Klaus DONSA, BSc

Development of Cross-sectoral Indicators for the Styrian Health Care Information System GeISt 2.0

Master Thesis

Institute for Health Care Engineering (HCE)

Graz University of Technology

Kopernikusgasse 24, A-8010 Graz

Head of department: Univ. Prof. Dr. N. Leitgeb

Supervisor/Evaluator TU Graz: Assoc.Prof. Dipl.-Ing. Dr.techn. Jörg Schröttner

Supervisor JOANNEUM RESEARCH: Dipl.-Ing. Stephan Spat; DI Dr. Peter Beck

Graz, (January, 2012)

This page intentionally left blank

ABSTRACT

Aim: The main aim of the master thesis was to process patient-related secondary (routine) data from the inpatient, general practitioner and community based specialist sectors in Styria, using data warehousing technology. This cross-sectoral data analysis served as a foundation for the development of indicators for health reporting purposes and quality assurance, as part of the GeISt 2.0 project. **Method:** Relevant projects addressing the cross-sectoral development of indicators using secondary data were identified. Relevant methods, where appropriate, were implemented into the development process of the GeISt 2.0 data warehouse (DWH). Assessment capabilities were selected and implemented into the developed research tasks. Using online analytical processing, "cubes" were generated, which allow the end-users access to the cross-sectoral data basis. Indicators for process monitoring, structural analyses and health reporting were developed and analyses using the indicators for certain clinical areas (diabetes, acute myocardial infarction, heart insufficiency and stroke) were performed. **Results:** Comparison of 30-day-mortality rates associated with certain complications revealed strong regional differences as well as differences at the hospital level. Interesting results were also observed regarding health service utilisation associated with comorbidity. Furthermore, examinations of patient flows before and after an acute event, diabetes prevalence approximations and burden of disease estimations revealed regional differences. **Conclusion:** Regional differences showed the importance of further analyses using secondary data over time and data from all health care sectors in Styria. The DWH that was developed enables a convenient risk adjustment of indicators in real-time and facilitates a comparison of cross-sectoral patient flows.

KEYWORDS: cross-sectoral, indicators, data warehouse, secondary data, 30-days-mortality

ÖSTAT CLASSIFICATION: 2913, 3906, 3909, 3911

This page intentionally left blank

KURZFASSUNG:

Zielsetzung: Das Ziel dieser Arbeit war die Aufbereitung von patientenbezogenen Sekundärdaten aus dem stationären und niedergelassenen Bereich des steirischen Gesundheitssystems mittels Data Warehousing Technologie. Darauf basierend erfolgte eine sektorenübergreifende Entwicklung von Indikatoren, für die Gesundheitsberichterstattung und Qualitätssicherung im steirischen Gesundheitswesen im Zuge des GeISt 2.0 Projektes. **Methodik:** Ähnliche Projekte, welche sich mit sektorenübergreifender Indikatorentwicklung auf Basis von Sekundärdaten beschäftigen, wurden im Vorfeld identifiziert. Relevante Methoden wurden daraus extrahiert und im Entwicklungsprozess des GeISt 2.0 Data Warehouse (DWH) berücksichtigt. Auswertemöglichkeiten wurden erarbeitet und in selbst definierten Forschungsaufgaben verwendet. Mittels Online Analytical Processing wurden „Würfel" generiert, welche dem Endnutzer die sektorenübergreifende Datenbasis zugänglich machen. Indikatorsets für die Bereiche Prozess Monitoring, Strukturanalyse und Gesundheitsberichterstattung wurden entwickelt und exemplarische Auswertungen für Patienten mit Diabetes, Herzinsuffizienz, akutem Myokardinfarkt oder Schlaganfall durchgeführt. **Ergebnisse:** Die 30-Tages-Mortalitäten wiesen hohe regionale Unterschiede auf. Auch auf Spitalsebene konnte bei den untersuchten Erkrankungen eine große Spannweite der 30-Tage-Mortalität beobachtet werden. Interessante Ergebnisse konnten bei der Auswertung der Inanspruchnahme von Gesundheitsleistungen in Abhängigkeit von Co-Morbiditäten aufgezeigt werden. Ebenso zeigten die Patientenpfade vor und nach einem akuten Ereignis, Diabetesprävalenz und „Burden of Disease" Berechnungen bedeutsame regionale Unterschiede. **Schlussfolgerung:** Die entdeckten regionalen Unterschiede führen zur Notwendigkeit weiterer Untersuchungen mithilfe von Daten aus anderen Jahren und Einbeziehung aller Gesundheitssektoren. Das entwickelte DWH liefert eine sehr komfortable Möglichkeit in Echtzeit Risikoadjustierungen für Indikatoren durchzuführen und sektorenübergreifende Patientenpfade darzustellen.

SCHLÜSSELWÖRTER: Sektorenübergreifend, Indikatoren, Data Warehouse, Sekundärdaten, 30-Tage-Mortalität

ÖSTAT KLASSIFIKATION: 2913, 3906, 3909, 3911

This page intentionally left blank

I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

Graz, 05.12.2011 _____

KLAUS DONSA

This page intentionally left blank

Table of Contents

Abbreviations:	**Explanations:**
AHRQ	Agency for Healthcare Research and Quality
AOK	Allgemeine Ortskrankenkasse, Regional health insurance
AMI	Acute Myocardial Infarction
APACHE II	Acute Physiology And Chronic Health Evaluation II
ATC	Anatomic, Therapeutic and Chemical Classification Number/System
BMG	Bundesministerium für Gesundheit; Federal Ministry for Health
CI	Charlson index
DWH	Data Warehouse, Data Warehousing
DB	Data Base
DMP	Disease Management Program
DRG	Diagnosis Related Groups
EQUAM	Externe Qualitätssicherung in der Medizin; External quality assurance in medicine
ETL	Extract, Transfer, Load
EU	European Union
FOKO	Folgekosten; Follow-up costs
GeISt	Gesundheitsinformationssystem Steiermark, Health Care Information System Styria
GP	General Practitioner
HI	Heart Insufficiency
ICD-10	International Statistical Classification of Diseases and Related Health Problems
LKF	Leisungsorientierte Krankenanstalten Finanzierung; Hospital financing system
MBDS	Minimal Basis Data Set
MDX	Multidimensional Expressions
OECD	Organisation for Economic Co-operation and Development
OLAP	Online Analytical Processing
SMR	Standardised Mortality Ratio
SQL	Structured Query Language
OLE DB	Object Linking and Embedding, Database
StGKK	Steiermärkische Gebietskrankenkassa; Styrian health insurance company
USA	United States of America
WHO	World Health Organisation

1 INTRODUCTION

Nearly every profession or field of science was introduced to quality assurance and measurement procedures in the recent past. Higher expectations and cost pressures have induced quality-assurance, -management and –steering processes in nearly every modern industry. If patients are considered as goods, then quality concerns should have the highest priorities. Therefore, patient's treatments should also underlie a continuous quality management process. In Austria quality assurance is performed on each sector separately and results are not available to the general public. Transparency of financing and quality control are therefore a big problem in the sectoral fragmented health care system of Austria. But in most cases an illness isn't treated in a single health care sector in Austria. Non adequate medication of patients in the general practitioners (GP) and community specialist sector can cause higher mortality rates in the hospital sector. Undersupply in one sector can lead to substitution effects in others. Reduction of capacities in one sector may lead to undesired effects in other sectors. An observation of quality has therefore to occur in a holistic way. Weaknesses in patient care have to be discovered and removed. Fair comparisons of service providers are only possible if all health care sectors are included in the comparison. Quality management on structure- or process level may not be sufficient to cover complex cross-sectoral quality measurement. In the course of the master thesis quality measurement was performed on output level, because it directly addresses the patient.

An important aim of this master thesis is the development of cross-sectoral indicators in the environment of the Styrian health care information system (GeISt), for the purposes of quality assurance and health reporting. The huge amount of data, gathered from different sectors in health care, is processed with data warehousing (DWH) technology. The development process, related work and evaluations of cross-sectoral indicators is presented and discussed in this master thesis.

The master thesis is embedded in the environment of the GeISt 2.0 project of the institute HEALTH of JOANNEUM RESEARCH.

2 SCOPE

This chapter presents an overview of the GeISt project of JOANNEUM RESEARCH and the structure and scope of the master thesis. The master thesis is embedded in the environment of the GeISt project. It addresses health care related subjects and associated questions which become increasingly important in near future. Due to the large scale of the topic of this master thesis, research tasks had to be defined and alongside these tasks, the structure of the master thesis was organised.

2.1 THE GEIST PROJECT

GeISt (Gesundheitsinformationssystem Steiermark) is a health care information system, developed and maintained by JOANNEUM RESEARCH. Since 2008 the Institute HEALTH - Instiute of Biomedicine and Health Sciences is working on a revision of the GeISt project based on Data Warehouse (DWH) technology to make it more flexible and more accessible.

The main aim of GeISt 2.0 is the provision of information on basis of cross-sectoral routine data from the health care system in a user-friendly manner. For experts, GeISt 2.0 should be a tool that grants them access to a comprehensive and complex data source of the Styrian health system for analysis and planning. Following functions should be supported by GeISt 2.0:

- Just-in-time monitoring of the Styrian health care system
- Planning and control of the health care system with the focus on integrated care
- Quality assurance (quality indicators, data quality inspection)
- Tool for solving health care related issues

In Figure 2.1-1 the system architecture of GeISt 2.0 is demonstrated. It contains data of the Styrian health care system in pseudonymised form and integrates demographic data. The data basis is data from acute-inpatient-, inpatient-rehab and outpatient-sector. Further hospital specific data, like equipment (large electro-medical devices etc.) and accounting data of GPs and community based specialists is included in the data basis.

GeISt 2.0 is footed on Data Warehousing (DWH) technology to give developers the needed flexibility and grant health care experts access to a user-friendly environment for analysis and planning.

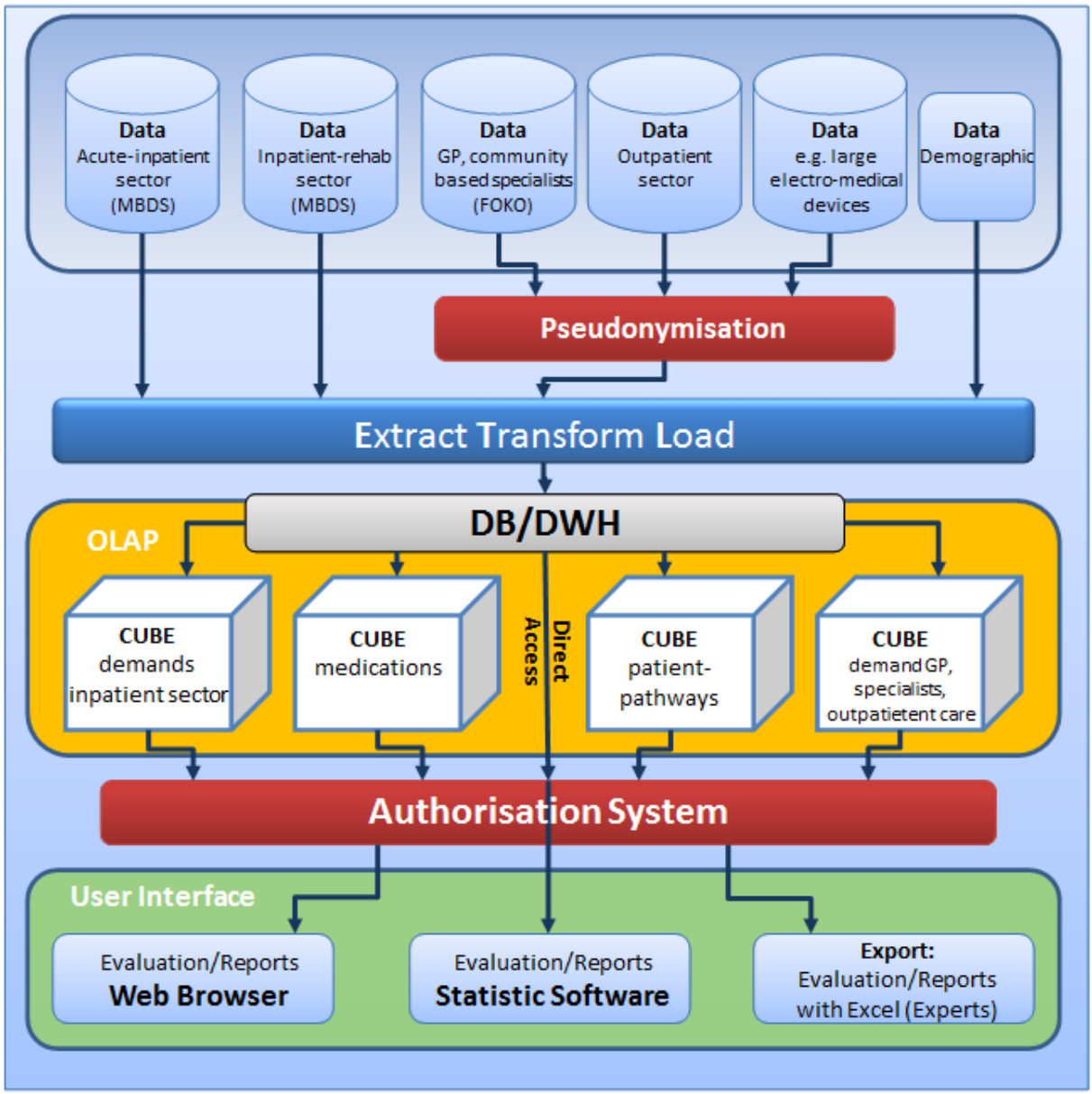

Figure 2.1-1: Demonstration of back- and front-end system architecture of GeISt 2.0.

With Online Analytical Processing (OLAP) technology, a real time and web based access for evaluation and creation of reports is possible. Over an authorisation system, different users have different access to services, which allow analysis on dissimilar level of detail. (JOANNEUM RESEARCH 2011)

2.2 SCOPE STATEMENT FOR THE MASTER THESIS OF JOANNEUM RESEARCH

GeISt 2.0 is trying to combine extramural and intramural sectors on patient level. Therefore it is possible to investigate cross-sectoral patient pathways and develop indicators that measure quality of care on patient level or discover undesirable developments in patient care.

The concrete aims of the master thesis are firstly, to demonstrate the cross-sectoral state of inpatient-, general practitioners- and, community based specialists-care as well as patient care with medicines. Therefor intramural and extramural data is joined on unique identifiers provided by the Styrian health care insurance company Steiermärkische Gebietskrankenkassa (StGKK). Services and medicines of patient contacts with service providers of the year 2005 should be demonstrated. This analysis will be performed for three different symptoms and the state of patient care will be demonstrated through descriptive statistics, application of statistical methods for comparison of specific patient groups and graphical demonstration of the results.

Secondly, the master thesis focuses on the design of quantitative indicators, with the cross-sectoral data basis for the Styrian health reporting system and quality assurance. Therefor for each symptom five indicators (including risk adjustments) will be developed. Embedded into a forgoing review of the literature relevant indicators should be identified.

2.3 STRUCTURE OF WORK

The structure of the master thesis should embed the solution process of the research tasks, which are presented at the end of this chapter, into a traceable scaffold. Related national and international work is presented in chapter 3, which points out the lack of cross-sectoral health care quality projects in Austria. Section 4 presents the theoretical background and definitions used in this master thesis. The chapter starts with a demonstration of the sectoral fragmented health care system in Austria, which also indicates the need for a cross-sectoral quality assessment. It is followed by a section that is related to quality in health care, quality management and quality measurement tools. Further indicators are discussed in greater detail. The applicability and risk adjustment of indicators are discussed in the frame of secondary/routine data analysis. Data Warehousing, the selected data processing technique, is discussed in context of health care information technology as a data basis for decision making. Due to the vast amount of assessment capabilities, feasible methods have been selected and further discussed. Particularly, 30-days-mortality, comorbidity, prevalence approximations and patient flows have been implemented into the analysis of the practical part of the master thesis.

This theoretical background has been used as a framework for the actual data processing and analysis. In chapter 5 the Extract, Transfer and Load (ETL) process,

which is described in the DWH chapter, is sketched for the development of Online Analytical Processing (OLAP) cubes. Developed indicators and patient flow methods are elucidated in this section.

In section 6 the data basis has been validated and the results are presented and discussed. Section 7 summarizes the work and presents an outlook for enhancements and future work.

As mentioned at the beginning, research tasks with a cross-sectoral relationship had to be defined and were organized in three research topics:

1. **Process-monitoring:** serves as an aid for health care planning and health service research. The continuous observation of relevant indicators serves as a tool for the discovery of undesirable events in their early stage.
    - **a.** Detection of heterogeneities of patient care patterns for diseases like:
        - **i.** Diabetes
        - **ii.** Acute myocardial infarction
        - **iii.** Stroke
        - **iv.** Heart insufficiency
    - **b.** Observation of patient flows before and after an acute event (e.g. acute myocardial infarction, stroke)
2. **Structural analyses:** help to make the right decisions in health care planning. Different quantitative indicators should inform health care authorities and aid as a basis for decision making.
    - **a. 30-days-mortality ratios:** on regional- and hospital-level for
        - **i.** Acute myocardial infarction
        - **ii.** Stroke
        - **iii.** Heart insufficiency
    - **b.** Identification of influences of comorbid conditions on demand of health care services
3. **Health reporting:** for the interested public and stakeholders in health care. Data analysis is performed to identify the “burden of disease”. This includes the identification of prevalence for diseases that are not covered sufficiently by national registers or the calculation of morbidity rates.

a. More exact **prevalence approximations:** due to the linking of inpatient diagnoses and information of the outpatient sector. The comprehensive data basis of GeISt allows demographic comparisons in greater detail.

b. Identification of regional varieties of the "burden of disease" for patients with:

i. Acute myocardial infarction

ii. Stroke

iii. Heart insufficiency

In this master thesis, the term heart insufficiency means also heart failure and cardiac insufficiency. Due to the ambiguity of the term in the literature, in this master thesis exclusively heart insufficiency was used. No particular reason led to the choice of the expression.

3 RELATED WORK

In this section an overview of related national and international work is presented. Related work had to be subdivided into Data Warehousing projects, Health Reporting systems and cross-sectoral evaluations. In chapter 4.2.1 the necessity of quality management in health care is discussed. The overall conclusion is that due to factors like socio-demographic developments and medical progress health care quality has to be measured and monitored. Therefore Austria and several other nations have recently implemented quality assurance programs, to fulfil these requirements.

3.1 NATIONAL WORK

The mandatory quality management initiative in Austria has led to several projects that try to measure quality of care or efficacy of health care (Czypionka et al. 2008) (Fuchs et al. 2010). Although the quality measurement has not been established in extent comparable to e.g. in the USA (Berndt et al. 2003), a lot of work has been done, especially in the field of health reporting (Legido-Quigley 2008). This section comprises projects in Austria which are measuring quality of care in the environment of the health care system.

Health Reporting Systems

Health reporting supports interested individuals and other stakeholders to gain information on policy, research and actors in health care. Health reporting is embedded in the Federal Gazette (BGBl Art. 15a B-VG 2005) and has to be performed annually in all sectors and professions according to uniform nationwide methods (Legido-Quigley 2008). The aim of health reporting is to detect deficits in patient care, develop measures for improvements and measure the efficiency of health care. Health reporting is a continuous process which should be established in all sectors and regions (Gesundheit Österreich GmbH 2011).

The European Union (EU) directive (The European Parliament 2008) states that a statistical element for the information system on public health has to be developed using, if necessary, the Community Statistical Programme to promote synergy and avoid duplication. Further a sustainable health monitoring system with mechanisms for collection of comparable data and information with appropriate indicators has to be

developed in EU member states. In the course of the mandatory health monitoring system, health reporting has been implemented in every province in Austria.

The Niederösterreichische Landeskliniken Holding has implemented an indicator set which is based on the indicator set of the AHRQ in the USA and which was refined for the German health care system. The Austrian Inpatient Quality Indicators (A-IQI) comprise indicators for 35 fields in medicine (e.g. stroke, hip fractures and knee joint replacements). In contrast to the mandatory inpatient health care quality assurance in Germany the results are not made public (Fuchs et al. 2010).

Data Warehousing Projects

Measurement and assessment of health care quality or status of public health is a massive information technology challenge. For health service research and health reporting purposes, DWH has been implemented in a variety of health care information systems. The Federal Ministry for health maintains a DWH for the demonstration of hospital accounting data. "DIAG" uses data of the acute-inpatient sector in the MBDS format. The Austrian Federal Institute for health care (ÖBIG) maintains two DWHs for nationwide and regional socio-demographic-, epidemiologic and health-behaviour-research (ÖBIG 2011). The federation of the Austrian social security institutions sustains DWHs which are data basis for performing nationwide analysis on health service research in primary care (Hauptverband der Sozialversicherungen 2010). Also, the social security institutions have DWHs for the demonstration of services and costs on focal point of patients and other stakeholders. The KAGes, a large owner of hospitals in Austria, has DWHs for radiology information systems, laboratory information systems and diagnosis and service documentation. This health care information system is called MedControl (G'sund.net 2003).

Cross-sectoral evaluation

Little work has been done in Austria on quality assurance using secondary data. Most work in the field of quality assurance in health care is targeting single sectors. Patient surveys are also a possibility to assess cross-sectoral quality in health care, but discussing quality assurance projects using patient surveys would go beyond the scope of this master thesis. The GeISt project, which was developed by JOANNEUM RESEARCH,

is a pilot project in the field of cross-sectoral quality assurance in Austria with pseudonymised patient-based data.

3.2 INTERNATIONAL WORK

There are several international projects which measure quality in the environment of health care. Most work has been performed for measuring inpatient quality on hospital level (Czypionka et al. 2008). Also, some cross-national programs have been developed which try to measure quality with indicator sets that are valid for the comparison between different nations and health care systems. Mostly these projects are only implemented for either inpatient or outpatient quality measurement only. Due to the similarity of the health care systems of Germany and Switzerland, the focus of the literature research lay on projects that were accomplished in these nations. But also quality projects in the USA should be examined, because of the long tradition of health care monitoring.

Health Reporting Systems

There are several national and cross-national indicator sets for measuring quality of care, particularly in the inpatient sector. As mentioned previously the AHRQ has released an indicator set which has been implemented in other nations than the USA. The current quality indicator modules represent various aspects of quality. The indicators cover four main topics:

1. Prevention quality indicators, which try to identify hospital admissions in geographic areas were evidence suggests that, hospitalisation has been avoided through high-quality of outpatient care.
2. Inpatient quality indicators are reflecting quality of care inside the hospital, as well as geographic areas, including inpatient mortality for medical conditions and surgical procedures.
3. Patient safety indicators reflect quality inside a hospital, as well as geographic areas, to focus on potentially avoidable complications and iatrogenic events.
4. Pediatric quality indicators use selected indicators from the other three modules with adaptions for children and neonates.

These indicators allow the comparison between different stakeholders in medicine and also allow a cross-national comparison (Agency for Healthcare Research and Quality

2011). The patient quality indicators have also been successfully implemented for the German inpatient health care. The comparison with American reference values showed a high correlation and applicability (Drösler et al. 2007).

As mentioned previously, health reporting with the use of appropriate comparable indicators is embedded in European law (The European Parliament 2007). Also the European Community heath indicators project (ECHI) has developed 88 indicators that allow comparisons between EU member states. They are grouped into five categories (European Community Health Indicators Monitoring 2008).

1. Demographic and socio-economic situation (e.g. population, birth rate, etc.)
2. Health status (e.g. infant mortality, HIV/AIDS, road traffic injuries)
3. Health determinants (e.g. regular smokers, consumption/availability of fruit)
4. Health interventions: health services (e.g. vaccination of children, hospital beds)
5. Health interventions: health promotion (e.g. policies on health nutrition)

Only a handful of European Union Member States are using quality indicators in practice. In Slovenia the Ministry of Health and the Medical Chamber were launching a national project to develop quality indicators across all specialist groups. Also the Swedish health services have 60 national health care quality registers which serve as a knowledge data base for continuous improvement. The Nordic Council has likewise linked its Quality Indicator Project with the Health Care Quality Indicator Project by the OECD. A national system for medical performance measurement was set up in 2001 to provide the 2200 German hospitals with quality measurement tools for benchmarking purposes. Quality goals for medicine and nursing had been defined for more than 30 diagnoses and procedures. Every year results and comments are published anonymously in quality reports. (Legido-Quigley 2008)(BQS Institut für Qualität und Patientensicherheit 2011)

In Denmark a national indicator project was launched similarly to the German indicator system. The aim is to measure the performance of hospitals and make the results transparent. In the development process all participant stakeholders in health care and nursing were invited to emphasise the acceptance of the indicators. Structure-, process- and outcome indicators have been developed for eight symptoms. The participation of

hospitals is compulsory and, unlike in Germany, the publication of results is not anonymous. (Czypionka et al. 2008)

Two projects in Switzerland are especially noteworthy. Firstly, the QuaZentral project which was launched to induce quality competition amongst health care providers in Switzerland. Service providers are bound to deliver an anonymised data set for statistical usage to the Federal Office for statistics. This data set should serve as a basis for health care quality related aspects in the style of the German indicator sets. Secondly, the EQUAM foundation, which is a managed care organisation for external quality assurance. Stakeholders which are included in the managed care process are monitored via selected indicators. Quality standards are established with the audited stakeholders and patients and as a final result a quality certificate is granted (Hess 2007).

Data Warehousing Projects

In the USA a project which is very similar to GeISt was launched in the early 1990s in Florida (Berndt et al. 1998). The project has been tested, refined and validated and is now in its current version footed on DWH technology. One of the main goals of the Comprehensive Assessment for Tracking Community Health (CATCH) project is to automate community health status reports and in consequence reduce time for report preparation from month to days. The CATCH project comprises 250 health and social indicators on a local community basis from different data sources. It uses an innovative comparative framework and weighted evaluation criteria to produce a rank-ordered list of community health problems. Secondary data sources include health care data from hospitals, federal health agencies and national health care groups. Primary data is gathered by door-to-door or mail-in surveys. All data is translated into common formats and is integrated within the DWH. The long-term added value of CATCH methods is the provision of cost-effective and thorough reports to communities and the creation of a fertile area for research and innovation in health care. It further provides a web-enabled information delivery system for long term analysis of regional public health parameters for a diverse group of community planners and stakeholders (Berndt et al. 2003).

DWH is used intensively for accounting and business intelligence purposes. The focus of the literature research lay in the identification of DWH projects, which are a data basis for health care decision making. There are numerous clinical DWHs which integrate

primary and secondary data for administration purposes. The following DWHs present the different possible uses of DWH in health care. In (Wisniewski et al. 2003) the authors demonstrated how a clinical DWH for infection control is developed from scratch. They showed that the infection control system based on a DWH led to savings of time and money and that the personnel was able to redirect their efforts, from acquiring data, to implementing infection control interventions. The systems provided close to real-time access for clinicians and investigators for monitoring infection rates and antimicrobial use, measuring performance and calculating costs of patient care. It is also possible to add additional value to an existing DWH when using data mining. In (Breault et al. 2002) the authors showed that it was possible to discover novel associations that are useful to clinicians and administrators. In (Meister et al. 2003) cancer registers for selected provinces of Germany, which are based on DWH technology, are demonstrated. DWH was used because for many issues regarding health care an interactive and dynamic ad-hoc-grouping and –classification plays a crucial role. The registers are used for monitoring, quality assurance and health reporting purposes.

Cross-sectoral evaluation

Only sectoral fragmented health care systems have need of cross-sectoral evaluations. Therefore only a few cross-sectoral health care evaluations were identified using routine data. The majority of identified work is related to routine data analysis of mandatory health insurance data in Germany.

In Germany cross-sectoral quality assurance is mandatory according to Federal Law (§ 137a SGB V). The Institute for Applied Promotion and Research of Quality in Health Care (Institut für Angewandte Qualitätsförderung und Forschung im Gesundheitswesen - AQUA) had been contracted in 2007 to implement a cross-sectoral quality assurance project. The main aim was the development of procedures for the measurement and demonstration of cross-sectoral quality of health care and the information technological implementation of the project (SQG 2010).

In (Dörning et al. 2008) the authors examined one-year mortality after surgical and non-surgical approaches to coronary revascularisation with administrative data of a German health insurance. Parameters for risk adjustment (e. g. age, gender, previous myocardial infarction) were derived from administrative claims data on outpatient physician

contracts, prescriptions and hospital claims data up to ten years before and one year after discharge. Adjustment for confounders based on routine data accounted for the observed differences between the various percutaneous interventions. The higher one-year mortality after coronary artery bypass graft remained unexplained.

(Hagenmeyer et al. 2010) executed a claims data analysis using propensity score matching. They performed a comparison of utilisation and costs of treatment for patients with type 2 diabetes using insulin glargin or insulin determir. The conclusion was that costs per patient were significantly lower for patients using insulin glargin, but hospital expenses did not differ.

In (Nolting et al. 2011) the authors investigated the impact of a disease management program (DMP) for diabetes on health care costs. They performed a retrospective cohort study with matched controls using claims data. The study supports findings that German DMPs may have improved the quality of care for diabetes patients. Costs are strongly influenced by selection of patients into the DMP with less serious comorbidities.

Methods of these studies could be used for indicator development and in addition for the monitoring of the health care system. Risk adjusted comparisons on regional varieties of patient care, health care expenses and utilisation of services could be performed on a regularly basis.

4 THEORETICAL BACKGROUND AND DEFINITIONS

In this chapter the theoretical background and definitions in context of this master thesis are demonstrated. It further presents the urgent need for cross-sectoral quality assessment and the introduction of DWH as a technology for health care data handling in Austria. Also, quality in context of quality management in health care, indicator development based on secondary data and selected assessment capabilities, such as 30-days-mortality, comorbidity, prevalence approximations and patient flows, are discussed.

4.1 HEALTH CARE SECTORS IN AUSTRIA

The primary aim of the master thesis is to investigate the quality of care on patient level. Due to the structural segmentation of the Austrian health care system it is difficult to

track the path of patients through the health care system. This chapter should emphasise the necessity of a cross-sectoral quality assurance and the need of cross-sectoral quality analysis.

In (Hofmarcher and Rack 2006) the authors criticized the sectoral fragmentation of health care in Austria. They stated that due to the sectoral fragmentation, the health care system is very intransparent and financing and responsibilities are not assigned clearly over sectorial boundaries. In the Federal Law Gazette (BGBl Art. 15a B-VG 2005) a more cross-sectoral administration of the health care system is demanded by law. The planning, structures and funds permit this now for the first time and steering of capacities and financing flows over sectoral boundaries are possible.

Organisation and structure of the health care system in Austria

The Austrian health care system is characterised by a federalist structure, the allocation of competences to self-governing stakeholders in the social insurance system and by cross-stakeholder structures at federal and province level. According to the Federal Constitution, nearly all areas of health care are administered by the federal government. This excludes the hospital sector (inpatient sector), where the federal government is only responsible for enacting basic law. Legislation on implementation and enforcement is the responsibility of the nine provinces. In the outpatient sector, the rehabilitation sector and in the fields of medicines, health care is organized by negotiation between the 21 health insurance funds, respectively the Federation of Austrian Social Insurance Institutions and the chambers of physicians and pharmacists. Traditionally the various sectors of the health care system have been characterised by the different stakeholders and regulation- and financing mechanisms. The Austrian health care system has developed virtually completely into a system which is primarily based on decentralized contracts with all service providers (Hofmarcher and Rack 2006).

Due to the sectoral fragmentation of the Austrian health care system the allocation of services is problematic. The GeISt project of JOANNEUM RESEARCH is in the unique position to allocate services and costs to patients over sectoral borders. In other countries, like Finland, epidemiologic studies on basis of routine data are more feasible due to a unique personal identification number assigned to all persons residing in Finland (Mähönen et al. 2000). For comparisons on level of different countries the

different structures of health care systems has to be kept in mind. The focus of the literature research lay in the identification of health care indicator projects and secondary data analysis of countries with a similar health care system like Austria.

4.2 QUALITY

According to the scope statement of the master thesis, quality concerns have to be investigated. Quality concerns are compulsory for health care in Austria according to Federal Law Gazette (BGBl 1993) and (BGBl Art. 15a B-VG 2005). "Quality" is a subjective term for which each person or sector has its own definitions. In technical usage, referring to (Quality Progress 2002), the word "quality" is widely accepted to have two meanings:

> *"1. The characteristics of a product or service that bear on its ability to satisfy stated or implied needs;*
> *2. A product or service free of deficiencies."*

There are many different definitions of quality and even among quality experts there is a lack of agreement on a definition of quality (Nanda 2005). In (Hoyer et al. 2001) the authors have categorised the philosophies about quality of eight quality experts into two categories:

> *"1. Quality is about satisfying applicable specifications. Quality is a simple matter of producing products or delivering services whose measurable characteristics satisfy a fixed set of specifications that usually are numerically defined.*
>
> *2. Quality is about satisfying the customer. Independent of any of their measurable characteristics, quality products simply are those that satisfy customer expectations for their use or consumption."*

For health care quality, expectations have to be satisfied for both categories described above. In (Leitheiser 2001) the author writes that the health care industry is unique in its needs to bring together efforts to improve the quality of individuals' health with the effort to cut costs to employers and governments. There are two different types of costumers with two dissimilar goals. The author further writes: "*To meet these requirements the health care organisations bring together, probably for their first time, financial data and clinical data. This integration is costly and time consuming. It also poses*

special problems for data quality." In chapter 4.4.1 additional information concerning data quality in the context of DWH can be found.

Especially in the health care environment many different contributors work together and therefore standards have to be adhered to. This in turn leads to the need of measuring and monitoring of outcome measures. In this chapter a brief description of the need for quality management in health care and the requirements of quality measurement tools are presented.

4.2.1 QUALITY MANAGEMENT IN HEALTH CARE

In health care quality management requires the integration of all structures and processes with the focus on the patient. Quality assurance in Austrian hospitals is regulated through Federal Law Gazette (BGBl 1993:§5b), where sponsors of hospitals are committed to set measures for quality assurance in their organisation. Further they are committed to deploy measures in a way where they are comparable with other hospitals. The quality assurance in Austrian hospitals is organised in structural-, process- and outcome-quality levels. This method was first displayed by (Donabedian 1966) and also finds its way into the Federal Law Gazette (BGBl Art. 15a B-VG 2005:sec. 6). Thereby cross-sectoral and cross-regional quality management is defined by law for the first time, with the focus on patient-orientation, transparency, effectiveness, efficiency, cost dampening and regular evaluations.

In many countries quality management is regulated by the government, especially because of the necessity of cost damping to ensure the range of offered services (Masing 1999). The reasons for the requirements of cost damping are the same, nearly in every developed country. According to (Haeske-Seeberg 2005) following reasons will lead to a future cost explosion:

- **Age and health situation of the population:** The bigger share of the older population requires more medical services and therefore causes higher costs. Additionally, older people and falling fertility rates result in fewer people able to finance the health care system. Higher life expectancy leads to more chronic diseases like diabetes and therefore causes costs.
- **Development of health care and increased range of medical services:** Preventive measures lead to an earlier detection of illnesses and therefore the

treatment-period is elongated, which causes additional costs. In contrast to free markets, where demand influences supply, supply influences demand in health care. More health care suppliers lead to more demand of services.

- **Medical progress:** On the one hand, due to the use of new technologies a partly cost reduction could be achieved. On the other hand, there is an increased use of medical resources, because of the introduction of new medical devices, e.g. medical robots, into clinical routine. Additionally new medical routines, e.g. minimal invasive surgery, lead to redundancy of equipment because it is procured additionally to the traditional equipment.
- **Development of information technology:** The development of information technology in health care has two different effects on costs. On the one hand implementation of chip-cards, digital-x-rays, telemedicine and hospital information systems have reduced costs and improved performance. On the other hand new developments are faster included into clinical routine, which cause higher consumption of resources than in the past.
- **Expectations of the patients regarding the health care system:** The access to information regarding specific health problems nowadays is easier, which leads to patient empowerment in decision making.

Especially the patient empowerment leads to quality related issues. Patients are able to compare treatment options on level of quality of life or on level of quality of hospital. This describes the necessity of thorough quality indicators and benchmarking. These indicators and measures are established on structure-, process- and outcome-quality level. These three levels, in which quality management in health care occurs, are described according to (Gesundheitsportal 2011) as follows:

1. **Structure quality:** The personnel and equipment of a health care organisation are described in quantity and quality. E.g. quantity of specialist, sum of hospital beds and sum of specific medical devices in a region or hospital. In Austria quality concerns regarding this level are organised in the structural plan for health care (Österreichischer Strukturplan Gesundheit).
2. **Process quality:** Treatment procedures and work flows are described in guidelines and standards. E.g. diabetes mellitus (type 2) guideline. In the

guideline requirements for an optimum of treatment quality and a minimum of patient risk are described.

