WIdO | Wissenschaftliches Institut der AOK

Risk Adjustment Using Administrative Data: Experiences from 10 years of public reporting in Germany

IQTIG-Workshop *Statistical Methods for Risk Adjustment in Health Care*
Berlin, 17.03.2021

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Wissenschaftliches Institut der AOK (WIdO)

Let data speak…

- 72 Mio. SHI insurees, 26 Mio. of which are insured with AOK
- Inpatient treatments in ~2,000 hospitals
- Medical care rendered by ~140,000 contracted physicians
- Reimbursed drug supply in ~20,000 pharmacies
- 50,000 different products in the finished drugs market
- Provision of remedies by ~50,000 occupational, physio and speech therapists
- Absenteeism data of 11 Mio. AOK members in 1,3 Mio. companies

Agenda

① Why risk adjustment?

② How is risk adjustment implemented in the QSR programme?

a. What is QSR (*Qualitätssicherung mit Routinedaten* / Quality Assurance with Administrative Data)?

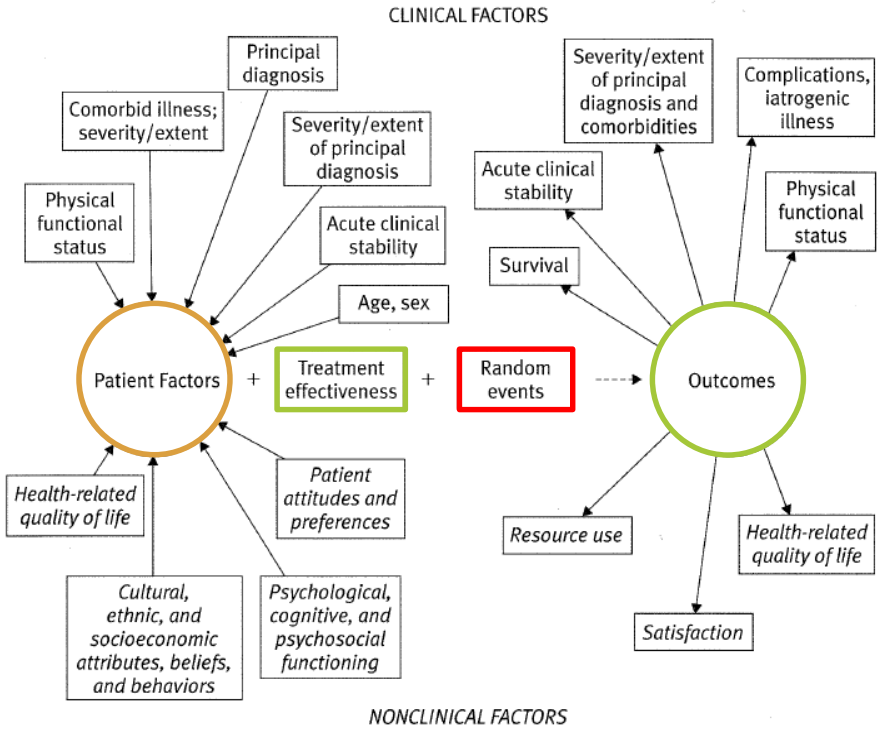
b. Methodology of risk adjustment

c. Examples

③ Conclusion and recommendations

Risk Adjustment in Quality Measurement

- Risk adjustment is necessary if the patient mix of the groups to be compared differs with regard to risk factors that influence the outcome
- Possible reasons for differences in patient mix include population differences, specialisation and risk selection
- The aim of risk adjustment is to achieve a fair group comparison - especially when comparing medical care facilities



Quelle: Iezzoni LI, Reasons for risk adjustment. In: Iezzoni LI (ed.), Risk adjustment for measuring health outcomes. 2003: 5

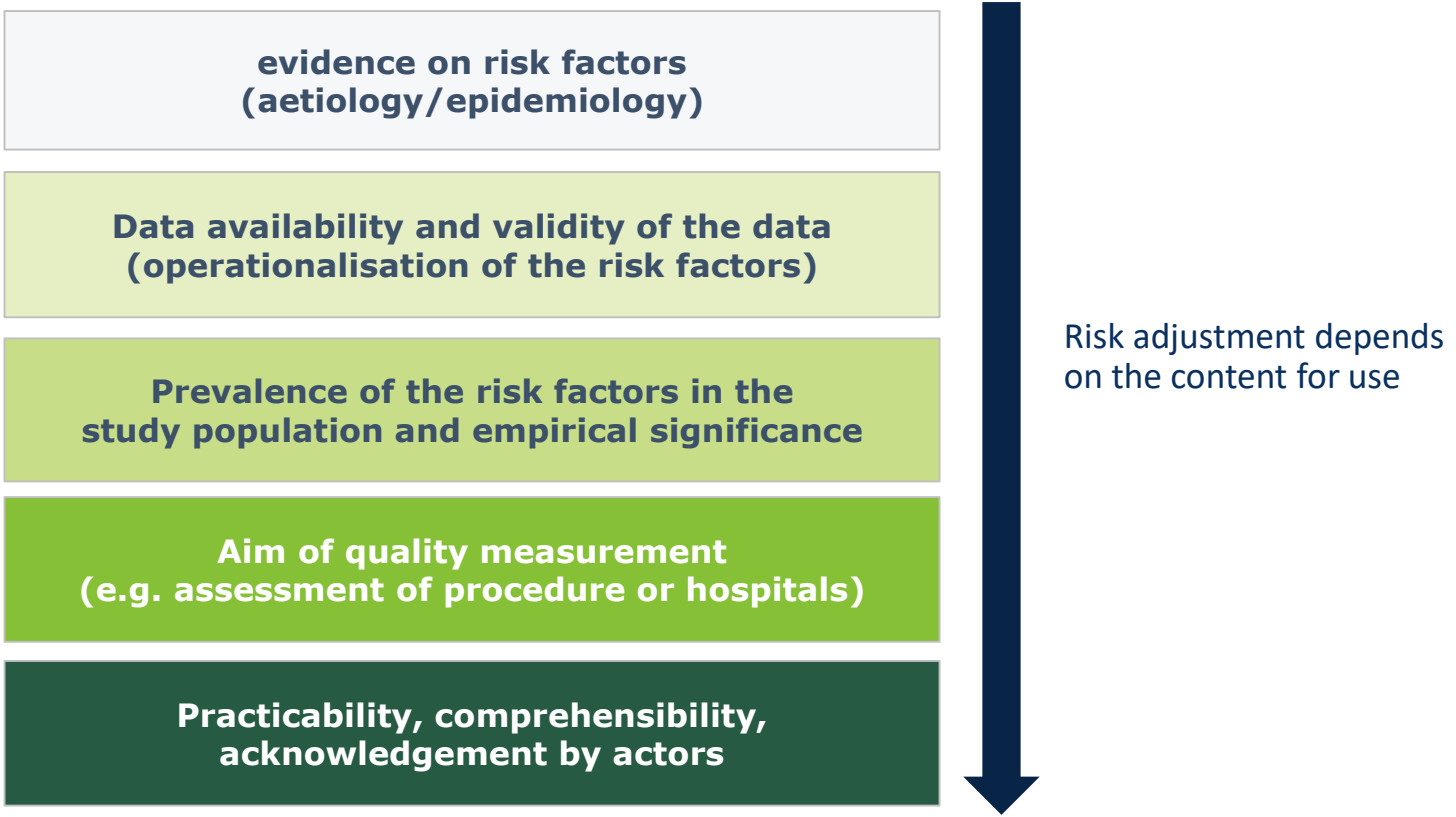
Methods of Risk Adjustment

- Definition von quality indicators with a population that is as homogeneous as possible (e.g. exclusion of patients with cancer if total hip replacement is surgical procedure of interest)

