AFIR MUNICH LIFE 2009

Does morbidity-modeling solve the problem of predicting death and disability ?

Dr. Paul Triggs
RISK-CONSULTING Prof. Dr. Weyer GmbH, Köln

Section Finance de l'AAI
IAA Finance Section
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IAA Life Section
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DAV
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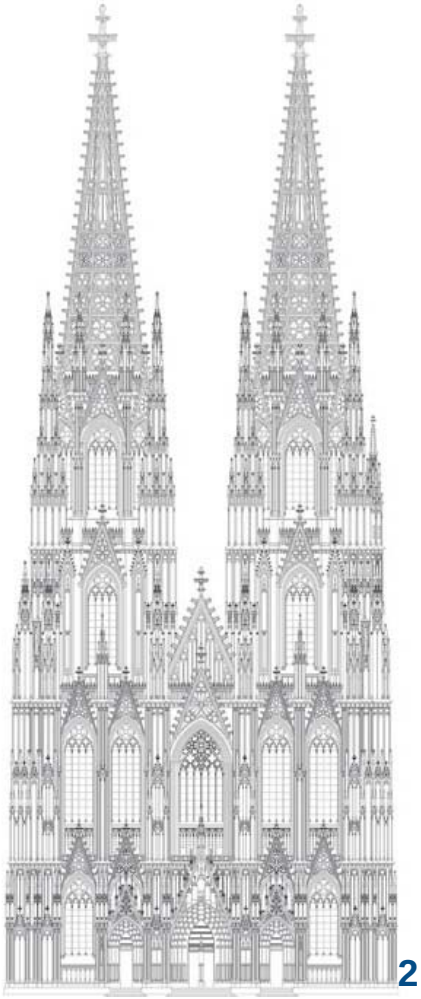
RISK-CONSULTING Prof. Dr. Weyer GmbH

Company Profile

- Actuarial consulting company with particularly strong position in life and health insurance
  - 5 of top 6 German health insurers use AktuarMed®, the Underwriting System developed by RISK-CONSULTING
  - > 50% of all new policies in the German private health insurance market are underwritten with RISK-CONSULTING know-how
- Worldwide largest data-base of health-insurance claims
  - Claims histories since 1972
  - Over 50 million contract-years of personal medical claims history
- Experience with large data-bases
- Interrogate database with various multivariate methods



Agenda

1. **Insufficient data for direct analysis**
2. Using "external" data sources
3. Predicting death and disability by using morbidity modeling
4. The challenge of morbidity modeling
5. Conclusions

The Challenge

Goal

- Assess biometric risk of individuals and portfolios
- Reliable forecast of mortality and/or disability

Applications

- Tariff calculation
- Solvency-models
- Underwriting

Frequently encountered difficulty

Presence of previous medical conditions
i.e. increased risk of these individuals

Problem

Insufficient claims data, particularly in disability

Key Issue: Low Number of Claims

Germany's largest life insurers (2005)

	Company	Contracts in millions	New disability cases p.a.	New claims p.a. (%)
1.	Allianz Leben	3.02	8,450	0.28
2.	AachenMünchener	1.39	3,034	0.22
3.	Hamburg-Mannheimer	0.98	3,752	0.38
4.	AXA und DBV-Winterthur *	0.92	2,465	0.27
5.	Victoria	0.61	1,251	0.20
6.	Volksfürsorge	0.57	1,198	0.21
7.	Debeka	0.46	623	0.14
8.	R+V	0.43	1,207	0.28
9.	Iduna	0.36	1,085	0.30
10.	Alte Leipziger	0.35	824	0.24