3. **Output quality:** Change of physical condition, quality of life or patient satisfaction are measured, documented and analysed. Therefore it is possible to compare results of different service providers or regions. The Federal Institute for Quality in Health Care, ordered by the Austrian government, has developed quality registers for selected medical sectors e.g. heart surgery, pacemakers, endoprosthesis of the hip. The quality registers contain information about e.g. the course of patient care, transports, waiting times, complications. This information is collected, analysed and provides a feedback for service providers e.g. hospitals.

In (Hess 2007) the author writes that in nearly all established quality measurement systems the focus lies on structure quality, because it is easy to measure and provides easy understandable indicators. Output quality indicator development on the other hand is highly demanding and complex. This creates the risk of focusing on measuring what is technical possible and not on measuring what is needed.

In context of the topic of the master thesis a concentration on output quality is demanded. Output quality takes place on patient level and therefore it is possible to use it as a cross-sectoral and cross-regional quality indicator, because only the patient crosses all health care sectors on his recovery.

4.2.2 QUALITY MEASUREMENT INSTRUMENTS

Measuring quality in health care is a very difficult endeavour. Every professional group, patient and organisation has its own definition and expectation of quality (Hess 2008). According to (Agency for Healthcare Research and Quality 2004), a quality measurement tool requires being objective, scientifically evident and not affecting or distorting results. It must be tested and ensured that it is:

- **Reliable:** Use of the tool results in the same reading regardless of who does the measuring or when and where the measurement is taken.
- **Valid:** The tool measures what is intended.
- **Standardised:** Definitions of data elements, data collection, and data analyses are sufficiently precise and comprehensible that they can be understood and applied in the same way regardless of who refers to or applies them.

Quality measures describe only observed conditions but do not give an explanation for the observed condition. Results cannot reveal which factors caused the differences. Quality measurement in health care is becoming common (see chapter 3) but it is important to bear in mind concerns about problems with data availability, accuracy, completeness or failure to meet standards of reliability, validity and standardisation (Agency for Healthcare Research and Quality 2004).

As mentioned in the previous chapter quality measurement takes place in the categories structure, process and outcomes. In (Donabedian 1966) the author writes that outcomes are: *"the ultimate validation of the effectiveness and quality of medical care".* There are also limitations in using outcomes when assessing quality. Outcomes are difficult to measure, can be affected by many factors outside of the medical care system and relevant outcomes may not be apparent for years (Mangione-Smith and McGlynn 1998).

In (Eikötter and Greiner 2008) the authors have evaluated different possibilities to measure the performance of the health care system and the quality in managed care in particular. The advantages and disadvantages of cross-sectoral measurement tools e.g. guidelines, quality indicators, patient questionnaires, benchmarking and analysis of routine data were balanced. The author's conclusion was that in future quality measurement tools, that are able to measure processes and outcome which exceeds borders of single contracts or indications which were included in an adapted evaluation concept, will be necessary to judge the quality of care adequately.

In this master thesis the focus lies on quality measurement on basis of routine data. Cross-sectoral patient pathways and indicators should be developed on basis of routine data. In the next chapter, further information on cross-sectoral and cross-regional quality measurement with indicators can be found.

4.3 INDICATORS

In the previous chapter the necessity of quality measurement on output level was described, an explanation of quality and the requirements for quality measurement tools were provided. This chapter is occupied with a deeper examination of indicators as quality measurement tools. A definition of the term indicator in context of health care, requirements for indicators and especially a controversy of indicators on basis of routine data is presented.

In literature there is no exact distinction between quality indicator and quality measure. In context of the master thesis no distinction between these terms has been taken. For the sake of completeness the distinction, found in some literature, should be discussed. (Shaughnessy and Hittle 2002) describe the difference between quality measure and quality indicator as follows:

- A **quality indicator** refers to an attribute of care that can be used to measure quality of care in a specific area.
- A **quality measure** is in effect a rule (or the result of a rule) that assigns numeric values to specific quality indicators. Quality measures take on numeric values, while quality indicators refer only to unquantified attributes (e.g. high, middle or low)

But Shaughnessy and Hittle also concede that many do not distinguish between these two terms. In (Mainz 2003) the author has gathered three different definitions, which describe indicators in perspective of health care. Indicators are:

1. Measures that assess a particular health care process or outcome (Worning et. al. 1992).
2. Quantitative measures that can be used to monitor and evaluate the quality of important governance, management, clinical and support functions that affect patient outcomes (JCAHO 1989)
3. Measurement tools, screens or flags that are used as guides to monitor, evaluate and improve the quality of patient care, clinical support services and organisational function that affect patient outcomes (Canadian Council on Health Services Accreditation 1996)

Especially the definition of the Canadian Council on Health Services Accreditation works well with the requirements for a cross-sectoral quality measurement on outcome level. An indicator shows the current state and compares it with a target or planned state.

Indicator measurement provides quantitative basis for many stakeholders and according to (Mainz 2003) makes it possible to:

- Document quality of care

- Perform benchmarking over time or between hospitals (make comparisons, learn from the best)
- Make judgements and set priorities (basis for decision making for patients or planners who are aiming to achieve improvement in care)
- Support accountability, quality improvement, patient choice of providers and regulation and accreditation

Indicators are not a direct measure of quality. Most of the time the reason for significant differences in indicator-output has to be further investigated.

4.3.1 INDICATOR REQUIREMENTS

In chapter 4.2.2 the requirements for quality measurement tools were described briefly. These requirements are very similar to indicator requirements. Validity and reliability are also very important qualifications of indicators. Due to the signalling impact of indicators also sensibility and specificity are relevant as indicator requirements. According to (Mainz 2003) the key characteristics of an ideal indicator are as follows:

- Is based on agreed definitions and described exhaustively and exclusively
- Is highly or optimal specific and sensitive
- Is valid and reliable
- Discriminates well
- Relates to clearly identifiable events for the user
- Permits useful comparisons
- Is evidence-based

(Schneider et. al. 2003) have also summarized characteristics and attributes of quality indicators. Additional to (Mainz 2003) they name:

- Feasibility (easy implementation e.g. on basis of routine data)
- Reduction of "burden of disease"
- Cost-effective (influencing indicator in one direction results in cost reduction)
- Indicator suitability (is there experience with a similar indicator?)
- Influenceable (planers and decision makers are able to effect the indicator)

Particularly for cross-sectoral outcome indicators it is necessary to have valid and reliable indicators, because they are often compared among groups or within groups

over time. Reliability is the degree to which repeated measurements of different data collectors, judges or instruments at different times and places get comparable results. Validity is the extent to which the indicator measures what it is intended to measure (Mainz 2003).

In Germany due to the legally obligated cross-sectoral quality assurance the Institute for Applied Promotion of Quality and Health Care Research (AQUA – Institut für angewandte Qualitätsförderung und Forschung im Gesundheitswesen GmbH) released a guideline for indicator development. In this guide they developed a set of quality criteria which were embedded into a multi-staged expert panel supervised quality management process. They came up with following quality criteria, which were designed especially for indicators based on routine data (SQG 2010).

- **Relevance:** Indicator is evidence based, able to distinguish between good and bad performance and has a high value for the patient. Further the benefit of the indicator exceeds the risks and it has a high value for the health care system.
- **Clarity and intelligibility:** Nominator and denominator of the indicator are exactly defined, unique, unambiguous and reproducible. The design is cross regional legitimate and independent.
- **Practicability:** The required information is available and not unduly time consuming at data collection. Further there should be no existing data acquisition method which has the same output with less effort.
- **Risk adjustment:** Is required when there are parameters e.g. age, gender, severity of illness etc. which have strong influence on the indicator. A more detailed description of risk adjustment can be found in chapter 4.3.5.
- **Measuring properties:** Reliability, completeness of the data basis and ability to discriminate results.
- **Suitable for public reporting:** Indicators are easily understandable and have a high interest for the public.

When indicators fail to meet required standards than information is produced that is likely to generate more noise than usable facts for decision making. At best such information will create confusion; at worst these poorly developed indicators will lead to bad decision making that affects the health of a population negatively (McGlynn 1998)

4.3.2 HEALTH CARE INDICATORS

Indicators are used in health care for inpatient and outpatient care, which is demonstrated in chapter 3. Cross-sectoral outcome indicators are not so widely used. This is particularly true in Austria. (Donabedian 1966) has written:

> *"The outcome of medical care, in terms of recovery, restoration of function and of survival, has been frequently used as an indicator of the quality of medical care"*

In this statement are three examples of indicators that are nowadays used for measuring inpatient quality of care. For a comparison with other illnesses, regions or hospitals these factors have to be referenced to a base value. An indicator is described as a proportion of a nominator value (e.g. diabetes patients) to a denominator value (e.g. all patients) (SQG 2010). These types of indicators are called rate-based indicators and are often expressed as proportions within a given time period, ratios or mean values for a sample population. These indicators permit comparisons among providers or trends over time (Mainz 2003).

Another type of indicator is called sentinel indicator and identifies individual events or phenomena that are naturally undesirable and always trigger further analysis and investigation. They are representing the extreme of poor performance and are generally used for risk management. Rate-based and sentinel indicators can be generic or disease-specific and related to structure, process or outcome (Mainz 2003). In Table 4.3-1 examples for structure, process and outcome indicators can be found. As mentioned in the previous chapters, the focus of the master thesis lay within the development of outcome-indicators. Outcome indicators are therefore discussed in greater detail.

Structure
Proportion of specialists to other doctors
Access to specific technologies (e.g. MRI scan)
Access of specific units (e.g. stroke units)
Clinical guidelines revised every 2nd year
Physiotherapists assigned to specific units
Process
Proportion of patients with diabetes given regular foot care
Proportion of patients with myocardial infarction who received thrombolyses
Proportion of patients assessed by a doctor within 24 hours of referral
Proportion of patients treated according to clinical guidelines
Outcome
Intermediate
HbA1c results for diabetics
Lipid profile results for patients with hyperlipidemia
Blood pressure results for hypertensive patients
End result (should be specified for diseases)
Mortality
Morbidity
Functional status
Health status measurement
Work status
Quality of life
Patient satisfaction

Table 4.3-1: Examples for structure- process- and outcome-quality indicators (Mainz 2003)

Outcome indicators/measures try to describe the effects of care on the health status of patients and populations. In (Lohr 1988) the author writes that outcomes can be expressed as "The five Ds'":

1. **Death:** worst outcome (mortality)
2. **Disease:** symptoms, physical signs and laboratory abnormalities (e.g. morbidity, incidence).
3. **Discomfort:** symptoms such as pain, nausea or dyspnea.
4. **Disability:** affected ability connected to usual activities at home, work or in recreation (e.g. sick leave).
5. **Dissatisfaction:** emotional reactions to disease and its care, such as anger and sadness (Mainz 2003)

In the course of this master thesis cross-sectoral outcome indicators for the detection of regional differences of mortalities and morbidities were developed.

Intermediate outcome indicators reveal changes in biological status that affect health outcomes. These changes are often detected via laboratory test results or anamnesis and represent intermediate results. End-result indicators are, as the name suggests, end-results of a sequence of processes e.g. mortality, morbidity. With routine data it is

possible to develop intermediate and end-result indicators. End-result indicators are generic, easy comparable and risk adjustable. Outcome quality indicators are often difficult to identify and are, in comparison to process and structure quality indicators, harder to interpret and less sensitive to small differences (Mainz 2003). (SQG 2010) and (Schneider et al. 2003) name the greatest strengths and weaknesses of health care quality indicators. A summary can be found in Table 4.3-2.

Strength	Weakness
Comparison between service providers (Networks, Hospitals, GPs) is possible	Promotion of a fragmented point of view in medicine and patient care
Objective assessment and comparison of service providers is easier enabled. Weaknesses are detectable and specific potential for improvement can be shown	Risk of neglecting subjective aspects in favour of easy measurable details
A discussion about quality of care and the use of resources is enforced	Quality indicators should be considered with caution. Fluctuations are ofen due to lack of proper risk adjustment
Quality indicators in daily business are often faster, more convenient and more efficient than other methods	Results can promote accusations and reduce motivation
They can serve as basis for contracts within integrated care. They can measure the success of restructurings and changes in procedures	The development is often time-consuming and expensive
Quality indicators can increase the transparency and assurance between contracting parties	Quality indicators tempt organisations to short-term observations, with the focus on measurable facts. Often long-term strategies are neglected

Table 4.3-2: Strengths and weaknesses of quality indicators in health care (SQG 2010) (Schneider et al. 2003)

The strengths and advantages were reason for the implementation of indicators into the GeISt project. Due to risks that go hand in hand with indicator development, particularly on basis of routine data, the weaknesses and requirements of indicators have to be kept in mind.

4.3.3 INDICATORS ON BASIS OF ROUTINE DATA

According to (SQG 2010) there are four possible data sources for monitoring the quality of care:

1. Routine data (secondary data)
2. Additional data from hospital information systems or other IT solutions (e.g. radiology information systems, laboratory information systems
3. Patient surveys
4. Questionings of health care service providers (medical doctors, hospitals etc.)

The setting of GeISt demands a closer look at indicators on basis of secondary data. Secondary data analysis is inquiry of data in scientific context without immediate reference to the primary reason for data collection (Swart 2005). The primary aim of data is e.g. for accounting purposes. The secondary aim is e.g. health care indicator development.

As mentioned in chapter 3 there are projects, national and international, that measure quality of care using secondary data. Despite some limitations, which are discussed later in this chapter, there are many reasons for the use of secondary data analysis. Firstly there is no additional need for data collection, because the information was gathered already for another purpose. Secondly, there is a comprehensive data pool collected over a large period of time. Because of this time series analysis is possible, which gives insight into developments within the health care system. Thirdly, the data pool is reviewed via accounting methods, which ensures that the consumed services are cross-sectoral allocatable to unambiguous patients. Finally, there are many established indicator sets on basis of secondary data (e.g. from the AHRQ). (Aylin et al. 2007), (Ghali et al. 2000) and (Pine et al. 2007) showed that it is possible for specific quality analysis on basis of secondary data to get similar results compared to using clinical data or register data. In Table 4.3-3 you can find a summary of (Schubert et al. 2008) presenting advantages and examples of use of the mandatory routine data in Germany.

Advantages of the mandatory routine data in Germany	
Advantage/Properties	**Examples of use**
Person-related	Prevalence/incidence, progress observation
Population-related	Denominator for epidemiologic rates
Practitioner/institute-related	Feedback-analysis, benchmarking, patterns of demand
Treatment data of all sectors	Patterns of demand, the course of patient care, substitution effects
Uninfluenced data: no selection bias, no drop-out, no refusals, no recall- or interview-bias	Demonstration of all insured patients, independent of age, language skills, morbidity, accessibility
Continuity of data	Retrospective and prospective surveys, longitudinal and horizontal analysis
Cost data	Cost of illness study
Economic way of data collecting	Comprehensive populations, long time-frames

Table 4.3-3: Advantages and examples of use of the mandatory routine data in Germany (Schubert et al. 2008)

There are many quality indicator projects on basis of routine data in Germany that are already successfully implemented. E.g. the quality assurance project of the Allgemeine Ortskrankenkasse (AOK) (WIdO 2007) showed that outcome quality indicators (e.g. mortality, rate of revision) are useful for health care decision making. Especially the long time-frame and the cross-sectoral data basis allowed a good demonstration of the course of patient care. Follow-up observations, allocation of treatments in different hospitals for patients and the registration of death outside the hospital are possible due to the cross-sectoral data basis.

Applicability of Routine Data in Quality Assessment

As mentioned previously there are issues connected to the use of indicators on the basis of routine data. In this chapter problems that are related to secondary data are discussed and their influence is evaluated.

In (van der Lei 1991) the author writes as follows:

> "*Data are collected with a purpose in mind; that purpose has a direct influence on what data are recorded*"

Routine data collected for accounting purposes reflects the patient or hospital in economic manner but is not valid for clinical decision making, according to van der Lei.

The data could be influenced by the payment system. Procedures with high profit for the service providers are performed more often.

Another problem that affects indicators based on secondary data is, if the insured patient changes the health insurance scheme during the fiscal year. Therefor it is not possible to uniquely identify patients that changed from one insurer to another. Referring to (Dörning et al. 2008) "lost to follow up" is negligible. The authors performed a one-year-mortality after coronary revascularisation survey, using data provided by the health care insurer Gmündner Ersatzkasse. Only 0.4 percent of the initial study population was lost to "follow-up". Certainly not all health care insurers have the same data-quality but according to the authors this circumstance enforced the power of their analysis.

Missing data results due to errors in data collection or during data processing. Accounting data of health care insurers is influenced by many stakeholders (doctors, pharmacists, hospitals etc.). Missing data requires individual data checks for every entity e.g. supplementation with default values.

There is only data available that is relevant for accounting purposes. Lab data e.g. blood pressure, information of quality of life and information on lifestyle (e.g. smoker, obesity) is not available (Schubert et al. 2008).

Changes of payment methods have a strong influence on the outcome of developed indicators. In (Reinhold et al. 2009) the authors have discovered that after implementation of the DRG-system in Germany, the patients were sicker than before, due to additional documentation and information. For time series analysis changes of the data collection methods are problematic because without an identical data basis comparisons on basis of time are not valid.

An additional problem that lay within the use of accounting data is the difference between moment of service consummation and moment of service accounting. E.g. medicines are prescribed over a period of time. In the secondary data there is no information about this period or the start of this period. In Austria prescriptions for medicines are valid for two weeks. They are collected at pharmacists and than the patients are credited in the month of consumption. Therefore it is not possible to get an exact date of consumption of medicine or if it was consumed according to the guideline.

Some health care costs and services are not refunded by the health care insurer. For economic studies on patient level it is not possible to access this information with routine data. These costs can only be estimated via patient surveys and then be extrapolated on patient cohorts in health care economic models.

Information of patients is only available for insured patients and often only for specific health care insurers. Risk adjustment is possible for age and gender but other socio-demographic influences like education or economic activity are not known (Schubert et al. 2008).

In (Giersiepen et al. 2007) the authors examined the quality of medical outpatient documentation in Germany. Outpatient diagnoses in Germany are documented using the ICD-10 classification. They discovered a reduction of diagnoses-prevalence for chronically ill patients ranging from 6 percent to 16 percent. According to the authors this encouraging result reflects probably the used software tools, because it is possible to set long-term diagnoses automated for the next patient record. Further they investigated relations between medications and diagnoses. For prescribed anti-diabetics a diagnose diabetes mellitus can be found with a very high probability (97.3 percent) in a three year time frame. On the other hand only half of the patients that became medication for gout had a related diagnose in the three year time frame. The finding of the paper is that multi-morbid patients often were found in the record only with the most severe diagnose, comorbidities are often neglected.

The very specific ICD-10 system for classification of diagnoses for outpatient-patients does not seem to be appropriate to reflect unspecific or suspected diagnoses of GPs (Erler et al. 2009). On the one hand there is an over reporting of severe diagnoses. On the other hand under reporting occurs due to the big effort for reporting comorbidities. In Germany, which has a similar structured health care system like Austria, (Erler et al. 2009) and (Giersiepen et al. 2007) showed, that it is only possible to use outpatient health insurance secondary data with restrictions.

In (Quan et al. 2008) the authors assessed the validity of ICD-10 administrative hospital discharge data. They calculated sensitivity values ranged from 12.7 to 80.8 percent and positive predictive values ranged from 32 to 100 percent. Specificity and negative predictive values were consistently high. For specific analysis inpatient routine data

provides similar results compared with quality register data. In (Drösler et al. 2007) the authors examined if the AHRQ patient safety indicators are applicable with German routine data. They came to the conclusion that it is possible to implement these patient safety indicators for regional comparisons and comparisons on level of hospitals. Referring to (SQG 2010) there are two possible scenarios for the implementation of routine data for indicator development:

- Additional use of routine data based indicators (e.g. for validation, integrity and plausibility checks)
- Substitution of less efficient methods through routine data based methods

The use of routine data for indicator development has limitations and should be performed with caution. The guideline *Good Praxis Secondary Data Analysis* was adopted on January 15th 2005 and it comprises 10 guidelines that target to set up standards for secondary data analysis (Swart 2005). Although the use of routine data involves the risk of using a data basis, which was not designed for health care decision making particularly, health care insurance data comprises cross-sectoral patient data and therefore was used as data basis for GeISt.

4.3.4 DATA BASES FOR ROUTINE DATA BASED INDICATORS

In this chapter possible sources for secondary/routine data are demonstrated in context of the GeISt project. In Figure 2.1-1 a split into following sources of data is presented:

- Inpatient data
  - Acute inpatient data
  - Rehabilitation inpatient data
- Outpatient data
- Community based specialists and GP data
- Hospital structure data (e.g. large electro-medical devices data)
- Socio-demographic data

The information of secondary data bases belong to different data holders and due to data security policies a combination of these data bases is problematic. The sensitive data of health care insurers has to be anonymised and then joined via primary and

reference keys. In Germany and Austria the data structure of secondary data is very similar and because of this comparisons are possible.

Inpatient Data

Inpatient data is recorded for each hospitalisation. The consumed services are accounted by the health care insurer. For reimbursements of hospitals, due to the DRG system in Austria, data is collected. This information is called Minimal Basis Data Set (MBDS). Since 1989, all Austrian hospitals have mandatory record keeping on basis of the WHO's ICD standard. The legislative basis for the recording of diagnoses and services is the 1996 Federal Act on Documentation in the Health Care System. In order to ensure nationwide unity of the documentation, the Ministry of Health published guidelines for good documentation practice. These data-sets have to be transmitted to authorities in the nine provinces on a monthly basis (Hofmarcher and Rack 2006). In Table 4.3-4 the content of the MBDS is demonstrated. It is divided into an administrative- and a medical-data part. This data-set is part of the performance-orientated hospital financing system (LKF) in Austria.

Administrative data	Data related to the patient's stay	Patient-related data
	Hospital number	Date of birth
	Admission number and date of admission	Sex
	Type of admission	Citizenship
	Department admitting patient, transfers	Main place of residence
	Date of discharge and type of discharge	Bearer of costs
Medical data	Main diagnosis (according to ICD-10 BMSG 2001, four-figure) Additional diagnoses (according to ICD-10 BMSG 2001, four-figure) Selected medical service items (according to the benefit catalogue, BMGF 2005)	

Table 4.3-4: MBDS of Austrian hospitals (Hofmarcher and Rack 2006)

With this data-set it is possible for secondary data analysis to join patient data (e.g. age, gender) with diagnoses of the acute- or rehab-sector. Additional to the information based on hospitalisations also information of hospital structures is available. Number of beds, information on numbers and type of personnel and information about large medical devices are also implied in MBDS.

The MBDSs are collected by the health care insurers from every hospital. The health care insurer is able to link each hospitalisation by hospital number and admission number to the patient who consumed the hospital services.

Outpatient data and data of GPs and community based specialists

The information comprises billing data of outpatient clinics, practitioners, medications, medical aids, patient transports and inabilities to work. In Austria there are no recorded diagnoses in the outpatient sector, whereas in Germany a mandatory ICD-10 classification has been implemented into outpatient routine data. As mentioned in chapter 4.3.3 there are related problems with the too specific ICD-10 classification in the outpatient sector. In (Reinhold et al. 2011) the authors summarise data sources of the mandatory health care insurance in Germany for secondary data analysis. In Table 4.3-5 routine data of Austrian health care insurers, which is similar to the German mandatory routine data, is presented.

Services	Specification
Patient data	Sex, year of birth, Address, Nationality, Reason for ending of insurance (e.g. death)
Inpatient services	Day of admission, Day of dismissal Principal diagnose, Additional diagnoses, Reason for hospitalisation Medical Procedures DRG Scores, Costs
Rehabilitation	Start and end date of treatment Principal diagnose
GPs and community based specialists	Year and quarter of billing Pseudonymised number of practitioner Category of specialisation Day of service consumption Medical check-ups Costs
Medicines	Year and month of billing ATC code Quantity factor of medication Costs
Medical aids	Year and month of billing Type Costs
Inabilities of work	Begin and end Costs
Hospital transports	Day of service consumption Costs

Table 4.3-5: Health insurance data-sets

The main difference between Austrian and German health insurance data is the missing ICD-10 coding system. Both data sources are very similar and therefore comparisons could be performed between Austrian and German health care expenditures.

Socio-demographic data

For comparisons of patient cohorts on regional level also socio-demographic data is implemented in the DWH of the GeISt project. Information on numbers of males and females of all age groups and regions in Styria is therefore able to relate to specific patient cohorts. Also numbers of doctors and hospitals per region are available for structural comparisons.

4.3.5 RISK ADJUSTMENT OF INDICATORS

Comparisons that are meaningful and thorough generally require risk adjustment. Outcome measures have to be related to patient-associated factors before comparing with other patients, treatments, providers, health plans or populations. Sicker patients are on average related to higher costs, more service consumptions and do less well than healthier patients. This circumstance would not matter much if these individuals are randomly assigned to different comparison groups. Fact is, that many dynamics affect the way how persons find care and therefore the mix of patients (case mix) treated by different clinical interventions, providers or health plans varies (Iezzoni 2003). Especially outcome indicators are influenced by the patient case mix and if they are used for e.g. benchmarking these indicators have to be thoroughly risk adjusted.

In most cases, numerous factors contribute to a patient's survival and health outcomes. Figure 4.3-1 illustrates potential factors that contribute to outcome of medical care.

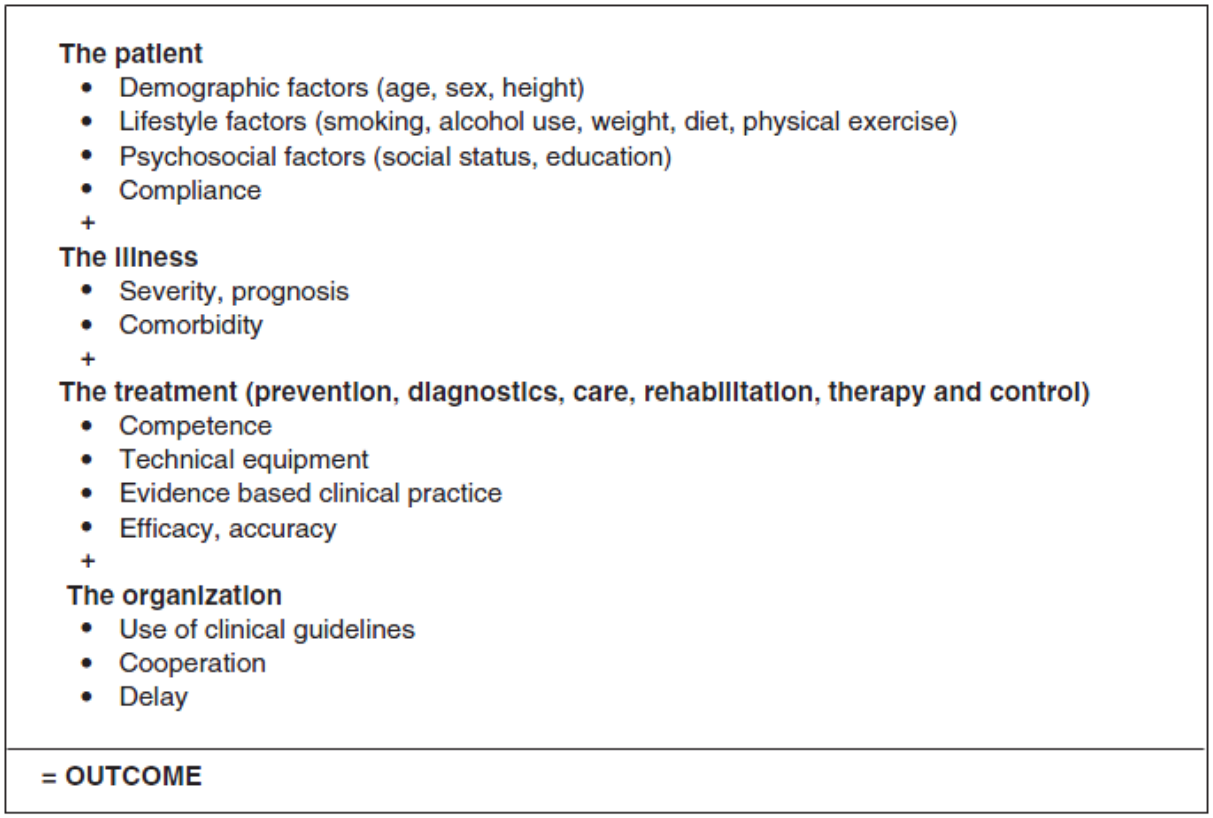

Figure 4.3-1: Factors determining the outcome of care and patient survival (Mainz 2003)

Components that relate to the medical care systems should be isolated if fair comparisons are to be made. This method is called risk adjustment.

According to (Iezzoni 2003) outcome is defined as a function of:

> *"Outcomes = **f**(intrinsic patient-related risk factors, treatment effectiveness, quality of care, random chance)"*

There are several factors that are influencing health care outcomes. Probably the most influences have human related attributes that are described below.

The patient

Demographic factors (e.g. age, sex), lifestyle factors (e.g. smoking, alcohol use) and psychosocial status (e.g. social status, education) influence outcome on patient level. Risk adjustment selecting for age and sex is easy because these attributes are routinely collected for accounting and admission purposes. Lifestyle factors and psychosocial factors for risk adjustment are problematic, due to ethic reasons and reasons of data security policy.

Aging is closely linked to significant chronic diseases, such as cardiovascular disease, certain cancers, diabetes and osteoarthritis (Iezzoni 2003). Older patients have on average worse clinical outcomes then younger patients. Symptoms and severity of illness can differ with age, thus age is not negligible for risk adjustment.

Another systematic effect which requires risk adjustment is the patient's gender. The two genders do not "only" differ chromosomally, anatomically, physiologically and hormonally, they also face different risks for certain diseases and death by age strata. Similarly to age, sex is a simply routinely available, easily measurable variable and therefore standard in risk adjustment (Iezzoni 2003).

The illness

Also the severities of the principal diagnoses and comorbidities have influence on comparisons. Mortality indicators which compare outcome on hospital level should be risk adjusted regarding comorbidities. If hospitals which treat only patients with mild comorbidities are compared with hospitals which treat mainly patients with severe comorbidities this comparison is not valid and unbiased. Furthermore the category of principal diagnose is responsible for diversities in mortality. Because of this risk adjustment also should happen on basis of diagnoses and comorbidities. In chapter 4.5.2 a method for the assessment of comorbidities is presented. The severity of an illness or injury has also to be considered when different doctors, hospitals, etc. are compared. There are a variety of injury severity scoring systems (ISS), which have the task of rating the patient's physical condition in intensive care units. E.g. Acute Physiology and Chronic Health Evaluation II (APACHE II) was developed as a disease classification system and comprises 12 routine physiologic measurements to provide a general measure of severity of disease (Knaus et al. 1985).

Process and structure quality also influences outcome quality. Figure 4.3-1 shows that also technical equipment and use of clinical guidelines have influence on outcome of care. In Austria information on the patient's life style is not available using routine data. Especially age, sex, diagnoses and comorbidities were used for risk adjustment in the practical part of the master thesis.

Not every indicator is risk adjustable and often an uncertainty remains. In (Thomas and Hofer 1999) the authors discovered in their survey that risk adjusted mortality

indicators had a sensitivity of only 20 percent and only predicted correct with an accuracy of 50 percent. Although this study permits some criticism on risk adjustment, it is the only way of getting valid results for comparisons and therefore it was implemented in the practical part of the master thesis. One important aim of GeISt is to deliver convenient tools for analysis in health care. Because of this DWH was chosen as data processing and accessing technology. DWH offers ways for convenient risk adjustment, which is presented in the next chapter.

4.4 DATA PROCESSING TECHNIQUES

The large amount of data and the requirements of the GeISt 2.0 project (see chapter 2.1), have need of special data processing techniques. In this chapter the basic way and elucidation on how to create an OLAP cube, which was used for the processing and demonstration of the in section 4.3.4 described data basis, can be found. The OLAP cube is the final product of a complex process which is described in this chapter.

This chapter also provides a detailed explanation of the technical term Data Warehousing (DWH), its usage in Health Care and a definition of data quality in relation to DWH.

4.4.1 DATA WAREHOUSING

The technical term DWH is ambiguously defined in literature and therefore definitions often vary. (Inmon and Hackathorn 1994) describe it as follows:

> *"A data warehouse is a collection of subject-oriented, integrated, nonvolatile, and time-varying data to support management decisions."*

In (Malinowski and Zimányi 2008), they describe the aspects in this definition as follows:

- **Subject oriented** means that the DWH is orientated alongside the structure of the organisation/company. E.g. this would mean dimensions are customers, products, purchases or inventory. These subjects vary depending on the kind of activities performed by the organisation/company. The focus lies in support of analysis and decision support, rather than performing specific applications or operative processes.

- **Integrated** represents the complex effort of integrating and unifying data of various data sources, see also chapter 4.4.2.
- **Non-volatile** means that durability of data is ensured. A DWH normally stores data for a longer time frame than operational systems.
- **Time-varying** means that it is possible to analyse time-varying processes with a DWH.

Another less restricting and more general definition, with the focus more on the analysis function, is from (Kimball et al. 1998):

> *„A data warehouse is a copy of transaction data specifically structured for querying and reporting.“*

The most general definition found is out of (Hammergren 2009) and interprets it through the specific definitions of the two words that make up the term:

> *„**Data:** Facts and information about something*
> ***Warehouse:** A location or facility for storing goods and merchandise“*

To put this definition in a broader more forward looking definition, (Hammergren 2009) describes following characteristics of a DWH:

- It provides centralisation of corporate data assets.
- It is contained in a well-managed environment.
- It has consistent and repeatable processes defined for loading data from corporate applications.
- It is built on an open and scalable architecture that can handle future expansion of data.
- It provides tools that allow its users to effectively process the data into information without a high degree of technical support.

This definition meets the requirements of the GeISt 2.0 project discussed in chapter 2.1. According to (Berndt et al. 2003), DWH enables people without database or query programming skills to investigate the content of the DWH with simple browsing tools. The emphasis lies on end-user data access, on an understandable database design, which provides an intuitive basis for navigating through the data.

In Figure 4.4-1, the scheme of data processing techniques that accompanies us through the whole chapter 4.4, can be found. In the centre of the scheme, the DWH tier, where all the data of different data sources is stored in a way that makes Online Analytical Processing (OLAP) possible, is demonstrated. This concept is called dimensional modelling and has proven to be the most sophisticated and cost effective approach building DWHs (Inmon and Hackathorn 1994).

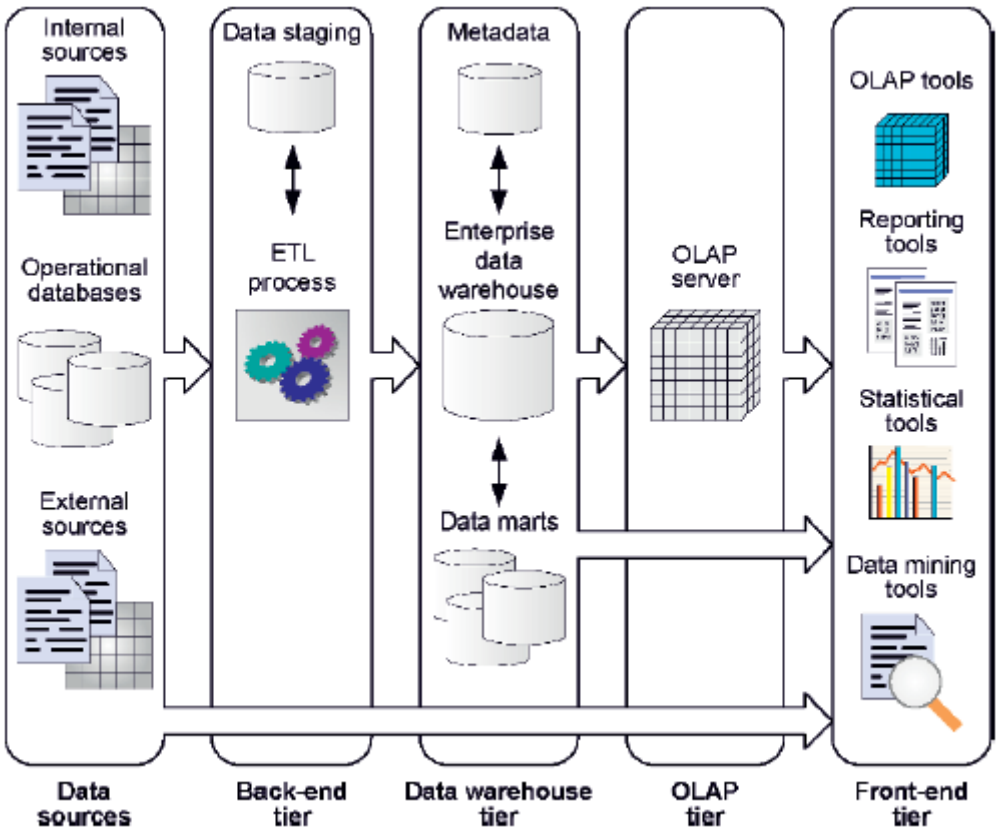

Figure 4.4-1: Scheme of the data processing and analysis tools used in this master thesis (Malinowski and Zimányi 2008)

At the same time, because the dimensional structures are similar throughout multiple DWHs, reuse of code modules and specific development logic is possible (Kimball and Caserta 2004).