- Risk stratification through separate comparisons of subgroups that are as homogeneous as possible (e.g. comparison according to the selected surgical procedure)

- Regression analysis to compensate for the influence of a large number of competing risk factors by including categorical (e.g. gender) and continuous variables (e.g. age in years)

Put risk adjustment into context



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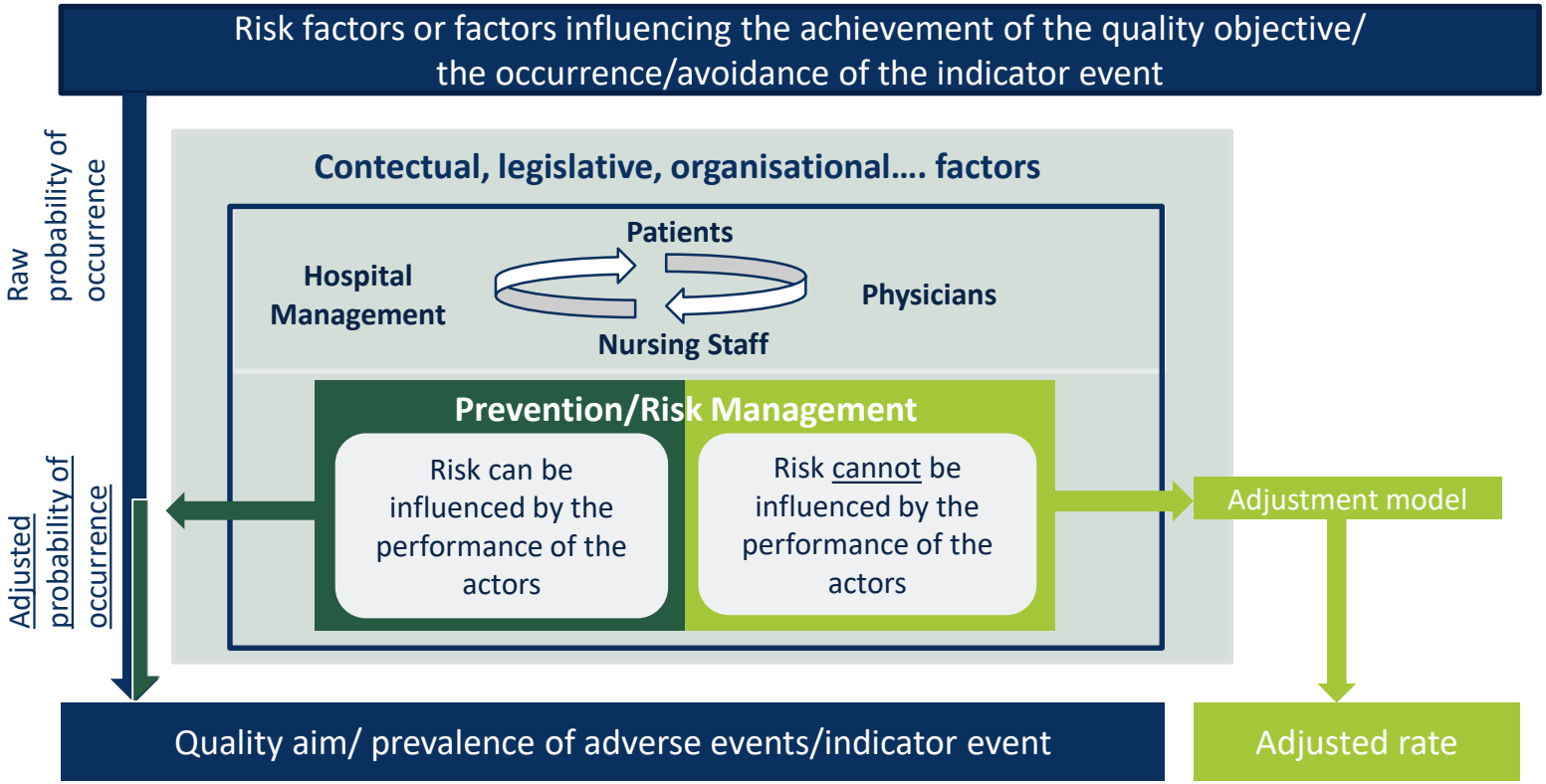

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The QSR Programme

- Aims to measure quality of common inpatient treatments
- Initiated by AOK-Bundesverband, HELIOS (private hospital group) and FEISA (Affiliated Institute of University of Magdeburg) in 2002
- Secondary use of anonymized administrative data of Germany's largest statutory health insurance AOK
- Focus on outcomes
- Advantage: Follow-up beyond the hospital stay without additional documentation effort
- Further developed and conducted by the AOK Research Institute (WIdO)
- www.wido.de
- www.qualitaetssicherung-mit-routinedaten.de

QSR Qualitätssicherung mit Routinedaten

The QSR Programme: Scientific und Clinical Advisors

Scientific Advisory Board

Advises on the selection of procedures and fundamental decisions

- Otto-von-Guericke-Universität Magdeburg
- PMV Forschungsgruppe der Universität zu Köln
- TU Berlin, FB Strukturentwicklung und Qualitätsmanagement, Berlin
- HELIOS Kliniken GmbH, Berlin
- Flying Health, Berlin
- IQTIG-Institut, Berlin
- Bertelsmann Stiftung, Gütersloh
- Patientenvertreter im Gemeinsamen Bundesausschuss (G-BA), Berlin

Expert Panels

Support the further development of methodology and the development of quality indicators in the individual disciplines

- Physicians and practitioners with special expertise (from different institutions)
- Quality experts
- Epidemiologists
- Statisticians

Currently nine panels

Abdominal surgery, endocrine surgery, obstetrics and neonatology, heart valve therapy, cardiology, orthopaedics and trauma surgery (endoprosthetics, fracture care), otorhinolaryngology, urology

SHI Data: Service Sectors

Data Sets	Social Code Book
Insuree master data	V: § 288
Hospital care	V: § 301 Abs. 1
Outpatient services at hospitals	V: §§ 115-120, 140
Medical care by SHI-accredited physicians	V: § 295 Abs. 2
Drug prescriptions	V: § 300 Abs. 1
Inpatient preventive measures / therapeutic cures / rehabilitation	V: § 301 Abs. 4
Incapacity to work	V: § 295 Abs. 1
Remedies and aids	V: § 302
Care for the chronically ill in DMPs	V: § 137f
Outpatient care, day care, home care and full-time longterm care	XI: §§ 36-38, § 41; V: § 37, § 43

Collection and storage of social data (§ 284 SGB V) of a total of
72 Mio. insurees
in 105 statutory health care funds

