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The projected increase in glaucoma due to the aging population in Austria from 2001 to 2031: Results based on data of the Salzburg-Moorfields Collaborative Glaucoma Study

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PURPOSE. *The aim of this study is to present the projected increase in definite primary open angle glaucoma (POAG) and related diseases in Austria from 2001 to 2031.*
METHODS. *The present work is based on two data sources: population projections in Austria and detection rates of the Salzburg-Moorfields Collaborative Glaucoma Study for Austrians in the age groups 40-54 years, 55-69 years, and 70 years and above. The estimates of this glaucoma screening program are based on a total of 3419 subjects. Sensitivity analyses were applied to test the effects of higher and lower sets of prevalence assumptions on the extent of the probable projections.*
RESULTS. *The number of Austrians with definite POAG, early POAG, POAG suspects, and ocular hypertension (OHT) is expected to increase until 2031 by 0.5%, 43.1%, and 65.6% in the three age groups specified above, respectively. The overall number of Austrians with POAG at the age of 40 or older is estimated to increase from 67,600 in 2001 to 96,400 in 2031. This corresponds to an increase of 42% from 2001 to 2031 (lower scenario: 37%, upper scenario: 47%). Similar increases are expected for individuals with early POAG, POAG suspects, and OHT.*
CONCLUSIONS. *These projections provide an objective basis to estimate the resources that may be needed by health authorities and care providers such as ophthalmologists in the future and should help to design glaucoma blindness prevention programs or screening studies in Austria. The predicted continuous increase of Europe's older population will prove to become a challenge for public health professionals not only for diagnosis and monitoring, but also for the treatment of glaucoma. (Eur J Ophthalmol 2007; 17: 45-52)*

KEY WORDS. *Future, Glaucoma, Population, Prevalence, Projection, Screening*

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INTRODUCTION

Official population projections provided by EUROSTAT-the Statistical Office of the European Community-predict a considerable increase of Europe's older population. From 2000 to 2030, the number of residents over 70 years will increase by 48% in Germany, 50% in Norway, 54% in Greece, 55% in Switzerland, 80% in Luxembourg, and 81% in the Netherlands (1). In Austria, one out of five residents was over 60 years

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in 2001, but it is estimated that every third resident will be over 60 years old in 2035 (2). These developments will lead to a large variety of consequences for the EU's health and social system that cannot be neglected for diseases with age-dependent prevalences.

Several studies that focused on the relationship between age and prevalence of glaucoma (3-6) have clearly demonstrated an increase in prevalence with increasing age. Combining both facts leads to the following question: How will the number of cases with primary open angle glaucoma (POAG) and related diseases in the elderly population of Europe and other countries change over the next few decades?

In different countries, several studies have been conducted to attempt to answer this question. Using official population projections as well as projected numbers of glaucoma cases, results have been published for Australia (7) and England and Wales (8) for the years 2001, 2011, 2021, and 2031. For Austria, however, no data for the prevalence of glaucoma and related diseases together with projected total numbers of cases have yet been published. The aim of this study is to present projections for Austria and thereby to contribute to a better understanding of the effects of population graying in Europe.

All estimates of the absolute numbers of glaucoma cases and related diseases need to be treated with caution, as they are only approximations based on several methodologic assumptions such as estimated population projections.

METHODS

Data sources

Two different data sources were used to estimate the projected numbers of Austrians with POAG and related diseases in 2001, 2011, 2021, and 2031 at 40 years or older: 1) population projections for Austria (2) based on the 2001 countrywide census (Tab. I) and 2) detection rates with lower and upper 95% confidence limits for the detection rates of POAG and related diseases based on the Salzburg-Moorfields Collaborative Glaucoma Study (SMCGS).

