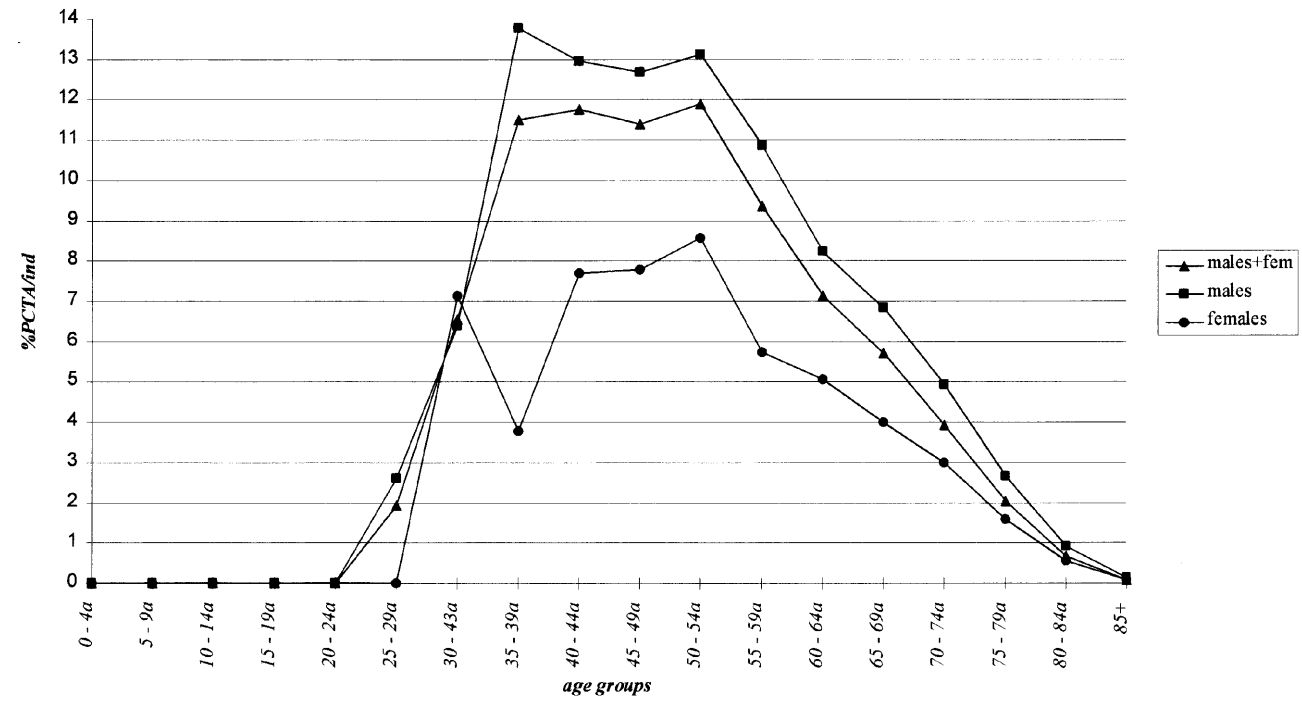


Figure 2 Intervention rate in Austria in 1995, gender/age comparison.

disease) were subsummized under the diagnosis angina pectoris for pragmatic reasons: even CHD is not an indication per se in the cardiological sense of meaning but only when taken together with signs of ischaemia, it is the most often documented diagnosis in the context of PTCA); and for MI: 410, 410.0, 410.1, 410.2, 410.3, 410.5, 410.6, 411, 411.0, 411.1, 411.3.

Statistical methods

Census data from 1991 were used to calculate the standardised morbidity rates of indications and interventions at district level because the prospective demographic data for 1993–1995 were only obtainable at Federal State level. The census data were merged with the Minimum Basic Data Set by postal codes. Merging of the prospective demographic data of 1993–1995 with the Minimum Basic Data Set by postal codes was done for calculation of morbidity and intervention rates at Federal State level. Pearson's correlation coefficient was used for the estimation of the association between morbidity as demand factor and distribution of PTCA utilisation at district level. Geographic maps of the distribution of standardised morbidity rates for indications and PTCA application were done by REGIO GRAPH. Chi-squared test was used to calculate gender differences and regional differences by gender. Multiple logistic regression modelling was done to adjust results for age, gender and region.