27 Mio. of which are insured with AOK

SHI Data: Outpatient Services at Hospitals

Legal Form	SGB V	Contract Type / Billing
Outpatient surgery in hospitals (115B)	§ 115b	EBM, federal regulations
Outpatient treatment in hospital (116B)	§ 116b (2 ff.) (alt)	EBM, federal regulations
Outpatient specialist care (ASV)	§ 116b (neu)	EBM, federal regulations
University outpatient clinics (HSA)	§ 117 (1) und (2)	Individual contracts, lump sums
Outpatient clinics at training centres according to § 6 PsychThG (APA)	§ 117 (3)	Individual contracts, EBM
Psychiatric outpatient departments (PIA)	§ 118	Individual contracts, documentation of services via „PIA-OPS“ in the OPS table
Social paediatric centres (SPZ)	§ 119	Individual contracts, lump sums
Medical treatment centres for adults with intellectual disabilities or severe multiple disabilities (MZEB)	§ 119c	Individual contracts, lump sums
Paediatric special outpatient departments/special outpatient departments at paediatric hospitals (KSA)	§ 120 (1a)	Individual contracts, lump sums
Special care (AIV)	§ 140a	Individual contracts

A Patient's Treatment Journey… in Administrative Data

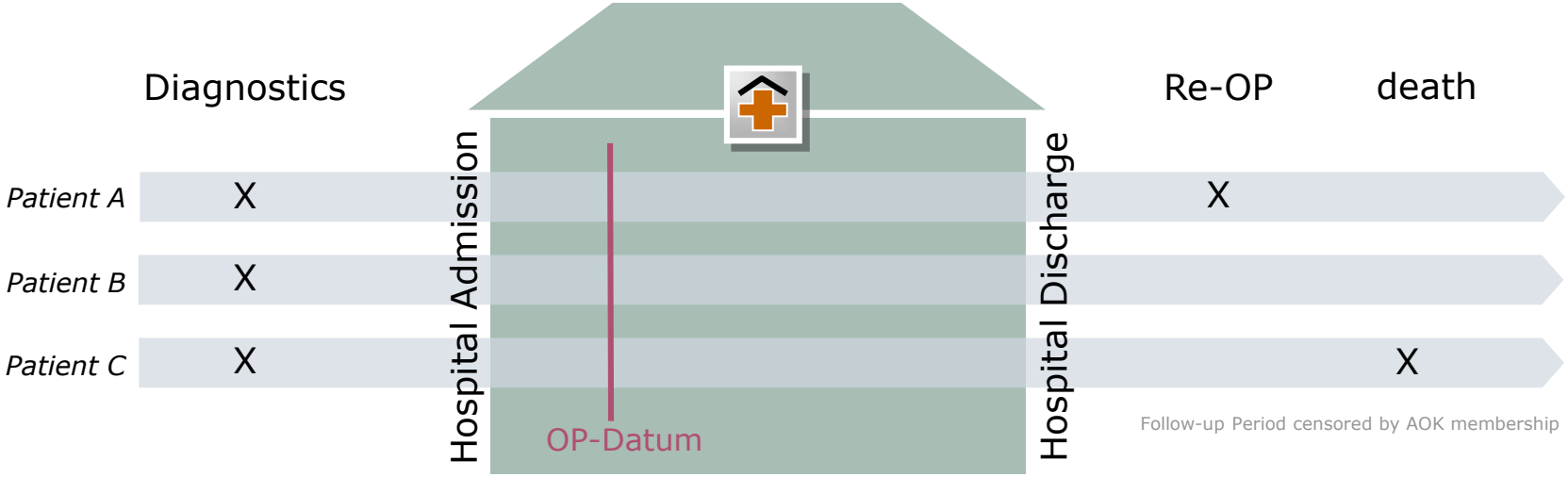


Fig. 1 Study timeline

QSR Pros and Cons

Advantages

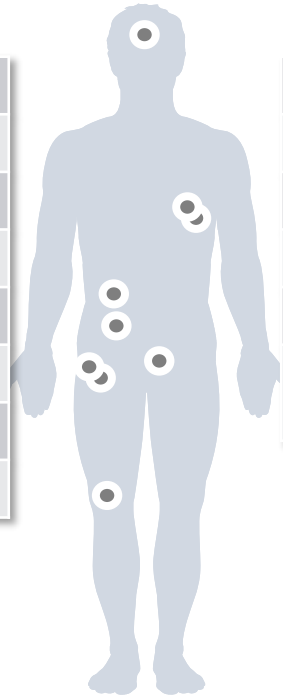
- Outcome quality
- Additional quality information through follow-up
- No additional effort for hospitals

Limitations

- Only usable for selected quality statements, as data were collected for other purpose (billing)

QSR: Indicator Sets for 22 Inpatient Treatments (1)

- Appendectomy*
- Gall bladder removal*
- Colon/rectum surgery for colorectal cancer
- Closure of an inguinal hernia*
- Surgery for benign thyroid disease
- Sectio
- Vaginal delivery
- Care of premature babies (VLBW)

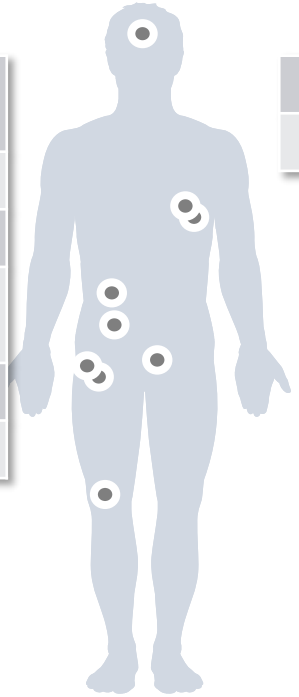


- Heart attack
- Heart failure
- Coronar angiography
- PCI in patients without myocardial infarction*
- PCI in patients with myocardial infarction
- Transvascular transcatheter aortic valve implantation (TV-TAVI)

* with public reporting

QSR: Indicator Sets for 22 Inpatient Treatments (2)

- Cerebral infarction or intracerebral haemorrhage
- Hip joint replacement for coxarthrosis*
- Changing a hip joint endoprosthesis*
- Hip joint replacement/osteosynthesis for hip fracture*
- Knee joint replacement for gonarthrosis*
- Knee joint replacement



- Prostate surgery for benign prostatic syndrome*
- Prostate removal (RPE) for prostate cancer*

* with public reporting

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Identification of Risk Factors

- Common Patient Factors
  - age
  - gender
  - comorbidities according to the Elixhauser comorbidity classification

- Additional procedure-specific or endpoint-specific factors, e.g.
  - advanced inflammation in appendectomy
  - peritoneal adhesions in inguinal hernia surgery
  - extent of procedure (change of endoprosthesis, stem, cup or inlay, ...) in case of change of a hip joint endoprosthesis or components (aseptic, single-stage)
  - preoperative antithrombotic therapy for bleeding complications

Identification of Risk Factors

- Research of potential risk factors
  - literature research
  - explorative empirical analysis, if possible as a longitudinal analysis
  - expert interview and consensus

- Criteria for selection risk factors
  - construct validity (does the factor capture an endpoint-relevant risk?)
  - predictive validity (is the factor associated with an increased endpoint rate?)
  - operationalizability (can the factor be documented - especially in routine data?)
  - homogeneity of documentation (is the factor documented uniformly?)
- for comparison of hospitals with regard to outcomes:
  - no adjustment for comorbidity acquired in the clinic (did the factor already exist on admission?)
  - if possible, no adjustment for factors influenced by the clinic
  - no adjustment for process variables

Tasks for Risk Adjustment

- Identification of risk factors
- Decision on timing of risk factor measurement (pre-existing or sequel to intervention)
- Decision on the adjustment procedure and statistical method for modelling
- Reduction of the model with involvement of medical experts
  (exclusion of non-significant or counterintuitive risk factors)
- Statistical assessment of the model
  - Test for multicollinearity using variance inflation factors
  - Evaluation of model fit using common fit measures (e.g. AUROC, Pseudo r2, Hosmer-Lemeshow test)
  - Test for systematic unexplained variance by group comparisons (university hospitals, maximum care hospitals, specialist hospitals, etc.)
- Output observed and model-predicted outcomes
- Computation of risk-adjusted quality measures (e.g. rate O/E, SMR)

Risk-adjusted Quality Measure: SMR

- **Definition**

  Standardised mortality/morbidity ratio (SMR) is a ratio of

$$SMR = \frac{Number\ of\ events\ observed}{Number\ of\ expected\ events}$$

- **Calculation**

  For each clinic, the observed events are counted and the expected events are calculated using logistic regression.