In Figure 4.4-2 a demonstration of linked fact and dimension tables in a star schema can be found. This figure also shows how a part of the actual diabetes patient flow cube, which was part of the practical exercise in the master thesis, is organised and linked. A more detailed explanation of the OLAP cubes is provided in section 5.3.

As mentioned in chapter 3, DWH finds application in several national and international health care services. Most of the time DWH is used for business intelligence applications (like business data analysis) but it can also be used in health care; e.g. to offer an effective and thorough way to provide experts and communities with reports in different level of detail, to gather a data repository over a large period of time to improve quality for analysis with symptoms that have a small number of cases and to enable web-access to diverse groups of community planers and stakeholders to investigate important health care issues using comparable data (Berndt et al. 2003).

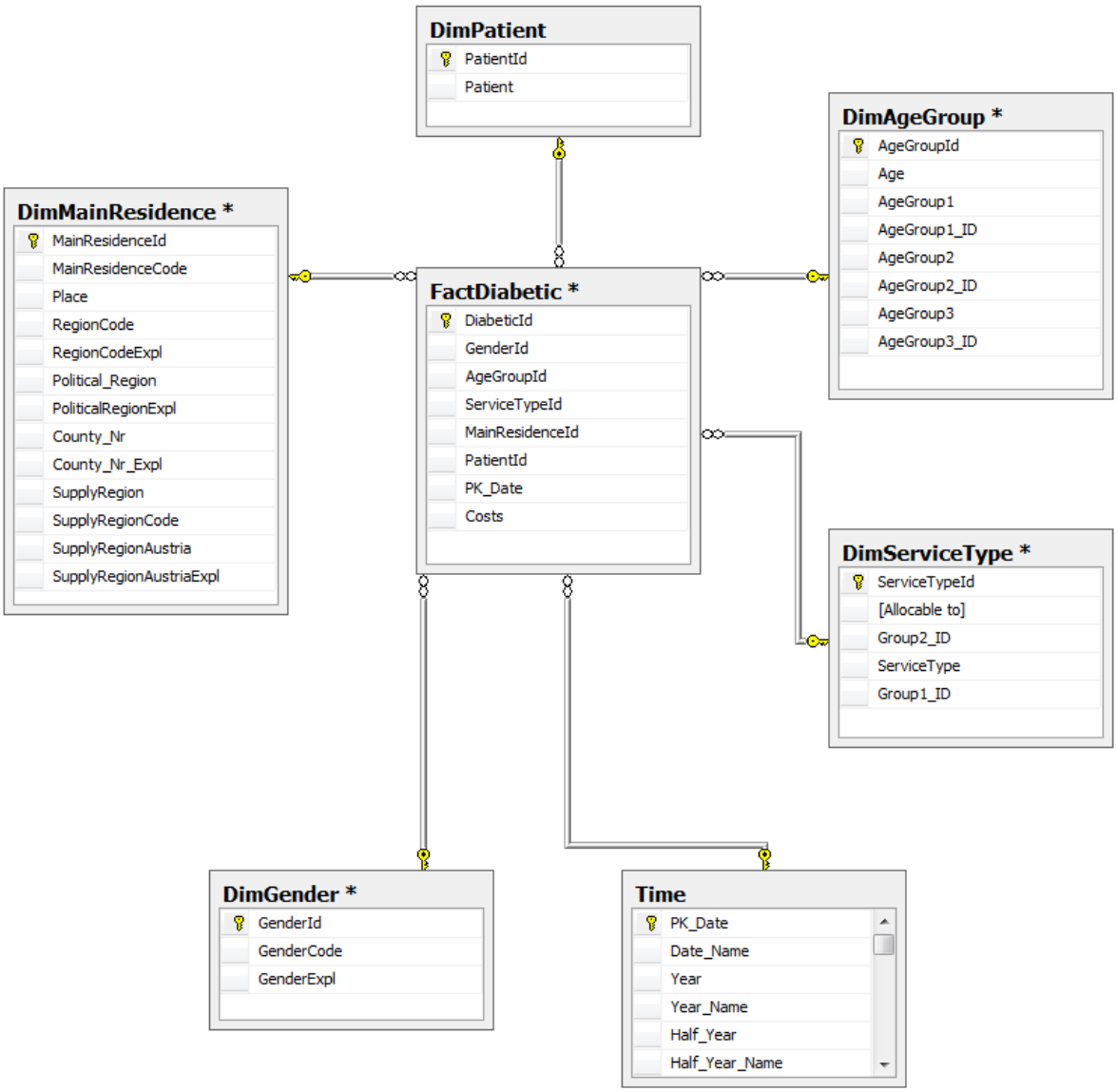

Figure 4.4-2: Star Schema of a part of the diabetes patient flow cube, with fact and dimension tables.

Further, DWH can be used for the development of indicators and can be the basis of data mining algorithms. In the finding of (Prather et al. 1997), DWH and data mining is

referred to as promising for determining complex associations and for searching relationships in large clinical databases.

There are specific major challenges for DWH in health care that go beyond those required for commercial DWH. (Berndt et al. 2003) described firstly, that data comes from a very diverse set of sources. This is demonstrated in the data source tier in Figure 4.4-1. Data in health care is available in a wide variety of formats with different semantics. There are currently few data standards available in the field of health care. The data integration task to build a DWH in the environment of health care requires a significant effort, see also chapter 4.4.2. Secondly, the socio-political issues of health care planning impact security, availability, data quality and performance. It is necessary to anonymise data of patients and restrict data access to different specific stakeholders.

In chapter 4.2, quality was discussed in greater extent. While data quality is important for all systems, it is especially important for DWH environments (Leitheiser 2001). As DWH has different definitions, data quality too has different definitions. The definition that may best describe data quality in context of DWH is from (Tayi and Ballou 1998):

> *"The term "data quality" can best be defined as "fitness for use," which implies the concept of data quality is relative. Thus data with quality considered appropriate for one use may not possess sufficient quality for another use. The trend toward multiple uses of data, exemplified by the popularity of data warehouses, has highlighted the need to address data quality concerns."*

In 1999 a press release of the Institute of Medicine in the USA shocked the public with the report that estimated 98,000 people to die every year from medical errors. Some of these errors are related to missing or bad information about drugs, commands and treatments (Institute of Medicine 1999). (Redman 1998) has evaluated poor data quality on organisations. His finding was that unless an organisation makes extraordinary efforts on data quality, it should expect data error rates around one to five percent (error rate = number of fields with error/number of all fields). Because many parts of DWHs can be reused, these errors in the data basis have a strong influence on the quality of the DWH.

Despite DWH having found its way into health care, unfortunately about 40 percent of e-health data warehouse implementation projects fail and up to 85 percent fail to satisfy

their owner's objectives (Tan 2005). According to the author the reason appears to be that data is often collected without a clear understanding of how they are applied in a DWH.

4.4.2 ETL-PROCESS

The Extract, Transfer and Load (ETL) process is the most important and most time-consuming step in creating a DWH. Figure 4.4-1 shows this process in the back-end tier after the creation of the data sources. This process is responsible for the data-immigration of different data sources and the transformation and loading into the DWH.

The rough workflow, referring to (Kurz 1999), is as follows:

1. Analysis of the source-databases
2. Extraction of the selected objects
3. Transformation of the selected objects
4. Validation and cleaning of the selected objects
5. Preparation of the DWH routines
6. Load of the cleaned and transformed data into the DWH

The analysis and extraction of data (steps 1 and 2) are demonstrated in chapter 5.1. The transformation and data linkage (step 3) is established in chapter 5.2.1 and 5.2.2. The data cleaning and validation (step 4) is shown in chapter 5.2.2 and 6.1. The final two steps are demonstrated in chapter 5.3.

4.4.3 OLAP CUBES

A DWH is designed to provide its users with quick and convenient access to data. The OLAP system provides this mechanism for viewing and analysing information quickly. An OLAP cube is a data structure that allows fast analysis of data, see (Codd et al. 1993). Within the OLAP system, the data takes the form of measures, dimensions, hierarchies and cubes (Larson 2008). Figure 4.4-1 shows the OLAP tier after the DWH tier, because out of the transformed data of the ETL process the data is pre-aggregated and pre-calculated on an OLAP server to allow quick browsing.

(Malinowski and Zimányi 2008) and (Larson 2008) describe specific convenient operations with OLAP cubes. Slicing, dicing, drill-down and drill-up are demonstrated

below, with dimensions and facts which were used in the practical part of the master thesis.

In Figure 4.4-3 a slicing operation is performed. In this example it is possible to select all facts (e.g. deaths, costs, number of services etc.) for all diagnoses and age groups for January. This operation selects a subset of a multi-dimensional array. In this example, the subset is the information of the other dimensions, diagnose and age group, for the month of January.

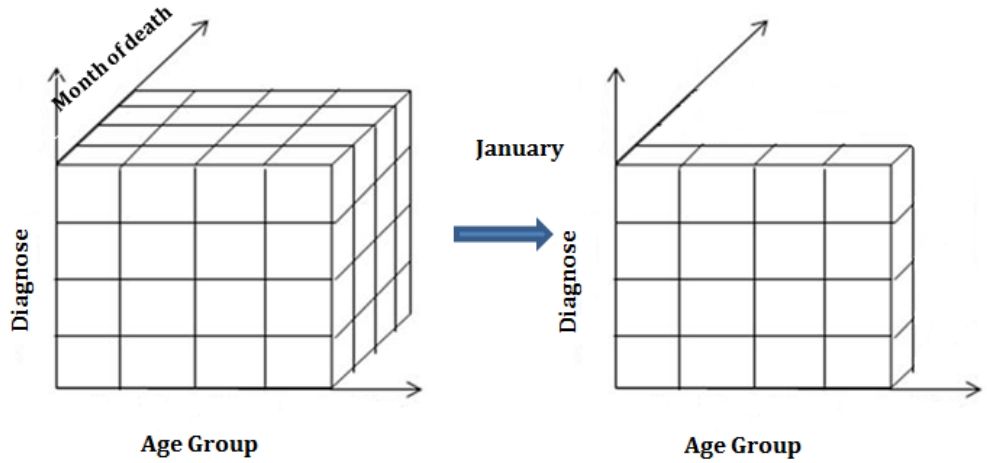

Figure 4.4-3: Slicing with an OLAP cube

Another OLAP operation is called dicing and is demonstrated in Figure 4.4-4. This operation performs multiple slices and therefore a smaller data-mart is processed, which is a subset of the entire cube. In this example a selection for the diagnoses Acute Myocardial Infarction (AMI), Heart Insufficiency (HI) and stroke was executed. As a result it is possible to select specific entities in a dimension and aggregate facts.

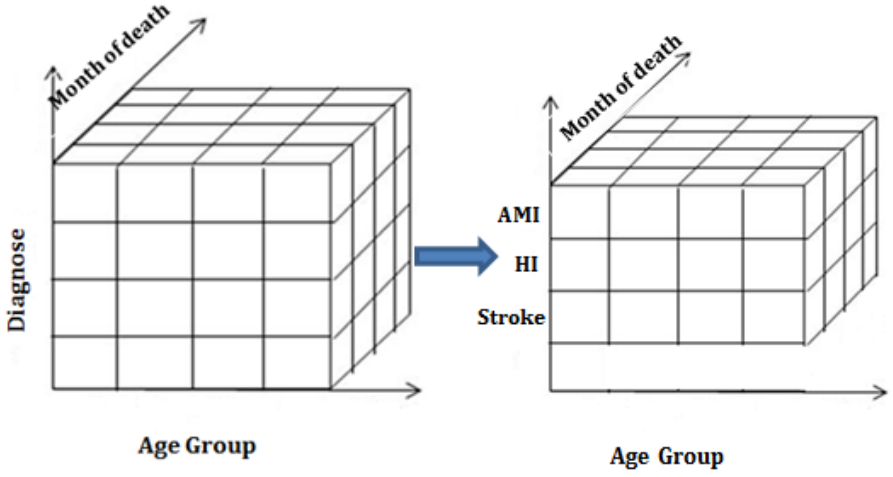

Figure 4.4-4: Dicing operation to select for Acute Myocardial Infarction (AMI), Heart Insufficiency (HI) and Stroke

Figure 4.4-5 shows the Drill-Down/Up operation, which allows us to increase/decrease the level of detail. This example shows that it is possible to conveniently Drill-Down in the diagnose dimension and to display the subgroups of cardiovascular diseases.

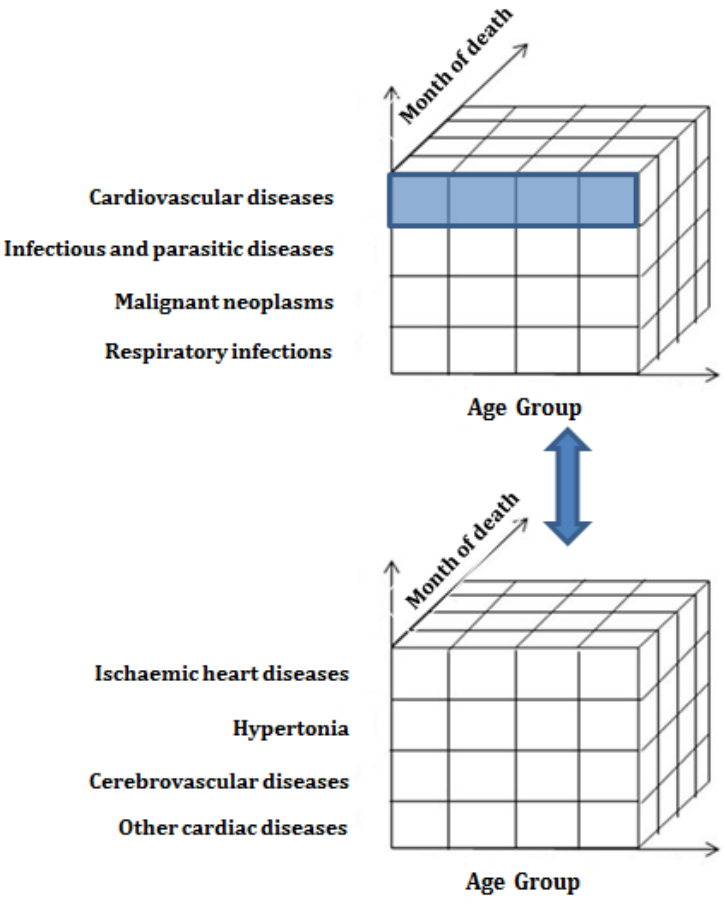

Figure 4.4-5: Drill-Down/Up operation to increase/decrease the level of detail of the OLAP cube

For the enhancement of the cube information content the Multidimensional Expressions (MDX) query language was used. This query language enables the DWH developers to write MDX scripts for the aggregation of facts within the multidimensional cubes. It is possible to relate facts of different cubes for comparisons.

4.5 SELECTED ASSESSMENT CAPABILITIES

Secondary data analysis is used in numerous possible ways for economic and scientific analysis in health care, see also chapter 3. In this chapter possible practices of secondary data usage are demonstrated. In context of the master thesis, feasible assessment capabilities are selected. Mortality, (co)morbidity and prevalence estimations are discussed in greater detail in this chapter.

The GeISt DWH will in its final version be able to perform all presented health care economic and scientific assessment methods. In (Reinhold et al. 2011) the authors have performed a potential analysis on health care economic evaluation methods based on the mandatory routine data in Germany. The methods are as follows:

- Cost analysis/disease related cost analysis
    - Cross-sectional analysis
    - Longitudinal analysis
- Cost-benefit analysis
- Cost-effectiveness analysis

Another potential analysis based on health service research identified following capabilities using mandatory secondary data in Germany (Schubert et al. 2008):

- Providing data-basis for analysis in:
    - Prevalence approximations and morbidity/incidence estimations
    - Utilisation of services
    - Patterns of patient care (Swart et al. 2008)
    - Quality of care
    - Consumption of resources/costs
    - Policy impact assessment
    - Outcome research
    - Patient flows
- Investigation of patient care concepts
    - Design
    - Monitoring and evaluation

Other scientific capabilities of secondary data usage are:

- Mortality and survival analysis (Dörning et al. 2008)
- Identifying the influence of Disease Management Programs (DMP) on costs for services (Nolting et al. 2011)
- Resource allocation and costs for patients with specific disease using different medications (Hagenmeyer et al. 2010)

In context of the master thesis and the limited available data basis, the empathy lay on analysis of 30 days mortality, morbidity estimations, prevalence approximations and patient flows. Due to the limited time-frame available in the data basis of the master thesis (only data of the year 2005 was available) no incidence estimations could be performed.

4.5.1 30-DAYS-MORTALITY

Mortality is a demographic term and is defined as the number of deaths in relation to a population and unit time. For specific mortality, e.g. mortality for myocardial infarction, the number of persons who died because of myocardial heart infarction is related to all persons with myocardial heart infarction. Most of the time mortality is defined as death per 10,000 or 100,000 people per year (Hildebrandt et al. 1997).

For quality auditing of hospitals, mortality rates have been used for decades in the USA as benchmarking tools to gauge efficacy of therapeutic interventions (Takanishi Jr. et al. 2008). Mortality rate calculations on basis of routine data have some issues which are discussed in this chapter. As mentioned in chapter 4.3.5, risk adjustment for quality indicators is crucial. Especially end-result indicators, such as mortality, need to account for dissimilarities and heterogeneity in critically ill patient cohorts studied (Garnick et al. 1995). The time-frame of mortality observations has a direct influence on mortality calculations. Nowadays patients in hospitals are released earlier and therefore fewer deaths are registered in hospitals routine data. The GeIst project has the possibility to relate deaths outside the hospital with the previous hospitalisation, due to the cross-sectoral data basis. For the calculation of mortality the start date of hospitalisation until 30-days, 60-days, half a year or one year after hospitalisation is used. If the time-frame is too large also other impacts, others than the reason for hospitalisation e.g. accidents, are influencing the analysis. If the time-frame is too narrow people who died as follow up to

the reason of hospitalisation are not selected for the analysis. In (Garnick et al. 1995) the authors came to the conclusion that using data from 30-days mortality or 180-days mortality time-frame was not influencing the outcome of their study. In context of the master thesis a 30-day time-frame was chosen for mortality calculation, because more relevant studies were identified using 30-days mortality compared to 180-days mortality.

A factor which was not influenceable in the analysis of the master thesis is the stage of disease at hospital admission. It stands for reason that a patient, hospitalised in an end stage of a disease, dies earlier than a patient at the beginning of the disease. As mentioned in 4.3.5, the use of severity scores would increase the quality of the analysis.

Also, the patient's chronic condition influences mortality calculations. In (Iezzoni et al. 1994), the authors recommend studies which are associated with low risk of death to account for chronic conditions. The impact of chronic conditions on mortality is less severe with generally high mortality, but even among these patients some chronic conditions increase the odds of death.

When calculating mortality rates on basis of ICD-10 codes, the restrictions of secondary based data analysis has to be kept in mind. As mentioned in chapter 4.2.1 coding quality, specificity and sensitivity have a strong influence on the outcome of the analysis. Despite the disadvantages of routine data and ICD-10 coding, calculation of mortality rates on basis of ICD codes is national and international frequently used (Takanishi Jr. et al. 2008). Particularly age standardised mortality rates are used for regional comparisons (Swart et al. 2008). The standardisation process is demonstrated in chapter 5.2.3.

4.5.2 COMORBIDITY

Morbidity is a statistical parameter in health care. It serves as an indicator for frequencies of illnesses in populations. Morbidity is measured for a specific population in a defined time-frame and is described as incidence and prevalence of an illness (Carels and Pirk 2004).

Comorbidity is described in medicine as the occurrence of one or more disorders in addition to a primary disease, or the effect of such additional disorders (Wikipedia contributors 2011). For the elder population the presences of a single diagnose is less likely. Therefore additional diagnoses have to be included in health care analysis. As

mentioned in chapter 4.3.5, for a thorough comparison of two e.g. hospitals a risk adjustment which includes comorbidities has to be performed.

Comorbidity can not only serve as a risk adjustment method, it provides further a method of discovering structural differences in health service research. The effect of case-mix can be demonstrated on hospital level. This information may serve as a basis for health care decision making.

Charlson comorbidity index

The selected comorbidity assessment method in the practical part of the master thesis is the calculation of the Charlson index. The reasons for the selection of the Charlson comorbidity index are as follows: Firstly, (Needham et al. 2005) validated the Charlson index for mortality predictions and came to the conclusion that, although with the use of physiological data (e.g. APACHE II) mortality predictions could be better, the routine data based Charlson index performed well. Secondly, (Luthi et al. 2007) suggested the use of routine data instead of single-day chart review, when assessing comorbidities in the context of the evaluation of nosocomial infection. The routine data based assessment saved time and costs. Thirdly, (Sundararajan et al. 2007) evaluated the risk adjustment performance of different Charlson index calculation methods using ICD-10. They showed that risk adjustment performed satisfactorily. Furthermore, the algorithm, which was used for the calculation of the Charlson index in the analysis of the master thesis, showed a trend toward outperforming the other Charlson index calculation methods.

The Charlson comorbidity index was established to predict 1-year mortality using hospital chart review data. In its final version the Charlson index score is the sum of 19 predefined comorbidities that were assigned weights of 1, 2, 3, or 6 (Needham et al. 2005). In Table 4.3-1 the implemented comorbidities and associated weights are listed. The single scores are added up and the sum represents the Charlson index. The higher the index, the more severe is the physical state of the patient. In Table 4.5-1 the ICD-10 codes, which were used in the practical part of the master thesis, for the calculation of the Charlson index are presented.

Comorbid condition	Weight
Myocardial infarct	1
Congestive heart failure	1
Peripheral vascular disease	1
Cerebrovascular disease	1
Dementia	1
Chronic pulmonary disease	1
Connective tissue disease	1
Ulcer disease	1
Mild liver disease	1
Diabetes	1
Hemiplegia	2
Moderate or severe renal disease	2
Diabetes with end-organ damage	2
Any tumor	2
Leukemia	2
Lymphoma	2
Moderate or severe liver disease	3
Metastatic solid tumor	6
AIDS	6

Table 4.5-1: Comorbid conditions and associated weights of the Charlson index (Charlson et al. 1987)

A validation of the use of the Charlson index can be found in chapter 6.1. The used algorithm for the calculation is evaluated and the conclusion is that the Charlson index selects particularly comorbidities in the elder population. The Charlson index does not present a complete picture of the "burden of disease". No genetic defects are included in the algorithm for calculating the Charlson index.

Comorbidities	Deyo's ICD-9-CM	ICD-10
Myocardial infarction	410.x, 412.x	I21.x, I22.x, I25.2
Congestive heart failure	428.x	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5–I42.9, I43.x, I50.x, P29.0
Peripheral vascular disease	443.9, 441.x, 785.4, V43.4 Procedure 38.48	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9
Cerebrovascular disease	430.x–438.x	G45.x, G46.x, H34.0, I60.x–I69.x
Dementia	290.x	F00.x–F03.x, F05.1, G30.x, G31.1
Chronic pulmonary disease	490.x–505.x, 506.4	I27.8, I27.9, J40.x–J47.x, J60.x–J67.x, J68.4, J70.1, J70.3
Rheumatic disease	710.0, 710.1, 710.4, 714.0–714.2, 714.81, 725.x	M05.x, M06.x, M31.5, M32.x–M34.x, M35.1, M35.3, M36.0
Peptic ulcer disease	531.x–534.x	K25.x–K28.x
Mild liver disease	571.2, 571.4–571.6	B18.x, K70.0–K70.3, K70.9, K71.3–K71.5, K71.7, K73.x, K74.x, K76.0, K76.2–K76.4, K76.8, K76.9, Z94.4
Diabetes without chronic complication	250.0–250.3, 250.7	E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9
Diabetes with chronic complication	250.4–250.6	E10.2–E10.5, E10.7, E11.2–E11.5, E11.7, E12.2–E12.5, E12.7, E13.2–E13.5, E13.7, E14.2–E14.5, E14.7
Hemiplegia or paraplegia	344.1, 342.x	G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0–G83.4, G83.9
Renal disease	582.x, 583–583.7, 585.x, 586.x, 588.x	I12.0, I13.1, N03.2–N03.7, N05.2–N05.7, N18.x, N19.x, N25.0, Z49.0–Z49.2, Z94.0, Z99.2
Any malignancy, including lymphoma and leukemia, except malignant neoplasm of skin	140.x–172.x, 174.x.–195.8, 200.x–208.x	C00.x–C26.x, C30.x–C34.x, C37.x–C41.x, C43.x, C45.x–C58.x, C60.x–C76.x, C81.x–C85.x, C88.x, C90.x–C97.x
Moderate or severe liver disease	456.0–456.21, 572.2–572.8	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6, K76.7
Metastatic solid tumor	196.x–199.1	C77.x–C80.x
AIDS/HIV	042.x–044.x	B20.x–B22.x, B24.x

Table 4.5-2: ICD codes associated to the comorbid conditions which are included in the Charlson index (Quan et al. 2005)

4.5.3 PREVALENCE APPROXIMATION

Routine data is also suitable for prevalence approximation, due to the large and comprehensive data basis. Prevalence is the frequency of occurrence of a disease in a specific population at a certain time (Reuter 2004). Prevalence data is essential for health care decision making and to estimate the political and economic impact of a disease (Stock et al. 2006). As in Germany, in Austria e.g. no national diabetes register exists and therefore prevalence estimations on basis of secondary data analysis may present vital information. In the environment of the master thesis, two possibilities of

relating a disease to a patient were identified. Firstly, the previous mentioned ICD-10 coding for diseases presents a way of relating inpatient diagnoses to patients. Secondly, the Anatomical Therapeutic Chemical (ATC) Classification System of the WHO offers useful information for relating medical prescriptions to specific symptoms.

Diabetes Prevalence Approximation

The presence of a diabetes diagnosis has big economic impacts and influences on quality of life. Diabetes is ranked as the fourth or fifth leading cause of death in most developed countries. People with diabetes have a higher risk of developing cardiovascular diseases, if the disease is left undiagnosed or poorly controlled. They also have elevated risks for sight loss, foot and leg amputation and renal failure (OECD 2009). In (Morgan 2000) the authors performed a cross-sectoral study using record linkage. They combined an electronic death register with a diabetic patient register constructed from a variety of routine health data sources. The finding of the paper was that the diabetic population had a four time higher mortality rate when compared with non-diabetic population. Males with diabetes lost on average 7 years, females 7.5 years from the year of diagnosis. Diabetes is recorded on a minority of death certificates as a cause of death and therefore detection with ICD-10 codes is a poor method for estimating diabetic mortality.

Sickness funds spend up to 4.1 times as much for diabetes patients who develop macro- and micro-vascular complications compared with non-diabetic patients (Liebl et al. 2001). Around 15 to 25 percent of persons aged over 60 years have diabetes. With the rising diabetes prevalence and the fact that in the future the elder population increases, diabetes related costs will become a major part of the health care costs in developed countries (Hauner 2005).

4.5.4 PATIENT FLOWS

Another possibility of assessing the complex structures in health care is the analysis of patient flows. The aim of patient flow analysis is the demonstration of the way of the patient through the health care system. The focus lay within analysis of service utilisation and resource consumption of specific patient groups. The gathered information could serve as a data basis for health care modelling, e.g. decision-trees, Markov models etc. (Reinhold et al. 2011). In Figure 4.5-1 the development of costs for

medications after a stroke are demonstrated on a timeline with weeks before and after the acute event.

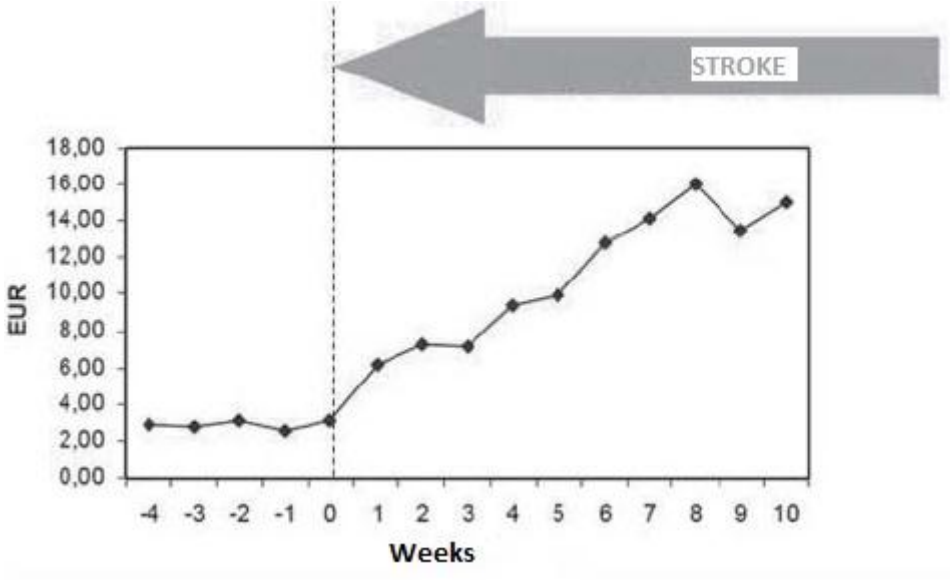

Figure 4.5-1: Demonstration of costs for consumption of medicines of a longitudinal cost of illness study (Reinhold et al. 2011)

This method combined with a cross-sectoral data basis enables health care analysts to compare patient groups with differing treatments, medicines or comorbidities. These results may be used for health care planning purposes.

5 METHODS

This chapter demonstrates the development process of the practical part of the master thesis. The information of the prior literature research was used for a thorough development of the DWH and the systematic approach in answering the research tasks, presented in chapter 2.3. First the DWH had to be compiled. Because of this the ETL process is reflected in this chapter. Therefor different data sources were joined according to the need of the research task. Indicators and patient flows are developed on basis of the created DWH. The selected indicators and methods for the development and demonstration of patient flows are presented in this chapter.

5.1 AVAILABLE DATA

The GeISt project integrates data of different sources and sectors. In chapter 2.1 the aims and structure of GeISt 2.0 were discussed. In context of the master thesis not all data presented in Figure 2.1-1 is available. Due to data security policy and unavailability of data, the analysis had to be performed with a limited data set. Data from the outpatient- and inpatient-rehab-sector was unavailable and data of GPs and community based specialists was limited. The amended structure of the GeISt project is shown in Figure 5.1-1. The volume of the available data only comprises data of the year 2005. Therefore time series analysis and the demonstration of trends have not been possible.

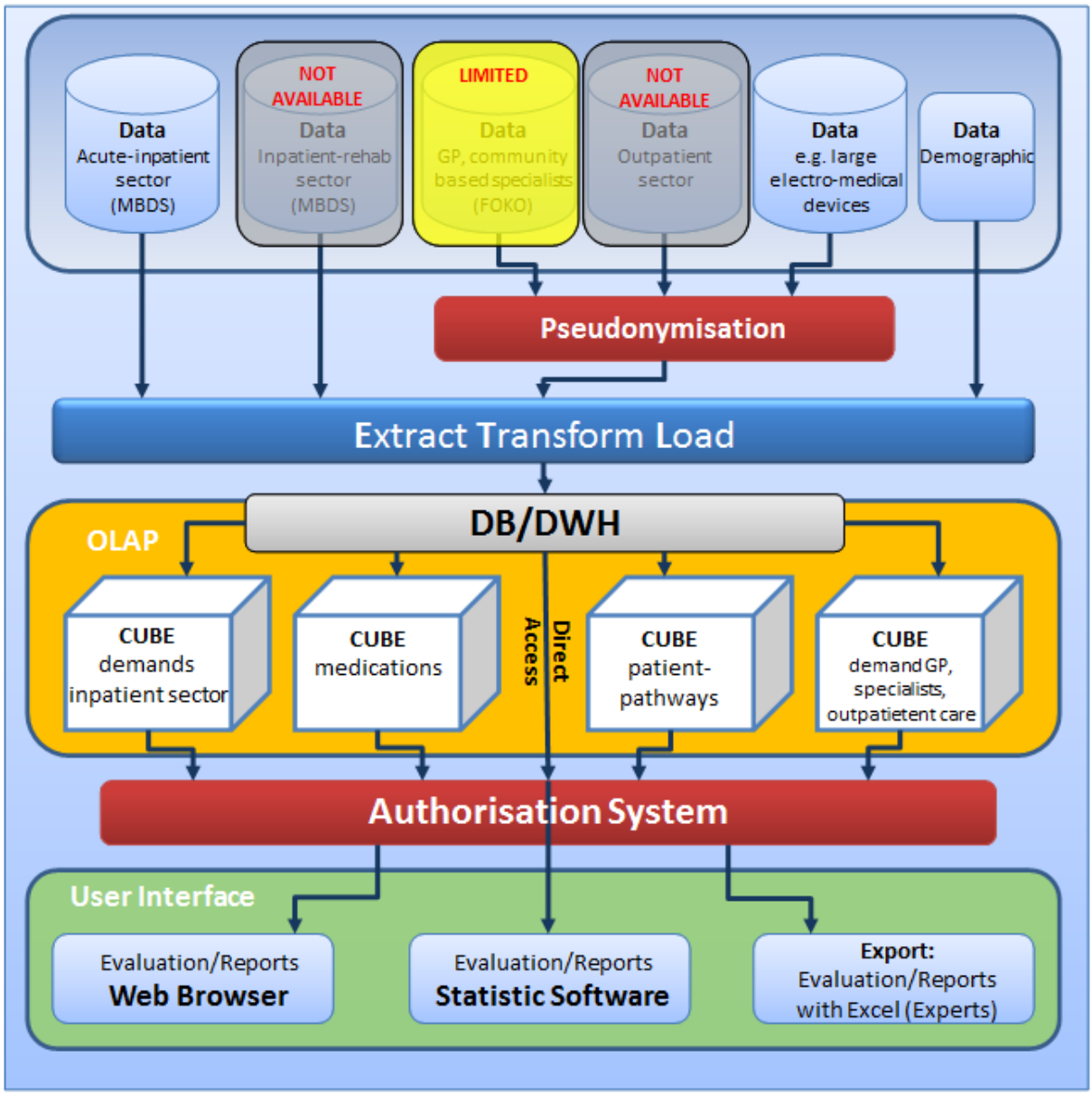

Figure 5.1-1: Amended back- and front-end system architecture of the developed DWH

5.1.1 AVAILABLE DATA INTRAMURAL

The basis for the intramural data is the compulsory Minimum Basic Data Set (MBDS) of 251 hospitals in Austria. For each visit in a hospital a record is created that contains accession number, number of hospital, principal and additional diagnoses, length of hospitalisation, individual medical performances (registered procedures for the Austrian accounting of inpatient care), scorings of individual medical performances, date of hospitalisation, discharge date and patient related data like age, gender and main residence.

5.1.2 AVAILABLE DATA EXTRAMURAL

The basis for extramural data was the routine/accounting data of the medical insurance company StGKK (Steiermärkische Gebietskrankenkassa) from the fiscal year 2005. In the accounting data are services and related costs listed for each patient registered for the service of the StGKK. This data is linked over a unique identifier (Patient ID) to reference data, like gender, age and date of death. Available service data that can be linked to the patients are general practitioner visits, specialist visits, medical substances, preventive medical examinations, medical aids, pregnancy and early childhood records and hospitalisations. Each of these services has related costs and the date of consumption. Unfortunately no selection for specific professions of specialists could be performed due to the limited data set.

5.1.3 DEMOGRAPHIC DATA

As mentioned in chapter 4.4.3 it is possible to group patient cohorts with selected properties (e.g. gender, age, main residence) and relate it to demographic identification numbers. For this purpose data of the Office for Regional Statistics in Styria of the year 2005 was used. The data comprises information on every age group in every post code in Styria. Consequently it is possible to consider regional demographic disparities in the analysis.