Minimum Basic Data Set data were obtained from 156 hospitals and entered into data bank using ACCESS. Data of all three data sets were transferred to SPSS, EPI-INFO and EXCEL for further processing and calculation (SMRs, Pearson's correlation coefficient, means, standard deviations, crude and adjusted odds ratios, confidence intervals, *P*-values, chi-squared-test, Fisher exact test). To avoid multiple counts of patients we identified those coding for angina pectoris *and* myocardial infarction and those with repeated hospital admissions during the same year. All calculations were done as person based and not case based.

Ethical aspects

The data used was statutory data gathered in accordance with the requirements of the Austrian Ministry for Social Affairs and the Austrian Ministry for Health and Consumer Protection.

Results

Demographic characteristics

Austria has a size of approximately 84,000 sq km with an estimated population for 1995 of 8,046,535 (males: 3,902,334, females: 4,144,201). Austria comprises nine Federal States, each divided into several political districts.

Ten most common diagnoses in the context of PCTA

Results of coding in the Minimum Basis Data Set are congruent with the created categories angina pectoris and myocardial infarction as used in this paper: in 1995 coronary heart disease, angina pectoris and myocardial infarction were coded as the three main indications in 98%. Furthermore the 'top ten' main diagnoses which were coded in the Minimum Basic Data Set in the context of PCTA did not change between 1993 and 1995 (Table 1).

Morbidity for typical indications for PTCA

In 1995 the mean age of patients was 71.5 y (males: 68.1, females: 75). The overall morbidity was 1.06% A minor increase of 0.15% for the whole Austrian population in comparison to 1993 (0.91%) was observed (Table 2). There were minor differences between males (1.08%) and females

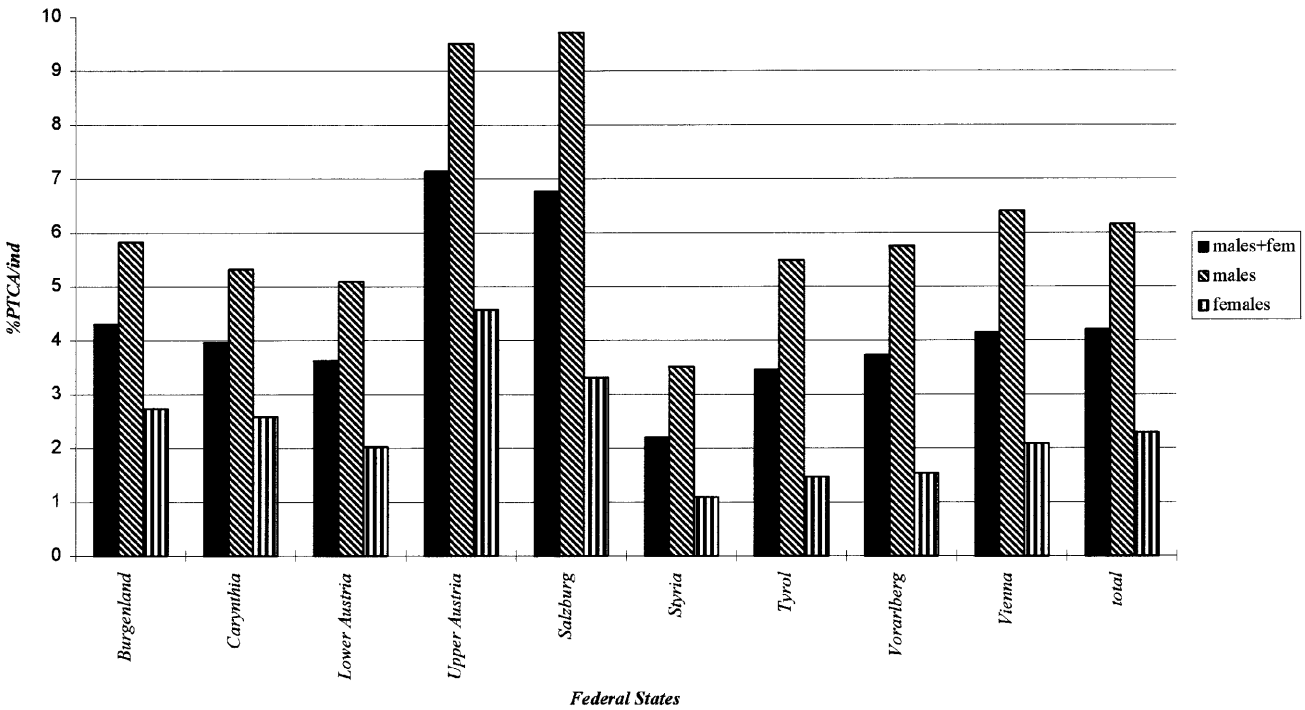


Figure 3 Intervention rate in Austria in 1995, gender/region comparison.