- **Interpretation**

  The SMR is a risk-adjusted quality indicator with values of

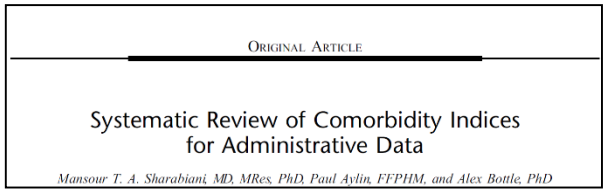
  = 1.0 Observed number corresponds to the risk-adjusted average of all clinics when treating AOK patients.

  < 1.0 Fewer events than expected occur in a clinic. At 0.5, half as many.

  > 1.0 More events than expected occur in a clinic. At 2.0 twice as many.

Comorbidity Indices

- Charlson Comorbidity Index (CCI)
  - developed in 1987, updated several times, 19 (17) comorbidities, original endpoint: mortality
- Elixhauser Comorbidity Measure (ECM) / Elixhauser Comorbidity Conditions
  - developed in 1998, 30 comorbidities, original endpoint: hospital expenditure, length of stay, hospital letality



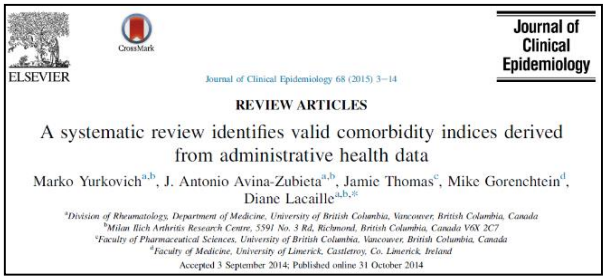
ORIGINAL ARTICLE

Systematic Review of Comorbidity Indices for Administrative Data

Mansour T. A. Sharabiani, MD, MRes, PhD, Paul Aylin, FFPHM, and Alex Bottle, PhD

Systematical review: studies comparing comorbidity measures in use with administrative data

Conclusions: The performance of a given comorbidity measure depends on the patient group and outcome. In general, the Elixhauser index seems the best so far, particularly for mortality beyond 30 days, although several newer, more inclusive measures are promising.



ELSEVIER

Journal of Clinical Epidemiology

Journal of Clinical Epidemiology 68 (2015) 3–14

REVIEW ARTICLES

A systematic review identifies valid comorbidity indices derived from administrative health data

Marko Yurkovich[a,b], J. Antonio Avina-Zubieta[a,b], Jamie Thomas[c], Mike Gorenchtein[d], Diane Lacaille[a,b,e]

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[b]Milan Ilich Arthritis Research Centre, 5591 No. 3 Rd, Richmond, British Columbia, Canada V6X 2C7
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[d]Faculty of Medicine, University of Limerick, Castletroy, Co. Limerick, Ireland

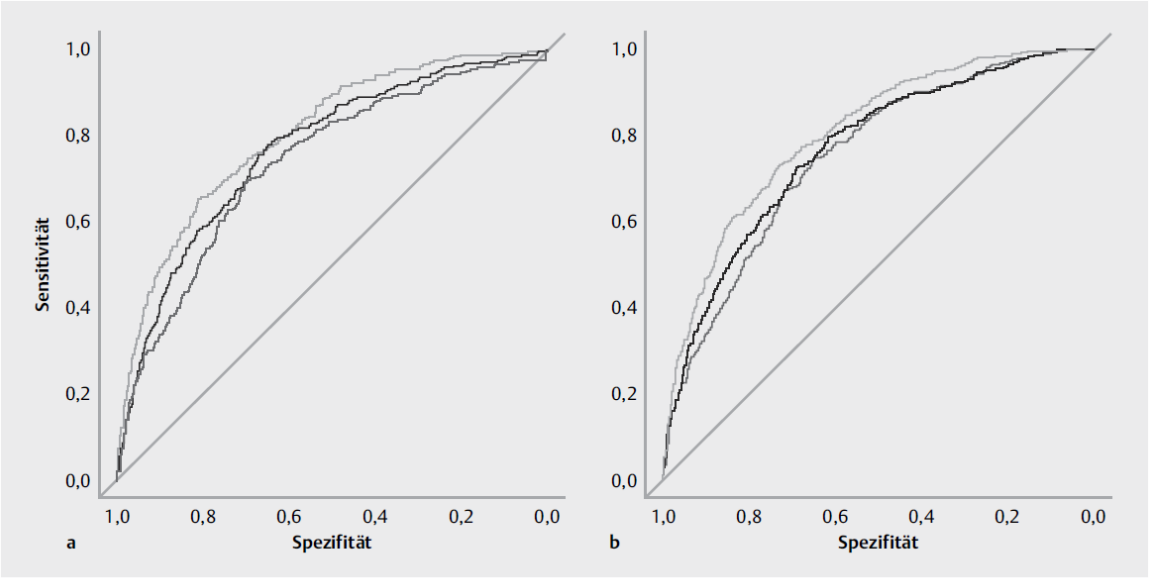
Accepted 3 September 2014; Published online 31 October 2014

Systematical review: studies reporting on the development or validation of comorbidity indices using administrative health data and compare their ability to predict outcomes related to comorbidity (i.e., construct validity)

Results: The ability of indices studied to predict morbidity-related outcomes ranged from poor (C statistic 0.69) to excellent (C statistic 0.80) depending on the specific index, outcome measured, and study population. Diagnosis-based measures, particularly the Elixhauser Index and the Romano adaptation of the Charlson Index, resulted in higher ability to predict mortality outcomes.

Comparison of Common Risk Models: Colorectal Cancer

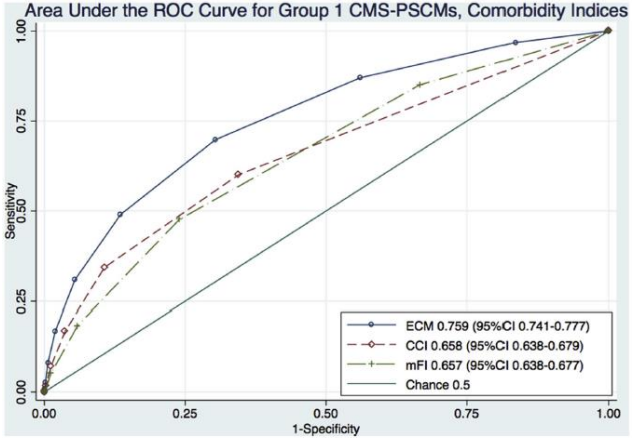
Crispin, A., et al. (2018). Risikoberechnung mit Routinedaten? Entwicklung und Validierung multivariabler Modelle zur Prädiktion der 30- und 90-Tage-Mortalität nach chirurgischer Behandlung kolorektaler Karzinome. Gesundheitswesen 80(11):963-973



► **Abb. 1** Receiver Operating Characteristic Curves für die Modelle zur Prädiktion der Mortalität in der Validierungsstichprobe nach 30 **a** und 90 Tagen **b** auf der Basis der Elixhauser Comorbidities (hellgrau), Charlson Conditions (schwarz) und Charlson Scores (mittelgrau). Dargestellt ist die Sensitivität als Funktion der Spezifität der jeweiligen Modelle in der Validierungsstichprobe. Die ideale ROC-Kurve verläuft durch die obere linke Ecke der Zeichenfläche, sodass die Fläche unter dem Grafen (Area Under the Curve, AUC) einen Wert nahe 1 annimmt.