Description of the SMCGS

The SMCGS is embedded into a 10-year glaucoma blindness prevention program for the County of Salzburg in Austria. This ophthalmic examination main-

TABLE I - SCENARIOS WITH OFFICIAL POPULATION PROJECTION WITH LOWER AND UPPER SCENARIOS OF POPULATION DEVELOPMENT IN AUSTRIA IN 2001, 2011, 2021, AND 2031 CATEGORIZED IN THREE AGE CLASSES

	Age, yr	2001	2011	2021	2031
Lower scenario	40–54	1663*	1975	1770	1665
	55–69	1243	1400	1695	1756
	70+	910	1041	1183	1381
	Totals	3815	4417	4648	4803
Official projection	40–54	1663	1977	1774	1671
	55–69	1243	1403	1707	1779
	70+	910	1058	1244	1507
	Totals	3816	4437	4725	4956
Upper Scenario	40–54	1663*	1978	1778	1676
	55–69	1243	1406	1719	1801
	70+	910	1074	1305	1633
	Totals	3815	4459	4801	5111

*In thousands, based on 2001 census in Austria (2)

ly focuses on information provision, identification of glaucoma suspects, and treatment of clear-cut cases of glaucoma. The study was supported and approved by the Health Administration Council of the Federal State of Salzburg, Austria, and conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000). Every patient gave informed consent and patient anonymity was preserved. From 1996–2004, a total of 4831 subjects of the Salzburg population over 40 years of age were screened.

A detailed description of this population-based screening study and its intentional use as a preventive medical checkup has been published elsewhere (9, 10).

Diagnostic criteria for glaucoma and related diseases

There is much debate regarding the diagnosis of various types of glaucoma. In order to work with the diagnostic criteria suggested by the European Glaucoma Society, we follow the European Guidelines for Glaucoma (11) and adhere to the following definitions:

- Definite POAG: POAG normal pressure glaucoma, POAG high pressure glaucoma.
- Early POAG: early POAG normal pressure glaucoma, early POAG high pressure glaucoma.
- OHT: ocular hypertension.
- POAG suspects: all other cases which are not classified as normal or artefacts (10, 11).

The criteria were applied separately to both eyes and individuals then classified based on the diagnosis of the worse eye.

Statistical methods

Data were categorized in one of three age groups (40–54, 55–69, and 70+) and projected numbers of Austrians were estimated in each age class for the years 2001, 2011, 2021, and 2031. Tuck and Crick (12) and Quigley and Vitale predictive regression equations (13) were applied to our data to check whether the predictions of these equations correspond with the detection rates in our glaucoma screening program.

Missing data

The range of each variable was inspected and if necessary data records of individuals who do not fulfill inclusion and exclusion criteria as well as data records with incorrect data entries were removed. After the database was cleaned and strict inclusion and

TABLE II - LOWER AND UPPER 95% CONFIDENCE INTERVALS FOR DETECTION RATES OF POAG AND RELATED DISEASES BASED ON THE SALZBURG-MOORFIELDS COLLABORATIVE GLAUCOMA STUDY

	Diagnosis	Count	Sample size	Point estimator	Lower 95% confidence limit*	Upper 95% confidence limit†
40–54	Definite POAG	10	958	1.0%	0.5%	1.9%
55–69	Definite POAG	30	1967	1.5%	1.0%	2.2%
70+	Definite POAG	17	494	3.4%	2.0%	5.5%
40–54	Early POAG	32	958	3.3%	2.3%	4.7%
55–69	Early POAG	46	1967	2.3%	1.7%	3.1%
70+	Early POAG	20	494	4.0%	2.5%	6.2%
40–54	POAG suspects	95	958	10%	8.1%	12%
55–69	POAG suspects	155	1967	7.9%	6.7%	9.2%
70+	POAG suspects	40	494	8.1%	5.8%	11%
40–54	OHT	20	958	2.1%	1.3%	3.2%
55–69	OHT	45	1967	2.3%	1.7%	3.0%
70+	OHT	10	494	2.0%	1.0%	3.7%

*Lower and †upper 95% confidence interval for the corresponding detection rate in the glaucoma blindness prevention program in Salzburg, Austria.