Table 3 Intervention rate in Austria between 1993 and 1995, regional comparison per gender

	Males			Females		
	OR	CI	*P*-value	OR	CI	*P*-value
			1993			
Austria	1			1		
Burgenland	1.22	0.92–1.62	0.090	1.59	0.96–2.67	0.072
Carynthia	0.85	0.70–1.04	0.114	0.81	0.60–1.11	0.206
Lower Austria	1.18	1.03–1.35	0.001	1.31	1.04–1.65	0.021
Upper Austria	0.7	0.63–0.79	< 0.001	0.49	0.42–0.58	< 0.001
Salzburg	0.57	0.47–0.68	< 0.001	0.42	0.31–0.57	< 0.001
Styria	1.42	1.23–1.65	< 0.001	2.15	1.66–2.8	< 0.001
Tyrol	1.12	0.91–1.38	0.300	1.44	0.96–2.19	0.08
Vorarlberg	0.88	0.70–1.11	0.294	0.84	0.57–1.25	0.42
Vienna	1.13	1.01–1.27	0.040	1.21	1.01–1.46	0.04
			1994			
Burgenland	0.87	0.69–1.09	0.237	1.2	0.79–1.84	0.417
Carynthia	0.83	0.69–0.99	0.042	0.72	0.55–0.95	0.02
Lower Austria	1.12	0.99–1.27	0.067	1.07	0.88–1.31	0.515
Upper Austria	1.03	0.92–1.17	0.598	0.66	0.56–0.78	< 0.001
Salzburg	0.75	0.62–1.92	0.005	0.6	0.43–0.83	0.002
Styria	1.24	1.09–1.41	< 0.001	1.93	1.53–2.44	< 0.001
Tyrol	1.20	0.96–1.4	0.14	1.23	0.86–1.77	0.276
Vorarlberg	0.87	0.70–1.08	0.201	1.19	0.77–1.85	0.471
Vienna	0.87	0.79–0.97	0.10	0.96	0.82–1.13	0.671
			1995			
Austria	1			1		
Burgenland	1.06	0.85–1.32	0.616	0.83	0.60–1.15	0.290
Carynthia	1.17	0.98–1.40	0.081	0.88	0.68–1.14	0.364
Lower Austria	1.22	1.09–1.37	< 0.001	1.14	0.95–1.36	1.173
Upper Austria	0.63	0.57–0.68	< 0.001	0.49	0.43–0.56	< 0.001
Salzburg	0.61	0.52–0.72	< 0.001	0.68	0.51–0.92	0.010
Styria	1.80	1.58–2.07	< 0.001	2.11	1.69–2.64	< 0.001
Tyrol	1.13	0.96–1.34	0.137	1.57	1.14–2.15	0.004
Vorarlberg	1.08	0.90–1.31	0.435	1.49	1.03–2.18	0.033
Vienna	0.96	0.88–1.05	0.406	1.10	0.94–1.28	0.231

(1.03%) in general but there were obvious gender differences in age (Figure 1): males reached an Austrian-wide morbidity of about 1% in their fifties, they passed the 5% mark in their sixties and ended up with 9.7% morbidity in the highest age-group (85 +). Females reached the 1% mark in their sixties, passed the 5% mark in their seventies ended at 8.2% in the highest age-group. In other words: female morbidity started to increase about ten years later than in males and did not reach the level of male morbidity.

Regional differences in morbidity of between 0.7 and 1.3 for males and 0.6 and 1.3 for females were observed in 1995 (Table 2). The Federal States with lowest morbidity for both genders were Salzburg and Tyrol, those with highest morbidity were Vorarlberg and Vienna for males and Styria and Vienna for females.

Intervention rate

In 1995 4% of patients with given indications received PTCA. The overall intervention rate increased from 0.03 in 1993 to 0.04 in 1995 with marked regional differences (Table 2): the highest increase was in Burgenland (65.3%) which then reached the Austrian average of 0.04. The lowest increase was in Salzburg (3%) which with a rate of 0.07 was markedly over the Austrian average. There was a decrease of 7.5% in Vorarlberg which had been 0.04 in 1993 so that with a rate of 3.7 it lay below the Austrian average in 1995.