*** AXA: Average 1998-2002**

Source: map-Report

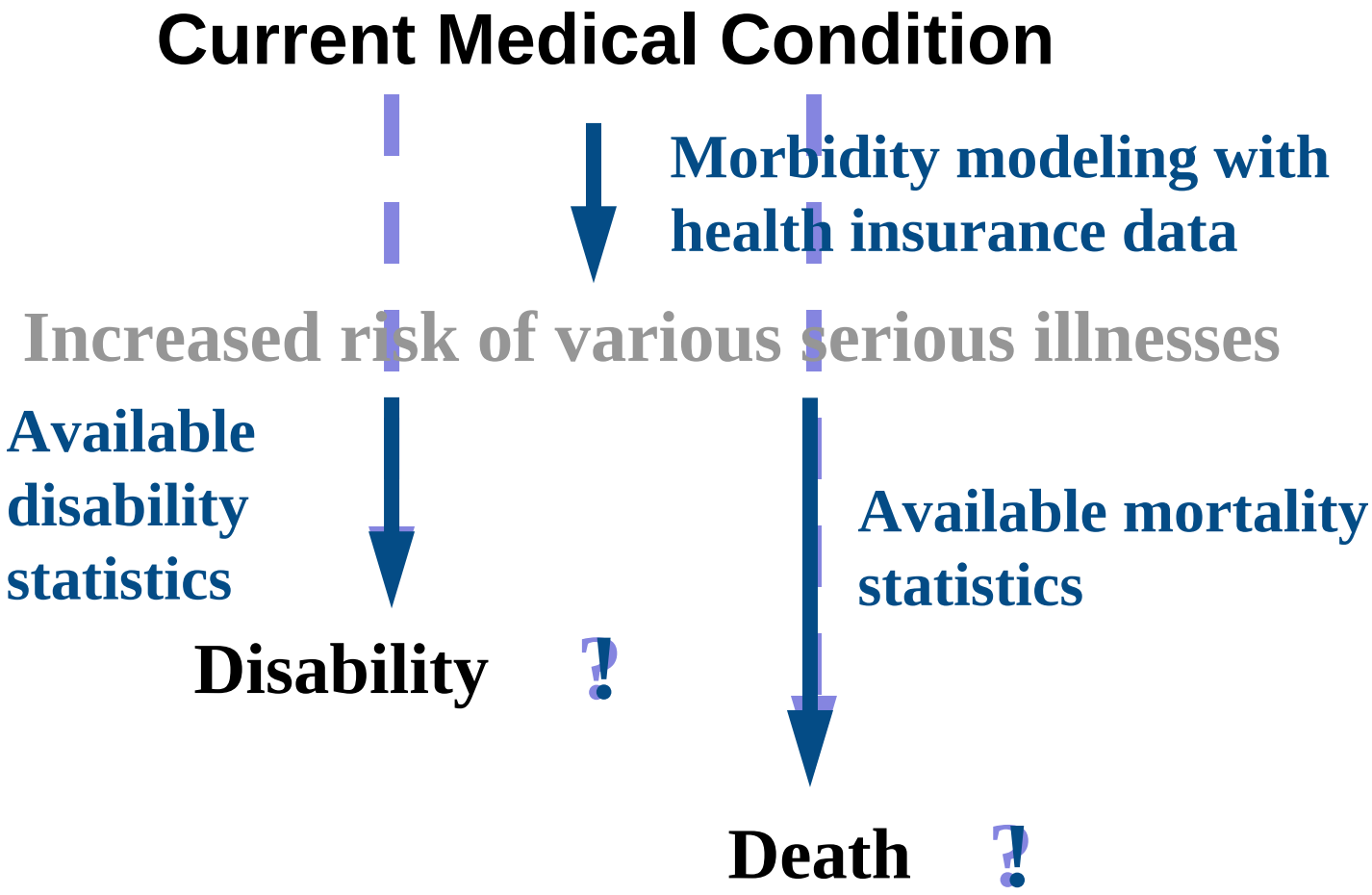
Low Statistical Significance

- Claims per year lies around 0.3%.
- Even largest insurers have only a few thousand claims per year.
- These have to be segmented by gender, age, occupation and medical condition.
- Trillions of different applicant profiles

→ **Direct statistical analysis impossible.**

Solution: Indirect approach using data on morbidity, disability and mortality?