Modell	AUC (95 %-KI)
Elixhauser Comorbidities	
30-Tage-Mortalität	0,804 (0,776–0,832)
90-Tage-Mortalität	0,805 (0,782–0,828)
Charlson Conditions	
30-Tage-Mortalität	0,769 (0,738–0,799)
90-Tage-Mortalität	0,767 (0,742–0,793)
Charlson Score	
30-Tage-Mortalität	0,738 (0,706–0,771)
90-Tage-Mortalität	0,752 (0,727–0,777)

Comparison of Common Risk Models: THA und TKA



Models	90 Days*	
	OR (95% CI)	*C* Statistic
Base (model 1)	–	0.69
Unweighted co-morbidity scores		
Elixhauser (model 2)	1.60 (1.45–1.77)	0.78
Charlson (model 3)	1.83 (1.57–2.13)	0.76
RxRisk-V (model 4)	1.20 (1.13–1.28)	0.75
Weighted co-morbidity scores		
Elixhauser (model 5)	1.14 (1.11–1.17)	0.77
Charlson (model 6)	1.43 (1.30–1.57)	0.75
RxRisk-V (model 7)	1.12 (1.08–1.17)	0.74
Specific conditions within each measure†		
Elixhauser (model 8)	–	0.79‡
Charlson (model 9)	–	0.75‡
RxRisk-V (model 10)	–	0.78‡
Combined Elixhauser, Charlson, and RxRisk-V (model 11)	–	0.82‡

OR = Odds ratio. CI = Confidence intervals.
* All include age, gender, and primary diagnosis unless otherwise specified.
† See Table V for models with specific conditions.
‡ Model was better fit with age and primary diagnoses.

Endpoints according to THA: (1) acute myocardial infarction, pneumonia, sepsis/septicemia/shock (2) surgical site bleeding, pulmonary embolism, death (3) mechanical complications, periprosthetic joint/wound infection (4) Extended Length of Stay (5) Discharge to Facility

Risk factors: Charlson comorbidity index, Elixhauser comorbidity measure, modified frailty index (mFI), age, gender, obesity

Results: ECM outperformed CCI and mFI for the occurrence of all 5 adverse outcomes.

Ondeck et al., The Journal of Arthroplasty 2018

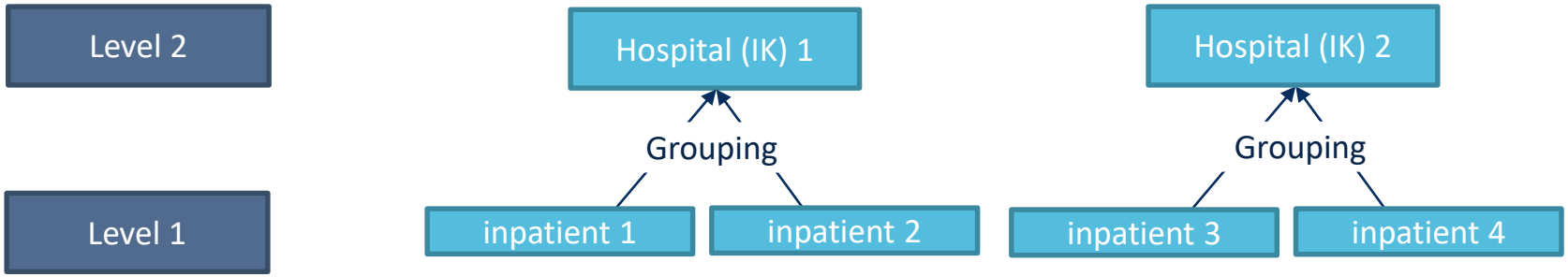
Endpoints according to THA und TKA: (1) 90 days mortality (2) 1 year mortality

Risk factors : Charlson comorbidity index, Elixhauser comorbidity measure, RxRisk-V

Results: Individually, the model with Elixhauser conditions performed best with 90 days mortality (c = 0.79, P = 0.435) and all performed similarly at 1 year (c = 0.74-0.75, all P > 0.05).

Inacio et al., Osteoarthritis and Cartilage 2016

Not to be ignored: Clustering



- The underlying data represent different levels of analysis:
  - the personal and
  - the hospital-related level
  - ➢ **clustered data with hierarchical structure**
- Individual units of enquiry clearly belong to superordinate groups.
- Individuals within the group are subject to common influences or experiences.

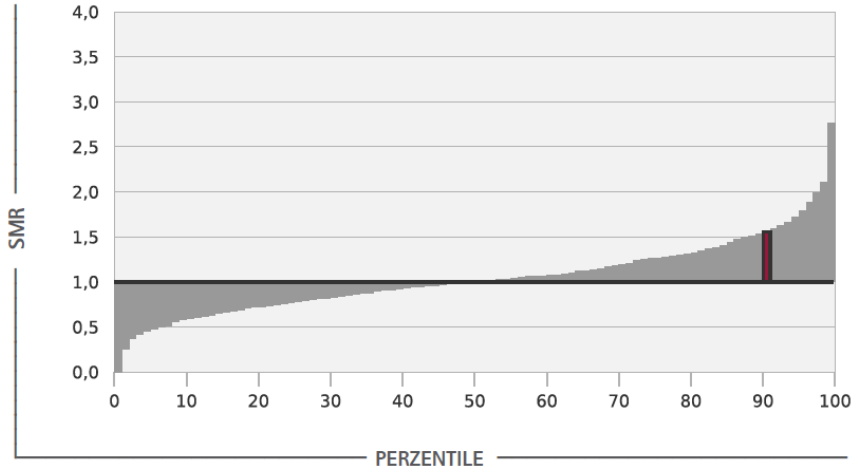
Ignoring this structure leads to
- Underestimation of standard errors
- Overestimation of statistical significance

Output: Hospital Report Card (*QSR-Klinikbericht*)

Abbildung 6.5.3

Sterblichkeit innerhalb von 30 Tagen bei PCI bei Patienten mit HI
Standardisiertes Mortalitäts-/Morbiditätsverhältnis, SMR (2014–2016)

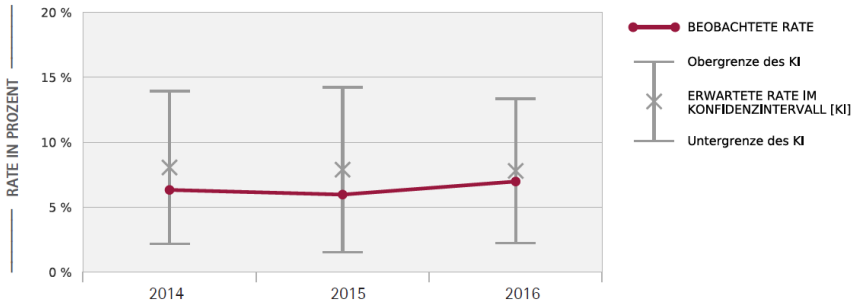
Qualitätsziel: Niedriges Perzentil, SMR-Wert kleiner als 1



Die Markierung zeigt den Rang Ihres Krankenhauses in Bezug auf die jeweilige Kennzahl im Vergleich zu allen Krankenhäusern. Dabei gilt: je größer die Kennzahl eines Krankenhauses, desto höher sein Rangplatz. Liegt Ihr Krankenhaus auf Rang 60 (60. Perzentil), so bedeutet das, dass 40 Prozent der Krankenhäuser einen höheren Kennzahlenwert haben als Ihr Haus.