The rate was investigated further in respect to four variables: morbidity, age, gender and geographical distribution at regional and district level.

Morbidity

PTCA application increased for 33% whereas morbidity increased only for 16.4%. Marked gender differences were revealed by comparison of morbidity with intervention rate stratified by age (Figures 1 and 2): the intervention rate of $\geq 5\%$ was between 30 and 74 y for males and between 30 and 64 y for females. Morbidity of $\geq 1\%$ started at about 50 y for men and for women at about 60 y. For women the 5% intervention rate-peak had passed when morbidity began to increase.

Age

In 1995 the overall intervention rate of $\geq 5\%$ was between 30 and 69 y whereas the overall morbidity reached 1% at about 50 y of age with a sharp increase towards the highest

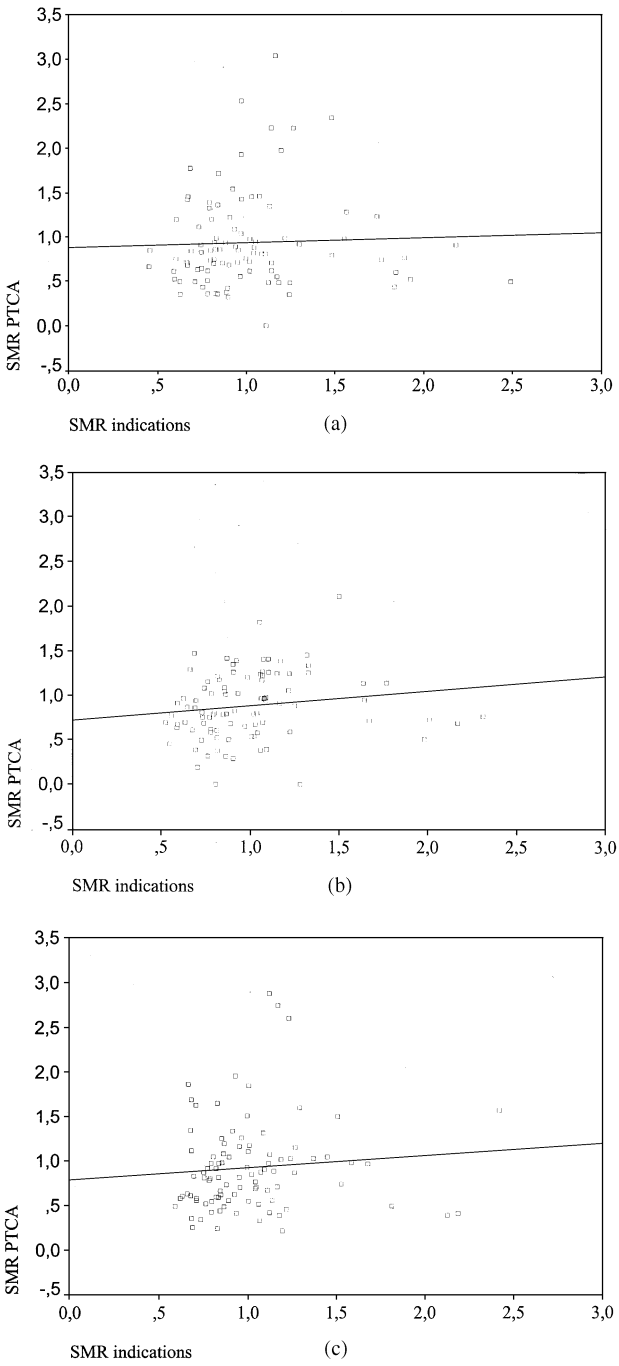


Figure 4 Relationship between SMR indication and SMR PTCA in Austria (*a*) 1993; (*b*) 1994; (*c*) 1995.

age group (85+). This pattern was constant over time (Figures 1 and 2).

Gender

The mean age of patients receiving PTCA for women was about 5 y higher than that for males (mean age males: 60.6, mean age females: 65.7). The female intervention rates were with respect to age-groups in general about one quarter to one third lower than those for males. In respect to Federal States the female intervention rate was only about half (49%—Carynthia, 48%—Upper Austria and 46%—Burgenland) to one quarter (27%—Tyrol and 26%—Vorarlberg) as high as the male intervention rate (all *P*-values <0.001) (Figure 3). This pattern was consistent over time.