5.2 DATA PREPARATION

After the definition and selection of the data sources the actual work for creating the OLAP cubes was performed. Data had to be joined, cleaned and transformed. This section gives insight into the methods that were used for creating OLAP cubes. In chapter 5.3 created cubes, which were used as a data basis in the subsequent analysis, are presented. This section reflects the general way of developing the data basis with the used tools.

5.2.1 JOINING EXTRA AND INTRAMURAL DATA

The medical insurance company provided a dataset that related the unique patient ID to the accession number of the treating hospital. This made it feasible to link the extramural data of the medical insurance company with the MBDSs of the hospitals. In this dataset were 221,762 entries of 139,845 patients. The total extramural dataset of the medical insurance company consists of 835,403 patients in Styria. Styria had in 2005

1,198,543 citizens (Source Statistic Austria). This means the StGKK had insured in 2005 approximately 70 percent of Styrian citizens. A validation of the data basis can be found in section 6.1. The data basis now consists of hospitalisations with accession date, release date, Patient ID (the extramural unique identifier), accession number and hospital number. All the additional information described in section 5.1 is now joinable.

5.2.2 PREPARING THE CROSS-SECTORAL DATA BASIS USING MICROSOFT BUSINESS INTELLIGENCE STUDIO 2008©

All steps for developing the dimension and the fact tables, which were described in chapter 4.4.1, were performed in Microsoft Business Intelligence Studio 2008©. With this software it was possible to integrate SQL queries, excel files, perform further OLE DB processes and data cleaning. The fact and dimension tables were integrated on a Microsoft SQL Analysis Services 2008© server and processed to OLAP cubes, which were accessible with Microsoft Excel 2010© and INFOR Performance Management Application Studio© (web based).

The OLAP Cube structure was chosen, because this technology met the requirements of GeISt 2.0 best, allowed to adjust dimension parameters and calculate facts in real time. Another criterion was that the technology was able to process and demonstrate the cube in a web service. Special restrictions on secure access with INFOR Performance Management Application Studio© allow the admission to content of GeISt to a variety of different user groups.

The Cube was built in a star schema, where every identity in the facts table is linked over a foreign key to a primary key in the corresponding dimension table as demonstrated in Figure 4.4-2. Additional fact tables were necessary to normalise the facts of the cube in real time. With the demographic data from the Styrian Office for statistics it is possible to standardise regional results e.g. for 100,000 citizens or for all hospitalisations for a specific symptom.

Data cleaning for further processing

To grant the consistency of the data basis inconsistencies (e.g. missing-, redundant- and implausible-entries) had to be excluded from the data basis. In the case of mortality calculations patients who had a hospitalisation from end of 2005 until 2006 had to be

excluded from the calculation. This matter is discussed in greater detail in the chapters which present the developed OLAP cubes.

5.2.3 STANDARDISATION AND NORMALISATION WITH DEMOGRAPHIC DATA

One primary aim of the development of health care indicators is the comparison of relevant ratios over a period of time or between regions. In chapter 4.5.1 mortality is presented as: "persons who died within one year, per 100,000 people of a population". This definition does not take account of the age and gender distribution in different areas of Styria. Rural and urban areas have considerable different distributions and therefore have influence on mortality ratios. The gender specific influence is typically corrected by separate analysis of female and male populations. The influence of age could be corrected by performing analysis on every age group. This would lead to a large amount of data and increase confusion. Age standardisation presents a way to reduce age specific influences when using a single indicator. There are two possible ways of age standardisation:

1. Indirect age standardisation
2. Direct age standardisation

For the analysis performed in the master thesis both, the indirect and the direct, age standardisations were used. Because of the better performance for analysis with small number of cases indirect age standardisation was used in these cases. Direct standardisation would add too much value to random fluctuations.

The **indirect age standardisation** is performed in three steps. Firstly, the expected number of death has to be calculated according to formula 5.2-1.

$$Expected\ number\ of\ deaths = \sum \frac{n_i \cdot MR_i}{100\ 000} \tag{5.2-1}$$

Where n_i is the number of persons in age group *i* of the observed population and MR_i is the mortality ratio of age group *i* of the selected standard population. Secondly, observed cases (*d)* are related to the expected number of death. This is called the Standardized Mortality Ratio (SMR) and is demonstrated in formula 5.2-2:

$$SMR = \frac{Observed\ number\ of\ cases}{Expected\ number\ of\ deaths} = \frac{d}{\sum \frac{n_i \cdot MR_i}{100\,000}}$$

(5.2-2)

Thirdly, the SMR is multiplied with the Crude Death Rate *(CDR)* of the standard population and the result is the indirect standardised mortality ratio (MR_{is}). This step is demonstrated in formula 5.2-3:

$$MR_{is} = CDR \cdot SMR = \frac{Number\ of\ deaths}{Average\ population} \cdot 100\,000 \cdot SMR$$

(5.2-3)

Direct age standardisation is a reversal of the indirect standardisation method. Age specific ratios e.g. mortality ratios are related to a standard population of free choice. In the analysis standardisations were performed with the old European standard population and the population of Styria. The standardisation is performed according to formula (5.2-4)

$$MR_{DS} = \frac{\sum(N_i \cdot mr_i)}{\sum N_i}$$

(5.2-4)

N_i is the number of persons in the standard population and mr_i is the age specific e.g. age mortality or morbidity ratio for 100,000 citizens of the investigated population. The crude rates are standardised and therefore age structural influences are minimized. Age standardised parameters are fictive and represent only differences of standardised populations. The difference depends on the used standard population. For a better interpretation of the results a standard population with a similar age structure should be chosen.

These methods are presented in greater detail in (Arbeitsgemeinschaft für die Gesundheitsberichterstattung der Länder (AOLG) 2003). Further it is also possible to standardise morbidity ratios (prevalence and incidence) with the methods presented above. The standardisation was performed with Microsoft Excel© and INFOR Performance Management Application Studio™, after the actual cube development.

5.3 IMPLEMENTATION OF THE OLAP CUBES IN MICROSOFT BUSINESS INTELLIGENCE STUDIO 2008©

In this section the criteria for the selection of the data basis for the OLAP cubes are presented and exclusion criteria for each cube are demonstrated respectively. The ETL process is performed for each cube particularly according to the scheme presented in section 4.4.2. A more detailed description of creating OLAP cubes in a DWH structure is presented in (Larson 2008).

In the following sub-chapters the developed cubes in the environment of the GeISt 2.0 DWH are presented:

1. 30-days-mortality cube
2. Diabetes prevalence cube
3. Diabetes patient flow cube
4. Stroke patient flow cube
5. Heart insufficiency patient flow cube
6. Acute myocardial infarction patient flow cube

5.3.1 IMPLEMENTATION OF THE CUBE 30-DAYS-MORTALITY

The data bases for this cube are all persons who died within 30 days after hospitalisation. All patients who died in 2005 are selected and joined with their latest hospitalisation. After that, only persons who died within 30 days are selected. If only MBDS data would be the basis for further analysis, no persons who died outside the hospital would be included. If the analysis would be performed with data of the social insurer only, no diagnoses for further investigations would be available. The cross-sectoral data basis allows the relation of time of death with the latest diagnose and hospitalisation. The attributes of extramural and intramural data presented in chapter 5.1 are joined.

In the year 2005 died 6,720 StGKK insured patients according to the data set provided. 4,967 of these patients had a hospitalisation in 2005. Due to some peculiarities of the data basis, some entries in the database had to be cleaned manually. For example there were problems when a patient had a transfer to another hospital at the day of death. This resulted in multiple entries according to the different hospitalisations on the day of death. 20 patients with multiple entries in the 30-days-mortality data basis were detected. There were two different cases:

In the first case patients had principal diagnoses in the same ICD chapter. E.g. patients had in one record a principal diagnose I50.1 and in the other record I50.9. I50.1 is a left heart insufficiency and I50.9 is a general heart insufficiency without further specifications. In this case the more exact specification was taken for the 30-days-mortality data basis.

In the second case patients had the principal diagnoses in different ICD chapters. E.g. the patient was in a mental hospital with a mental illness and then moved to a general hospital, where the patient died on a haemorrhagic infarct. In this case the latter principal diagnoses were taken for the data basis.

Transports at the day of death caused a shorter time until death. Therefore the previous (longer) hospitalisation record was used in the data basis. Out of the joined data set 3,747 patients died 30 days after hospitalisation.

Fact tables:

The 30-days-mortality cube comprises three fact tables. The following facts are directly measureable:

30-days-mortality fact table:

1. Deaths (every person who died in a time-frame of 30 days after hospitalisation).
2. Amount of diagnoses of the last hospitalisation (principal and additional)
3. Amount of consumed extramural services for the fiscal year until death
4. Amount of consumed intramural services for the fiscal year until death
5. Intramural costs of the last visit in the hospital
6. Extramural costs after discharge until death
7. Extramural costs for the fiscal year until death
8. Intramural costs for the fiscal year until death
9. Charlson index of the patient at last hospitalisation

Hospitalisations-fact table:

1. Number of hospitalisations
2. Charlson index on basis of hospitalisations

Demographic fact table:

- Number of citizens

Calculated facts:

With Microsoft Business Intelligence Studio 2008© it is possible to develop Multidimensional Expressions (MDX) queries for OLAP cubes. Facts of the three prior presented fact tables could be linked and further present results with higher information content. E.g. it is possible to relate facts per case, per 100,000 citizens or per number of hospitalisations. Additionally extrapolations of results and calculation arithmetic means of facts are possible.

Dimension tables:

For the stratification of the facts are following dimensions available:

1. Age
2. Diagnose
3. Case (Patient ID)
4. Gender
5. Main residence
6. Hospital
7. Month of death
8. Days until death
9. Extramural or intramural death
10. Number of hospitalisations
11. Charlson index

All dimensions except dimension "gender" and dimension "extramural or intramural death" have finer- and coarser-grained subcategories.

5.3.2 IMPLEMENTATION OF THE CUBE FOR DIABETES PREVALENCE

Diabetes patients are detected via the use of antidiabetic agents. The social insurance data includes records on types of prescribed medicines on every insured patient. With the ATC code "A10" diabetes patients are detected in the routine data. The data basis is footed on the identification of individuals. Therefore it is possible to allocate service consumption individually. The cross-sectoral information is the linkage of patients with the Charlson comorbidity index which is developed of intramural diagnosis data and the

identification of non-drug treated patients on basis of hospital records. 29,761 insured patients could be identified using antidiabetic agents. During the ETL process no peculiarities led to the exclusion of data base records.

Fact tables:

The diabetes prevalence cube has two fact tables. Following facts are directly measurable:

Diabetes patient's fact table:

1. Number of diabetes patients
2. Number of medical substances consumed
3. GP visits
4. Specialist visits
5. Number of hospitalisations
6. Period of hospitalisation
7. Sick leave
8. Period of sick leave

Demographic fact table:

- Number of citizens

Calculated facts:

Similarly to the 30-days-mortality cube the Microsoft Business Intelligence Studio 2008™ allows the development of MDX queries to enhance the information content of the facts. E.g. it is possible to calculate the diabetes prevalence and relate GP and specialist visits per case or per 100,000 citizens.

Dimension tables:

For the stratification of the facts are following dimensions available:

1. Age
2. Case (Patient ID)
3. Gender
4. Main residence

5. Charlson index of all 2005 hospitalisations

5.3.3 IMPLEMENTATION OF THE PATIENT FLOW CUBE FOR DIABETES PATIENTS

Also, for the diabetes patient flow cube the identification of patients was performed via the ATC code "A10". Unlike to the prevalence calculations, where the aggregations are patient based, the data basis is service based. Available data from intramural and extramural services are demonstrated alongside a time axis. Therefore it is possible to follow individual patient flows and patient cohort flows over the year 2005. Costs for following services are included into the cube:

- Extramural services
    - GP visits
    - Specialist visits
    - Patient transport services
    - Medical or therapeutic aids
    - Medical substances
    - Additional not further specified services
    - Sick leave
- Intramural services
    - Hospitalisations

Fact tables:

The diabetes patient flow cube includes two fact tables.

Patient flow service fact table:

- Number of services
- Costs

Demographic fact table:

- Number of citizens

Calculated facts:

Similarly to the other cubes the Microsoft Business Intelligence Studio 2008© allows the development of MDX queries to enhance the information content of the facts.

Extrapolations and linking to demographic data enhances the information content of the cube.

Dimension tables:

For the stratification of the facts are following dimensions available:

1. Age
2. Case (Patient ID)
3. Gender
4. Main residence
5. Service type
6. Charlson index of all 2005 hospitalisations
7. Time of service consumption

Service types are the previously presented extramural and intramural services.

5.3.4 IMPLEMENTATION OF THE PATIENT FLOW CUBE FOR STROKE PATIENTS

For the stroke patient flow cube services were aggregated for patients with a stroke in 2005. Following ICD-10 codes for the identification of stroke patients in hospital records were used:

- Haemorrhagic stroke
    - I60.0-I60.9 (Subarachnoid haemorrhage)
    - I61.0-I61.6, I61.8, I61.9 (Intracerebral haemorrhage)
    - I62.0, I62.1, I62.9 (Other nontraumatic intracranial haemorrhage)
- Ischaemic stroke
    - I63.0-I63.6, I63.8, I63.9 (Cerebral infarction)
    - I64 (Stroke, not specified as haemorrhage or infarction)

As the patient flow cube for diabetes patients, this cube is based on services presented in chapter 5.3.3. The fact tables, calculated facts and dimension tables are equal to the diabetes patient flow cube. Additional to the directly measurable facts of the diabetes patient flow cube the period of hospitalisation and sick leave periode is measurable. For a better comparison of patient groups the service consumption is aligned on a transformed time axis. The transformation process is described in greater detail in chapter 5.5.1.2.

5.3.5 IMPLEMENTATION OF THE PATIENT FLOW CUBE FOR HEART INSUFFICIENCY PATIENTS

This cube is based on the identification of patients with a diagnosed heart insufficiency in 2005. Following ICD-10 codes for the identification of heart insufficiency patients in hospital records were used:

- I11.0 (Hypertensive heart disease with (congestive) heart failure)
- I13.0 (Hypertensive heart and renal disease with (congestive) heart failure)
- I50.0 (Congestive heart failure, Right ventricular failure)
- I50.1 (Left ventricular failure)
- I50.9 (Heart failure, unspecified)
- R57.0 (Cardiogenic shock)

As the patient flow cubes this cube is based on services presented in chapter 5.3.3. The fact tables, calculated facts and dimension tables are identical to the patient flow cube for stroke and heart insufficiency patients.

5.3.6 IMPLEMENTATION OF THE PATIENT FLOW CUBE FOR ACUTE MYOCARDIAL INFARCTION

The cube is service based like the other patient flow cubes. Patients with acute myocardial infarction were identified with following ICD-10 codes of hospital records:

- I21.0 (Acute transmural myocardial infarction of anterior wall)
- I21.1 (Acute transmural myocardial infarction of inferior wall)
- I21.2 (Acute transmural myocardial infarction of other sites)
- I21.3 (Acute transmural myocardial infarction of unspecified site)
- I21.4 (Acute subendocardial myocardial infarction)
- I21.9 (Acute myocardial infarction, unspecified)

The identification includes patients with a myocardial infarction specified as acute or with a stated duration of 4 weeks or less from onset. It excludes complications followed by acute myocardial infarctions or subsequent myocardial infarctions. The fact tables, calculated facts and dimension tables are equal to the patient flow cube for stroke patients.

5.4 IMPLEMENTATION OF THE CHARLSON COMORBIDITY INDEX

In Table 4.5-2 the used ICD-10 codes for the estimation of the Charlson comorbidity index are demonstrated. In the analysis two different methods were used for summing up the Charlson index score. Firstly, the score was calculated exclusively on diagnosis data of the actual hospitalisations. Secondly, the maximums of scorings in each of the 19 comorbid conditions in the year 2005 are summed up for patients with multiple hospitalisations. An example for both calculation methods is demonstrated in Table 5.4-1. This example shows a diabetes patient with an acute myocardial infarction at the first hospitalisation in the year 2005. The reason for the second hospitalisation is related to the patient's diabetes or is not a morbid condition detected by the Charlson index algorithm. The third reason for hospitalisation is related to diabetes with end-organ damage. If only the maximum of the Charlson index would be selected, the method would miss the patient's acute myocardial infarction and would be correspondingly lower.

Comorbid condition/ Charlson index	weight	hospitalisation 1	hospitalisation 2	hospitalisation 3	Max
Myocardial infarction	1	1			**1**
Diabetes	1	1	1	1	**1**
Diabetes with end-organ damage	2			2	**2**
Any Tumour	2				
Leukaemia	2				
Charlson index hospitalisation 1		**2**	0	0	
Charlson index hospitalisation 2		0	**1**	0	
Charlson index hospitalisation 3		0	0	**3**	
Charlson index 2005					**4**

Table 5.4-1: Demonstration of the calculation methods for the Charlson index based on the actual hospitalisation and the whole year of observation for one patient

The second method has been implemented especially for detection of badly done coding of chronic illnesses and to get an overview on the patient's "burden of disease". The calculation of the Charlson index was performed with hospital record data in SQL. The calculated indexes were either joined on hospital admissions or, in case of the Maximum-Charlson index estimation method, on the patient ID.

5.5 INDICATOR DEVELOPMENT

Based on routine data, end-result indicators have been developed. In this chapter these indicators, which are embedded in the solution process of the research tasks presented in chapter 2.3, are discussed in greater detail. Indicators are developed for purposes of:

1. Process-monitoring
2. Structural analyses
3. Health reporting

The developed indicators are rate based and are developed in the OLAP environment. Indicators are risk adjustable in real time. For a better comparison and more valid results indicators are adjustable for:

- Age
- Gender
- Main residence
- Comorbid condition

In some cases the OLAP cubes serve as data basis and the indicators are further processed in Microsoft EXCEL©, Microsoft MAPPOINT© or INFOR Performance Management Application Studio™.

5.5.1 PROCESS-MONITORING INDICATORS

The continuous observation of relevant indicators serves as a tool for discovering undesirable events in their early stage. Due to the limited time-frame the data set represents, process monitoring with mortality indicators for rare symptoms provides no meaningful results. Patient flows present a way of detecting heterogeneities in patient care. On basis of patient flow cubes, following indicators have been developed:

5.5.1.1 VARIATION OF HEALTH CARE UTILISATION PATTERN INDICATORS

As a result of the large health care economic burden diabetes patients and other patient groups are causing, investigations on service consumption have been performed. Cross-sectoral character of this indicator set has been achieved with the identification of health care utilisation, the possibility of risk adjustment with comorbid conditions and by the identification of patient groups with the diagnoses of hospital data. The analysis has been performed for following symptoms:

1. Diabetes
2. Stroke
3. Acute myocardial infarction
4. Heart insufficiency

Regional varieties of service consumption are detectable with this indicator set. Risk adjustment can be performed for gender, age groups and comorbid condition. Further the number of services is normalised for 100,000 citizens or per case. The indicator allows the comparison of services on every month of consumption. Therefore it is feasible to monitor seasonal fluctuations on service consumptions. Each service has allocated costs and consequently it is possible to monitor regional varieties on a monetary basis.

The indicator set comprises following services:

1. GP-visits
2. Specialist-visits
3. Medications
4. Hospitalisations
5. Period of hospitalisation
6. Sick leaves
7. Period of sick leave
8. Patient transports
9. Medical or other therapeutic aids
10. Additional not further specified services

5.5.1.2 INDICATORS FOR PATIENT FLOWS BEFORE AND AFTER AN ACUTE EVENT

One advantage of the cross-sectoral data basis of GeISt is the possibility to track patients over hospital borders. Especially acute events, e.g. acute myocardial infarction or stroke, may have influences on patient care patterns. These indicators enable the demonstration of regional varieties of patient care patterns before and after an acute event.

The data bases are the patient flow cubes of stroke and acute myocardial infarction patients. For a better comparison of patient cohorts the timeline of patient service consumption has been transformed. This was achieved by identifying acute events and

setting this as a starting point for the analysis. Services are aligned on a 365 day time axis. Consumption before the acute event is indicated with a minus and days until the acute event. Consumption after the acute event is indicated by positive days after the acute event. Therefore it is possible to align patient cohorts along a time-axis, all having the same starting point. Risk adjustment is feasible for age, gender and comorbid condition. The cross-sectoral character of the indicator was achieved by identifying the patients (including service utilisation) and by performing risk adjustment for comorbid conditions. Patients who died after the acute event had to be considered in further analysis. Mortal events after the acute event had to be excluded for the estimation of per case values. The mortality has been calculated on a weekly basis (one week, two weeks up to 8 weeks). The algorithm for the identification of mortal events is the same as for the 30-days mortality cube data basis presented in chapter 5.3.1, performed for every week.

The indicator set allows comparisons of service consumptions on regional level and therefore the identification of varieties after an acute event. An aggregation of following services and related costs is possible:

1. GP-visits
2. Specialist-visits
3. Medications
4. Hospitalisations
5. Sick leaves
6. Patient transports
7. Medical or other therapeutic aids
8. Additional not further specified services

5.5.2 STRUCTURAL ANALYSES INDICATORS

These indicators are intended to serve as support for making the right decisions in health care planning. Indicator results may be used as basis for contracts or for choice of location. Health care authorities should have more easily understandable insight into the complex structure of the Styrian health care system.

5.5.2.1 30-DAYS-MORTALITY INDICATORS ON REGIONAL- AND HOSPITAL-LEVEL

Measuring 30-days-mortality is one way to assess the quality of health care, see chapter 4.5.1. Therefore it is necessary to compare the results on regional and hospital level. The 30-days-mortality indicator set comprises two indicators and is applicable on all ICD-10 diseases registered by the WHO. In the context of this master thesis the focus is set on the analysis of:

1. Stroke
2. Acute myocardial infarction
3. Heart insufficiency

The data basis provides the 30-days-mortality cube, which is described in chapter 5.3.1. The cross-sectoral character of the indicator set has been achieved by joining hospital diagnoses with registered deaths of the social insurance company. Risk adjustment was performed for gender, age and comorbid condition. Further processing for presentation of the indicators had to be performed in INFOR Performance Management Application Studio™, Microsoft MapPoint© and Microsoft Excel©.

30-days-mortality vs. hospital mortality on hospital level

This indicator is described in (Heller and Günster 2008). In their analysis, the dependency of 90-days-mortality and hospital mortality of heart insufficiency patients was investigated. Their finding was that it is possible to predict 90-days-mortality with hospital mortality. They revealed another important circumstance for hospital quality assessment on basis of mortality. Some investigated hospitals had no mortal events. But when considering the 90-days-mortaltity, mortal events could be assigned. In Figure 5.5-1 every dot not aligning on the regression line indicates hospitals with higher 90-days-mortality compared to hospital mortality. This means, these hospitals would have been completely unsuspicious when quality assessment would be performed on hospital mortality only. This circumstance indicates the necessity of quality assessment over hospital borders.

This indicator has been implemented on the data basis of the GeISt project. The 30-days-mortality cube serves as data basis. As the name of the cube suggests, 30-days-mortality was used instead of 90-days-mortality. Reasons for the decision of using the 30-days-mortaltity are presented in chapter 4.5.1. Only hospitals with more than five

hospitalisations on the investigated mortality have been used in the analysis. The point cloud in Figure 5.5-1 represents the variety of mortality in hospitals. Every dot in the resulting diagram represents a hospital.

The 30-days-mortality ratio was calculated as presented in formula 5.5-1:

$$M_{30\ Days} = \frac{Deaths\ within\ 30\ days\ of\ hospitalisation\ for\ a\ specific\ symptom}{All\ hospitalisations\ within\ a\ hospital\ for\ a\ specific\ symptom} * 100 \quad (5.5\text{-}1)$$

The hospital-mortality ratio was calculated as presented in formula 5.5-2:

$$M_H = \frac{Deaths\ within\ the\ hospital\ for\ a\ specific\ symptom}{All\ hospitalisation\ within\ a\ hospital\ for\ a\ specific\ symptom} * 100 \quad (5.5\text{-}2)$$

Symptoms are selected using ICD-10 codes. Used ICD-10 codes are presented in the chapters representing the cube selection criteria.

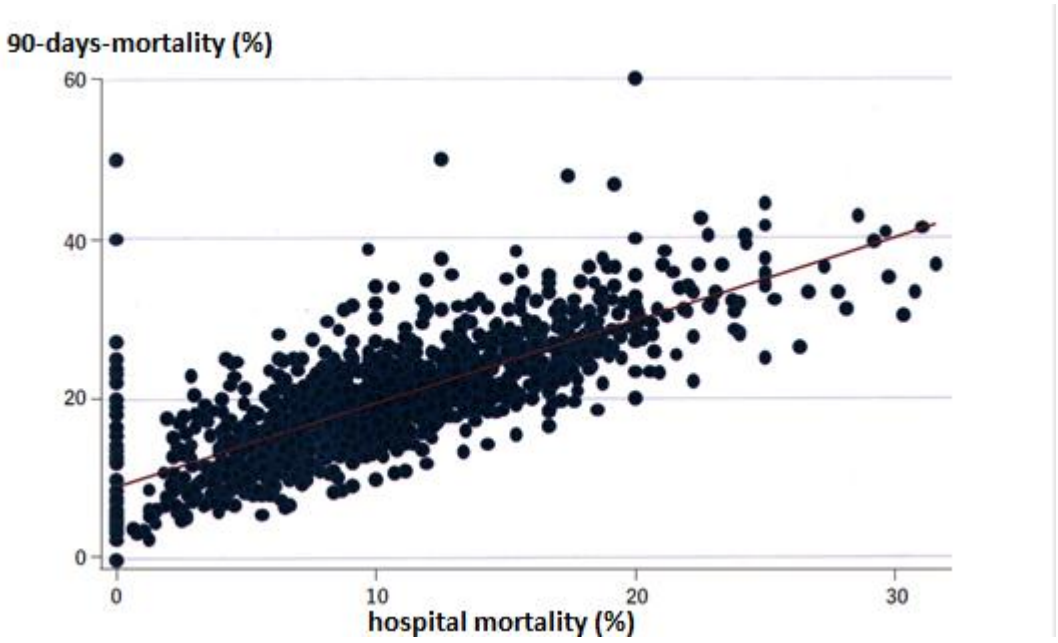

Figure 5.5-1: Dependency of 90-days mortality ratio and hospital mortality ratio for heart insufficiency of around 124,500 patients, of 1,358 hospitals with more than five cases in 2005 in Germany (Heller and Günster 2008)

Regional varieties of 30-days-mortalities per 100,000 citizens

The aim of the indicator is the detection of regional varieties of 30-days-mortality on basis of the patient's main residence. Standardisation has been performed with the

indirect age standardisation method, presented in chapter 5.2.3. Therefore it is possible to minimise age structural influences on the 30-days-mortality. For a better demonstration of the results, the 30-days-mortality is demonstrated on a map of Styria. The calculation of the 30-days-mortality is also demonstrated in chapter 5.2.3.

5.5.2.2 INDICATORS FOR THE IDENTIFICATION OF INFLUENCES OF COMORBID CONDITIONS ON DEMAND OF HEALTH CARE SERVICES

For the identification of influences of different patient groups on demand of health care services, following indicator set has been implemented. The development of this indicator set is a logical next step of the indicator set presented in chapter 5.5.3.2. Due to the identification of comorbid conditions of patients it is possible to detect varieties of demand patterns of patient groups with diverse comorbid conditions.

Identification of Influences of Comorbid Conditions on Demand of Health Care Services

This indicator set detects differences in patient care for patient groups with diverse comorbid conditions according to the Charlson index. Services are aggregated for patients with a specific Charlson index. Following services have been implemented:

1. GP-visits
2. Specialist-visits
3. Medications
4. Hospitalisations
5. Patient transports
6. Medical or other therapeutic aids
7. Additional not further specified services

The cross-sectoral character was achieved by identifying the patients with diagnoses of hospital records and by combining the Charlson index with extramural and intramural service consumptions. The indicator set is applicable for following symptoms:

1. Diabetes
2. Stroke
3. Acute myocardial infarction
4. Heart insufficiency

Identification of Influences of Comorbid Conditions on Demand of Health Care Services before and after an Acute Event

Again, the method of aligning services of patients on a transformed time axis is used. This time, not regional differences, but the influence of comorbid conditions on demand of services are investigated. Also, mortal events after the acute event (e.g. stroke) had been excluded for the calculations. The indicator set has been implemented for the previously mentioned services and symptoms. Additionally, probabilities of service consumptions are selectable.

5.5.3 HEALTH REPORTING INDICATORS

Quality aspects are transmitted to the interested public and stakeholders in health care via health reporting. Indicators present a way for identifying varieties in quality concerns. Therefore health reporting identifies deficits in the public health situation and helps to develop measures for improvement.

5.5.3.1 DIABETES PREVALENCE IN STYRIA

For identification of the "burden of disease" a diabetes prevalence approximation is crucial. In chapter 4.5.3, economic and quality of life impacts of diabetes have been discussed. Attributable to the fact that there has not been a comprehensive diabetes survey in Styria, diabetes prevalence approximations on basis of routine data present vital information for health care planning. The cross-sectoral character has been achieved by joining the Charlson index for risk adjustment and by using extramural health insurance data and intramural hospital records data for the diabetes prevalence approximation.

The data basis is the diabetes prevalence cube, described in section 5.3.2. The diabetes prevalence is adjustable for age, gender, region and comorbid condition and was standardised to minimize age structure dependent influences. Due to the large number of cases the direct age standardisation was used and the prevalence was standardised to the old European standard population. For a better demonstration, the results were processed onto a Microsoft MapPoint© map of Styria. The indicator points out regional varieties of diabetes prevalence and enables health care decision makers to take these varieties into consideration for planning.

5.5.3.2 BURDEN OF DISEASE INDICATORS

For the identification of regional varieties in the distribution of patients with a high "burden of disease", this indicator set has been developed. It relates the Charlson comorbidity index to patient data (e.g. age, gender, main residence) and consumption of services.

Distribution of diabetes patients with high comorbidity

The data basis is the same as the one was used for the diabetes prevalence approximation. In this case only diabetes patients with a hospitalisation in the year 2005 were selected. The distribution of diabetes patients is direct age standardised to the old European standard population to reduce age structural influences. StGKK patients are selected for a specific Charlson index and the result is further processed onto a map of Styria, using Microsoft MapPoint©. The cross-sectoral character was achieved by identifying the diabetes patients with the relation to the Charlson index.

Burden of disease in Styrian regions

These indicators relate the Charlson index on basis of the year 2005 to patients with a specific illness. The average Charlson index for each region in Styria was calculated. This indicates distributions of patient-case-mixes and enables health care decision makers to watch trends of the distribution of the "burden of disease". The cross-sectoral character was achieved by identifying the patients with diagnoses of the intramural sector on basis of hospital admissions and relating this information to a unique patient ID of the social insurer. In the analysis of this master thesis the indicator has been implemented for patients with:

1. Stroke
2. Acute myocardial infarction
3. Heart insufficiency
4. Diabetes

5.6 PROCESSING AND PRESENTATION OF THE RESULTS

Indicator results are processed in Microsoft Excel© and/or in INFOR Performance Management Application Studio™, on basis of the previous demonstrated OLAP cubes. For a better demonstration of the results Microsoft MapPoint© was used. With this

software it is possible to demonstrate e.g. 30-days-mortality, prevalence etc. on a map of Styria. Because of the fact that post codes are no exact regional boundaries the demonstrated facts are demonstrated not on exact regional borders. This issue has no influence on the calculated facts.

6 DISCUSSION OF RESULTS

This chapter presents a validation of the cross-sectoral data basis. Suitability of 30-days-mortality and the use of the Charlson index are discussed. The Styrian population is compared with the comprehensive database of StGKK insured patients.

The major part of this chapter is covered by the demonstration and discussion of the developed DWH environment and the developed cross-sectoral indicators. In this master thesis not all compiled indicators are demonstrated for all symptoms and services. The master thesis represents a proof of concept analysis of cross-sectoral data examinations. Only the most noteworthy results of an indicator type are presented.

6.1 VALIDATION OF THE DATA BASIS

In order to validate the cross-sectoral data basis, a comparison with the total population of Styria is necessary. The StGKK population structure differs only marginally from the Statistik Austria dataset. This is presented in Table 6.1-1. The total dataset of the medical insurance company consists of 835,403 patients in all of Styria. Styria had 1,198,543 registered citizens in 2005. This means the StGKK had insured approximately 70 percent of Styrian citizens in that year. On a regional basis the maximum age structural difference was detected for 20 to 64 year old citizens with main residence in Leoben. The divergence lies within minus 5 percent to the Styrian population. The average deviation lies within one percent for males and females respectively.

	Statistik Austria Steiermark 2005		**StGKK Accounting Data**	
Age group	Citizens total	Citizens Percentage	Insured Patients total	Insured Patients Percentage
	#	%	#	%
0 - 19	251,893	21.02	193,476	23.16
20 - 64	737,118	61.50	511,950	61.28
65 and older	209,532	17.48	129,977	15.56
Total	**1,198,543**	**100.00**	**835,403**	**100.00**

Table 6.1-1: Comparison of StGKK and Statistik Austria population data

In Figure 6.1-1 and Figure 6.1-2 a comparison of the population in Styrian hospitals of StGKK insured patients with the Styrian population is demonstrated. In the hospital

dataset, which joined the patient ID with a hospital- and an accession-number, were 221,762 entries of 139,845 patients. As expected, the hospitalized population was older than the Styrian population. The mean of the female population in hospitals is 50.49 years, as compared to 42.23 years. The mean of the male population in hospitals is 46.32 years, as compared to 38.84 years. The difference is slightly larger for females. This fact is supported in Figure 6.1-3, where beginning with around 20 years, women have more hospitalisations than men. These considerable structural differences in age, that are also dependent on symptoms, had to be considered in further analysis.

Additionally, the differences of insured people by different health care insurance companies have to be considered in the analysis. Although age and gender probably do not differ much, socio-economic factors need to be considered as well. Factors such as the social-status, group of profession or education may vary. These may contribute to a different distribution of prevalence and incidence of symptoms. In the course of the master thesis no consideration of social-economic factors could be performed. This issue could be target of future work in the environment of the GeISt project.