Predicting death and disability by using morbidity modeling



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Available Data Sources in Germany

Mortality

- DESTATIS (www.gbe-bund.de)
- Information about mortality and causes of death
- i.e. number of deaths, classification by: years, region, age, sex, nationality, ICD-10

Reduced earning capacity / disability

- German statutory pension insurance scheme (www.deutsche-rentenversicherung.de)
- Information about reduced earning capacity / disability
- i.e. number of new pensions, classification by: years, age, sex, ICD-10

Morbidity

- DESTATIS (www.gbe-bund.de)
- Information about hospital stays and inability to work
- i.e. number of stays, classification by: years, age, sex, ICD-10, days
- RISK-CONSULTING Prof. Dr. Weyer GmbH morbidity database

Example: Mortality Statistics

TODESURSACHEN

2.1 Sterbefälle 2007 nach ausgewählten Todesursachen, Altersgruppen und Gesch

2.1.1 Insgesamt

Pos-Nr. der ICD-10	Todesursache		Gestorbene insgesamt	Davon im Alter von ... bis unter ... Jahren: < 1 Jahr	1 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 - 35	35 - 40	40
			Anz										
A00-T98	**Insgesamt**	m	391.139	1.518	301	220	223	990	1.503	1.575	1.755	3.257	
		w	436.016	1.138	248	131	168	425	527	621	821	1.704	
		z	827.155	2.656	549	351	391	1.415	2.030	2.196	2.576	4.961	
A00-B99	**KAPITEL I: Bestimmte infektiöse und parasitäre Krankheiten**	m	6.293	15	16	4	7	16	19	27	33	67	
		w	7.597	7	13	7	4	5	11	9	24	54	
		z	13.890	22	29	11	11	21	30	36	57	121	
A15-A19	Tuberkulose	m	209	-	-	-	-	1	-	2	1	1	
		w	135	-	-	1	-	-	-	-	-	2	
		z	344	-	-	1	-	1	-	2	1	3	
C00-D48	**KAPITEL II: Neubildungen**	m	115.938	17	53	53	53	89	137	155	232	521	
		w	101.351	14	37	28	42	57	79	128	275	648	
		z	217.289	31	90	81	95	146	216	283	507	1.169	
C00-C97	Bösartige Neubildungen	m	113.405	11	51	52	50	85	132	149	227	508	
		w	98.360	11	35	27	39	53	79	123	267	640	
		z	211.765	22	86	79	89	138	211	272	494	1.148	
C15-C26	Bösartige Neubildungen der Verdauungsorgane	m	36.312	3	5	-	-	4	12	24	46	148	
		w	31.880	1	3	-	2	3	7	27	54	87	
		z	68.192	4	8	-	2	7	19	51	100	235	
C30-C39	Bösartige Neubildungen der Atmungsorgane und sonstiger intrathorakaler Organe	m	30.702	-	-	1	-	5	8	9	14	68	
		w	12.800	1	2	1	1	1	4	9	13	60	
		z	43.502	1	2	2	1	6	12	18	27	128	
C50	Bösartige Neubildung der Brustdrüse (Mamma)	m	249	1	-	-	-	-	-	-	1	1	
		w	16.780	-	-	1	-	1	1	14	54	198	
		z	17.029	1	-	1	-	1	1	14	55	199	
C51-C58	Bösartige Neubildungen der weiblichen Genitalorgane	w	10.645	-	-	-	-	-	5	10	32	108	
C60-C63	Bösartige Neubildungen der männlichen Genitalorgane	m	11.769	1	-	1	-	3	11	7	8	18	
C81-C96	Bösartige Neubildungen des lymphatischen, blutbildenden und verwandten Gewebes	m	8.667	2	15	16	15	24	42	43	54	71	
		w	7.887	3	8	3	12	15	21	24	31	50	
		z	16.554	5	23	19	27	39	63	67	85	121	
D50-D89	**KAPITEL III: Krankheiten des Blutes und der blutbildenden Organe sowie bestimmte Störungen mit Beteiligung des**	m	903	6	2	3	2	5	3	8	6	9	
		w	1.233	7	4	2	-	3	3	8	1	5	