Intervention rates were compared with the Austrian average on Federal State level for each gender separately (Table 3). In 1993, 1994 and 1995 the male and female intervention rate in Salzburg were significantly higher ($P<0.01$) and in Styria significantly lower ($P<0.001$) than the Austrian average. The situation in the other Federal States changed over the years.

Geographical distribution

The highest overall intervention rates were found in Upper Austria and Salzburg (IR = 0.07), the lowest was found in Styria (IR = 0.02). The same was true for the genders: highest male rate (IR >0.09) and female rate (IR >0.03) in Upper Austria and Salzburg, lowest male rate (IR = 0.03) and female rate (IR = 0.01) in Styria. This pattern was also constant over time. (Table 2)

For investigation of the geographical differences at district level the demand factor morbidity was tested for correlation with PTCA utilisation by means of standardized morbidity rates. Pearson's correlation coefficients were not significant (1993: $P=0.71$; 1994: $P=0.133$; 1995: $P=0.399$) and visual inspection of geographic maps did not show association between the demand factor and the PTCA utilisation (Figure 4a,b,c; Figure 5a,b).

Logistic regression modelling

Compared to the Austrianwide average, patients from Upper Austria ($P<0.001$), Salzburg ($P<0.001$) and Vienna ($P=0.03$) were significantly more likely to receive PTCA application whereas patients from Styria ($P<0.001$), Lower Austria ($P<0.001$), Tyrol ($P=0.01$) and Vorarlberg ($P=0.002$) were significantly less likely to receive PTCA application (after adjustment for gender and age). The odds ratio of males in comparison to females being treated by PTCA dropped by regession modelling from 2.8–1.36 (95% CI = 1.31–1.42, $P<0.001$). This effect was mainly due to age being a confounding factor.