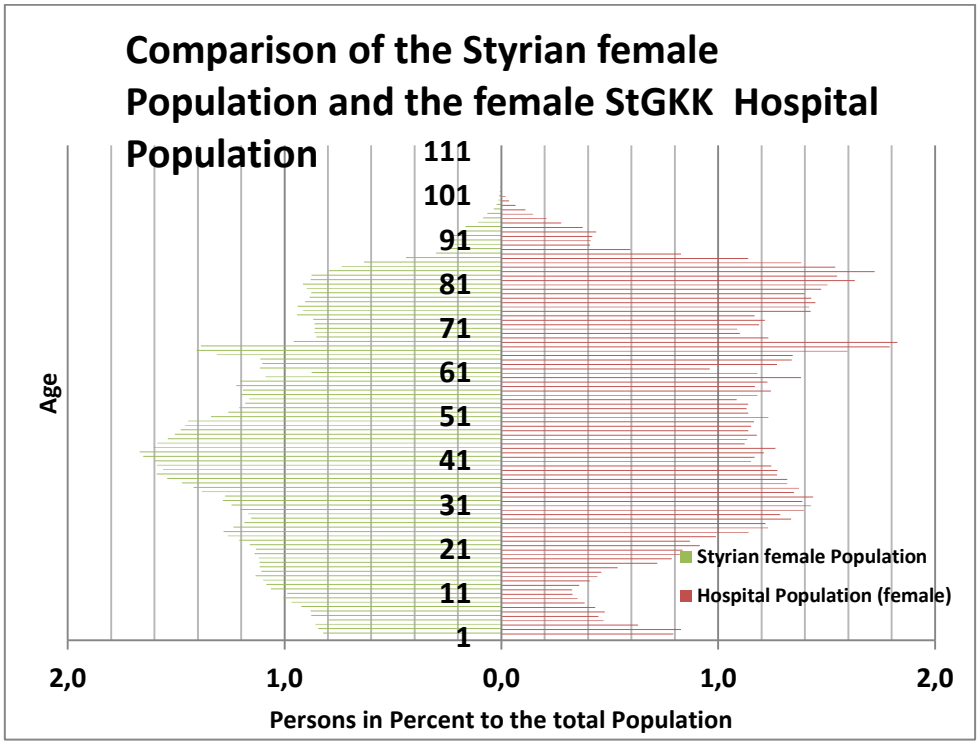

Figure 6.1-1: Comparison of the Styrian female population and the female StGKK hospitalized population normalised to the total number of people

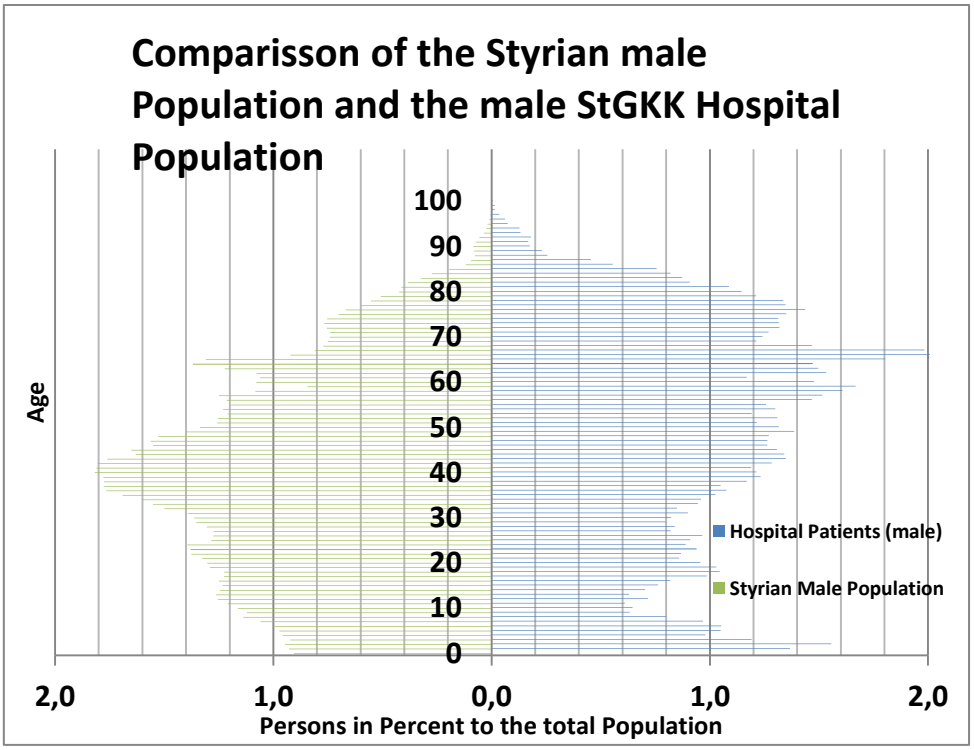

Figure 6.1-2: Comparison of the Styrian male population and the male StGKK hospitalized population normalised to the total number of people

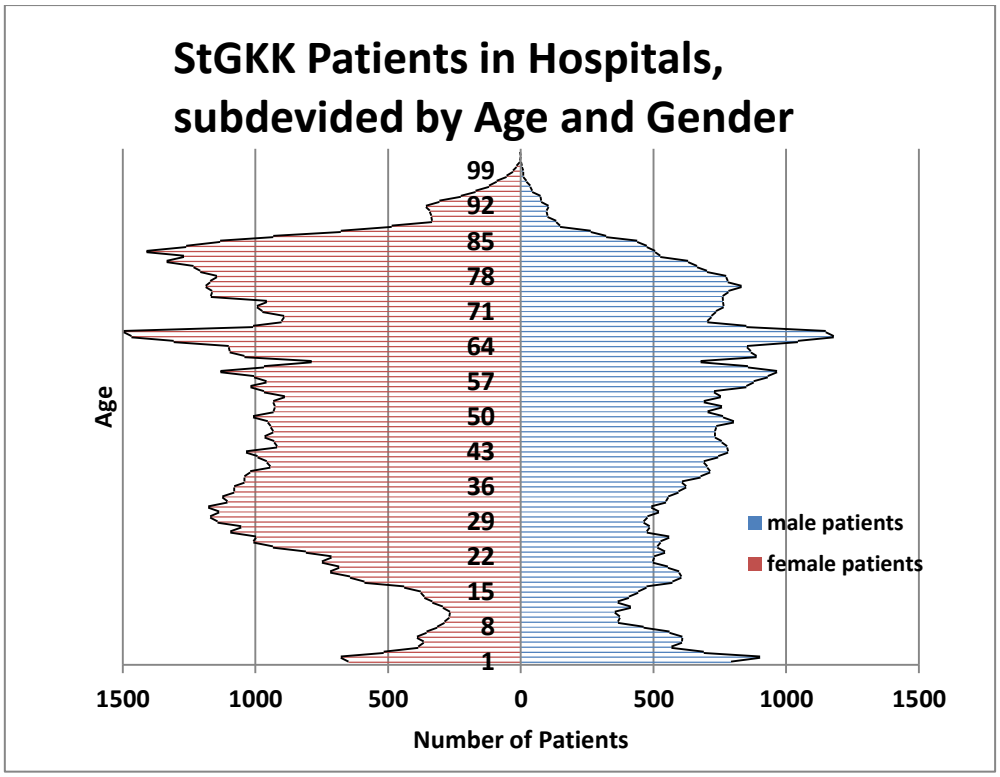

Figure 6.1-3: Comparison of the age structure of the StGKK dataset subdivided by age and gender

It was necessary to neglect specific age groups in order to reduce age dependent effects in the analysis. Therefore a fitting of the structural differences was achieved and effects which disguised statistical significance were reduced.

Plausibility check for the use of the 30-days-mortality

For the identified 30-days-mortality cases a plausibility check has been performed. Table 6.1-2 shows that there are differences between the shares of allocatable causes of death between the 30-days-mortality and the causes of death from the Statistik Austria data. A possible explanation for these differences is that many people who die on natural causes have no hospital record. The relatively big difference between cardiovascular diseases supports this fact, because most natural causes of death are related to cardiovascular diseases (OECD. 2009). Another fact which supports this statement is that there are small differences in the causes of death for neoplasms. This makes sense, because the period from diagnosing the neoplasm to the actual death is relatively long compared to e.g. an acute myocardial infarction, and thereby more people are recorded in hospitals. In chapter 4.5.1, reasons for the choice of 30-days-mortality as an indicator for measuring quality of patient care are presented.

Death allocatable to ICD-10 chapter	30-days-mortality		Mortality (Statistik Austria)	
	#	%	#	%
Congenital malformations, deformations and chromosomal abnormalities	8	0,21		
Certain infectious and parasitic diseases	86	2,30	83	0,72
Certain conditions originating in the perinatal period	9	0,24		
Endocrine, nutritional and metabolic diseases	94	2,51	798	6,97
Factors influencing health status and contact with health services	2	0,05		
Disorders of the skin and subcutaneous tissue	18	0,48		
Diseases of the respiratory tract	473	12,62	657	5,74
Diseases of the eye and adnexa	4	0,11		
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	12	0,32		
Diseases of the circulatory system	1104	29,46	4937	43,11
Diseases of the musculoskeletal system and connective tissue	23	0,61		
Diseases of the nervous system	67	1,79		
Diseases of the ear and mastoid process	1	0,03		
Diseases of the genitourinary system	134	3,58	180	1,57
Diseases of the digestive system	304	8,11	528	4,61
Neoplasms	841	22,44	2931	25,59
Mental and behavioural disorders	71	1,89	86	0,75
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	322	8,59		
Injury, poisoning and certain other consequences of external causes	174	4,64	698	6,09
Total	**3747**	**100,00**		

Table 6.1-2: Comparison of causes of death for the calculated 30-days-mortality and the 2005 Statistik Austria mortality of selected ICD-10 chapters

Validation of the use of the Charlson comorbidity index on the GeISt data basis

In chapter 4.5.2 reasons for the decision of using the Charlson comorbidity index as a risk adjustment variable are presented. The used algorithm for identifying illnesses allocated to the Charlson index involves 979 ICD-10 codes of 12,970 ICD-10 codes in total. These codes are coding for different symptoms registered by the WHO. The MBDS comprise 1,155,715 recorded primary and additional diagnoses. 144,158 diagnoses were identified for the calculation of the Charlson index. This means that around 12.5 percent of the confirmed diagnoses in 2005 are included in the algorithm for the calculation of the Charlson index. The index represents no total picture of the "burden of disease", because e.g. no genetic diseases are included in the calculation algorithm.

Especially symptoms occurring in the elder population are covered with the use of the Charlson index, see Figure 6.1-4 and Figure 6.1-5. The cumulative distribution function is shifted towards the elder population for female and male patients. The histograms demonstrate the number of StGKK insured patients with one or more ICD-10 codes, coding for the calculation of the Charlson index in respect to age.

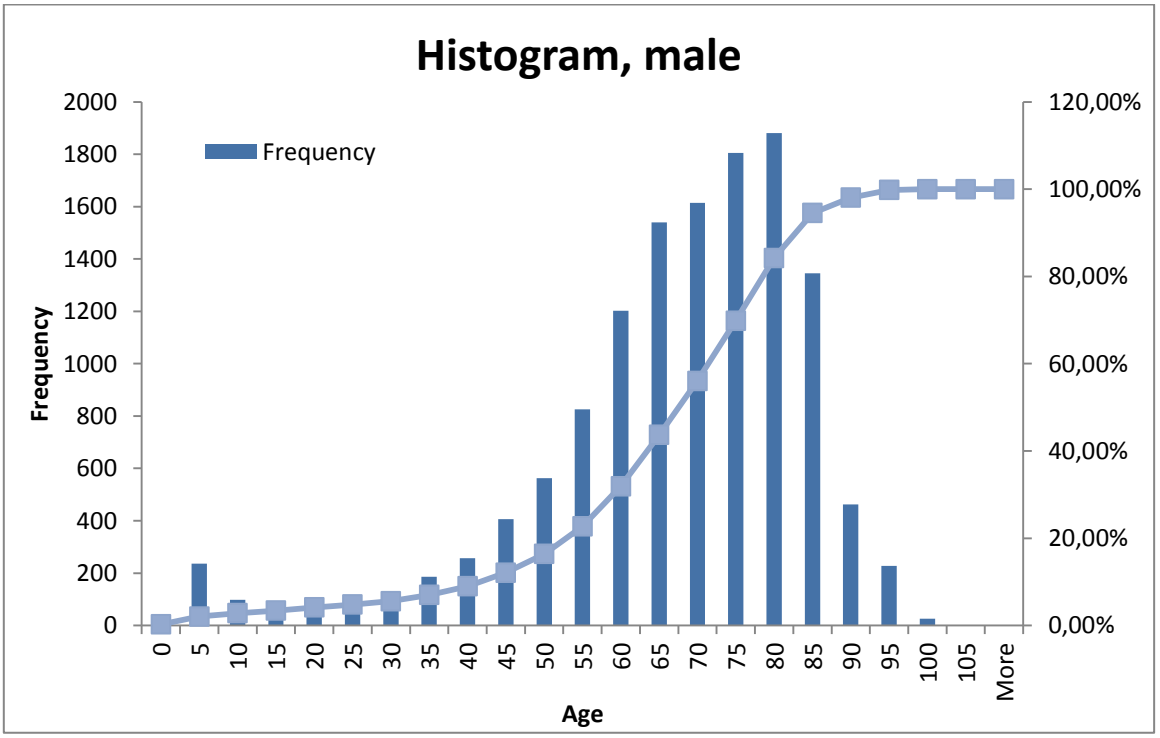

Figure 6.1-4: Histogram and cumulative distribution function for male patients insured by the StGKK, having ICD-10 diagnoses used for calculation of the Charlson index

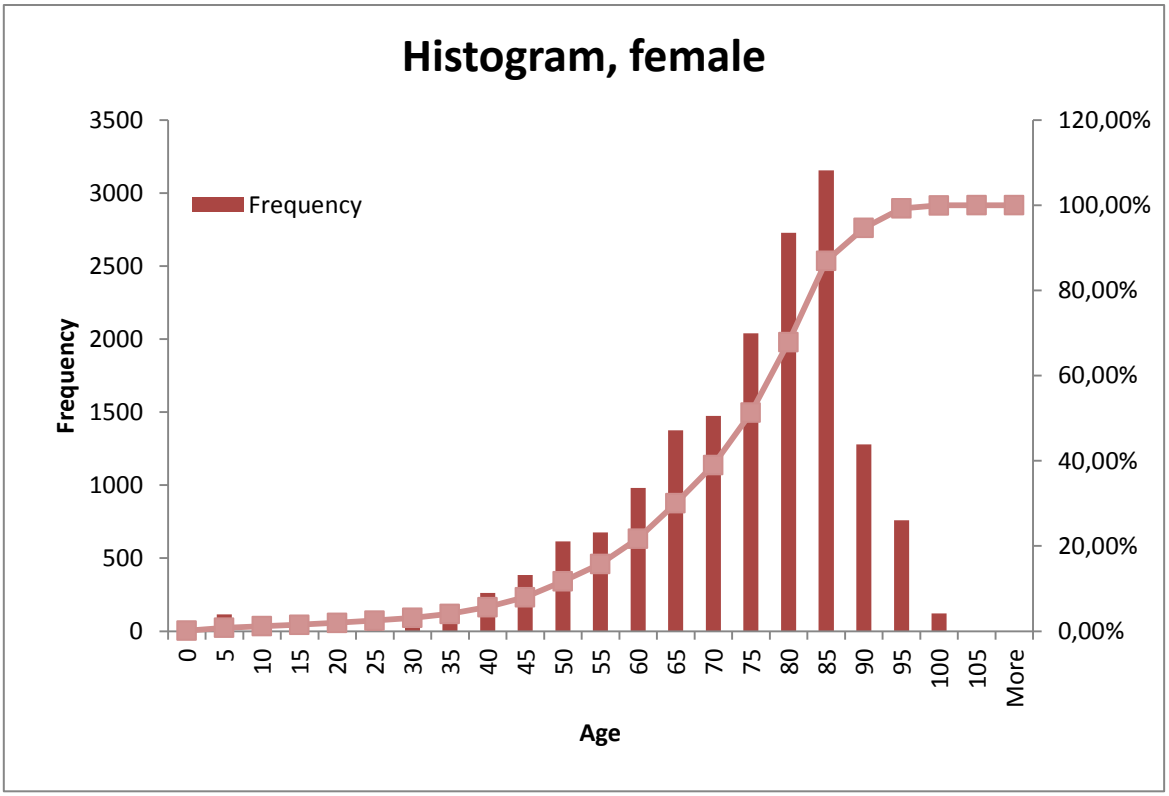

Figure 6.1-5: Histogram and cumulative distribution function for female patients insured by the StGKK, having ICD-10 diagnoses used for calculation of the Charlson index

This validation also shows the need of selection for specific age groups. The use of the Charlson index helps particularly for risk adjustment of the elder population which is causing the most costs of care. In future work also other comorbidity indexes e.g. Elixhauser index (Quan et al. 2005) or severity scores e.g. APACHE II should be implemented to increase the possibilities of risk adjustment for indicator results.

6.2 THE GEIST 2.0 DATA WAREHOUSE

Figure 6.2-1 demonstrates the final structure of the DWH developed in the course of the master thesis. The data sources are the MBDS from the acute-inpatient sector, accounting data of GPs and community based specialists, hospital structural data and demographic data. The information of the data bases has been handled in an ETL process, which has been described in greater detail in the methods section. The developed OLAP cubes, presented in chapter 5.3, are the basis for the supported analysis tools. The DWH is embedded into a Microsoft SQL Server 2008© environment. Indicators are primarily processed in the MDX cube query language. They are conveniently risk adjustable. The indicator sets are arranged in sets for purposes of:

1. Process-monitoring
2. Structural analyses
3. Health reporting

In chapter 5.5 the developed indicators are presented and their purpose is elucidated. The content of the DWH is only accessible via an authorisation system. If the DWH is addressed via Microsoft EXCEL Analysis Services© the information is only available inside the JOANNEUM RESARCH network. If the DWH is addressed with a web browser, only authorized persons, with username and passphrase, have access. In some cases the indicators had to be standardised to reduce age structural effects. The standardisation process is demonstrated in chapter 5.2.3 and was performed in Microsoft Excel© and Infor Performance Management Studio™. Also, for better demonstration the results have been further processed in Microsoft MapPoint©. Access is also possible with statistic software like Microsoft Excel© or R statistical computing©. Therefore it is possible to access the OLAP cubes or directly the unprocessed data via Microsoft SQL© client software.

The DWH presents a convenient way of demonstrating pathways of single patients or patient cohorts with specific selected characteristics. In Figure 6.2-2 this is demonstrated for a 71 year old male diabetes patient with a cardiovascular comorbidity. The process of care is visible on a 12 month, 52 weeks and 365 day time axis. Medicines and services are monetary valued and health care expenditure comparisons for different patient groups are displayable.

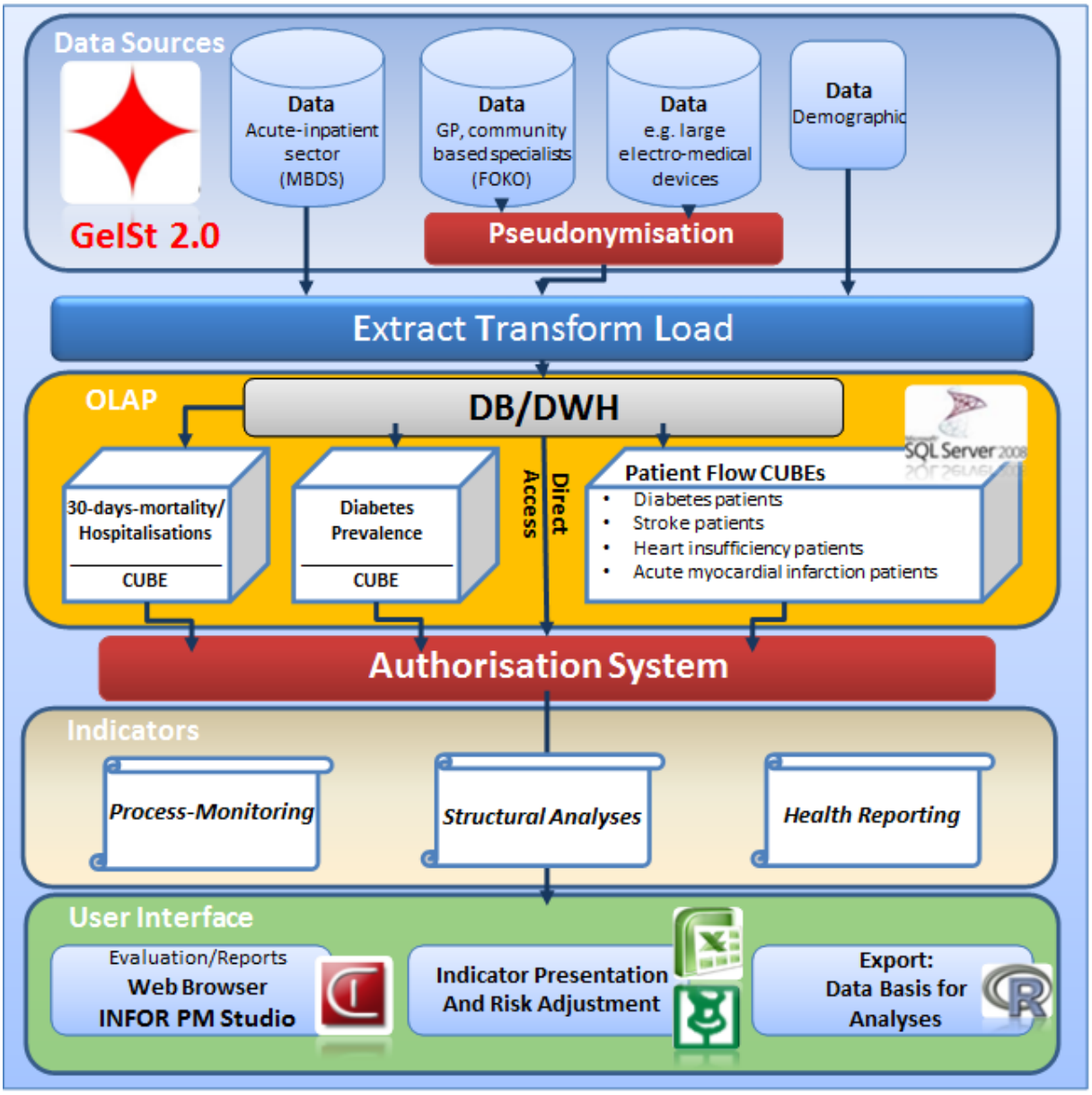

Figure 6.2-1: Structure of the developed GeISt 2.0 DWH

In Figure 6.2-3 the selection process for a specific disease in the 30-days-mortality cube is demonstrated using Microsoft Analytical Services©. It is possible to select for main ICD-10 chapters, sub chapters and single ICD-10 codes by selecting checkboxes. Specific diseases are selected by choosing multiple ICD-10 codes. Also, all other dimensions and facts are customisable by selecting specific checkboxes. The table contents and graphics are updated automatically. As mentioned in chapter 4.4.3, DWH and OLAP cubes present a way of processing huge amounts of data quickly and very conveniently for end users. Therefore, GeISt 2.0 would present a faster way for generating reports and help users with no SQL knowledge to explore a vast cross-sectoral data basis.

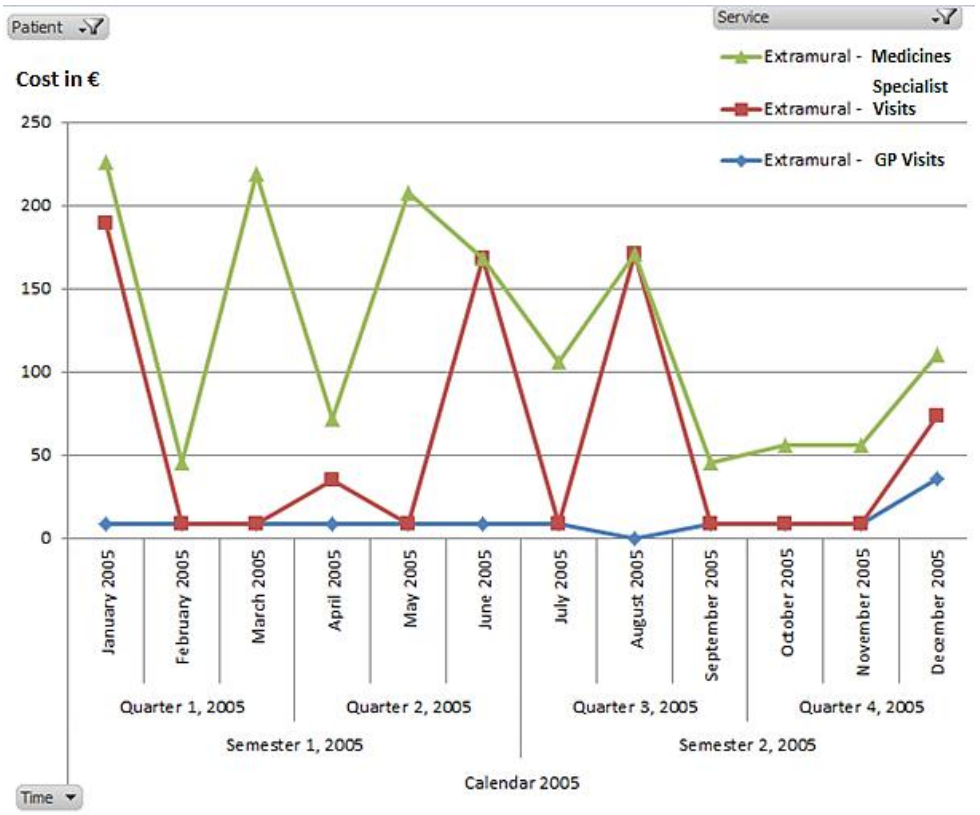

Figure 6.2-2: Patient pathway demonstrated in costs for service consumptions of a 71 year old diabetes patient with an additional cardiovascular disease living in Weiz

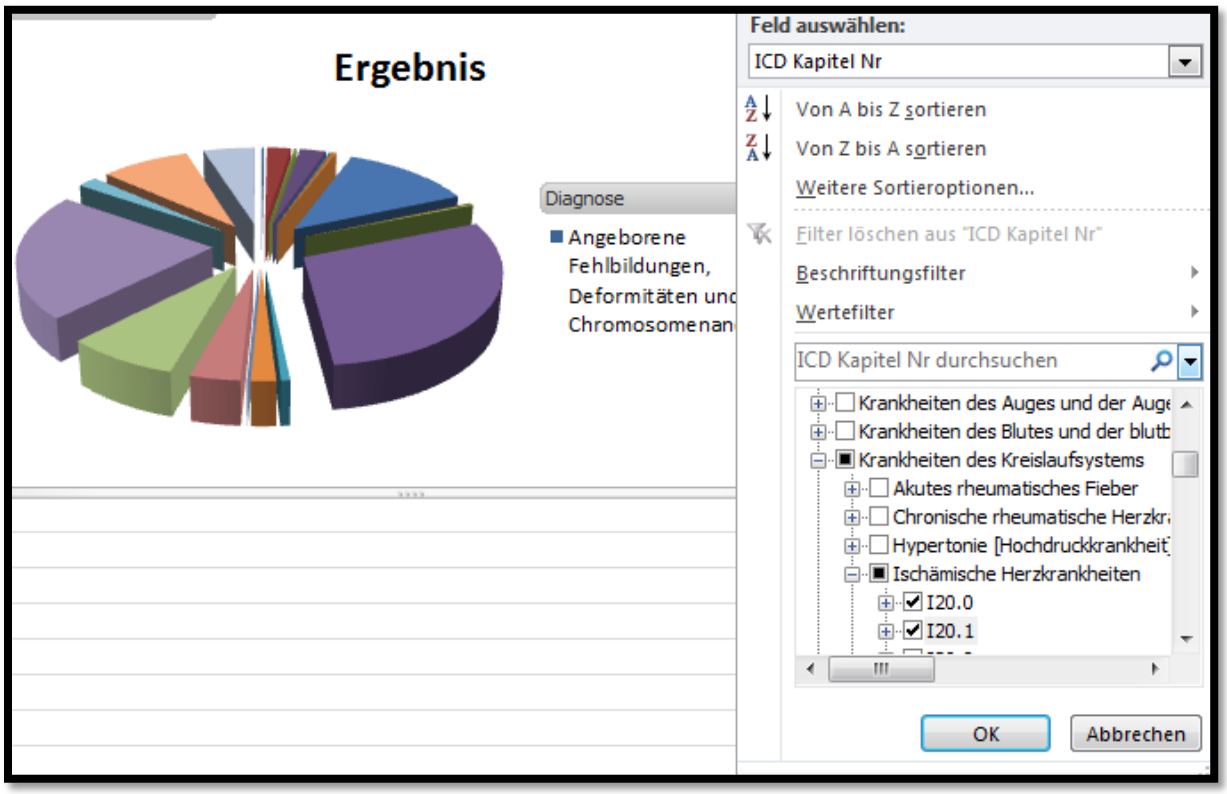

Figure 6.2-3: Diagnose selection process using Microsoft Analysis Services© and the 30-days-mortality cube. Screen Shot in German language

6.3 INDICATOR EVALUATION

In this section the developed indicators, which are described in chapter 5.5, are presented and discussed. Due to the large amount of data produced by the developed indicators with including risk adjustment and standardisation, only the most meaningful examples of the complete indicator set are demonstrated. The indicators are organized in research tasks of process monitoring, structural analyses and health reporting and were performed for the following symptoms:

1. Acute myocardial infarction
2. Stroke
3. Heart insufficiency
4. Diabetes

For better understanding some facts on the investigated symptoms and the cross-sectoral data basis are presented. In Table 6.3-1 a presentation of the number of identified patients with a principal diagnose heart insufficiency, stratified by main residence, age and gender can be found. As the raw frequencies of heart insufficiency patients show, it is necessary to take account of the influence of gender and age for regional comparisons. Additionally, it is possible to select comorbidities to increase validity of the developed indicators. Also, interpretations of results should always include further investigations, because indicators are mainly developed on basis of a small number of cases. In the final version of the GeISt 2.0 DWH it will be possible to compare results with data of other years to increase the validity of the developed indicators.

The regional differences of cases per 100,000 citizens insured by the StGKK who are older than 64 years, demonstrated in Table 6.3-1, are not discussed on purpose. The analysis would not include cross-sectoral evaluations. The presentation should only demonstrate the feasibilities of the GeISt 2.0 DWH.

Data quality problems have strong influences on indicator results. Coding heterogeneities of diagnoses are influencing all developed indicators. The purpose of an indicator is also to show regional differences of coding quality. To establish a comparison of quality of care these influences have to be eliminated.

Heart Insufficiency	Age group							
Main Residence	**20 - 34**		**35 - 64**		**>=65**		**cases per 100,000 >= 65 years StGKK patients**	
	male	female	male	female	male	female	male	female
Bruck an der Mur			6	1	15	19	704.9	487.8
Deutschlandsberg			2		6	13	234.1	311.5
Feldbach			1		2	7	84.1	185.0
Fürstenfeld			3		5	7	535.3	443.9
Graz(Stadt)			9	8	61	185	597.0	908.5
Graz-Umgebung			6		18	32	340.5	378.8
Hartberg			8	4	22	35	929.8	880.1
Judenburg			2		6	13	300.6	381.2
Knittelfeld			1		2	2	206.8	109.2
Leibnitz				2	21	27	703.8	541.5
Leoben			4		10	9	500.3	212.0
Liezen			3	3	25	31	751.9	565.7
Murau			4		15	21	1111.1	986.8
Mürzzuschlag			1		13	11	604.4	325.5
Radkersburg			1		9	16	1015.8	1021.7
Voitsberg			4	2	19	22	843.3	647.2
Weiz			2		12	16	320.9	275.2
Total	**0**	**0**	**57**	**20**	**261**	**466**	**549.2**	**565.2**

Table 6.3-1: Number of heart insufficiency patients in the cross-sectoral data basis of the year 2005

6.3.1 EVALUATION OF PROCESS-MONITORING INDICATORS

This set of indicators serves as a tool for discovering undesirable events in their early stage. Examples of developed indicators in chapter 5.5.1 are presented. It should give GeISt 2.0 a just-in-time monitoring possibility. Identification of regional variation of health care utilisation patterns and patterns before and after an acute event should help health care decision makers in planning and steering purposes. As mentioned previously, because of many different possible evaluation scenarios, the indicators presented in this chapter only demonstrate the feasibility of the indicator set. Only the most meaningful results are demonstrated, to give a basis for further discussion.

6.3.1.1 *VARIATION OF HEALTH CARE UTILISATION PATTERN INDICATORS*

In Figure 6.3-1 and Figure 6.3-2 the service consumptions of male and female persons with diabetes who are older than 45 years, are demonstrated. Section 4.4.3 presented convenient operations with OLAP cubes. Another useful feature working with OLAP cubes is the possibility to compare results in real-time just by selecting another aggregation mode. In this case results are demonstrated normalized to the mean GP and specialist visits. Therefore regional varieties of service consumptions are comparable for two or more facts.

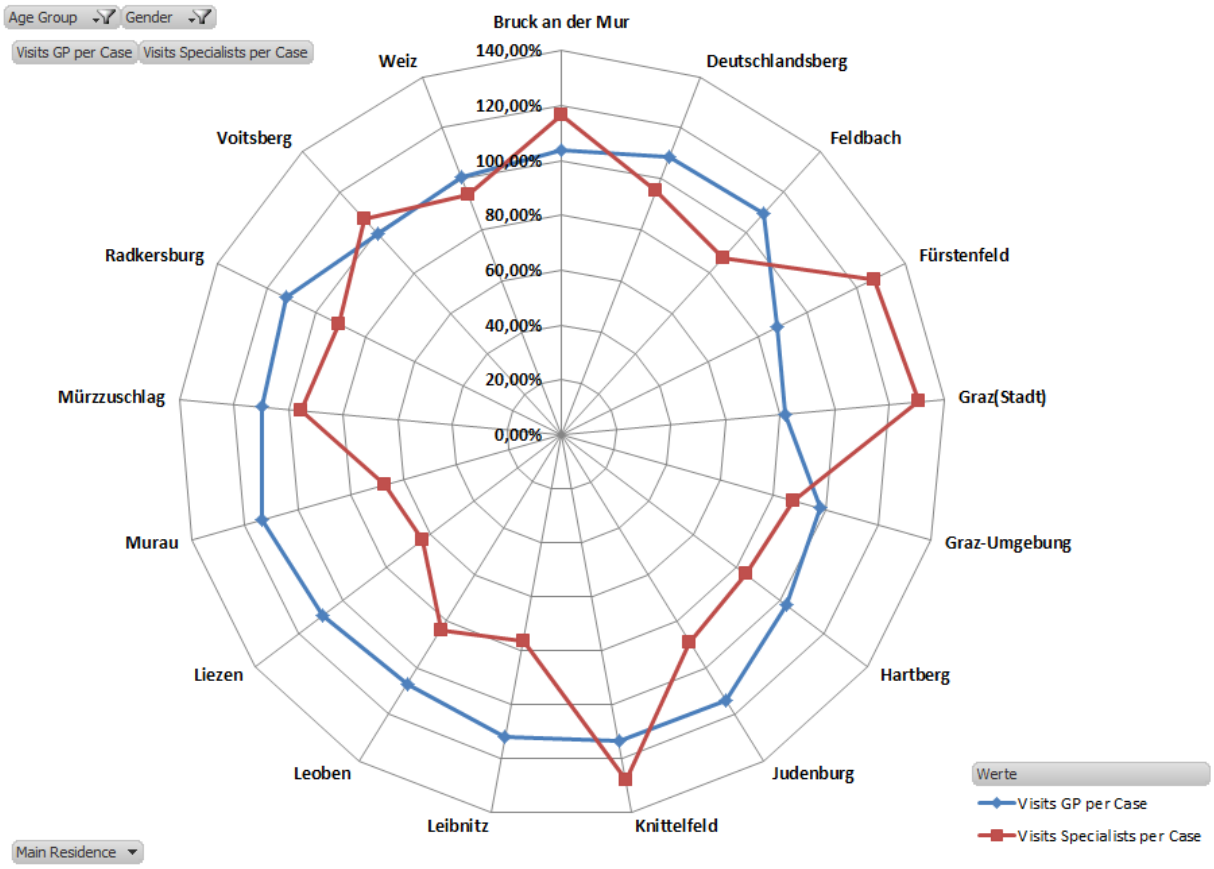

Figure 6.3-1: Regional comparison of GP visits and specialist visits per case normalised to the Styrian average for male patients with diabetes older than 45 years (number of cases: 12,156)

The discussed economic effects of patients with diabetes, in chapter 4.5.3, are emphasising the need of indicators for service consumption. These indicators should enforce the need of regional investigations of service consumption. They clearly show regional differences for physician visits. The physician visits per case in numbers are demonstrated in Table 6.3-2 and show strong differences. The range of difference, for female diabetes patients older than 45 years, is 3.53 specialist visits and 9.44 GP visits.

For male diabetes patients older than 45 years it is 3.34 specialist visits and 7.25 GP visits.

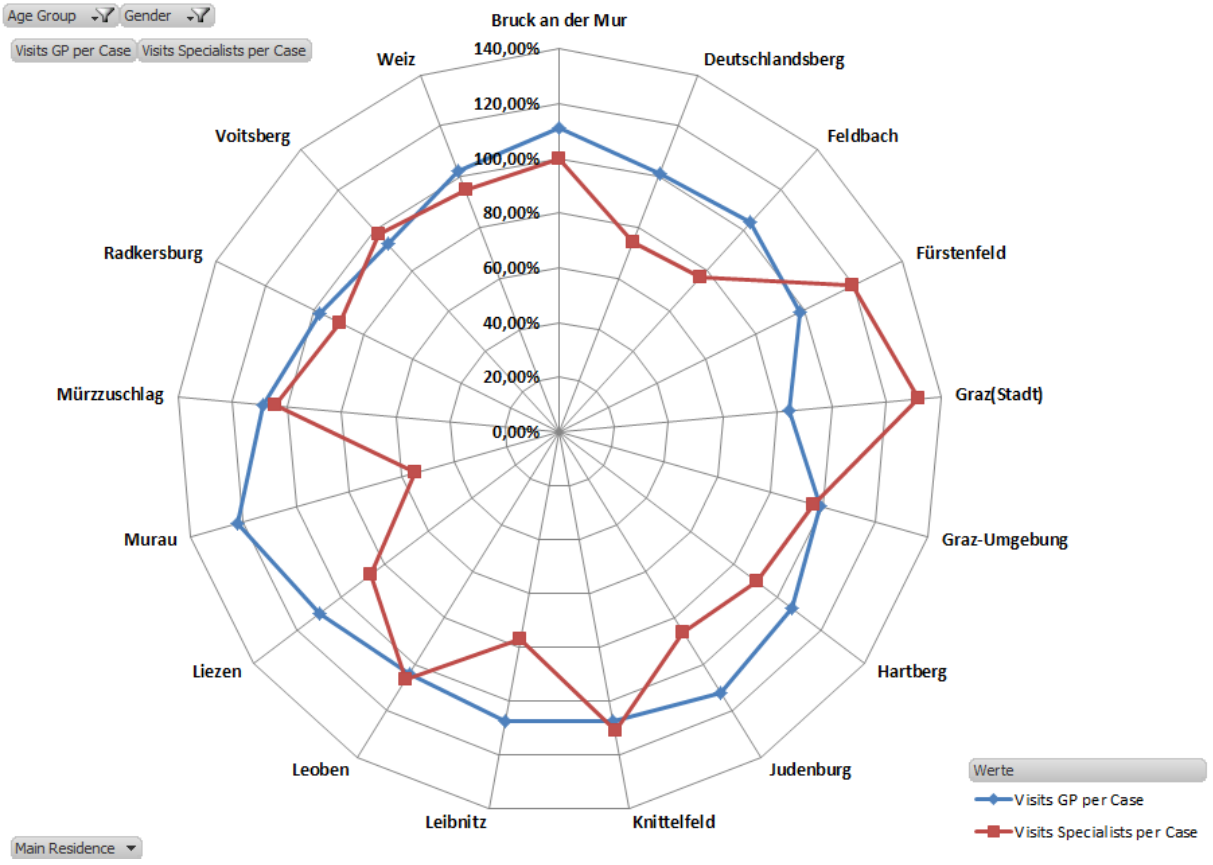

Figure 6.3-2: Regional comparison of GP visits and specialist visits per case normalised to the Styrian average for female diabetes patients older than 45 years (number of cases: 15,267)

As mentioned in chapter 4.2.1 in contrast to a free market, where demand influences supply, supply influences demand in health care. More health care suppliers lead to more demand of services. This is reflected in the two previously presented figures. Regions with high specialist densities like Graz and Fürstenfeld record more specialist visits than regions like Murau and Judenburg with low densities. The regional specialist densities are demonstrated in (Steirische Statistiken 2007). These regions also reflect substitution effects where the number of GP visits is high compared to regions with a high density of specialists.