POAG = Primary open angle glaucoma; OHT = Ocular hypertension

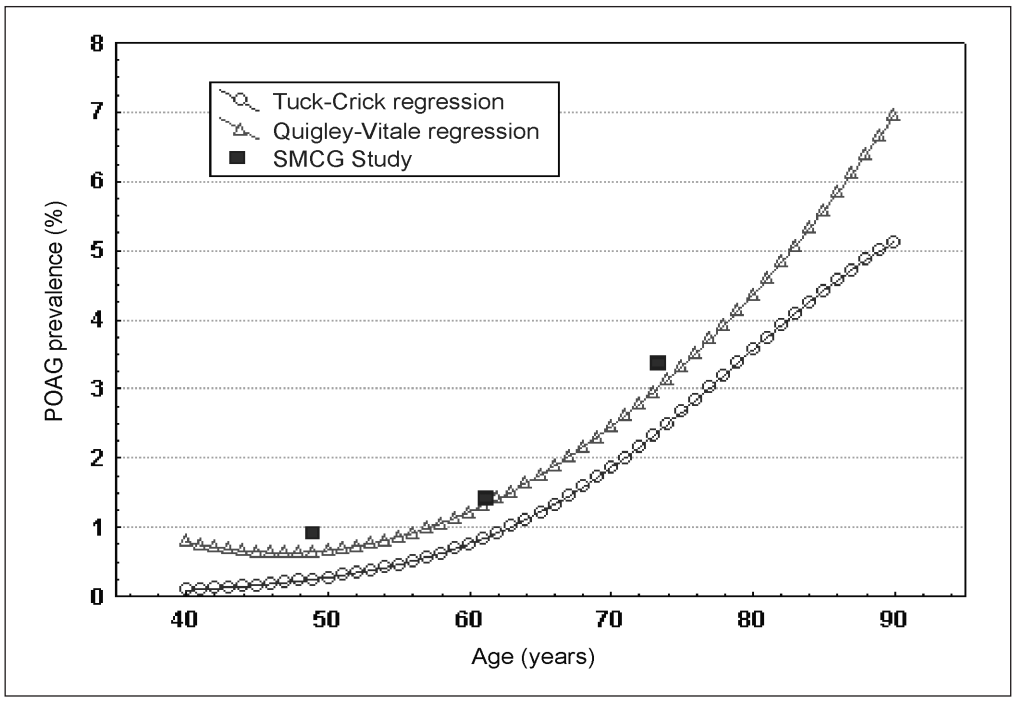

Fig. 1 - *Illustration of Tuck and Crick and Quigley and Vitale predictive regression curves for prevalence of primary open angle glaucoma and observed detection rates (means in each age group, with 95% CI) in the Salzburg-Moorfields Collaborative Glaucoma Study in the age categories 40–54, 55–69, and 70+.*

exclusion criteria were applied, a total of 3419 subjects were enrolled into this study. Ninety-five percent confidence intervals for the detection rates in each age class were computed based on Pearson–Clopper confidence intervals (14).

All computations were done with Statistica 6.1 (StatSoft, Inc., Statistica data analysis software system); version 6. www.statsoft.com, 2004), and Mathematica 3.1 (Wolfram Research, Inc. Mathematica; version 3.0, Champaign, IL, 1996).

RESULTS

Population projections in Austria from 2001 to 2031 (Tab. I)

For the age group 40–54 years, the shifts in Austria's population are as follows (2001 = 100%): 2001 to 2011: 18.8% (±0.1%), 2001 to 2021: 6.7% (±0.2%), 2001 to 2031: 0.5% (±0.3). The numbers given in parentheses are based on the lower and upper scenario, provided by Statistics Austria, the official Austrian research center for information and statistics. This shows that there is little difference in Austria's population in this age class when comparing 2031 with 2001.

For the age group 55–69, the corresponding percentages are as follows: 2001 to 2011: 12.9% (±0.3%), 2001 to 2021: 37.3% (±1%), 2001 to 2031: 43.1% (±1.8%). This shows that the population in Austria will increase considerably in this age group. For the oldest group (70 years and older), the population shift is assumed to reach 66% from 2001 to 2031. The corresponding numbers are as follows: 2001 to 2011: 16.2% (±0.8%), 2001 to 2021: 36.7% (±6.7%), 2001 to 2031: 65.6% (±14.8%). Again, these projections suggest a considerable increase in Austria's population in this highest age group. The overall number of subjects age 40 or older is expected to increase from 3,816,000 in 2001 to 4,956,000 in 2031, which corresponds to an increase of 30%.