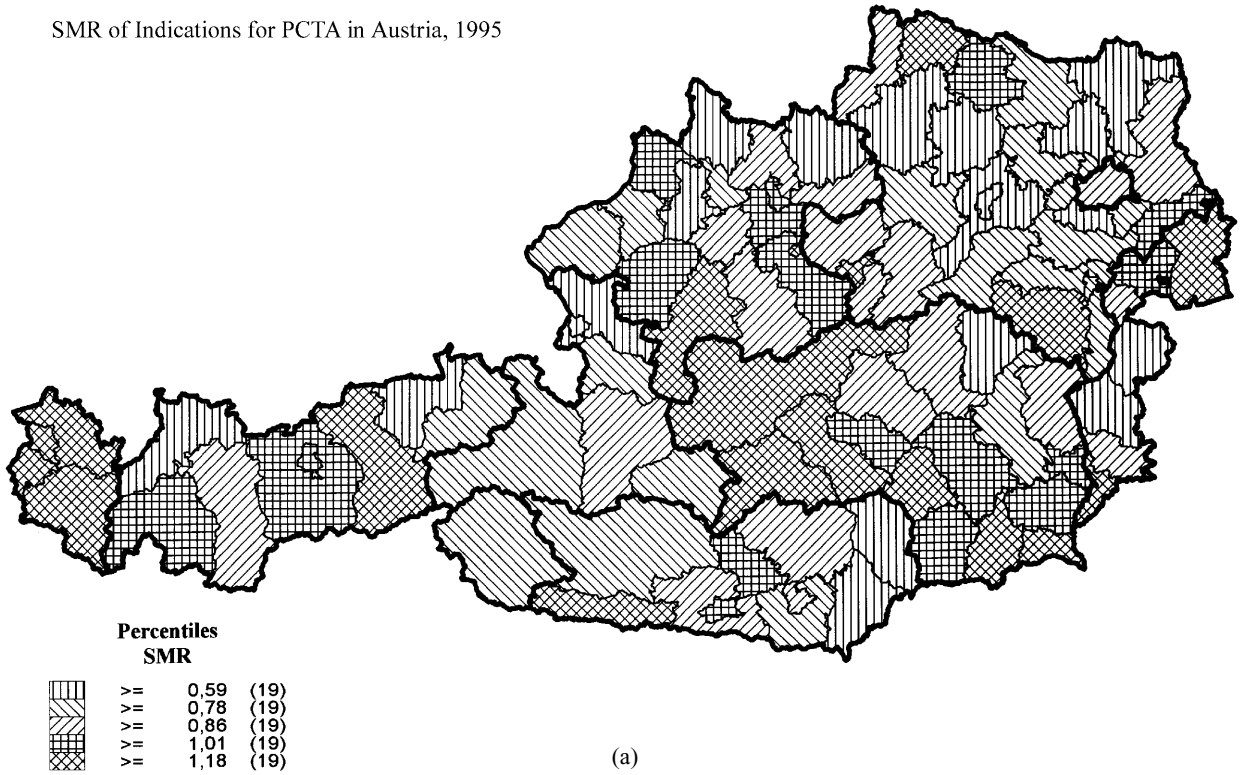
Discussion

Limitations

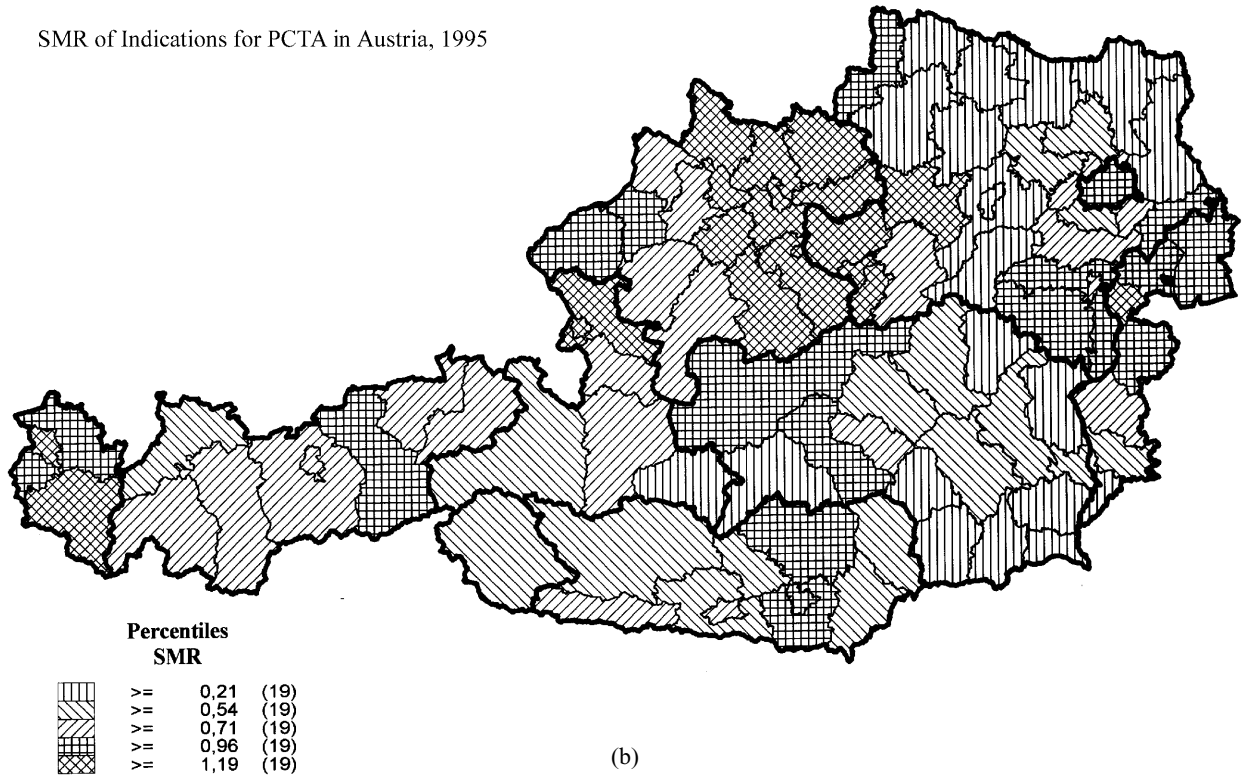
Quality control of data was done by comparing the study data with the data set gathered by the Austrian Cardiological Society for intern quality control[23] and identification of limitations due to documentation and coding. Documentation of the Minimum Basis Data Set was done mainly by junior house officers and registrars in addition to their regular duties. The quality of the documentation obtained had no consequences either for the doctors themselves or for the hospital administration so they could be regarded as being disinterested. Coding in the Minimum Basic Data Set is based on the ICD-9 catalogue, which allows no classification of severity of disease. Therefore our morbidity rates might not reflect the real demand for intervention.