Abbildung 6.5.9

Trenddarstellung: Wiederaufnahme wegen Herzinfarkt, Hirninfarkt oder TIA (MACCE ohne Tod) innerhalb von 365 Tagen (2014–2016)



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PCI for Inpatients with Acute Myocardial Infarction

- Anonymized billing and master data of 26 Mio. AOK insurees (2016)
  - **Inpatient care:** 6,9 Mio. cases per year
    - diseases (ICD-10; case-related; without date)
    - interventions (OPS; case-related; with date)
    - length of stay, transfers, reason for discharge, etc.
  - **Drug prescriptions:** about 285 Mio. per year
  - **Master data**: age and gender, vital and insured status
  - Hospitalisations or prescriptions can be assigned to a person without being re-identifiable

- **PCI with AMI:** 119.455 AOK patients with acute Myokardal infarction and PCI from 2014 to 2016 (after exclusion of patients with PCI or cardiac surgery in the individual previous year)
- **End points:** (1) mortality within 30 days, (2) MACCE within one year (death or new hospitalisation with myocardial infarction, stroke or TIA)
- **Risk factors:** Age, gender, Elixhauser comorbidities (excluding heart failure), number of affected vessels, main stem stenosis and PCI or antithrombotic medication in the previous year…

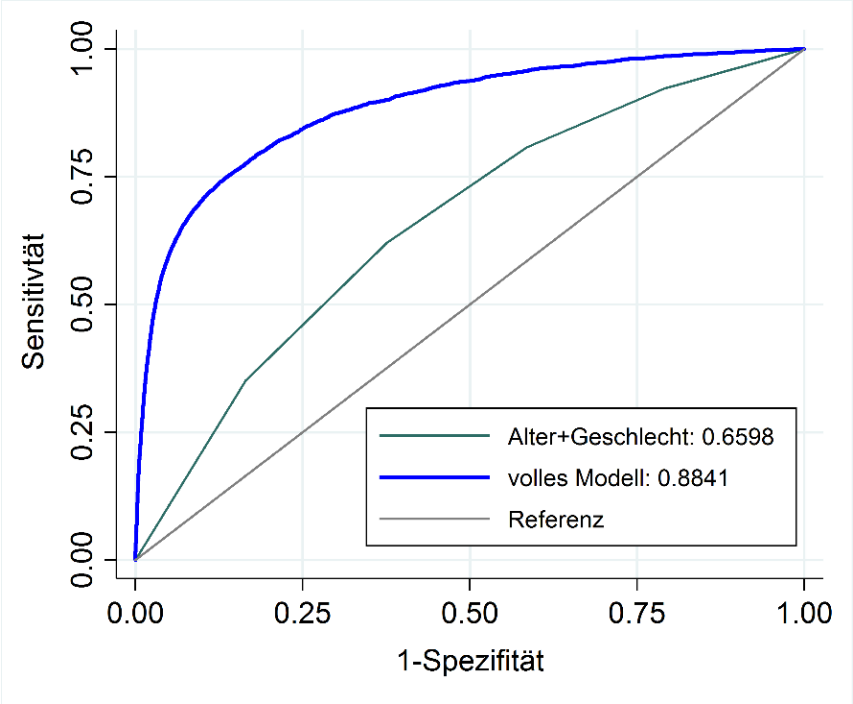
PCI for Inpatients with Acute Myocardial Infarction: Risk factors

- Age
- Gender
- Concomitant diseases according to Elixhauser et al. (index episode; with the exception of cardiac arrhythmia, as this is considered in a differentiated way*)
- Shock (start case)
- NYHA stage > 1 (start case)
- Main stem stenosis (start case)
- 2-vessel disease (start case)
- 3-vessel disease (start case)
- Ventricular fibrillation3rd degree AV block
- Cardiac arrhythmias other than ventricular fibrillation or 3rd degree AV block
- Number of PCI (1 coronary artery vs. at least 2)
- Antithrombotic medication in the previous year Dialysis (previous year)
- Heart attack (previous year)
- BUT: Time until admission is MISSING

**Indicator other complications: other exceptions*
Pulmonary heart disease and diseases of the pulmonary circulation, as the endpoint pulmonary embolism is included;
Renal failure/insufficiency without dialysis, since endpoint;

PCI for Inpatients with Acute Myocardial Infarction

ROC curves of the 30-day mortality prediction models



- The 30-day mortality rate for PCI in patients with myocardial infarction was 6.20 %.
- The mortality risk increases with age, number of affected vessels and concomitant diseases.
- The full model is clearly superior to a pure gender model in terms of its discriminatory ability. The area under the receiver operator characteristic curve (AUC) is 0.8841 vs. 0.6598.
- The inclusion of myocardial infarction or antithrombotic medication in the previous year increases the model quality.

PCI for Inpatients with Acute Myocardial Infarction

Risk factor	*Mortality within 30 days*	*MACCE within 365 days*
	Odds Ratio (95%-KI)	Odds Ratio (95%-KI)
Age (Reference: under 60)		
60 bis 68 years	1,59 (1,41-1,80)	1,38 (1,29-1,48)
69 bis 74 years	2,82 (2,52-3,15)	2,08 (1,94-2,23)
75 bis 79 years	4,57 (4,08-5,12)	2,86 (2,66-3,07)
over 79 years	9,07 (8,08-10,17)	4,63 (4,30-4,98)
Gender (Reference: male)		
female	1,22 (1,15-1,30)	0,67 (0,62-0,73)
Card. disease. u. Sympt. (selection)		
Shock	16,68 (15,41-18,06)	6,19 (5,81-6,59)
Peripheral vascular disease	0,86 (0,78-0,95)	1,28 (1,21-1,35)
Three-vessel disease	1,16 (1,07-1,24)	1,38 (1,32-1,43)
Stenosis of the left main stem	1,50 (1,35-1,66)	1,32 (1,23-1,41)
Cardiac arrhythmia without ventricular flutter/fibrillation and without 3rd degree AV block	-	1,25 (1,21-1,30)
Ventricular flutter and fibrillation	2,63 (2,36-2,94)	1,92 (1,77-2,08)
Heart attack (in previous year)	1,32 (1,04-1,69)	1,94 (1,70-2,22)
Antithrombotic medication in previous year	1,20 (1,12-1,28)	1,41 (1,36-1,47)

Continued:

Risk factor	*Mortality within 30 days*	*MACCE within 365 days*
	Odds Ratio (95%-KI)	Odds Ratio (95%-KI)
Dialysis in previous year	2,19 (1,79-2,67)	2,65 (2,32-3,02)
Elixhauser comorbidities (selection)		
Alcohol abuse	-	1,38 (1,20-1,59)
Lymphoma	-	2,25 (1,51-3,36)
Metastatic cancer	2,45 (1,62-3,71)	3,59 (2,74-4,70)
Solid tumors without met.	-	2,35 (2,03-2,72)
Chronic pulmonary disease	-	1,33 (1,26-1,41)
Diabetes complicated	1,20 (1,12-1,28)	1,29 (1,23-1,34)
Diabetes uncomplicated	1,13 (1,01-1,26)	1,35 (1,28-1,43)
Weight loss	-	1,47 (1,27-1,71)
Coagulopathy	-	1,43 (1,30-1,56)
Paralysis	-	1,25 (1,12-1,39)
Liver disease	1,60 (1,36-1,89)	1,51 (1,35-1,70)
Renal failure	-	1,20 (1,15-1,26)
Fluid and electrolyte disorders	1,34 (1,23-1,45)	1,39 (1,33-1,45)
Other neurological disorders	2,41 (2,13-2,72)	2,26 (2,09-2,45)
…		

Comparison with Berlin Heart Attack Register

Table 2 Comparison of documentation of treatment and outcome of matched cases, with measurement of agreement

Comparison for matched patients	AOK ($n = 2305$)	BMIR ($n = 2305$)	*Kappa coefficient*	Classification according to categories
PCI	82.1 %	82.5 %	*0.903*	I
(PCI for pts. coded as STEMI in AOK and BMIR)	94.7 %	94.1 %	*0.885*	
(PCI for pts. coded as NSTEMI in AOK and BMIR)	71.9 %	72.1 %	*0.925*	
Hospital mortality	9.2 %	9.2 %	*0.979*	I
Length of stay in hospital (median IQR)	6 days (4/10)	6 days (4/9)	*0.868*	I

Maier B et al. Comparing routine administrative data with registry data for assessing quality of hospital care in patients with myocardial infarction using deterministic record linkage. BMC Health Services Research (2016) 16:605

Comparison with Berlin Heart Attack Register

Comparison of ROC curves for model based on AOK and register data

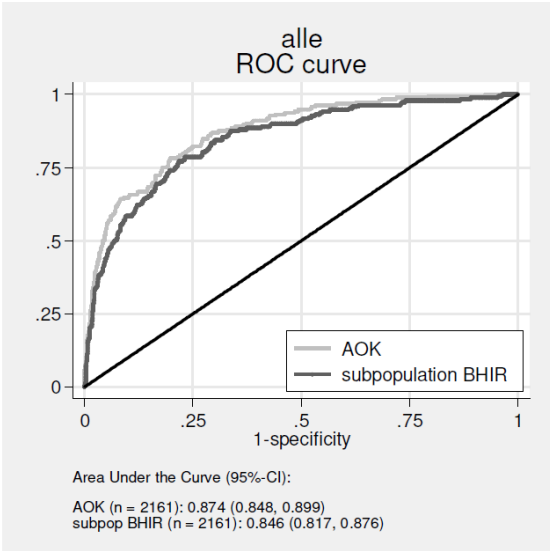


Abbildung 3: ROC-Kurven für Prognosemodelle basierend auf AOK (grau) und BHIR-Daten (schwarz). Der Unterschied in der AUC ist nicht signifikant, DeLong Test p=0.070

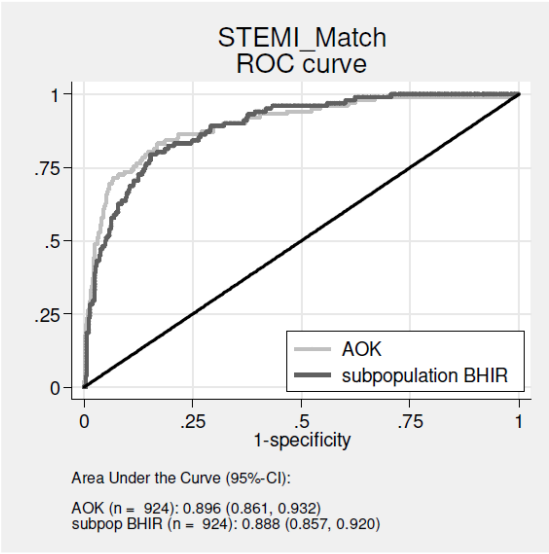


Abbildung 12: ROC-Kurven für Prognosemodelle basierend auf AOK (grau) und BHIR-Daten (schwarz). Der Unterschied in der AUC ist nicht signifikant, DeLong Test p=0.690

Agenda

① Why risk adjustment?

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a. What is QSR (*Qualitätssicherung mit Routinedaten* / Quality Assurance with Administrative Data)?

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③ Conclusion and recommendations

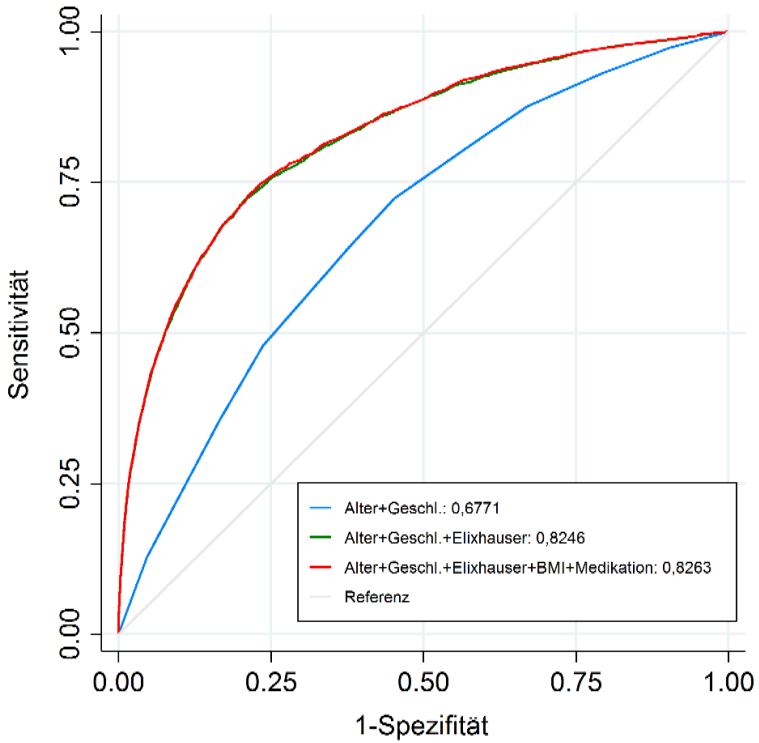
Total Hip Arthroplasty (THA)

- Anonymised billing and master data of 26 Mio. AOK insurees
  - **Inpatient care:** 6,9 Mio. cases per year
    - diseases (ICD-10; case-related; without date)
    - interventions (OPS; case-related; with date)
    - length of stay, transfers, reason for discharge, etc.
  - **Drug prescriptions:** about 285 Mio. per year
  - **Master data**: age and gender, survivorship and insured status
  - Hospitalisations or prescriptions can be assigned to a person without being re-identifiable
- **THA:** 133.367 tumor-free AOK patients with Implantation of a hip joint endoprosthesis for coxarthrosis in the period from 2014 to 2016
- **Endpoints:** (1) hip prosthesis revision within one year, (2) severe general complications (mechanical ventilation over 24h, resuscitation, sepsis, myocardial infarction, stroke, pneumonia, SIRS, transfusion >= 6 TE etc.)
- **Risk factors:** age, gender, Elixhauser comorbidies (without tumor and obesity), BMI (30-34, 35-39, 40+) and antithrombotic medikation in the previous year

Definitions according to QSR programme (WIdO 2018a, WIdO 2018b).