Observed detection rates of POAG and related diseases and application of predictive regression equations for estimating prevalence

An overview of the predictions of the Tuck and Crick and Quigley and Vitale regression equations together with the observed detection rates of POAG is illustrated in Figure 1.

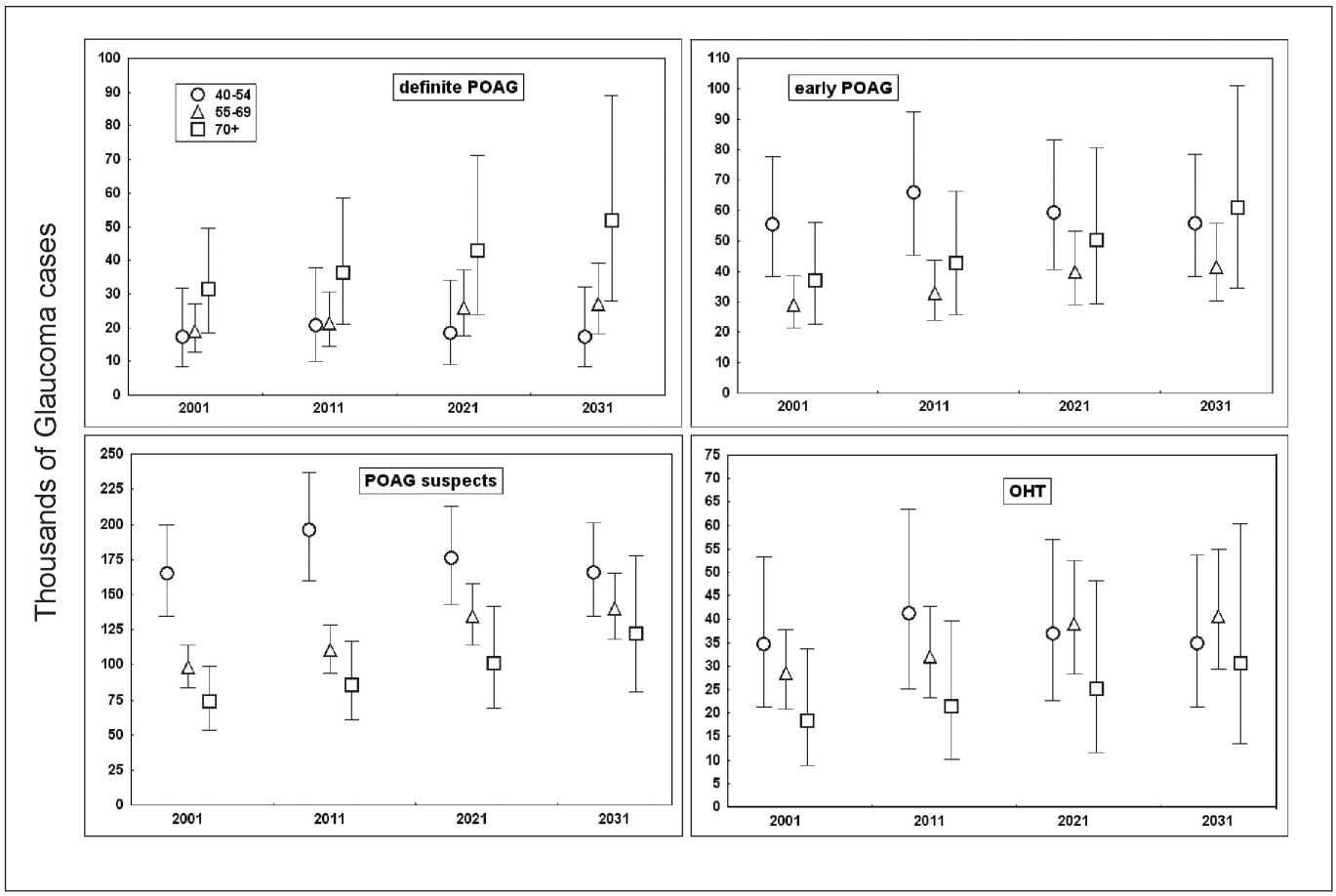

Fig. 2 - *Overview of projected numbers of patients with definite primary open angle glaucoma (POAG), early POAG, POAG suspects, and ocular hypertension in three different age groups in 2001, 2011, 2021, and 2031 (in thousands).*

Projected numbers of Austrians with POAG, POAG suspects, and related diseases at age 40 or older in 2001, 2011, 2021, and 2031

An overview of the projected numbers (in thousands) of Austrians classified as definite POAG, early POAG, POAG suspect, and OHT categorized into three age classes is shown in Figure 2.

Number of Austrians with definite POAG

Starting with 17,400 Austrians with definite POAG at the age of 40–54 years in 2001, we expect the number to remain fairly stable over the years to 2031. The number of definite POAG cases in people aged 55–69 is similar to that in the younger age group in 2001 (19,000) but by 2031 there is expected to be a marked difference between the numbers affected in the two age groups with 27,000 POAG cases expected in the 55–69 age group. In people aged 70 years or more, we estimate 31,300 Austrians with definite POAG in 2001 and by 2031 expect this to increase to a total of 51,200 POAG cases. The overall number of Austrians with definite POAG at the age of 40 or older is expected to increase by 42% (lower scenario: 37%, upper scenario: 47%) while the population in Austria for residents age 40 or older is expected to grow by 30% only.

Early POAG cases

In 2001, the number of Austrians aged 40–54 years with early POAG – approximately 55,500 cases – is

considerably higher when compared to the other age groups. In people aged 55–69 years, our analysis estimates that in 2001, 29,000 Austrians had early POAG; however, 41,600 Austrians of this age group are expected to have early POAG in 2031. For Austrians age 70 years and older, the number of early POAG cases is estimated to be 36,800 in 2001 and 61,000 in 2031. The overall number of Austrians with early POAG at age 40 or older is expected to increase by 30% (lower scenario: 25%, upper scenario: 36%).