The indicator set should enable a just-in-time monitoring of service consumptions, to help health care decision makers to include this information for steering and planning purposes. Further it should enable them to make policy impact assessments. Effects of changes in the structural plan for health care are detectable as soon as new cross-

sectoral data is loaded into the DWH. This could be achieved on a monthly, quarterly, semester or yearly basis.

Table 6.3-2 demonstrates diabetes patients GP and specialist visits. These indicators demonstrate not only a difference in physician visits per case between male and female diabetes patients, but also big regional differences. Graz shows the fewest visits per case for males and females. According to the supply influences demand thesis statement, Graz, with the highest physician densities, should have the highest number of physician visits per case. One possible explanation for this circumstance is that some GP or specialist visits are substituted by outpatient clinic visits. Unfortunately no data of this health care sector is available to support this theory. Another explanation could be that more specialist visits in Graz lead to a reduction of physician visits.

This is a good example to show the difficulty for evaluations in fragmented health care systems and point out the necessity of cross-sectoral estimations of utilisation of services or consumption of resources studies.

Main Residence	Visists Specialists per Case		Visits GP per Case		Total visits per case	
	female	male	female	male	female	male
Bruck an der Mur	4,58	5,77	27,68	23,31	32,26	29,09
Deutschlandsberg	3,41	4,73	25,15	24,39	28,56	29,12
Feldbach	3,5	4,32	25,82	24,54	29,32	28,86
Fürstenfeld	5,49	6,31	24,41	19,74	29,9	26,04
Graz(Stadt)	6,04	6,48	20,99	18,41	27,03	24,89
Graz-Umgebung	4,41	4,35	24,61	22,03	29,02	26,38
Hartberg	4,16	4,17	26,54	23,1	30,69	27,27
Judenburg	3,94	4,4	27,84	25,66	31,78	30,06
Knittelfeld	5,08	6,35	26,74	25,5	31,82	31,85
Leibnitz	3,54	3,79	26,76	25,23	30,3	29,02
Leoben	4,86	4,15	25,84	24,03	30,7	28,18
Liezen	3,96	3,14	27,3	24,58	31,26	27,72
Murau	2,51	3,33	30,43	25,55	32,94	28,87
Mürzzuschlag	4,78	4,72	26,97	24,73	31,76	29,45
Radkersburg	4,11	4,49	24,27	25,24	28,38	29,73
Voitsberg	4,47	5,28	23,14	22,29	27,61	27,57
Weiz	4,34	4,65	25,45	22,69	29,79	27,34
Steiermark	**4,58**	**4,95**	**24,86**	**22,49**	**30,18**	**28,32**

Table 6.3-2: Regional differences of GP and specialist visits for female and male diabetes patients older than 45 years (number of cases: 12,156 males; 15,267 females)

The additional information of the outpatient clinic sector and also comparable secondary data of other years would enhance the validity and information content of this indicator set. The demonstrated example of variation of health care utilisation pattern indicator will need further investigations on structure and process level to discover the reasons for the regional variations. But especially for end-result indicators on output level, the primary aim is to indicate variations, which lead to further investigations.

6.3.1.2 PATIENT FLOWS BEFORE AND AFTER AN ACUTE EVENT

This indicator set has been implemented for the identification of regional varieties of service consumption before and after an acute event. Table 6.3-3 demonstrates the probability of specialist visits and medicine costs, two month before and after an acute myocardial infarction. The probability of specialist visits is the percentage of visits of persons with an acute myocardial infarction, older than 65 years and with a Charlson index smaller than three, related to the number of those persons. The costs for medicines are calculated per person. These facts are demonstrated for male and female persons on a transformed time axis aligned on month and weeks. The regional comparison was performed for Graz and Mürzzuschlag to demonstrate differences of urban and rural areas.

Costs for medicines in the week before the myocardial infarction are up to six times higher for male StGKK patients compared to females. Also the probability of specialist visits is higher for males in the week before the acute event. The probability of specialist visits for females in Graz is lower before the acute event compared to males and females in Mürzzuschlag. This could be due to missing data of the outpatient clinic sector. Specialist visits could be substituted by visits in the outpatient clinics. In Mürzzuschlag no specialist visits for three weeks in a row after acute myocardial infarction were recorded for male patients. This could be due to the small number of cases available for the calculation of the facts. Males have nearly a four times higher probability of specialist visits in Mürzzuschlag in the first month after the myocardial infarction, compared to females. No strong differences between costs for medicines could be detected. This indicator set helps to discover regional inconsistencies of patient care patterns. The indicator is applicable for all symptoms and services described in chapter 5.5.1.2. Service consumption can be demonstrated as probabilities per case, costs per case or

number of consumed services per 100,000 StGKK patients. This enables health care authorities to discover adverse developments of patient care and therefore this indicator set could be used for monitoring purposes in all regions in Styria. The use of secondary data in the outpatient clinic- and inpatient rehab- sector would help to get a more complete picture of patient care and would help to discover substitution effects. Also, routine data of other years would help to make comparisons and to increase the validity of the indicators.

Transformed Time	Graz				Mürzzuschlag			
patients >= 65years CI < 3	Probability of specialist visit		Costs for Medications		Probability of specialist visit		Costs for Medications	
	female	male	female	male	female	male	female	male
	%		€		%		€	
-2 Month	28,8	42,5	€ 47,66	€ 51,73	36,4	26,7	€ 54,64	€ 30,80
-8	11,9	2,5	€ 6,63	€ 3,13	0,0	0,0	€ 7,64	€ 11,40
-7	6,8	5,0	€ 12,64	€ 7,55	18,2	0,0	€ 10,64	€ 0
-6	5,1	12,5	€ 6,02	€ 7,13	18,2	0,0	€ 28,73	€ 4,53
-5	5,1	22,5	€ 22,37	€ 33,93	0,0	26,7	€ 7,64	€ 14,87
-1 Month	37,3	70,0	€ 48,08	€ 84,03	90,9	60,0	€ 64,27	€ 93,87
-4	6,8	10,0	€ 10,37	€ 12,53	36,4	6,7	€ 16,00	€ 19,80
-3	10,2	17,5	€ 5,92	€ 3,73	18,2	26,7	€ 6,18	€ 0
-2	11,9	20,0	€ 11,34	€ 6,53	18,2	0,0	€ 31,64	€ 4,73
-1	8,5	22,5	€ 20,46	€ 61,25	18,2	26,7	€ 10,45	€ 69,33
Acute Event	3,4	7,5	€ 0,36	€ 9,45	9,1	0,0	€ 12,91	€ 12,53
1 Month	30,6	29,2	€ 137,55	€ 147,00	10,0	38,5	€ 143,00	**€ 116,67**
1	0,0	3,4	€ 29,17	€ 42,10	0,0	0,0	€ 24,00	€ 35,38
2	10,7	7,4	€ 24,88	€ 47,26	0,0	25,0	€ 0,00	€ 21,00
3	2,0	16,0	€ 59,67	€ 26,92	0,0	0,0	€ 84,40	€ 19,75
4	16,3		€ 20,94	€ 45,54	10,0	16,7	€ 34,60	€ 37,58
2 Month	41,7	66,7	€ 118,77	€ 105,83	40,0	41,7	€ 132,60	€ 118,83
5	4,1	12,5	€ 29,43	€ 19,79	0,0	8,3	€ 13,80	€ 77,75
6	14,6	16,7	€ 27,13	€ 2,25	10,0	8,3	€ 30,80	€ 6,92
7	12,5	16,7	€ 23,92	€ 12,54	10,0	16,7	€ 52,80	€ 10,75
8	10,4	20,8	€ 37,69	€ 71,25	20,0	8,3	€ 35,20	€ 23,42
Total			**€ 352,07**	**€ 412,86**			**€ 394,51**	**€ 369,75**

Table 6.3-3: Probability of specialist visits and costs for medications per case before and after an acute myocardial infarction for female and male patients older than 64 years with a Charlson index < 3 and main residence respectively in Graz or Mürzzuschlag. (Number of cases Graz: 59 females and 40 males; Number of cases Mürzzuschlag: 11 females and 15 males)

6.3.2 EVALUATION OF STRUCTURAL ANALYSES INDICATORS

In this section the indicators presented in section 5.5.2 are evaluated and discussed. Examples of developed indicators ought to show the feasibility of this indicator set. This should give health care authorities a more easily understandable insight into the complex structure of the Styrian health care system and should detect regional differences in patient care.

6.3.2.1 30-DAYS MORTALITY ON HOSPITAL- AND REGIONAL LEVEL

30-days-mortality as an end-result indicator presents ways to measure quality of health care on regional and on hospital level. Again the cross-sectoral data basis enables health care decision makers to become a more comprehensive picture of patient care. In this chapter possible ways of using the developed indicator set are demonstrated.

30-days-mortality vs. hospital mortality on hospital level

These indicators show differences between 30-days-mortality and hospital-mortality of different hospitals in Styria and for specific symptoms. In Figure 6.3-3 a comparison of the female 30-days- and hospital-mortality for AMI, of 622 hospitalisations within 25 hospitals with more than 5 hospitalisations, is presented. In this case the 30-days-mortality is predictable with hospital-mortality data. This finding is also consistent with (Heller and Günster 2008). Another noticeable fact is the relatively high range of 30-days-mortality values. The range is from 5 hospitals with no mortality, to one with a mortality of 43 percent.

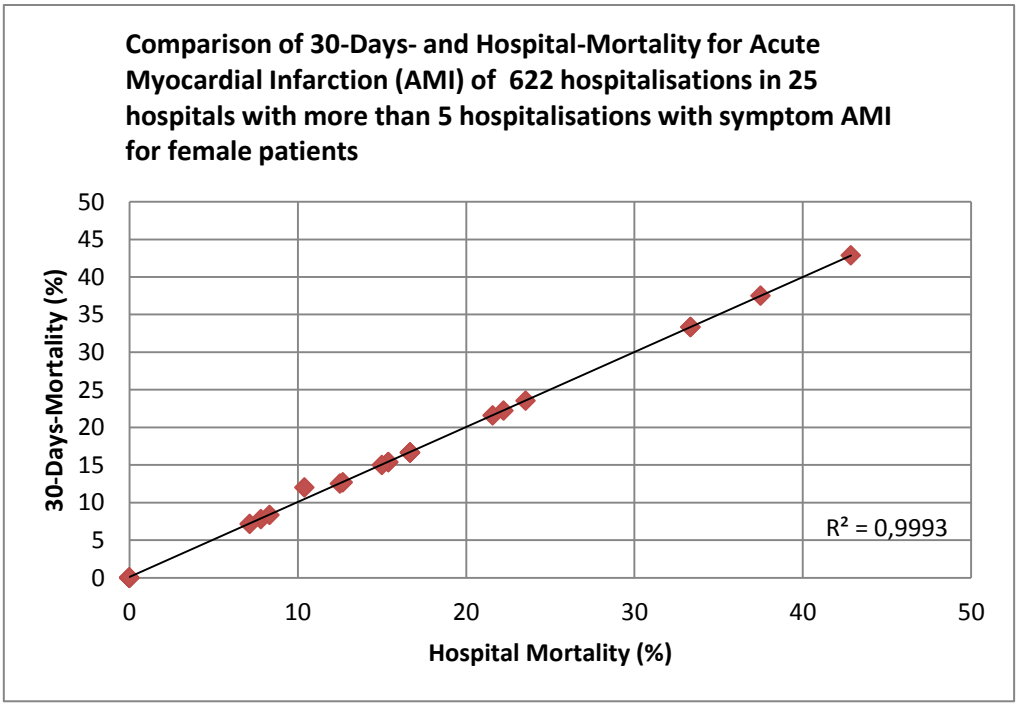

Figure 6.3-3: Comparison of 30-Days- and Hospital-Mortality for Acute Myocardial Infarction (AMI) of 622 hospitalisations within 25 hospitals with more than 5 hospitalisations for female patients with symptom AMI

In Figure 6.3-4 another noticeable fact is presented. Dots not lying on the regression line indicate hospitals with a higher 30-days-mortality compared to hospital mortality. With these indicators, it is possible to detect clinics which would be unsuspicious if quality assessment would be performed on basis of hospital mortality only. They also let assume if patients are discharged to early.

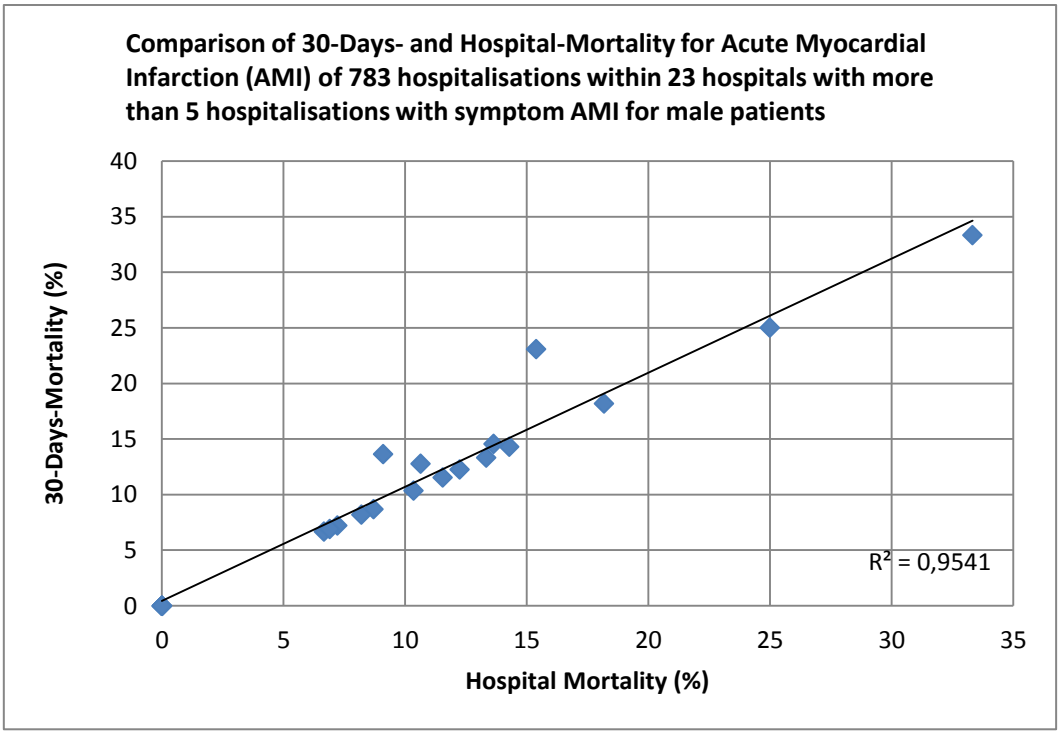

Figure 6.3-4: Comparison of 30-Days- and Hospital-Mortality for Acute Myocardial Infarction (AMI) of 783 hospitalisations within 23 hospitals with more than 5 hospitalisations for male patients with symptom AMI

One additional noteworthy circumstance is the different 30-days mortality between females and males. On average women have a 30 percent higher 30-days-mortality for the symptom AMI. Also, with the selection of only persons who died because of AMI, older than 60 years and with a Charlson index higher or equal to three, this fact remained unchanged. Due to the small number of cases no further meaningful risk adjustment with finer grained comorbidities could be performed. The spread of different mortalities in hospitals need further investigations, which should include considerations of specialised clinics and also comparisons of other fiscal years.

In Figure 6.3-5 and Figure 6.3-6 the same indicator is presented for the symptom heart insufficiency. The indicator demonstrates 30-days-mortality over hospital mortality for patients older than 60 years and with a Charlson index higher or equal to three. On average the 30-days-mortalites of females and males in hospitals is nearly equal (males: 12.5 percent; females 11.75 percent). The indicator also shows a higher difference between hospital- and 30-days-mortality for females. This could point out that female patients are discharged to early. Again further investigations regarding this topic should be performed to support these indicator results.

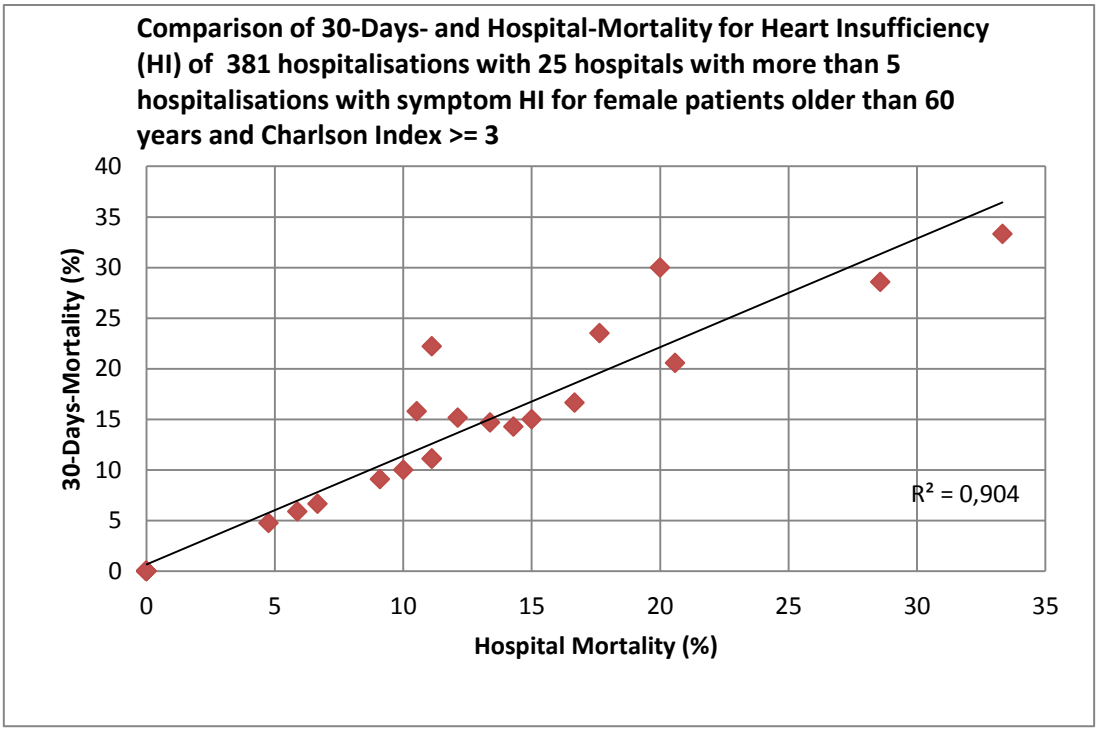

Figure 6.3-5: Comparison of 30-Days- and Hospital-Mortality Heart Insufficiency (HI) of 381 hospitalisations with 25 hospitals with more than 5 hospitalisations with symptom HI for female patients older than 60 years and Charlson index equal or higher than three

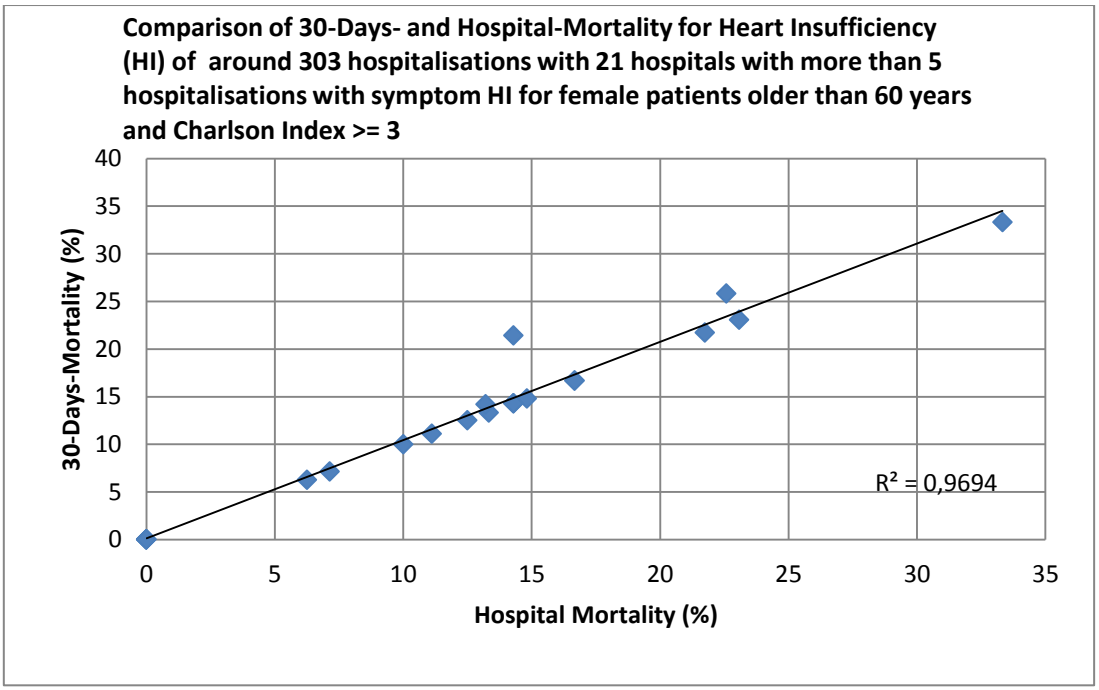

Figure 6.3-6: Comparison of 30-Days- and Hospital-Mortality Heart Insufficiency (HI) of around 303 hospitalisations with 21 hospitals with more than 5 hospitalisations with symptom HI for male patients older than 60 years and Charlson index equal or higher than three

For a more unbiased 30-days-mortality evaluation on hospital level additionally non-StGKK insured patients and non-Styrian patients have to be included. Especially hospitals near to province borders treat patients with non-Styrian main residence. The 30-days-mortality is not identifiable for non-Styrian patients with data used in the practical part of the master thesis. Because of this mortality rates could be influenced to a now non-predictable extent. In future evaluations the share and influence of these patients has to be identified and evaluated.

Regional varieties of 30-days-mortalities per 100,000 citizens

Compared to the previously presented indicator set, where the basis was the treating hospital, in this case the indicator set was developed on basis of the patient's main residence. In Figure 6.3-7 and Figure 6.3-8 regional differences of 30-days mortality for AMI are presented. In the first figure the indirect age standardised 30-days mortality per 100,000 male citizens insured by the StGKK for AMI is presented. In Fürstenfeld and Radkersburg no insured patients by the StGKK died in the year 2005 because of AMI within 30 days of hospitalisation. Styrian regions show big differences for 30-days-mortality for AMI. Leibnitz and Knittelfeld have a nearly twice as high indirect age standardised 30-days mortalities for AMI, compared to the Styrian average. Also Murau, Feldbach, Graz-Umgebung and Graz have a nearly 50 percent higher mortality when compared to the Styrian average.

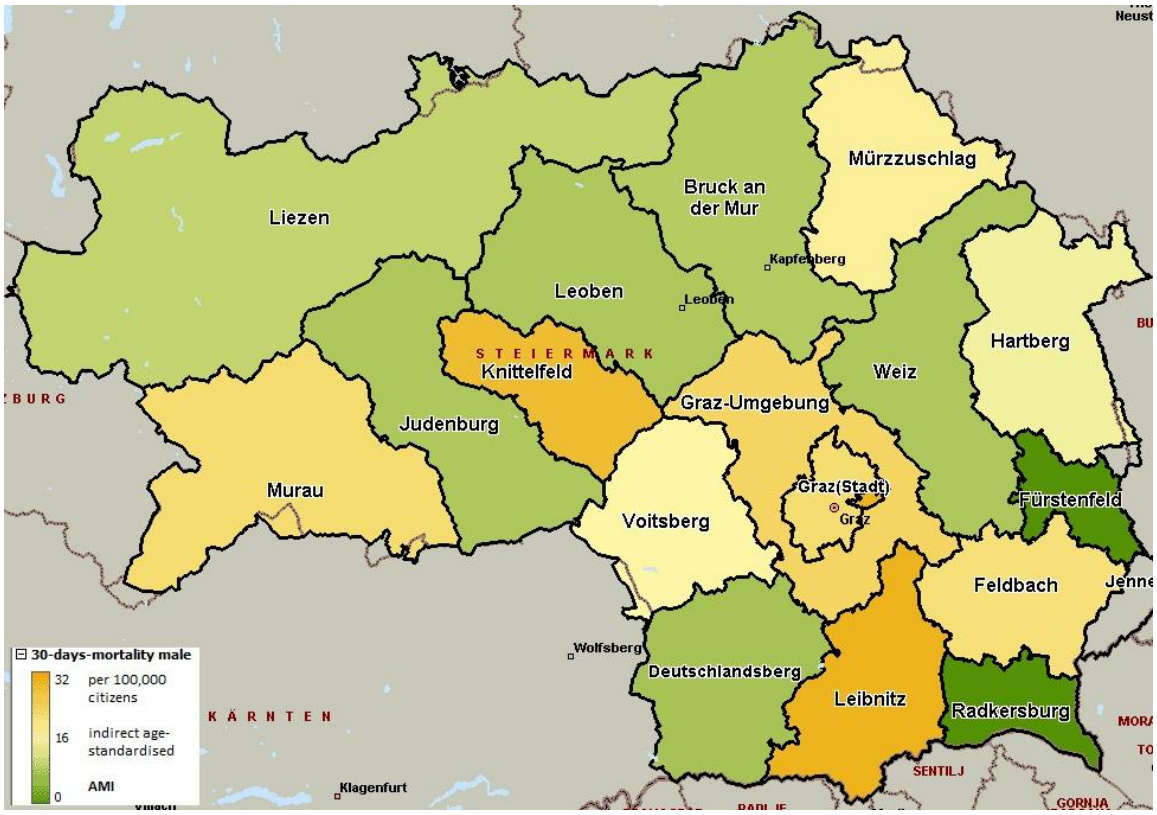

Figure 6.3-7: Indirect age standardised 30-days-mortality for male Acute Myocardial Infarction (AMI) patients per 100,000 citizens insured by the StGKK (Number of cases: 85 males)

Figure 6.3-8 displays the indirect age standardised 30-days mortality for females, died because of AMI. In this figure another colour coding and demonstration method was used to show the deviation of the indirect age standardised 30-days mortality, directly in percentage to the average. Also in this case strong regional differences were detected. In Murau and Leoben no female StGKK insured patients died within 30-days because of AMI. Knittelfeld has a 150 percent higher 30-days-mortality compared to the Styrian average for females. Also Radkersburg, Feldbach and Liezen have 50 percent higher 30-days mortalities when compared to the Styrian average.

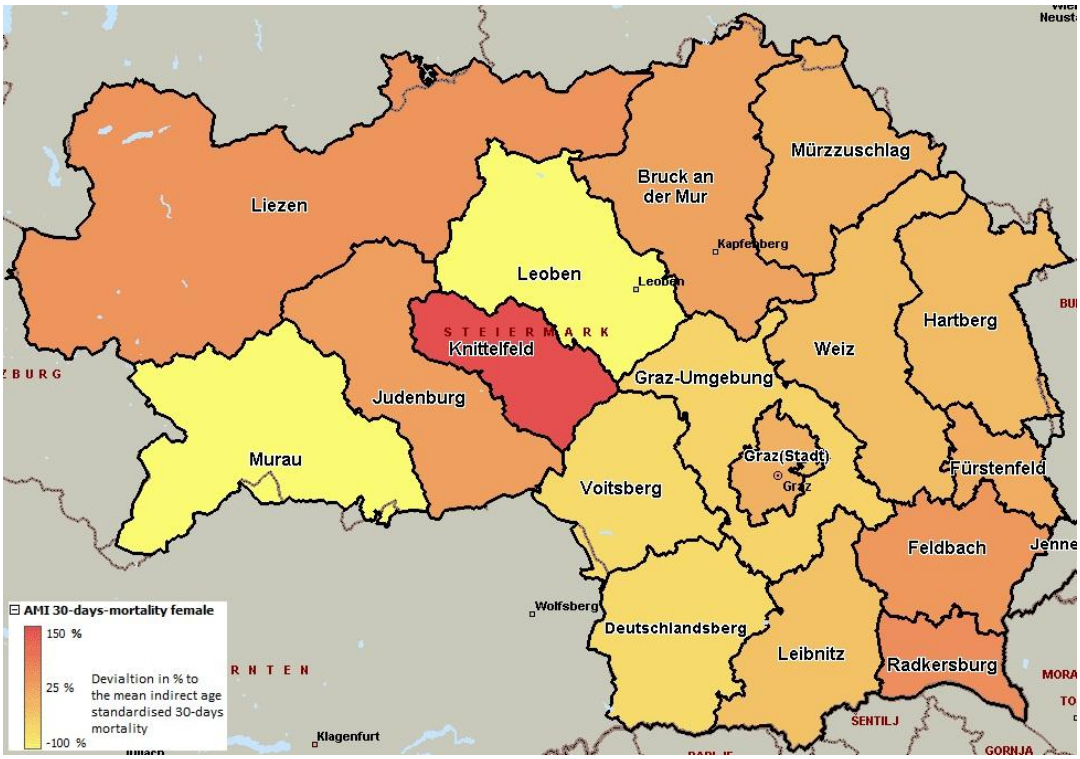

Figure 6.3-8: Deviation of indirect age standardised 30-days-mortality for female Acute Myocardial Infarction patients in percent to the mean indirect age standardised 30-days-mortality (Number of cases: 87 females)

The difference between 30-days mortality for females and males has decreased compared to the previous presented evaluation for AMI using indirect age standardisation on basis of the main residence. The Styrian average for females is still 13 percent higher compared to the average male 30-days mortality. The regional differences will need further investigations on the process and the structural level. Comparisons with secondary data of other years will be necessary to support the discovered regional varieties of the 30-days mortality for AMI.

Regional varieties of 30-days mortality for heart insufficiency are presented in Table 6.3-4. In this case another presentation method was used. The number of 30-days mortality cases, the crude death rate per 100,000 StGKK patients (CDR), the standardised mortality ratio (SMR) and the indirect age standardised 30-days mortality rate per 100,000 StGKK patients is displayed in a table for females and males. Again strong regional differences were discovered. In Fürstenfeld died around 85 percent more male StGKK insured patients compared to the Styrian average. But also regions like Bruck an der Mur, Graz and Graz-Umgebung have a high 30-days-mortality compared to the average for females and males. In Radkersburg the 30-days mortality for females is nearly 150 percent higher compared to the average for females. Leibnitz

and Fürstenfeld have also strong elevated values compared to the average for female citizens insured by the StGKK.

	Male				Female			
Regions	**Cases**	**CDR**	**SMR**	**MRis**	**Cases**	**CDR**	**SMR**	**MRis**
Bruck/Mur	13	76,4	0,0410	40,09	13	59,1	0,0387	39,64
Deutschlandsberg	6	28,3	0,0247	24,17	8	33,4	0,0309	31,65
Feldbach	5	24,0	0,0180	17,59	9	38,6	0,0297	30,43
Fürstenfeld	5	55,0	0,0539	52,81	5	48,5	0,0465	47,60
Graz	41	50,0	0,0414	40,54	48	47,2	0,0385	39,39
Graz Umgebung	20	46,4	0,0386	37,74	15	29,9	0,0281	28,75
Hartberg	4	19,6	0,0155	15,13	11	47,8	0,0423	43,28
Judenburg	6	41,7	0,0270	26,41	8	46,5	0,0347	35,48
Knittelfeld	3	36,7	0,0216	21,19	2	19,2	0,0135	13,85
Leibnitz	6	21,2	0,0206	20,19	15	46,9	0,04915	50,29
Leoben	5	30,2	0,0143	14,00	8	35,8	0,0213	21,79
Liezen	6	25,3	0,0163	15,93	15	50,0	0,0410	41,94
Mürzzuschlag	8	68,4	0,0363	35,53	8	54,3	0,0359	36,68
Murau	5	56,6	0,0367	35,95	3	29,4	0,0222	22,76
Radksersburg	3	39,9	0,0290	28,37	10	115,3	0,0867	88,66
Voitsberg	7	38,7	0,0294	28,80	2	9,8	0,0079	8,12
Weiz	9	29,5	0,0258	25,26	8	23,8	0,0226	23,14
Steiermark	**152**	**39,9**	**0,0297**	**29,08**	**188**	**41,4**	**0,0340**	**34,77**

Table 6.3-4: Number of cases, crude death rate per 100,000 StGKK patients (CDR), indirect age standardised mortality ratio (SMR) and indirect age standardised mortality per 100,000 StGKK patients (MR_{is}) for females and males with Heart Insufficiency

Mortality rates for quality measurement have a long tradition in the USA (Takanishi Jr. et al. 2008). With a cross-sectoral data basis it is possible to enhance the information and validity of these indicators in Austria. It will be necessary in future evaluations to include other years for a time series analysis. On the one hand this would increase the validity of the indicators. On the other hand this indicator set could be used for monitoring purposes of the Styrian health care system.

6.3.2.2 INFLUENCES OF COMORBID CONDITIONS ON DEMAND OF HEALTH CARE SERVICES

For planning purposes in health care it is necessary to know where the sources of costs are. These indicators show differences of the influence of different patient groups on health care costs. Especially the influence of comorbid conditions are investigated with this indicator set. As mentioned for the other indicator sets, the demonstrated figures

and tables are only examples of the investigated services and symptoms presented in chapter 5.5.2.2.

Influences of comorbid conditions on demand of health care services

These indicators help to investigate the distribution of costs allocable to intramural and extramural services for patients with a specific symptom and comorbid condition. In Table 6.3-5 the developments of health care expenditures per StGKK patient, older than 64 and with heart insufficiency, for different Charlson indexes are displayed. The table shows that with increasing Charlson index the health care expenditures are also increasing. An interesting fact is that for StGKK patients with a Charlson index equal and higher to five, costs are only increasing in the intramural sector. Extramural costs e.g. for medications are not differing very much between patients with Charlson index equal or higher to three and patients with Charlson index equal or higher to five. This circumstance could indicate that treatment patterns in the extramural sector are not adjusted to comorbid conditions. Another reason could be that these patients are mainly treated in the hospital because extramural treatments are not possible anymore.