Total Hip Arthroplasty (THA)

ROC curves of the models for the prediction of severe general complications



- The revision rate within one year was 2.64 %, a severe general complication occurred in 2.44 %.
- The risk of hip revision increases with increasing BMI.
- The full model is clearly superior to a pure gender model in terms of its discriminatory ability. The area under the receiver operator characteristic curve (AUC) is 0.6162 vs. 0.5214 (revision) and 0.8263 vs. 0.6771 (general complication).
- The differentiation according to BMI as well as the consideration of antithrombotic medication slightly increases the model quality.

Total Hip Arthroplasty (THA)

Risk factor	*Mortality within 30 days*	*MACCE within 365 days*
	Odds Ratio (95%-KI)	Odds Ratio (95%-KI)
Age (Reference: under 60)		
60 bis 68 years	-	1,39 (1,18-1,64)
69 bis 74 years	-	1,77 (1,49-2,10)
75 bis 79 years	-	2,47 (2,11-2,90)
over 79 years	-	2,99 (2,55-3,51)
Gender (Reference: male)		
female	0,88 (0,82-0,95)	0,67 (0,62-0,73)
BMI (Reference: BMI under 30)		
30 to 34	1,25 (1,11-1,41)	-
35 to 39	1,57 (1,38-1,79)	-
over 40	2,40 (2,10-2,74)	1,50 (1,23-1,82)
Antithrombotic medikation in the previous year	-	1,21 (1,11-1,33)
Elixhauser comorbidities		
Alcohol abuse	1,85 (1,33-2,57)	-
Hypertension complicated	-	1,39 (1,17-1,65)
Hypertension uncomplicated	-	1,30 (1,17-1,44)
Blood loss anaemia	-	2,00 (1,28-3,12)
Chronic pulmonary disease	1,22 (1,10-1,36)	1,25 (1,11-1,41)

Continued:

Risk factor	*Mortality within 30 days*	*MACCE within 365 days*
	Odds Ratio (95%-KI)	Odds Ratio (95%-KI)
Deficiency anemias	-	1,67 (1,30-2,15)
Depression	1,55 (1,37-1,76)	1,29 (1,12-1,49)
Diabetes complicated	1,38 (1,14-1,67)	1,42 (1,20-1,67)
Diabetes uncomplicated	1,11 (1,01-1,22)	1,17 (1,07-1,28)
Valvular disease	-	1,75 (1,52-2,01)
Weight loss	1,81 (1,39-2,36)	2,21 (1,72-2,85)
Cardial arrhythmia	1,13 (1,02-1,25)	-
Coagulopathy	2,31 (1,95-2,73)	-
Congestive heart failure	1,26 (1,11-1,42)	2,50 (2,23-2,81)
Paralysis	1,67 (1,22-2,28)	9,92 (8,02-12,28)
Liver disease	-	3,18 (2,51-4,03)
Renal failure	1,23 (1,10-1,37)	1,74 (1,57-1,93)
Peripheral vascular disease	-	1,59 (1,37-1,83)
Psychoses	1,95 (1,23-3,08)	1,89 (1,15-3,13)
Pulmonary circulation disorders	1,42 (1,05-1,92)	-
Rheumatoid arthritis/ collagen vascular dieseases	1,27 (1,05-1,54)	-
Fluid and electrolyte disorders	1,76 (1,60-1,94)	4,24 (3,86-4,65)
Other neurological disorders	1,25 (1,01-1,54)	2,23 (1,88-2,65)

Comparison of Comorbodity Indizes in Endoprosthetics

Ondeck et al.	The Journal of Arthroplasty 2018	THA	NIS	(1) acute myocardial infarction, pneumonia, sepsis/septicemia/shock (2) surgical site bleeding, pulmonary embolism, death (3) mechanical complications, periprosthetic joint/wound infection (4) Extended Length of Stay (5) Discharge to Facility	CCI, ECM, mFI	ECM (+) best overall
Ondeck et al.	J Am Acad Orth Surg 2018	THA	NSQIP	(1) severe adverse event (2) minor adverse event (3) ext. LOS (4) discharge to higher-level care	ASA, mCCI, mFI	ASA > mCCI > mFI
Inacio et al.	Osteoarthritis and Cartilage 2016	THA und TKA	DVA, Australia	(1) 90 days mortality (2) 1 year mortality	CCI, ECM, RxRisk-V	ECM (+)
Greene et al.	CORR 2015	THA	Swedish Hip Arthroplasty Register	(1)EQ-5D 1y (2) EQ Visual Analogue Scale 1y (VAS) (3) Pain VAS 1y (4) Satisfaction VAS 1y	CCI, CCI-RCS, ECM zusätzlich zu Charnley classification, preop HRQol, pain measures	no added value
Gordon et al.	The Bone & Joint Journal 2013	primary total hip replacement	Swedish Hip Arthroplasty Register	(1) re-operations 0-1 ys (2) re-operations 2-12 ys	CCI, CCI Royal College of Surgeons, ECM	ECM (+) re-op 0-1 ys
Kim et al.	J Shoulder Elbow Surg 2018	total shoulder arthroplasty, reverse total shoulder arthroplasty	NIS	(1) in-hospital death (2) ext. LOS (3) discharge to care faciltity (4) postop complications (postop hemorrhage, wound disruption, postop infection, implant complication), cardiac/pulmonary/renal complications, deep venous thrombosis, pulmonary embolism	ECM, CCI	ECM (+)

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GQH Procedure „Stroke Treatment“

Indicators

- Deaths in patients with cerebral infarction
- Mortality after thrombolysis
- Pneumonia in patients with cerebral infarction

Factors of Risk adjustment

- Gender
- Age
- Prestroke care needs
- NIHSS on admission (National Institutes of Health - Stroke Scale for classification of disability; e.g. level of consciousness)..
- Diabetes mellitus
- Atrial fibrillation
- Previous stroke

Risk adjustment based on the data pool of the Arbeitsgemeinschaft Deutscher Schlaganfallregister (ADSR) of the years 2010 - 2012

Todesfälle bei Patienten mit Hirninfarkt (Kennzahl 10-002)	
Berücksichtigte Faktoren	*OR*
Geschlecht: männlich	1,160
Alter: 65 - 74 Jahre	1,829
75 - 84 Jahre	2,808
≥ 85 Jahre	4,132
Versorgung prestroke: pflegebedürftig	1,625
NIHSS: 5 - 15	5,490
16 - 25	30,798
≥ 26	85,333
Diabetes mellitus	1,062
Vorhofflimmern	1,282
Früherer Schlaganfall	0,85

Further Limitations

- The problem of overfitting: More variables in statistical models and better fit measures are not synonymous with better risk adjustment, but can even worsen the comparability of hospitals.
    - Nicholl J, Case-mix adjustement in non-randomised observational evaluations: the constant risk fallacy.
      J. Epidemiol. Community Health 2007;61;1010-1013
    - Dimick JB et al. Risk adjustment for comparing hospital quality with surgery: how many variables are needed? J Am Coll Surg 2010, 210(4): 503-508
    - Heller G, Schnell R. Hospital mortality risk adjustment using claims data. JAMA. 2007;297:1983

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Conclusion and Recommendations

- Apply established comorbidity classifications (with modifications if necessary)
- Use established statistical methods for modelling
- Include clinical expertise and empirical analysis in the identification and timing of risk factors
- Carry out risk modelling per intervention of interest and quality indicator
- Use multiple data sources if necessary: Administrative data, pre-treatment data, clinical data, surveys
- Analysis of a meaningful(!) risk model provides insights for avoiding complications (Nesslage et al. ZfOU 2017)

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Thank you