POAG suspects

Starting with 165,000 POAG suspects age 40–54 years in 2001, we expect this number to increase slightly by 2011 and then to decrease again to 165,600 in 2031. In the other age groups, a considerable increase is expected: in the age group of 55–69 years, from 98,000 POAG suspect cases in 2001 to 140,000 in 2031, and from 73,700 in 2001 to 122,000 in people aged 70 and above. The overall number of Austrians who are suspected of having POAG at age 40 or older is expected to increase by 27% (lower scenario: 23%, upper scenario: 32%).

OHT

We estimate that there will be 34,700 ocular hypertensive patients aged 40–54 years, 28,400 aged 55–69 years, and 18,400 aged 70 or more. In 2031, these figures are expected to rise to 34,900, 40,700, and 30,500, respectively. The overall number of subjects with OHT at age 40 or older is expected to increase by 30% (lower scenario: 26%, upper scenario: 35%).

DISCUSSION

This study provides new information on the detection of individuals with definite POAG, early POAG, POAG suspects, and OHT in a homogenous screening population in Austria. This population-based study is based on the largest number – to our knowledge – of individuals screened in Austria. Furthermore, this study provides population projections together with lower and upper bounds for these disease entities in the years 2001, 2011, 2021, and 2031 in three different age classes.

Comparison of the results with Australia

In Australia, the number of people with glaucoma and ocular hypertension will double from 2001 to 2030 (7). This is considerably different from our results. The authors attribute this number to estimates that Australia's population will grow by 75% until the year 2030. The population in Austria for residents at the age of 40 or older is expected to grow by 30%. Expressing the percentage changes from 2001 to 2031, the following changes can be expected for Austrians at the age of 40 or older: 1) definite POAG: 42%, 2) early POAG: 30%, 3) POAG suspect: 27%, and 4) OHT: 30%. Our results are in very good correspondence with those published for the United Kingdom (8), where the number of people with POAG is estimated to rise by 50% (lower scenario: 43%, higher scenario: 57%) from 2001 to 2031. It would be very valuable to obtain results of their study for early POAG, POAG suspects, and OHT in order to obtain a more complete picture.