Gender

Our study revealed gender differences in morbidity and intervention rates: female morbidity started to increase over the 1% mark about 10 y later and female intervention rates



(a)



(b)

Figure 5 a, b Areas with high SMRs of PTCA utilization are not congruent with areas with high SMRs of indications.

were significantly lower in respect to age (about one quarter to one third) and region (about one quarter to one half). Having taken the $\geq 5\%$ intervention peak (30–64 y) into account women aged ≥ 64 y turned out to be the demographic strata with the lowest utilisation rate.

Our findings of marked gender differences in intervention rates are consistent with earlier findings in Austria and elsewhere. A Carynthian survey on experience with PTCA at the Landeskrankenhaus Klagenfurt[24] revealed that only 68 (18.8%) out of 343 PTCAs during the years 1986–1990 were performed on women. A Canadian queue management project[25] showed that even if they had had more serious symptoms before referral than had men, women were turned down for revascularisation by CABG or PTCA more often.

Studies on possible reasons for gender differences in

PTCA application are rare and have focused mainly on clinical factors with special regard to outcome differences. Smaller coronary artery diameter in women as a reason for a higher rate of adverse events[26] and more severe coronary heart disease at the time of hospital admission due to underestimation of female morbidity with negative effect on outcome are the main arguments that disqualify PTCA as appropriate methods for women.[27,28] In contradiction to this other authors[29] have stated, that improved PTCA technology has eliminated gender differences in outcome.

Identification of reasons for gender differences was not an objective of our study and therefore we are restricted to the description of facts. Since findings on medical factors are conflicting, further studies with regard to social factors as have been done in several British settings[30,31] might be helpful.

Age

Age differences in intervention ratios are already documented and this fact was also reflected in our study. People aged over 70 y less often received PTCA than did those who were younger. This pattern was constant over time. Age as factor of influence on PTCA utilisation rate turned out to be even more important than gender.

Medical reasons for differences are controversial: findings of increased event rate and unsatisfying outcome due to higher frequency of co-morbid factors[32] contrast encouraging results: favourable angiographic and hemodynamic outcomes were reported by Zaidi AR *et al.*[33] Jamin *et al*[34] described PTCA as a safe and efficient method even in patients aged 70 y or more. Pepine *et al*[35] evaluated PTCA as a procedure of benefit for elderly patients aged over 70 y when based on careful assessment of co-morbid factors.

The appropriate conclusion might be: age itself is not an appropriate exclusion criteria but careful case assessment in patients aged 70 y or more is of outstanding importance.

This argument is extremely important in discussions about cost effectiveness of medical services for the elderly. The common opinion nowadays is that aging of the population will lead to a cost explosion in the health care system due to increasing morbidity in the higher age groups. Zweifel's[36] perspective contrasts with this opinion: the most cost intensive period for the health care system caused by patients are the final years before death, which is not restricted to the elderly. Therefore an elderly person aged about seventy in good physical condition may be farther away from death than a younger person with a serious disease.

Up to now there has been no offical discrimination on age grounds in the types of medical care available to patients, as is the case in the British National Health System. Possible tendencies towards 'hidden exclusions' could easily be stopped by quality control based on careful case assessment, as is done by the quality control project of the Austrian Society of Cardiology.

Region

Geographical differences in the frequency of PTCA as found in our study are already known between countries in Europe.[37] Studies on possible reasons for these differences have mainly looked at *supply factors* and *demand factors.* Up to now only *supply factors* have been associated with utilisation rates. Those that had been considered; were availability of catheterisation laboratories,[37,38] the distance patients live from these facilities[39] and having a local cardiologist.[40] The phenomena of 'supply induced demand' as discussed nowadays by health economists[41] as reason for high numbers of medical services might be of interest in this context.

Conclusions

In our study we were interested in the impact of the demand factor morbidity as a reason for geographical differences. Surprisingly morbidity did not influence the frequency of PTCA application as shown by lack of correlation between the Standardised Morbidity Rates of interventions and frequency of PTCA. In a British cross sectional ecological study morbidity was even inversely associated with the rate of interventions.[40] Further studies on supply factors as well as on the economical and social situation per region are needed to identify underlying reasons for geographical differences. Results of these studies should serve as a basis for appropriate public health strategies in order to guarantee equal PTCA utilisation rates for the whole Austrian population.

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