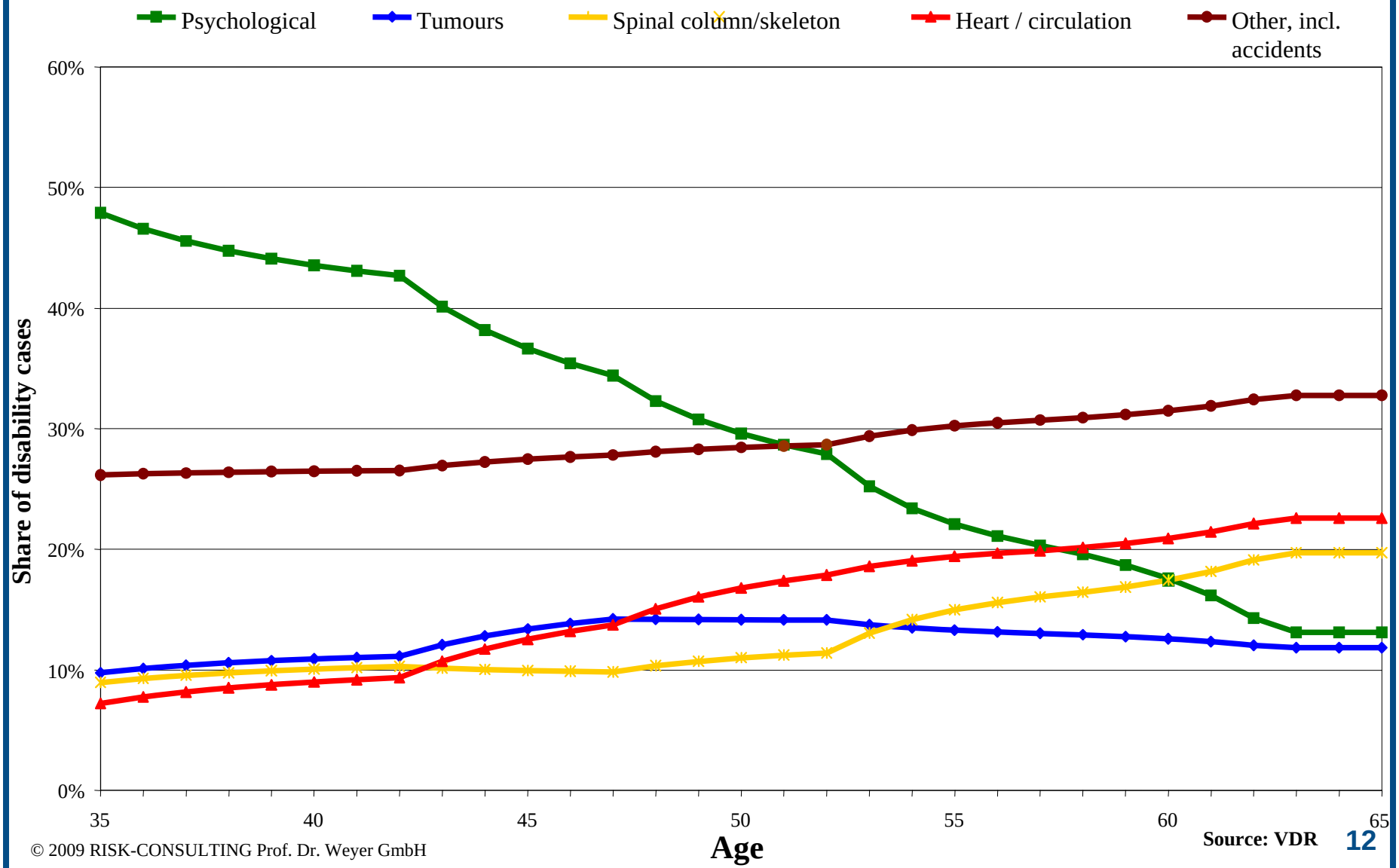
Example: Disability tables

Rentenzugänge 2007, Renten nach SGB VI wegen verminderter Erwerbsfähigkeit

220.01 Z I — **Verteilung nach Alter (Altersgruppen) bei Rentenbeginn sowie durchschnittliches Alter bei Rentenbeginn nach Diagnosen (1. Diagnose)**
Männer