Possible limitations of the study

Several sources of bias have to be considered and different strategies should be considered to quantify the influence of these effects.

1) The first source of bias is the sampling strategy. The age distribution in the general population of Salzburg differs somewhat from the age distribution in the pool of subjects that is examined in our glaucoma screening program. As a consequence, an unstratified sample taken in a strict sense cannot be regarded as being representative for the Austrian population aged 40 years or older. To overcome a possible bias, data were stratified into three age categories and the prevalences were estimated within these three strata and were compared with predictions of the Tuck and Crick and Quigley and Vitale equations. The results confirm the value of these equations providing evidence that our estimations are in excellent correspondence with both regression curves. An illustration of these regression curves and the observed prevalences of POAG in different age classes is given in Figure 1.

2) The second source of bias is the population projection of the expected number of Austrians in the future. Although these estimations are based on the official population projections of Statistics Austria, it is

evident that the future cannot be predicted precisely. Again, to overcome a possible bias, upper and lower scenarios of the expected number of Austrians – provided by (2) – were used.

3) A third possible limitation of the study is the lack of any universally agreed criteria for the diagnosis of glaucoma. The glaucoma literature has been weakened by the lack of a uniform definition and specific diagnostic criteria. In recent years considerable attempts have been made to standardize the definitions of the various forms of POAG. In order to make various published studies as comparable as possible, this study has adopted the diagnostic criteria suggested in the European Guidelines for Glaucoma (11).

In summary, this study uses data of our glaucoma screening study and official population projections based on Statistics Austria for Austria for 2001, 2011, 2021, and 2031. Due to the estimated population shifts predicted by Statistics Austria, the overall number of Austrians with definite POAG, early POAG, that are suspected of having POAG, and OHT is expected to increase by 0.5%, 43.1%, and 65.6% in the age groups of 40–54 years, 55–69 years, and 70 years or older, respectively.

The study predicts that in 2001 there were 67,600 Austrians aged 40 or more with definite POAG and that this number will increase to 96,000 in 2031, which corresponds to an increase of 42% (lower scenario: 37%, upper scenario: 47%). For the age group of 70+, an increase of Austrians with definite POAG of 65% is estimated (lower scenario: 52%, upper scenario: 80%).

Similar trends are expected for the other disease subgroups. Given the present high quality of health care for glaucoma, the preservation of this high level of service poses a serious logistical and financial challenge for the Austrian health care system in the next decades.

An important additional strategy must be to improve our current understanding of the factors contributing to the development of glaucoma in order to detect progressive glaucoma as early as possible and thereby to be able to keep the total number of cases with severe vision loss at the lowest level possible. For this purpose, more financial resources will be needed for ophthalmologists at the primary care level.

A variety of designs for cost effective medical care for glaucoma patients have been suggested by different authors. An important issue is how to optimize patient management: Statistical models now exist that estimate the risk of conversion from ocular hypertension to glaucoma (15). These models could be used to categorize patients into high and low risk groups with different timetables for follow-up visits. Other statistical models attempt to identify large population strata with a low risk for glaucoma so that screening can focus on subjects at greater risk of developing the disease (16).

Another important issue is public education and awareness. In prevalence studies and screenings of high-risk populations approximately 60% of patients were unaware they had glaucoma (17). More problematic is the fact that many patients identified as having glaucoma frequently do not come to follow-ups for further evaluation and treatment of this insidious disease.

New designs for glaucoma care will be needed to provide best-possible medical care while keeping the costs for such programs at an acceptable and justifiable level. Collaboration among diverse specialists, including ophthalmologists, community health care experts, glaucoma specialists, optometrists, and health economists, will have to be integral in organizing and implementing such programs.

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