	Costs per Case and Year					
Age >= 65	**CI < 3**		**CI>=3**		**CI >=5**	
Services	**male**	**female**	**male**	**female**	**male**	**female**
Number of cases	**127**	**245**	**134**	**221**	**48**	**67**
Extramural	**€ 2.037,17**	**€ 2.028,19**	**€ 2.350,63**	**€ 2.596,50**	**€ 2.353,35**	**€ 2.561,01**
GP Visits	€ 396,95	€ 406,93	€ 406,81	€ 562,95	€ 402,54	€ 578,67
Specialist Visits	€ 273,13	€ 206,21	€ 237,05	€ 173,53	€ 212,13	€ 133,63
Patient transport	€ 172,61	€ 136,52	€ 327,01	€ 229,73	€ 312,85	€ 321,88
Medicines	€ 1.007,13	€ 974,22	€ 1.157,10	€ 1.368,58	€ 1.202,10	€ 1.265,48
Medical or therapeutic aids	€ 124,83	€ 251,39	€ 158,87	€ 212,25	€ 170,04	€ 217,87
Other expenses	€ 62,50	€ 52,92	€ 63,80	€ 49,47	€ 53,69	€ 43,49
Intramural	**€ 4.148,35**	**€ 3.303,32**	**€ 5.123,74**	**€ 5.342,69**	**€ 5.597,35**	**€ 5.899,01**
Hospitalisations	€ 4.148,35	€ 3.303,32	€ 5.123,74	€ 5.342,69	€ 5.597,35	€ 5.899,01
Total	**€ 6.185,51**	**€ 5.331,51**	**€ 7.474,37**	**€ 7.939,19**	**€ 7.950,71**	**€ 8.460,03**
Additional Costs in %	**100,00%**	**100,00%**	**120,84%**	**148,91%**	**128,54%**	**158,68%**

Table 6.3-5: Influences of comorbid conditions on costs for extramural and intramural health care services per Heart Insufficiency case for patients older than 64 years.

For female patients with a Charlson index equal and higher to five, the costs are increasing for hospitalisations around 80 percent compared to female patients with a Charlson index smaller than three. Costs for medicines are increasing only around 30 percent. Costs for specialist visits are decreasing with increasing Charlson index for males and females. Furthermore, costs for GP visits of male patients are not influenced

by the comorbidity, but for females the expenditures for GP visits are increasing with increasing comorbidity.

Further investigations should clarify the culprit of rising healthcare costs for heart insufficiency patients. Are they related to longer hospitalisations, higher hospitalisation rates or due to the fact that patients have more additional diagnoses? Again, data from outpatient clinic- and inpatient rehab-sector would help to increase the validity of this indicator set and to account for substitution effects. Also comparisons with additional secondary data of different years would increase the validity of the indicator set and would enable health care decision makers to monitor regulatory measures retrospectively.

Influences of comorbid conditions on demand of health care services before and after an acute event

This indicator set is investigating the influence of comorbid conditions on the course of patient care. The information of this indicator helps to investigate policy impacts or changes in treatment plans. In Table 6.3-5 the influence of comorbid conditions on demand of health care services is demonstrated. As discussed previously, StGKK patients with higher Charlson index have different service consumptions. This indicator set is aligning service consumption on a transformed time-axis. Zero on the time axis indicates an acute event. It is possible to compare patient cohorts and investigate e.g. medication costs or probabilities of specialist visits before and after this acute event. In Figure 6.3-9 and Figure 6.3-10 the probability of a specialist visit before and after AMI with respect to the Charlson index for patients older than 64 years is presented.

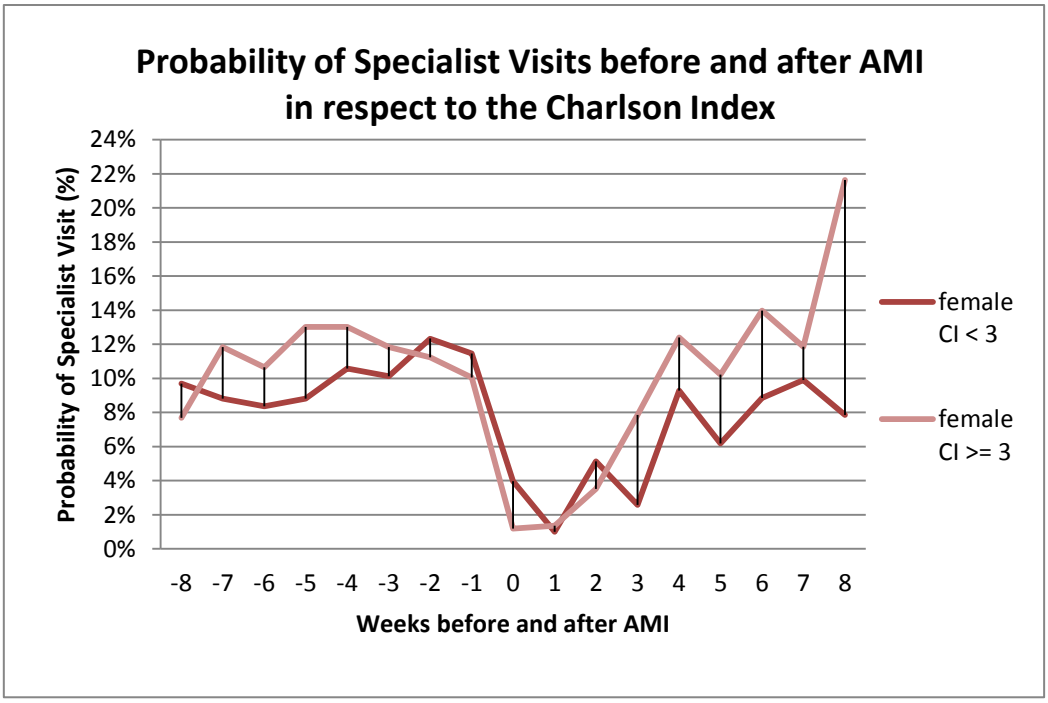

Figure 6.3-9: Probability of specialist visits before and after Acute Myocardial Infarction (AMI) in respect to the Charlson index (CI) of female patients older than 64 years (Number of cases: CI < 3: 227; CI >= 3: 169)

StGKK patients with a higher Charlson index have a higher probability of specialist visits. The probability is highest for males one week before the heart infarction and does not depend on comorbidity. Also, the probability one week before heart infarction for females does not depend on the comorbidity very much. Pre and follow up specialist visits are more likely for patients with a higher comorbidity. Males have a higher probability of specialist visits one month before an acute event. Females with a Charlson index equal and higher than three have a higher probability two month after the acute event compared to males.

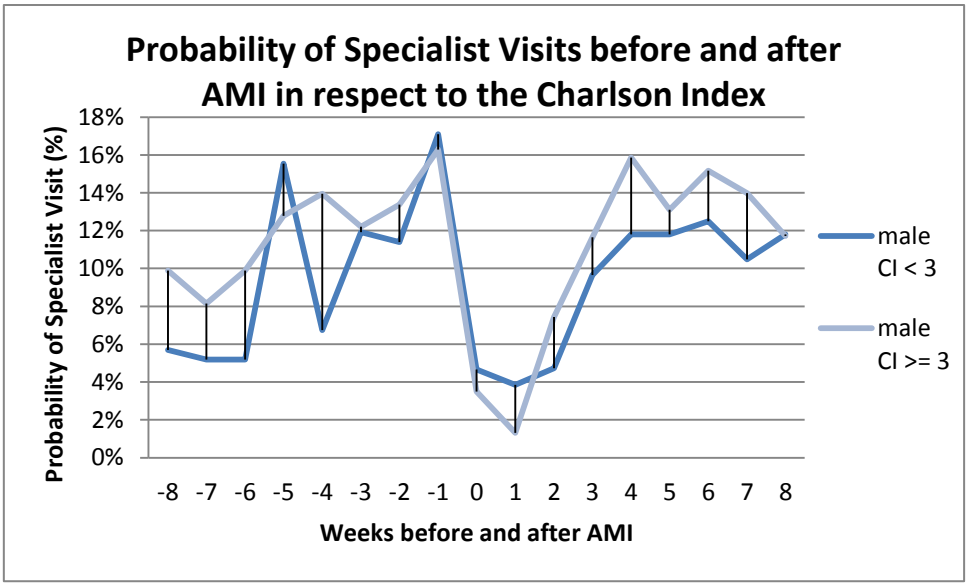

Figure 6.3-10: Probability of specialist visits before and after Acute Myocardial Infarction (AMI) in respect to the Charlson index (CI) of male patients older than 64 years (Number of cases: CI < 3: 193; CI >= 3: 172)

Comorbidity has an influence on course of care as the previously discussed figures show. With this indicator set it is possible to investigate the course of patient care for different services and symptoms. Figure 6.3-11 and Figure 6.3-12 show the development of costs for medications before and after a stroke, for male and female StGKK patients older than 64 years in respect to the Charlson index. The maximum peak of costs for medicines per stroke patient is 5 weeks after the acute event for females and males. Patients with higher Charlson index have continuously higher costs per case. There are no big differences between female and male medicine costs per case. Only men with a high Charlson index have an additional peak of medicine costs one month before the acute event. To increase the validity of these indicators, exclusion criteria for specific medicine groups should be developed. In the presented evaluation no medical substances were excluded. Also the limited GeISt dataset allowed no fine distinction between medical substances. This additional information would allow detailed analyses of patient cohorts treated with different medicines for the same symptoms. The information gathered from the indicator set delivers information about changes in treatment patterns and also helps to discover insufficient care of specific patient groups. Again, secondary data of other years would allow the monitoring of care of specific patient groups.

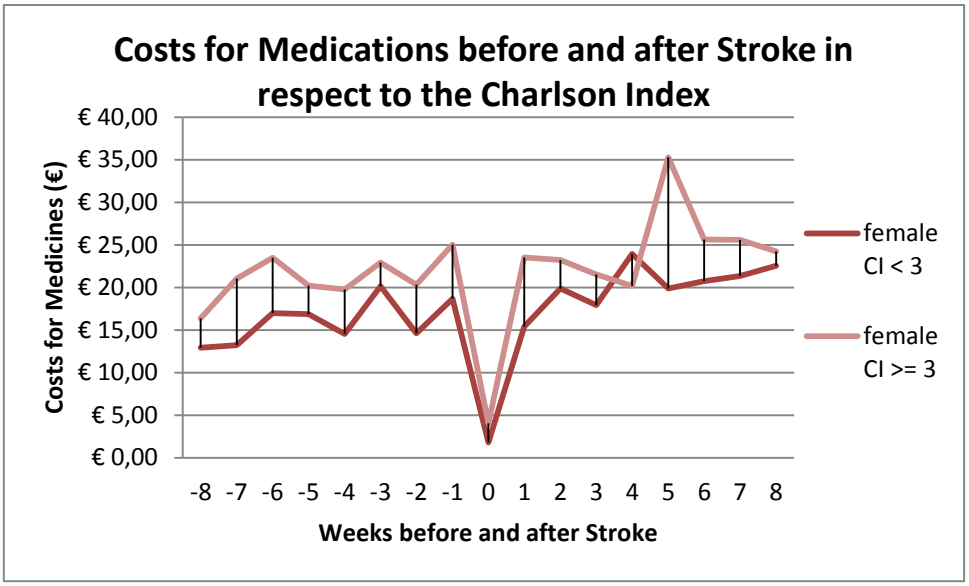

Figure 6.3-11: Costs for medications before and after stroke in respect to the Charlson index (CI) of female patients older than 64 years (Number of cases: CI < 3: 595; CI >= 3: 373)

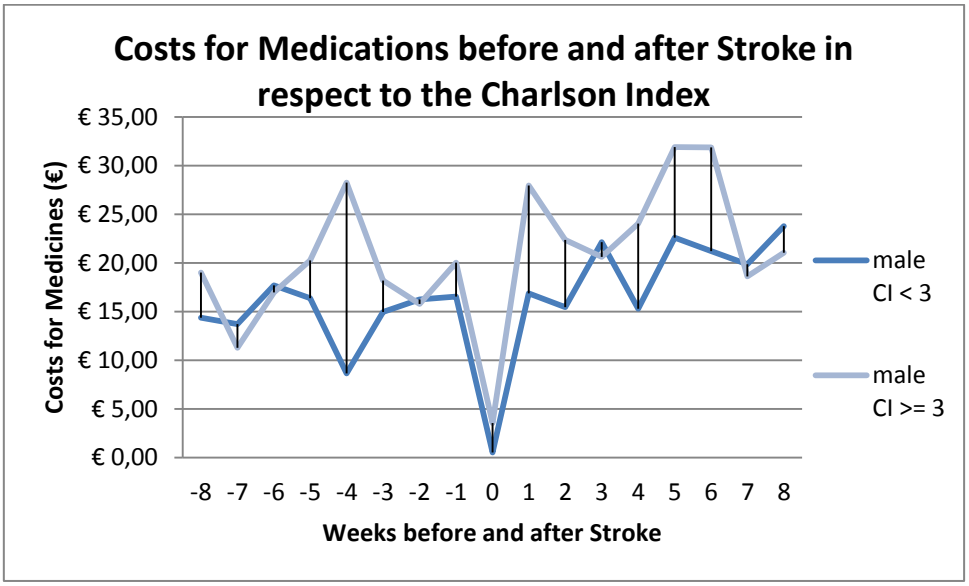

Figure 6.3-12: Costs for medications before and after stroke in respect to the Charlson index (CI) of male patients older than 64 years (Number of cases: CI < 3: 388; CI >= 3: 279)

6.3.3 EVALUATION OF HEALTH REPORTING INDICATORS

Health reporting occurs on a regular basis in every province in Austria. The level of detail is varying and so are the discussed topics. In Styria, the trend goes nowadays away from transmitting facts to the interested public from secondary data analysis to patient satisfactory surveys. This method also presents a way of cross-sectoral quality assessment because it targets the patient. Secondary data analysis would enhance the information content and validity of health reporting and indicators could be developed without additional costs for data acquisition. This chapter presents the indicator sets developed in chapter 5.5.3.

6.3.3.1 DIABETES PREVALENCE IN STYRIA

Figure 6.3-13 demonstrates the direct age standardised diabetes prevalence for female Styrian citizens. Direct age standardisation was used because of the large number of cases available for the analysis. The figure clearly shows a regional diabetes prevalence trend. In the East of Styria higher diabetes prevalence can be found compared to the West of Styria. Regions like Leibnitz, Feldbach and Radkersburg have up to 25 percent higher diabetes prevalence for female citizens compared to the female Styrian average. For male citizens Murau has even 40 percent lower diabetes prevalence when it is compared to the male Styrian average.

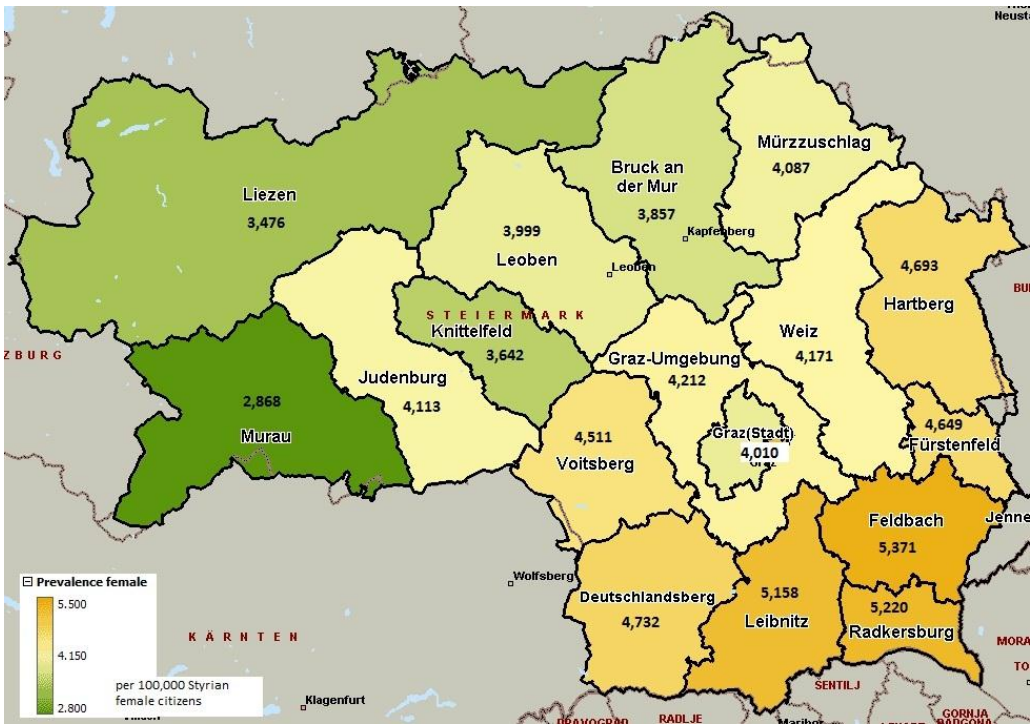

Figure 6.3-13: Direct age standardised diabetes prevalence for female Styrian citizens including the scale up to Styrian total and including non-drug treated diabetics

Alpine regions show lower diabetes prevalence compared to non-alpine regions. The direct age standardised prevalence is highest for females and males in the South-East of Styria. For female citizens the prevalence of diabetes in Feldbach is twice as high compared to the prevalence for Murau. For a better interpretation of this trend, patient surveys have to be designed to evaluate lifestyle factors of citizens with main residence in alpine and non-alpine regions. The results of the diabetes prevalence approximations are probably not influenced by physician densities. Graz with the highest physician densities has a diabetes prevalence very close to the Styrian average.

Table 6.3-6 demonstrates the direct age standardised diabetes prevalence for female and male Styrian citizens. Also the divergence within the gender and between genders is displayed. As mentioned previously there are strong regional differences of diabetes prevalence in Styria. But also between genders diabetes prevalence is differing. In Knittelfeld, Graz and Bruck an der Mur this difference is up to 36 percent. In all regions of Styria the diabetes prevalence for males is higher compared to females. On average males have 22 percent higher diabetes prevalence compared to females.

Regions	Male Prevalence			Female Prevalence	
	per 100,000 male citizens	in percent to Styrian male average	Difference to male prevalence in %	per 100,000 female citizens	in percent to Styrian female average
Bruck/Mur	5.607	1,9	31,20	3.857	-9,9
Deutschlandsberg	6.003	9,1	21,17	4.732	10,6
Feldbach	6.445	17,1	16,67	5.371	25,5
Fürstenfeld	6.184	12,4	24,82	4.649	8,6
Graz	5.947	8,0	32,58	4.010	-6,3
Graz Umgebung	5.490	-0,3	23,27	4.212	-1,6
Hartberg	5.558	1,0	15,57	4.693	9,6
Judenburg	4.878	-11,4	15,68	4.113	-3,9
Knittelfeld	5.701	3,6	36,11	3.642	-14,9
Leibnitz	6.153	11,8	16,17	5.158	20,5
Leoben	5.454	-0,9	26,68	3.999	-6,6
Liezen	4.835	-12,2	28,11	3.476	-18,8
Mürzzuschlag	5.146	-6,5	20,58	4.087	-4,5
Murau	3.327	-39,6	13,81	2.868	-33,0
Radksersburg	5.869	6,6	11,07	5.220	21,9
Voitsberg	5.912	7,4	23,69	4.511	5,4
Weiz	5.063	-8,0	17,62	4.171	-2,6
Steiermark	**5.504**			**4.280**	

Table 6.3-6: Direct age standardised diabetes prevalence for female and male citizens including the scale up to Styrian total and including non-drug treated diabetes patients

Figure 6.3-14 demonstrates the extrapolated diabetes prevalence as a percentage for male and female diabetes patients in respect to age. In (Stock et al. 2006) the authors performed a similar retrospective analysis from retrospective health insurance data in Germany. The results are very similar to the ones presented in Figure 6.3-14. In (Stock et al. 2006) and in the analysis of the master thesis the onset of high diabetes prevalence is around the age of 40 years. The peak of diabetes prevalence in the Styrian and German population is around the age of 80 years. The male diabetes prevalence curve bends earlier compared to the curve of females. This indicates that male diabetes patients are dying earlier as a consequence of diabetes. The very similar results compared to (Stock et al. 2006) support the validity of the cross-sectoral data basis for diabetes patients.

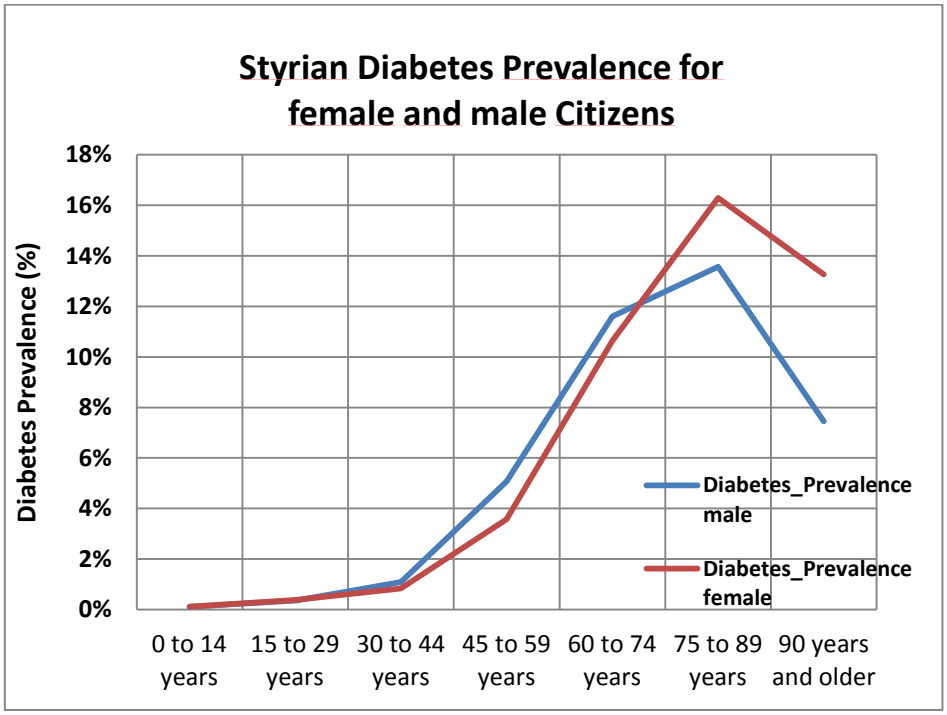

Figure 6.3-14: Total diabetes prevalence for men and women

The basis for diabetes prevalence estimations includes all persons using antidiabetic agents. This method is not able to identify persons treated with sugar diet or persons not knowing to have diabetes. For the sake of completeness, patient surveys are also not able to detect persons not knowing to have diabetes. In Figure 6.3-15 the distribution of diabetes patients in the cross-sectoral data basis is demonstrated. Out of 29,761 citizens, insured by the StGKK in 2005 using antidiabetic agents, around 40 percent had a hospital visit in 2005. 10,857 StGKK patients with diabetes diagnose were identified in the inpatient medical records, using ICD-10 codes. 8,549 patients were using

antidiabetic agents and were identified having diagnosed diabetes. This means further that 21.3 percent of the patients with hospitalisation in 2005 are having non-drug treated diabetes. In (Hauner 2005) the author estimated that non-drug treated diabetes patients have a share of 28 percent of all diabetes patients. The actual share of non-drug treated diabetes patients in Styria will be closer to 28 percent, because probably not all non-drug treated diabetes patients, particularly younger patients, had a hospitalisation in 2005.

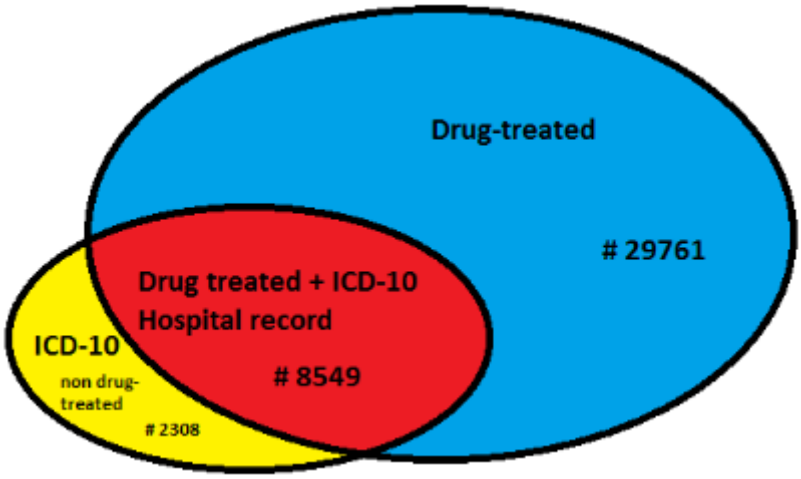

Figure 6.3-15: Distribution of diabetes patients in the cross-sectoral data basis. Blue plus red are all drug treated diabetes patients insured by the StGKK. Red are all diabetes patients who are drug treated and have a diabetes related diagnose in the inpatient sector. Yellow are all non-drug treated diabetes patients with diabetes related diagnoses in the inpatient sector

For the approximation of diabetes prevalence for each region, the prevalence per 100,000 citizens had to be extrapolated. The extrapolation included the scaling-up to Styrian total, because the diabetes prevalence was calculated on basis of StGKK patients only. Due to the fact that around 70 percent of the Styrian population is insured by the StGKK, the prevalence had to be scaled-up to 100 percent of the Styrian population. Also non-drug treated diabetes patients had to be considered in the diabetes prevalence approximation. Consequently 25 percent had to be added to the approximation. 25 percent is a conservatively estimated value and the share of non-drug treated diabetes patients could be higher. In total, the numbers for diabetes prevalence could be around 62.5 percent higher as the StGKK data for diabetes patients using antidiabetic-agents yields. Table 6.3-6, Figure 6.3-13 and Figure 6.3-14 demonstrate the scaled up values for diabetes prevalence.

6.3.3.2 BURDEN OF DISEASE

This indicator set was developed for the identification of regional varieties, in the distribution of patients with a high "burden of disease". Discovering the distribution of citizens with a high comorbidity could help health care decision makers in planning and steering purposes. The presented indicator sets should exemplify the feasibility of the cross-sectoral based developed indicators. The selected symptoms represent illnesses with a high frequency in the Styrian population.

Distribution of diabetes patients with high comorbidity

For all diabetes patients with a hospitalisation in 2005, the Charlson index was calculated. This was performed for 11,686 patients insured by the StGKK. In the StGKK data base 10,857 patients with an ICD-10 code for diabetes were detected. This means that 829 patients had a hospital visit with no recorded diabetes. The comprehensive cross-sectoral data base allows the use of the direct age standardisation because of the large number of cases. The direct age standardised distribution of diabetes patients with a Charlson index equal to three and higher can be found in Figure 6.3-16 and Figure 6.3-17. The figures show 80 percent higher occurrence of male and 68 percent higher occurrence of female diabetes patients, with a Charlson index equal or higher than three, in Murau compared to the average. These results are matching with the "burden of disease" calculation for Styrian regions but are in contrast with the regional diabetes prevalence approximation in the previous chapter. In Fürstenfeld female diabetes patients with a high Charlson index occur 50 percent more often when compared to the average. The primary aim of this indicator set is to demonstrate regional differences of "burden of disease". This information certainly needs further proof and should be carefully evaluated. Again secondary data of other years would enhance the validity of this indicator set.

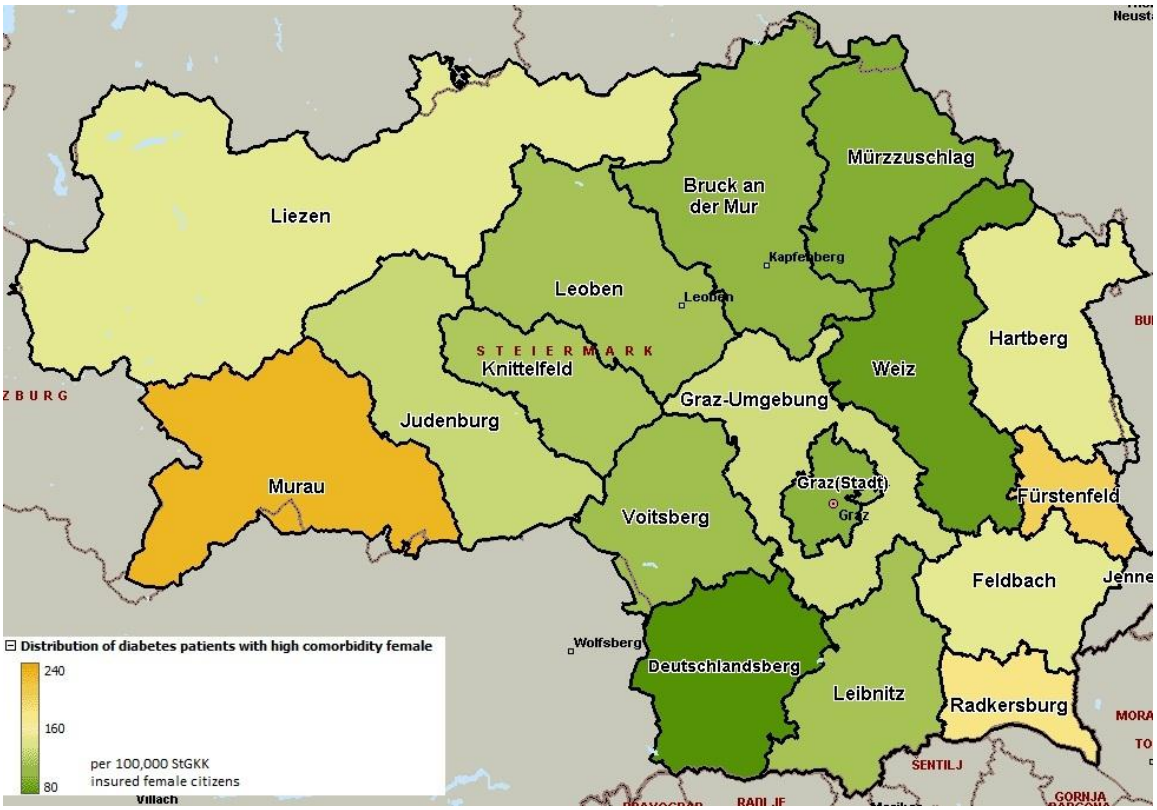

Figure 6.3-16: Direct age standardised distribution of female diabetes patients with a Charlson index equal and higher than three per 100,000 StGKK insured female citizens

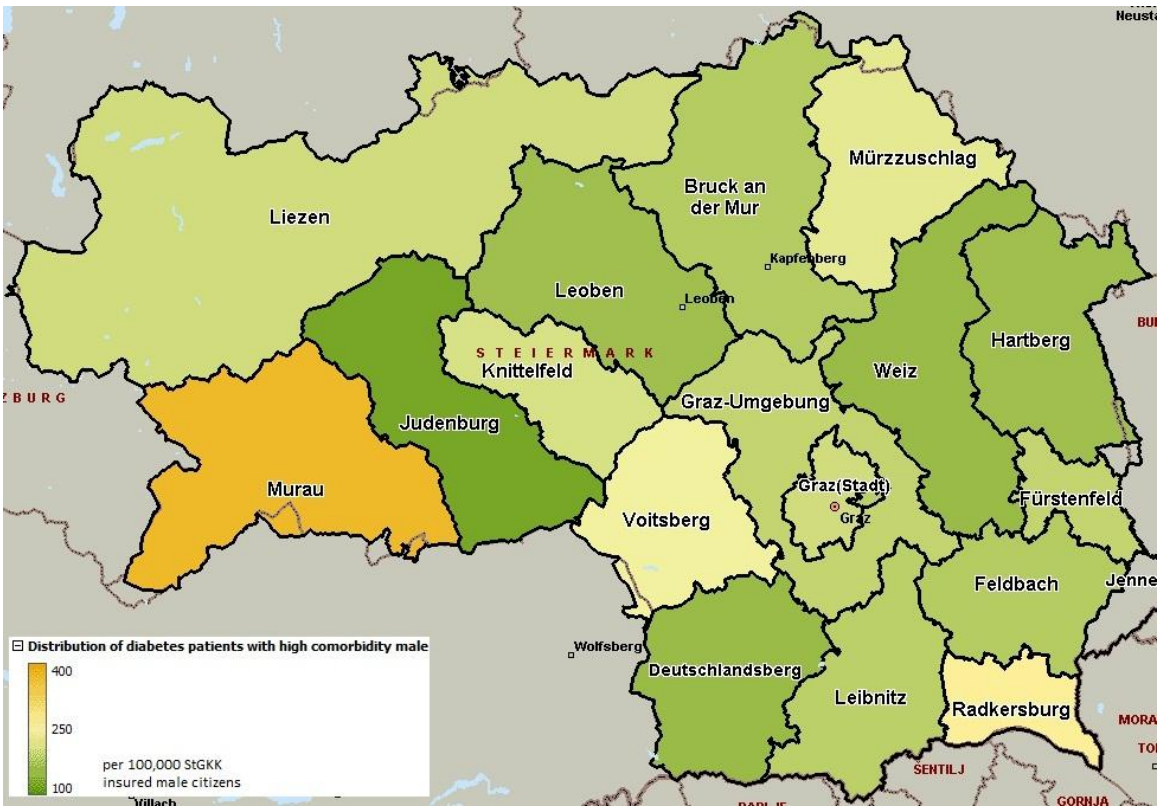

Figure 6.3-17: Direct age standardised distribution of male diabetes patients with a Charlson index equal and higher than three per 100,000 StGKK insured male citizens

Burden of disease in Styrian regions

This indicator set estimates the "burden of disease" for citizens insured by the StGKK, with at least one hospitalisation in the year 2005, on basis of the patient's main residence. Figure 6.3-18 and Figure 6.3-19 demonstrate the "burden of disease" for patients with diabetes, acute myocardial infarction, stroke and heart insufficiency. The "burden of disease" is calculated as the mean Charlson index for patients with a specific symptom for each region respectively. The figures show the highest "burden of disease" in Murau for female and male patients and for all four investigated symptoms. In Leoben, compared to the female average for heart insufficiency the "burden of disease" is nearly 60 percent higher. The figures show, except for Murau, that a high "burden of disease" for regions with one symptom significantly above the average does not indicate a higher "burden of disease" for other symptoms. For example, in Knittelfeld female patients have a 34 percent higher "burden of disease" for AMI, but all other investigated symptoms are below the average.

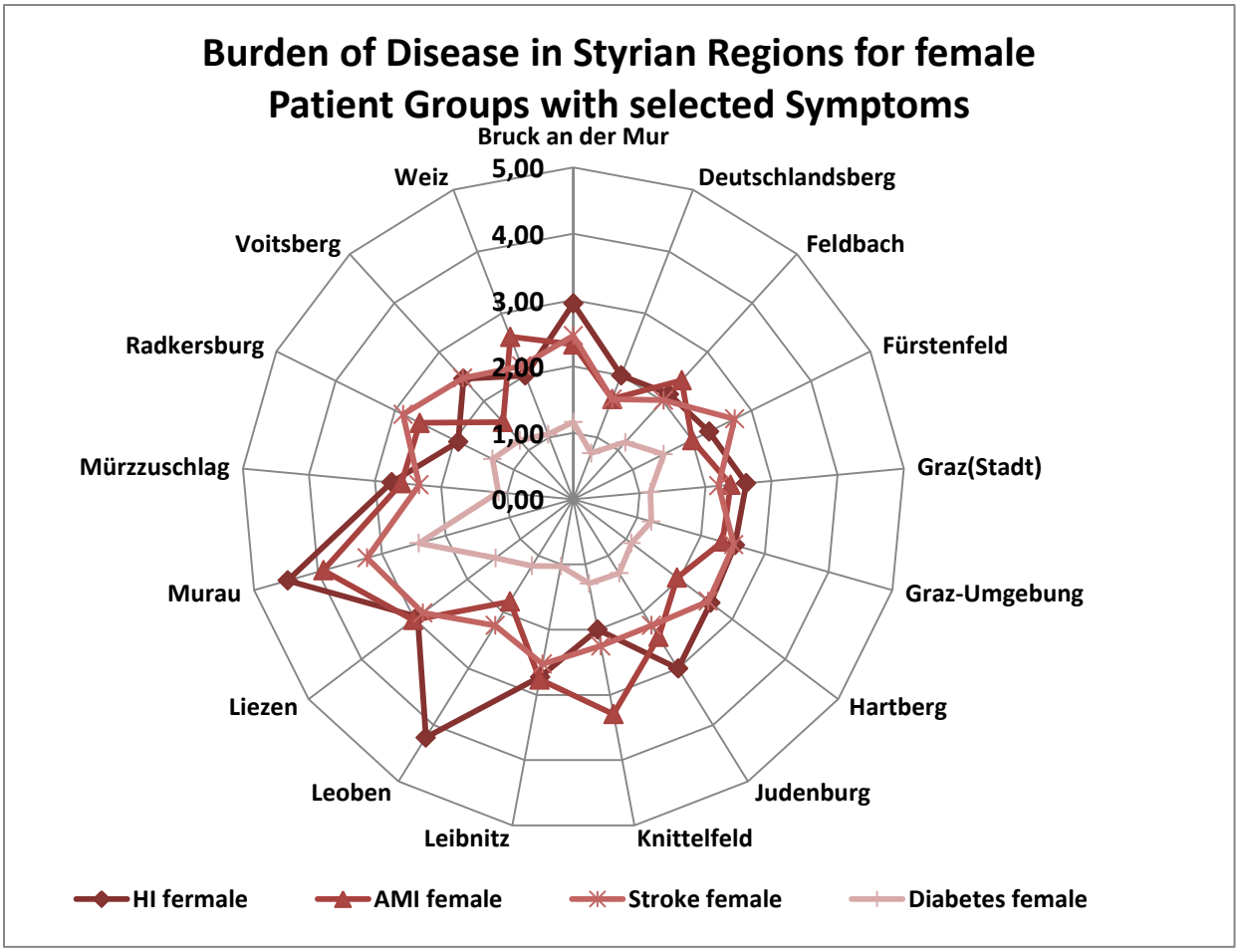

Figure 6.3-18: The burden of disease is calculated as the mean Charlson index for female patients with Heart Insufficiency (HI), Acute Myocardial Infarction (AMI), Stroke and Diabetes for each region respectively in Styria. Diabetes patients in this calculation are those who are drug treated and with a hospitalisation in 2005

For male and female patients insured by the StGKK in Deutschlandsberg the calculated "burden of disease" on basis of the Charlson index is significantly below the average. For all investigated symptoms for males and females the calculated "burden of disease" is at least 20 percent below the average. For all other regions, except Murau and Deutschlandsberg, no clear trends for "burden of disease" estimations are visible.

In Table 6.3-7, the difference of the regional mean Charlson index in percent compared to the regional average for all investigated symptoms is demonstrated. Also, the range of regional differences per symptom is presented. The range was calculated as the maximum of "burden of disease" minus the minimum, per symptom. This investigation displays strong differences between female and male patients insured by the StGKK. For male AMI patients the range of "burden of disease" is around 60 percent higher compared to the range of females. Male patients with HI have 48 percent and male patients with stroke a 22 percent higher "burden of disease" range. These investigations

do not match with the estimated 30-days-mortalities, where females showed higher mortalities for the investigated symptoms. Further investigations regarding this circumstance should be performed in future work. The range of "burden of disease" for diabetes patients between male and female StGKK insured citizens is nearly equal. Also the regional distribution matches with the previously presented direct age standardised distribution of diabetes patients. No big differences between the average "burden of disease" in Styria between males and females could be detected. On regional basis, females with heart insufficiency living in Leoben have a 44 percent higher mean Charlson index compared to males. In Weiz and Radkersburg the "burden of disease" for males with heart insufficiency is up to 46 percent higher. For other symptoms the regional differences between males and females are not so dramatic.

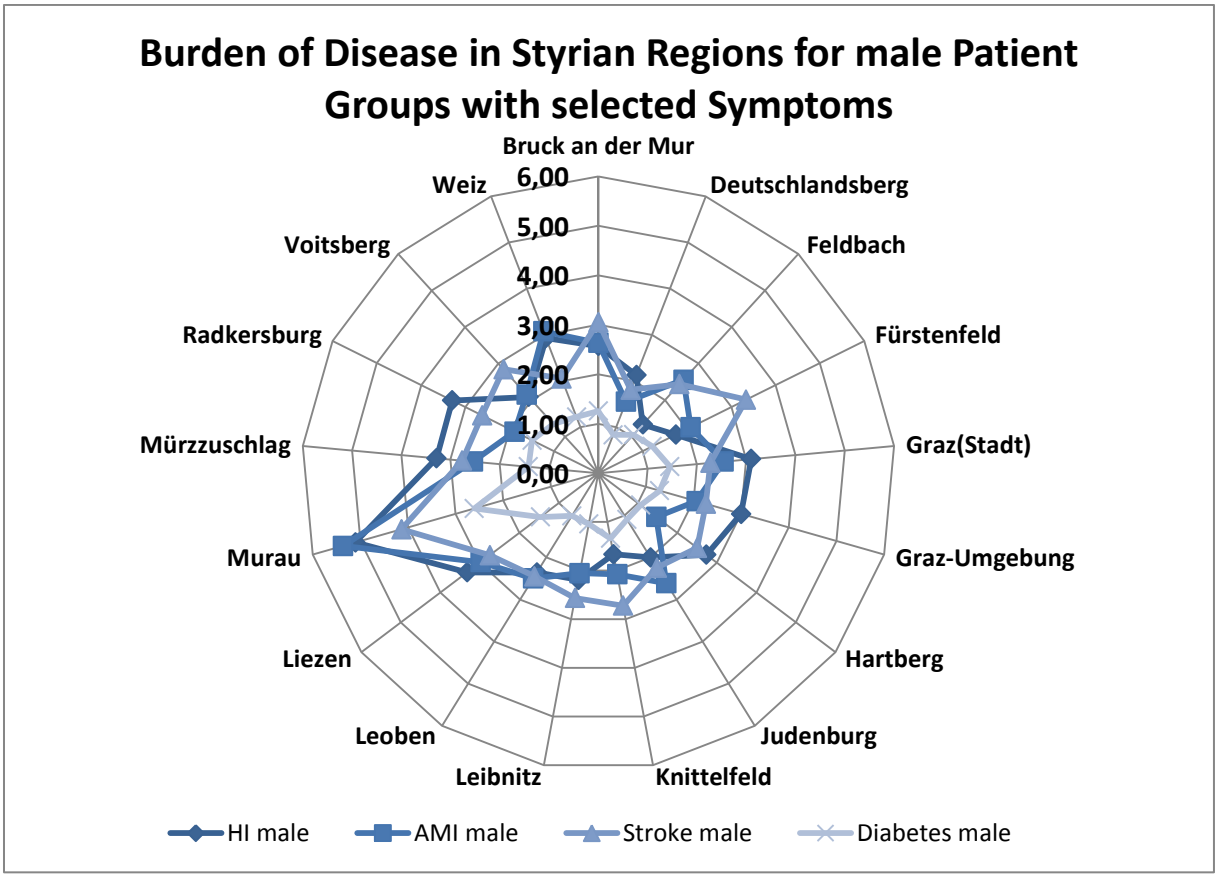

Figure 6.3-19: The burden of disease is calculated as the mean Charlson index for male patients with Heart Insufficiency (HI), Acute Myocardial Infarction (AMI), Stroke and Diabetes for each region respectively in Styria . Diabetes patients in this calculation are those who are drug treated and with a hospitalisation in 2005

The very high "burden of disease" in Murau has to be investigated in detail. Comparisons with other years would help to verify the results. Also coding problems should be investigated. Do practitioners in Murau record additional diagnoses more often? Are the

additional recorded diagnoses justified? Or do insured citizens by the StGKK wait longer until they have a hospitalisation and are recorded with more severe illnesses? 30-days-mortality investigations did not show extremely high mortality rates in Murau, compared to other Styrian regions. This indicator set should emphasise the need of cross-sectoral evaluations in quality of health care. Only if all sectors of health care are integrated in quality monitoring, fair and valid comparisons can be performed. As mentioned in chapter 6.1 the use of the Charlson index does not comprise all kinds of symptoms. In (Quan et al. 2005) the authors assessed coding algorithms for defining comorbidities in administrative data. Besides the Charlson index they presented the Elixhauser index. This index addresses other symptoms and could be target for future work in the environment of GeISt.

	HI		**AMI**		**Stroke**		**Diabetes**	
Region	female	male	female	male	female	male	female	male
	%	%	%	%	%	%	%	%
Bruck an der Mur	9,9	-2,5	-4,8	6,4	1,6	15,7	-8,1	-3,7
Deutschlandsberg	-25,5	-19,5	-34,0	-37,5	-33,3	-31,4	-41,2	-36,4
Feldbach	-20,2	-49,5	-1,1	3,0	-16,8	-7,6	-8,3	-19,2
Fürstenfeld	-14,8	-33,7	-18,4	-15,9	11,9	26,4	20,2	-7,0
Graz(Stadt)	-2,5	17,5	-2,9	2,4	-9,3	-13,8	-7,9	11,1
Graz-Umgebung	-5,7	13,7	-4,8	-16,7	3,7	-14,3	-3,6	-1,5
Hartberg	-3,5	3,6	-20,1	-40,8	5,1	-5,2	-13,2	-18,2
Judenburg	11,8	-24,2	-0,5	5,4	-7,7	-14,9	3,6	-16,1
Knittelfeld	-25,5	-36,8	34,4	-16,2	-7,2	3,3	2,1	2,5
Leibnitz	1,5	-17,0	12,8	-17,1	4,2	-2,7	-18,9	-20,1
Leoben	57,3	-10,7	-26,1	0,9	-7,7	-7,0	-6,6	-22,4
Liezen	9,6	25,9	23,2	20,2	17,2	4,3	16,2	12,2
Murau	66,8	93,5	59,8	116,4	33,2	56,9	91,1	99,4
Mürzzuschlag	2,5	24,5	6,0	2,7	-3,8	4,9	-10,4	8,7
Radkersburg	-27,8	25,1	5,4	-23,8	18,2	-0,4	7,4	14,4
Voitsberg	-8,4	-20,9	-35,9	-13,1	1,9	7,9	-5,2	3,1
Weiz	-25,5	11,0	7,1	24,0	-11,3	-22,2	-17,1	-6,7
Range	**94,6**	**143**	**95,7**	**157,2**	**66,5**	**88,3**	**132,3**	**135,7**
Difference of male and female range	**48,4**		**61,6**		**21,8**		**3,4**	

Table 6.3-7: Difference of the regional mean Charlson index in percent compared to the regional average for symptoms HI, AMI, Stroke and Diabetes. Range of regional differences and the difference of male and female range

7 SUMMARY AND OUTLOOK

The primary aim of the practical part of the master thesis was the development of cross-sectoral indicators for the Styrian health reporting system and quality assurance. Therefor a cross-sectoral data basis had to be created, using data of different health care sectors in Austria. This task demanded high technological efforts and DWH was chosen because it is a technology which allows developers to manage huge amounts of data. Another benefit of using DWH as data handling technology was, that it allows end-users not familiar with SQL to explore the vast cross-sectoral data bases. Consequently, other user groups than statisticians are enabled to perform analysis in health care. DWH will definitely be the technology of choice for the final GeISt 2.0 project.

The adoption of data, coming from more than one fiscal year, will need an adaption of the DWH, which was developed in the practical part of the master thesis. The workload for this adaption cannot be easily estimated because of differences in the data structure or coding systems, compared to the data of 2005. Similarly, for future work the implementation of the codes for registered procedures for the Austrian accounting of inpatient care will be obligatory. The yearly update of this coding system will require a lot of expertise to make a meaningful integration into the DWH. Correspondingly, the integration of data from the outpatient clinic- and inpatient rehab-sector will require a redesign of the DWH structure. More detailed data from the GP and community specialist sector will enable much more elaborate analyses. As mentioned in chapter 6.3.2.2, the influences of different medications for same patient groups could be investigated. Also, with comparable data of other years incidence approximations and monitoring for different parameters could be performed.

In the USA the CATCH project presented incontrovertible value, but encountered comparable problems as the GeISt project. Due to data security policy, developments of quality assurance and measurement projects in health care are problematic. The technology for projects like GeISt is available, but policy related problems cause the delay of these projects. Health reporting projects on basis of secondary data for the interested public have been established in Germany and other EU countries (SQG 2010). Similarly, benchmarking of hospitals is common in EU countries (Czypionka et al. 2008). In Austria such systems available for the public are far away from realisation. The focus of GeISt is not the delivering of information to the interested public, but the

identification of adverse regional or sectoral developments for planning and steering purposes in health care.

A nationwide implementation of a project with the same aims as GeISt would be a logical next step, because secondary data is homogeneous in most of Austria's provinces. This would save costs because projects regarding quality assurance and measurement need not be financed in all provinces. But a nationwide implementation also includes even greater responsibilities and data security issues. Additionally, the issues discussed regarding data sources should be kept in mind. Data quality is strongly influencing the value of secondary data analysis evaluations. Because of this, GeISt as a pilot project in Austria would be a cost effective way to assess the value of a cross-sectoral data-basis for quality assurance and measurement. GeISt 2.0 may serve as a role model for other Austrian provinces for cross-sectoral quality assessment. Additionally, provinces possibly will benefit from each other if most quality assurance and measurement projects have a similar structure as the GeISt 2.0 project. Due to future developments, such as the higher share of the elder population, medical progress and patient empowerment, the Austrian health care system will have to evolve. Cost pressure will lead to cuts in health care in the near future. Therefore a fair identification of the main culprits of rising health care costs requires cross-sectoral evaluations in health care.

On basis of the cross-sectoral data indicators have been developed and evaluations have been performed. These showed strong regional differences. Although no comparisons with secondary data of other fiscal years could be performed to verify the results, these differences need further investigation. Even if these differences are related to differences in the frequency of recording of diagnoses, this matter has to be further examined. For example, the analyses showed differences in diabetes prevalence. Further investigations on a regional basis are crucial. Lifestyle factors which are influencing diabetes prevalence should be estimated. Additionally, reasons for differences in service consumption of diabetes patients should be further investigated. Care for chronically ill patients requires a lot of coordination and resources. The indicators, which were developed in the course of the master thesis, should help in monitoring these patient pathways for the improvement of treatment processes and reduction of unnecessary, multiply prescribed services. These developed indicator sets ought to help assessing if treatment patterns are influenced by patient's comorbid conditions. As the evaluation of

heart insufficiency patients showed, the main culprit of rising health care costs for increasing comorbidity is the inpatient sector. Extramural services are not so much influenced, which led to assumption that treatment patterns are not adequately adjusted for different comorbid conditions.

On hospital level, the range of 30-days- and hospital-mortality for the investigated symptoms was very high. Also, the consideration of patient's comorbid conditions did not reduce this range. These results have to be treated with great care. A fair comparison between hospitals is very difficult. Multiple factors influence the outcome of patient care, in this case 30-days-mortality. Additionally, ambulance services, the severity of illness or the stage of chronic illnesses should be considered in the risk adjustment of outcome indicators. Also, the type of clinic could influence patient outcome. On the one hand, specialised clinics with stoke units may perform better compared to clinics without such specialised facilities. In this case, rather than comparing hospitals, comparisons between hospital departments, with similar structural quality, should be performed. This could also be target for future work in the environment of the GeISt project. On the other hand, if 30-days-mortalities are varying in the extent the indicators showed, organisational and/or structural countermeasures are urgently needed. This may indicate that patients are treated in inadequate health care facilities.

Also, the estimation of the Charlson index will have to be adapted because in the final version of GeISt routine data of more than one year will be available. Therefore it will be possible to derive a more comprehensive picture of comorbidities. This circumstance will increase the validity of comparisons between patient cohorts. Also, developments of "burden of disease" could be monitored and be the basis for planning and steering in health care.

With a retrospective comparison of patient groups with different registered treatment procedures, but equal other factors like gender, age and comorbidity, it will be possible to assess the effectiveness of treatments with measurements e.g. survival rates. The cross-sectoral data basis may help to compare "quality of life" by comparison of frequencies of doctor visits or other service consumption. This method may also be used to retrospectively verify the results of medical trials.

In the master thesis no reference ranges for the developed indicators are given. The GeISt project and particularly this master thesis can be considered as a feasibility study in the field of cross-sectoral indicator development in Austria. Therefore, without secondary data of comparable years and data of all other health care sectors, the findings of this master thesis may be biased to an unpredictable extent. The diabetes prevalence approximation may be an exception because the findings are very consistent with related literature. In future work, reference ranges for indicator sets in GeISt will have to be developed. Possible reference ranges are national or province averages. Also, international comparable studies or expert opinions may serve as reference ranges in the future GeISt project.

An additional target of future work should be a sensitivity analysis of the developed indicators. Properties like practicability, validity and reliability should be validated for each developed indicator respectively.

Although secondary data may have issues, which were discussed in this master thesis e.g. the influence of the payment system or missing data, the increased use, the higher availability and the better data quality through electronic data capture will increase the quality of secondary data. Similarly, data linkage methods with register data of existing disease registers in Austria may increase the information content and validity of analyses of secondary data.

A DWH was developed were research tasks could be treated, which were not even considered in this master thesis. Data from all sectors and comparable years would facilitate GeISt 2.0 usage as a powerful tool for making evaluations in health care. Future developments will increase the need of cross-sectoral quality assurance and measurement. This is particularly true for sectoral fragmented health care systems, such as in Austria.

8 LIST OF FIGURES

9 LIST OF TABLES

10 REFERENCES

Agency for Healthcare Research and Quality. “Child Health Care Quality Toolbox: Understanding Quality Measurement.” Accessed August 11, 2011 (http://www.ahrq.gov/chtoolbx/understn.htm). (2004)

Agency for Healthcare Research and Quality. “Quality Indicators.” Accessed September 27, 2011 (http://www.qualityindicators.ahrq.gov/). (2011)

Arbeitsgemeinschaft für die Gesundheitsberichterstattung der Länder (AOLG).“Statistische Methoden-Indikatorensatz für die Gesundheitsberichterstattung der Länder.” Accessed May 10, 2011 (http://www.statistik-bremen.de/Gesundheitsberichterstattung/Statistische_Methoden/Anhang1statistische methoden.pdf). (2003)

Aylin, P, Bottle A., Majeed A. “Use of administrative data or clinical databases as predictors of risk of death in hospital: comparison of models.” BMJ (Clinical Research Ed.) 334(7602):1044. Accessed August 25, 2011. (2007)

Berndt, D., Hevner A., Studnicki J., “CATCH/IT: a data warehouse to support comprehensive assessment for tracking community health.” Proceedings / AMIA ... Annual Symposium. AMIA Symposium 250-254. Accessed September 26, 2011. (1998)

Berndt, D., Hevner A., Studnicki J., “The Catch data warehouse: support for community health care decision-making.” Decision Support Systems 35(3):367-384. Accessed August 4, 2011. (2003)

BGBl. 1993. Bundesgesetzblatt für die Republik Österreich-801. Bundesgesetz, Änderung des Krankenanstaltengesetzes. (1993)

BGBl Art. 15a B-VG. 2005. Bundesgesetzblatt für die Republik Österreich-179. Bundesgesetz, Gesundheitsreformgesetz 2005, VEREINBARUNG gemäß Art. 15a B-VG über die Organisation und Finanzierung des Gesundheitswesens. (2005)

BQS Institut für Qualität und Patientensicherheit. 2011. “Benchmarking und Qualitätsvergleiche.” Accessed September 28, 2011 (http://www.bqs-institut.de/produkte/benchmarkingundqualitaetsvergleiche.html). (2011)

Breault, J., Goodall C., Fos, P. “Data mining a diabetic data warehouse.” Artificial Intelligence in Medicine 26(1-2):37-54. Accessed September 27, 2011. (2002)

Canadian Council on Health Services Accreditation. 1996. “A guide to the development and use of performance indicators. Ottawa: Canadian Council on Health Services Accreditation.” Accessed July 31, 2003 (http://www.cchsa.ca). 1996

Carels, J., Pirk, O. „Springer Wörterbuch Gesundheitswesen: Public Health von A-Z.“ 2nd ed. Springer Berlin Heidelberg. (2004)

Charlson, M., Pompei P., Ales K., MacKenzie, C. “A new method of classifying prognostic comorbidity in longitudinal studies: development and validation.” Journal of Chronic Diseases 40(5):373-383. Accessed September 13, 2011. (1987)

Codd, E., Codd, S., Salley, C. “Providing {OLAP} to {U}ser-{A}nalysts: {A}n {IT} {M}andate.” (1993)

Czypionka T., Kraus, M., Röhrling, G. “Institut für höhere Studien (IHS)-Messung von Effizienz und Qualität im Spitalswesen. Internationale Aspekte.” Accessed Mai 21, 2011 (http://www.ihs.ac.at/publications/lib/esd2008.pdf). 2008.

Donabedian, A. “Evaluating the Quality of Medical Care.” The Milbank Memorial Fund Quarterly 44(3):166-206. Accessed August 10, 2011. (1966)

Dörning, H., Bitzer, E., Grobe, T., Schwartz, F. “One-year mortality after surgical and non-surgical approaches to coronary revascularisation– results based on administrative data of a German health insurance.” Accessed August 26, 2011 (http://www.libsearch.com/view/1109037). (2008)

Drösler, S., Cools A., Köpfer T., Stausberg J. “Eignen sich Qualitätsindikatoren aus Routinedaten zur Qualitätsmessung im Krankenhaus? Erste Ergebnisse mit den amerikanischen Indikatoren zur Patientensicherheit in Deutschland.” Zeitschrift für ärztliche Fortbildung und Qualität im Gesundheitswesen - German Journal for Quality in Health Care 101(1):35-42. Accessed August 29, 2011. (2007)

Eikötter, T., Greiner, W. “Instrumente zur Messung der Versorgungsqualität in der integrierten Versorgung.” Gesundheitsökonomie & Qualitätsmanagement 13(1):25-31. Accessed August 12, 2011. (2008)

Erler, A., Beyer, M., Muth, C., Gerlach, F., Brennecke, R. "[Garbage in - garbage out? Validity of coded diagnoses from GP claims records]." Gesundheitswesen (Bundesverband Der Ärzte Des Öffentlichen Gesundheitsdienstes (Germany)) 71(12):823-831. Accessed August 25, 2011. (2009)

European Community Health Indicators Monitoring. 2008. "European Health Indicators: Development and initial implementation Final Report of the ECHIM Project." Accessed (http://ec.europa.eu/health/indicators/echi/index_en.htm). (2008)

Fuchs, F., Amon, M., Nimptsch, U., Mansky, T. "A-IQI| Austrian Inpatient Quality Indicators." Universitätsverlag der TU Berlin, urn: nbn: de: kobv. (2010)

G'sund.net. 2003. "MEDControl - G'sund.net." Accessed November 28, 2011 (http://www.gsund.net/cms/beitrag/10012802/711980/). (2003)

Garnick, D., DeLong, E., Luft, H. "Measuring hospital mortality rates: are 30-day data enough? Ischemic Heart Disease Patient Outcomes Research Team." Health Services Research 29(6):679-695. (1995)

Gesundheit Österreich GmbH. 2011. "Gesundheitsberichterstattung." Accessed September 28, 2011 (http://www.goeg.at/de/Gesundheitsberichterstattung). (2011)

Gesundheitsportal. 2011. "GesundheitsportalQualität im Gesundheitswesen - Öffentliches Gesundheitsportal Österreichs." Accessed August 10, 2011 (https://www.gesundheit.gv.at/Portal.Node/ghp/public/content/QualitaetimGesundheitswesen_LN.html#headline11). (2011)

Ghali, W., Rothwell, D., Quan, H., Brant, R., Tu, J. "A Canadian comparison of data sources for coronary artery bypass surgery outcome 'report cards'." American Heart Journal 140(3):402-408. Accessed August 25, 2011. (2000)

Giersiepen, K., Pohlabeln, H., Egidi, G., Pigeot, I. "Die ICD-Kodierqualität für Diagnosen in der ambulanten Versorgung." Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz 50(8):1028-1038. Accessed August 25, 2011. (2007)

Haeske-Seeberg, H. „Handbuch Qualitätsmanagement im Krankenhaus." Kohlhammer. (2005)

Hagenmeyer, E., Gothe, H., Landgraf, W., Kulik, M., Schiffhorst, G., Häussler, B."Ressourcen-Inanspruchnahme und Kosten der Behandlung von Typ-2-Diabetikern unter Insulin-glargin- oder Insulindetemir-Therapie (LIVE-KK): Analyse von Krankenkassen-Routinedaten mittels Propensity Score Matching." Gesundheitsökonomie & Qualitätsmanagement 15(03):121-126. Accessed September 1, 2011. (2010)

Hammergren, Tom. "Data warehousing for dummies. 2nd ed." Hoboken N.J.: Wiley. (2009)

Hauner, H. "Epidemiology and costs of diabetes mellitus in Germany." DMW - Deutsche Medizinische Wochenschrift 130:S64-S65. Accessed September 15, 2011. (2005)

Hauptverband der Sozialversicherungen. 2010. Business Intelligence im Gesundheitswesen. Accessed November 27, 2011 (http://www.sozialversicherung.at/mediaDB/703168_Ganjeizadeh-Rouhani_BIG_Business_Intelligence_im_Gesundheitswesen.pdf). (2010)

Heller, G., Günster, C. "Mit Routinedaten Qualität in der Medizin sichern; Aktuelle Entwicklungen und weitere Perspektiven." (2008)

Hess, K. "Klinische Indikatoren - Equam betritt Neuland, Medizinische Managed Care." Managed Care (2007)

Hess, K."Steuerung der Qualität in der medizinischen Versorgung, Care Management 2008." Managed Care (2008)

Hildebrandt, H., Dornblüth O., Pschyrembel W. „Pschyrembel Klinisches Wörterbuch. 258th ed." Gruyter. (1997)

Hofmarcher, M., Rack, H.. "Gesundheitssysteme im Wandel: Österreich." Vol. 8 No. 3 (2006)

Hoyer, R., Hoyer, B., Crosby, P., Edwards Deming, W. "What is quality?" Quality Progress 34(7):52. (2001)

Iezzoni, L., Heeren, T., Foley, S., Daley, J., Hughes, J. Coffman, G. "Chronic conditions and risk of in-hospital death." Health Services Research 29(4):435-460. (1994)

Iezzoni, L. “Risk Adjustment for Measuring Healthcare Outcomes, Third Edition.” 3rd ed. Health Administration Pr. (2003)

Inmon, W., Hackathorn, R. Using the data warehouse. Wiley. (1994)

Institute of Medicine. “Press Release: Preventing death and injury from medical errors dramatic system-wide changes.” November 29. (1999)

JCAHO. “Characteristics of clinical indicators.” QRB. Quality Review Bulletin 15(11):330-339. Accessed August 17, 2011. (1989)

JOANNEUM RESEARCH. 2011. “Gesundheits-Informationssystem Steiermark (GeISt v2.0).” Accessed August 8, 2011 (http://www.joanneum.at/?id=3216&L=0). (2011)

Kimball, R., Caserta, J. “The Data Warehouse ETL Toolkit: Practical Techniques for Extracting, Cleanin.” 1st ed. Wiley. (2004)

Kimball, R., Reeves, L., Ross, M., Thornthwaite, W. “The Data Warehouse Lifecycle Toolkit : Expert Methods for Designing, Developing, and Deploying Data Warehouses.” Wiley. (1998)

Knaus, W., Draper, E., Wagner, D., Zimmerman, J. “APACHE II: a severity of disease classification system.” Critical Care Medicine 13(10):818-829. Accessed September 13, 2011. (1985)

Kurz, A. “Data Warehousing. Enabling Technology.” 1st ed. mitp. (1999)

Larson, B. “Delivering Business Intelligence with Microsoft SQL Server 2008.” 2nd ed. McGraw-Hill Osborne Media. (2008)

Legido-Quigley, H. “Assuring the quality of health care in the European Union: a case for action.” World Health Organization. (2008)

van der Lei, J. “Use and abuse of computer-stored medical records.” Methods of Information in Medicine 30(2):79-80. Accessed August 26, 2011. (1991)

Leitheiser, R. “Data Quality in Health Care Data Warehouse Environments.” P. 6025 in Hawaii International Conference on System Sciences, vol. 6. Los Alamitos, CA, USA: IEEE Computer Society. (2001)

Liebl, A. Neiß, A., Spannheimer, A., Reitberger, U., Wagner, T. Görtz, A.“Kosten des Typ-2-Diabetes in Deutschland - Ergebnisse der CODE-2®-Studie -.” DMW - Deutsche Medizinische Wochenschrift 126(20):585-589. Accessed September 15, 2011. (2001)

Lohr, K. “Outcome measurement: concepts and questions.” Inquiry: A Journal of Medical Care Organization, Provision and Financing 25(1):37-50. Accessed August 19, 2011. (1988)

Luthi, J., Troillet, N., Eisenring, M. Sax, H., Burnand, B., Quan, H. Ghali, W. “Administrative data outperformed single-day chart review for comorbidity measure.” International Journal for Quality in Health Care: Journal of the International Society for Quality in Health Care / ISQua 19(4):225-231. Accessed September 12, 2011. (2007)

Mähönen, M., Salomaa, V., Keskimäki I., Moltchanov V. “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.” European Journal of Epidemiology 16(8):701-711. Accessed September 20, 2011. (2000)

Mainz, J. “Defining and classifying clinical indicators for quality improvement.” International Journal for Quality in Health Care 15(6):523 -530. Accessed August 17, 2011. (2003)

Malinowski, E., Zimányi, E. “Advanced data warehouse design: from conventional to spatial and temporal applications.” Springer. (2008)

Mangione-Smith, R., McGlynn E. “Assessing the quality of healthcare provided to children.” Health Services Research 33(4 Pt 2):1059-1090. Accessed August 11, 2011. (1998)

Masing, W. Handbuch Qualitätsmanagement. Hanser. (1999)

McGlynn, E. “The outcomes utility index: will outcomes data tell us what we want to know?” International Journal for Quality in Health Care 10(6):485 -490. Accessed August 23, 2011. (1998)

Meister, J., Rohde, M., Appelrath, H., Kamp, V. “Data-Warehousing im Gesundheitswesen (Data Warehousing in Health Care).” it - Information Technology 45:179-185. Accessed September 27, 2011. (2003)

Morgan, C., Currie, C., Peters, J. “Relationship between diabetes and mortality: a population study using record linkage.” Diabetes Care 23(8):1103 -1107. Accessed September 15, 2011. (2000)

Nanda, V. “Quality Management System Handbook for Product Development Companies.” 1st ed. CRC Press. (2005)

Needham, D., Scales, D., Laupacis, A., Pronovost, P. “A systematic review of the Charlson comorbidity index using Canadian administrative databases: a perspective on risk adjustment in critical care research.” Journal of Critical Care 20(1):12-19. Accessed September 12, 2011. (2005)

Nolting, H, Gottberg, A., Schiffhorst, G., Buhr, S., Engel, J. “Einfluss der Teilnahme am DMP Diabetes mellitus Typ 2 auf die Entwicklung der Leistungsausgaben – Ergebnisse einer retrospektiven kontrollierten Studie auf der Basis von GKV-Routinedaten.” Gesundheitsökonomie & Qualitätsmanagement 16(04):209-215. Accessed September 1, 2011. (2011)

ÖBIG. 2011. “Gesundheit Österreich GmbH | ÖGIS.” Accessed November 28, 2011 (http://www.goeg.at/de/Bereich/OeGIS.html). (2011)

OECD. 2009. “Health at a Glance 2009 OECD Indicators.” Accessed September 15, 2011 (http://www.oecd.org/document/11/0,3746,en_2649_33929_16502667_1_1_1_1,00.html). (2009)

Pine, M., Jordan, H., Elixhauser, A., Fry, D., Hoaglin, D., Jones, B., Meimban, R., Warner, D. Gonzales, J. “Enhancement of claims data to improve risk adjustment of hospital mortality.” JAMA: The Journal of the American Medical Association 297(1):71-76. Accessed August 25, 2011. (2007)

Prather, J, Lobach, D., Goodwin, L.,m Hales, J., Hage, m., Hammond, e. “Medical data mining: knowledge discovery in a clinical data warehouse.” Proceedings of the AMIA Annual Fall Symposium 101-105. (1997)

Quality Progress. 2002. “Quality Glossary.” ASQ. (2002)

Quan, H., Sundararajan, V., Halfon, P., Fong, A., Burnand, B., Luthi, J. Saunders, D., Beck, C., Feasby, T., Ghali, W. “Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data.” Medical Care 43(11):1130-1139. Accessed September 12, 2011. (2005)

Quan, H., Li, B., Saunders, D., Parsons, G., Nilson, C., Alibhai, A., Ghali, W. “Assessing validity of ICD-9-CM and ICD-10 administrative data in recording clinical conditions in a unique dually coded database.” Health Services Research 43(4):1424-1441. Accessed September 12, 2011. (2008)

Redman, T. “The impact of poor data quality on the typical enterprise.” Commun. ACM 41(2):79–82. (1998)

Reinhold, T., Andersohn, F., Hessel, F., Brüggenjürgen, B., Willich, S.“Die Nutzung von Routinedaten der gesetzlichen Krankenkassen (GKV) zur Beantwortung gesundheitsökonomischer Fragestellungen – eine Potenzialanalyse.” Gesundheitsökonomie & Qualitätsmanagement 16(03):153-159. Accessed August 30, 2011. (2011)

Reinhold, T., Thierfelder, K., Müller-Riemenschneider, F., Willich, S. “Gesundheitsökonomische Auswirkungen der DRG-Einführung in Deutschland – eine systematische Übersicht.” Das Gesundheitswesen 71(05):306-312. Accessed August 29, 2011. (2009)

Reuter, P. “Springer Wörterbuch Medizin: So schreibt man Medizin.“ 2nd ed. Springer, Berlin. (2004)

Schneider, A., Broge, B., Szecsenyi, J. “Müssen wir messen, um (noch) besser werden zu können? Die Bedeutung von Qualitätsindikatoren in strukturierten Behandlungsprogrammen und Qualitätsmanagement.” Z Allg Med 79:547–52. (2003)

Schubert, I., Köster, I., Küpper-Nybelen, J., Ihle, P.“Versorgungsforschung mit GKV-Routinedaten.” Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz 51(10):1095-1105. Accessed August 29, 2011. (2008)

Shaughnessy, P., Hittle, D. “Overview of risk adjustment and outcome measures for home health agency OBQI reports: Highlights of current approaches and outline of planned Enhancements.” Center for Health Services Research, University of Colorado Health Sciences Center. (2002)

SQG. 2010. “Sektorenübergreifende Qualität im Gesundheitswesen SQG / Hintergrund - Methodenpapier.” Accessed August 18, 2011 (http://www.sqg.de/sqg/upload/CONTENT/Hintergrund/Methodenpapier/AQUA_AllgemeineMethoden_Version_2-0.pdf). (2010)

Steirische Statistiken. 2007. “Niedergelassene Ärzte in der Steiermark 2007.” Heft 6/2007. Accessed October 22, 2011 (http://www.verwaltung.steiermark.at/cms/dokumente/10003178_97617/89a745a8/Publikation%206-2007.pdf). (2007)

Stock, S., Redaelli, M. Wendland, G, Civello, D., Lauterbach, K. “Diabetes—prevalence and cost of illness in Germany: a study evaluating data from the statutory health insurance in Germany.” Diabetic Medicine 23(3):299-305. Accessed September 14, 2011. (2006)

Sundararajan, V., Quan, H. Halfond, P., Fushimi, K., Luthi, J., Burnand, B., Ghali, W. “Cross-national comparative performance of three versions of the ICD-10 Charlson index.” Medical Care 45(12):1210-1215. Accessed September 12, 2011. (2007)

Swart, E. “Good practice of secondary data analysis.” Journal of Public Health 13(3):175-175. Accessed August 25, 2011. (2005)

Swart, E., Deh, U., Robra, B.“Die Nutzung der GKV-Daten für die kleinräumige Analyse und Steuerung der stationären Versorgung.” Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz 51(10):1183-1192. Accessed September 1, 2011. (2008)

Takanishi Jr., D., Yu, M., Morita, S., Daniel, S., Severino, R. “Twenty-eight-day mortality in critically ill surgical patients is an imprecise temporal end-point measure for in-hospital mortality.” The American Journal of Surgery 196(5):768-773. Accessed September 2, 2011. (2008)

Tan, J. “E-health care information systems: an introduction for students and professionals.” John Wiley and Sons. (2005)

Tayi, Gi., Ballou, D. “Examining data quality.” Commun. ACM 41(2):54–57. (1998)

The European Parliament. 2007. DECISION No 1350/2007/EC. establishing a second programme of Community action in the field of health Accessed (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:301:0003:0013:en:PDF) (2007)

The European Parliament. 2008. REGULATION (EC) No 1338/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 on Community statistics on public health and health and safety at work. Accessed (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:354:0070:0081:EN:PDF). (2008)

Thomas, J., Hofer, T. "Accuracy of risk-adjusted mortality rate as a measure of hospital quality of care." Medical Care 37(1):83-92. Accessed September 21, 2011. (1999)

WIdO. "Qualitätsicherung der stationären Versorgung mit Routinedaten (QSR) - Abschlussbericht." AccessedMai 23, 2011 (http://wido.de/fileadmin/wido/downloads/pdf_ggw/wido_ggw_aufs3_0108.pdf) (2007)

Wikipedia contributors. 2011. "Comorbidity." Wikipedia, The Free Encyclopedia. Accessed September 12, 2011 (http://en.wikipedia.org/w/index.php?title=Comorbidity&oldid=445116879).

Wisniewski, M., Kieszkowski, P., Zagorski, B., Trick, W., Sommers, M., Weinstein, R. "Development of a clinical data warehouse for hospital infection control." Journal of the American Medical Informatics Association 10(5):454-462. Accessed September 27, 2011. (2003)

Worning, A., Mainz ,J., Klazinga, N., Gotrik, J., Johansen K. "Policy on quality development for the medical profession [in Danish]." Ugeskr Laeger. (1992)