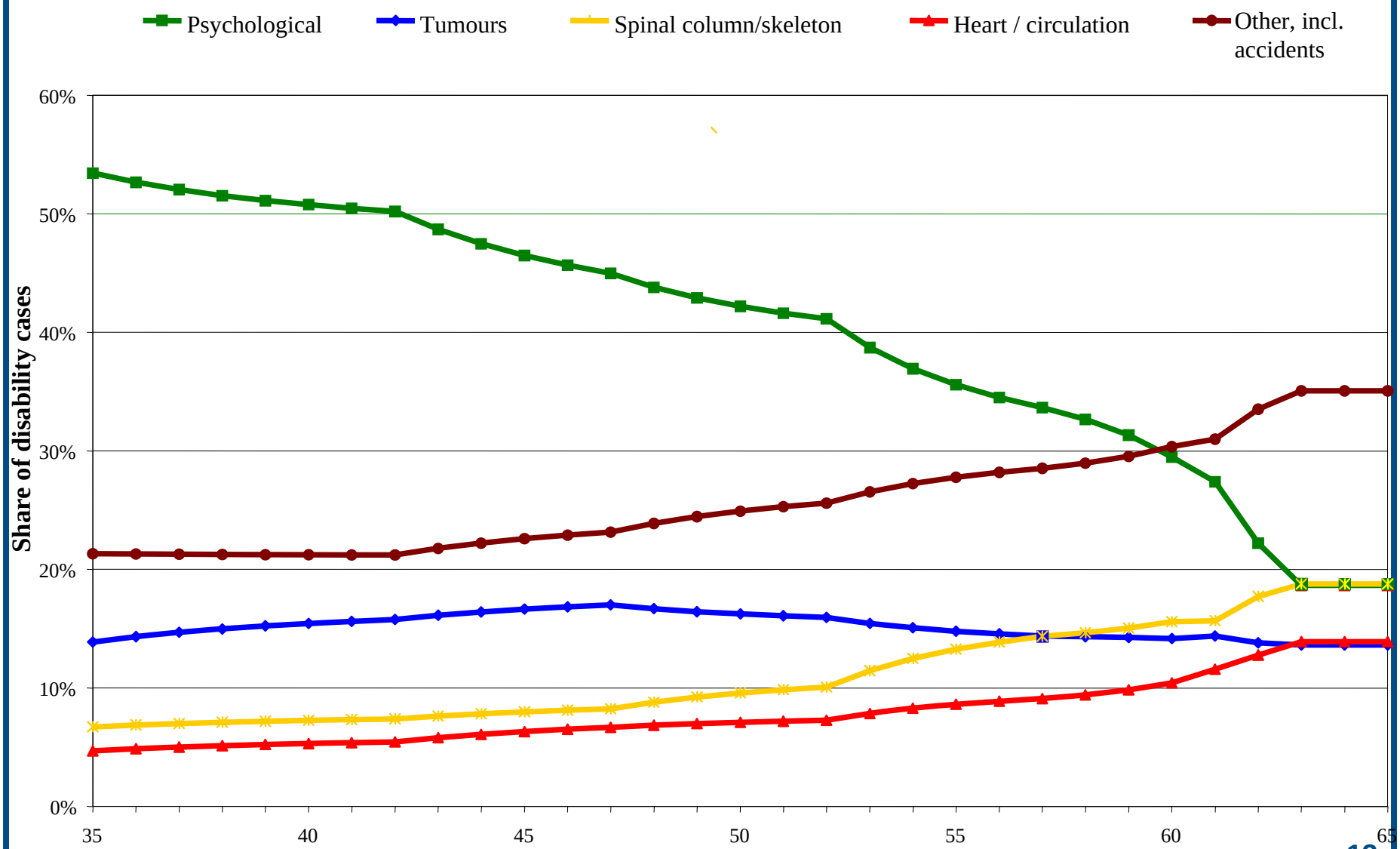
Diagnosen-schlüsselzahl	Diagnose	Renten wegen verminderter Erwerbsfähigkeit* insgesamt	Zugangsalter (Unterschied zwischen Rentenbeginns- und Geburtsjahr) bis 30	30–34	35–39	40–44	45–49	50–54	55–59	6 und höl
		Anzahl								
		1	2	3	4	5	6	7	8	9
A00-B99	**Bestimmte infektiöse und parasitäre Krankheiten**	**577**	**9**	**16**	**55**	**109**	**146**	**106**	**111**	
A00-A09	Infektiöse Darmkrankheiten	**23**	1	–	3	2	6	5	6	
A15-A19	Tuberkulose	**31**	–	–	–	2	8	7	10	
A20-A28	Bestimmte bakterielle Zoonosen	**1**	–	–	–	–	–	1	–	
A30-A49	Sonstige bakterielle Krankheiten	**26**	–	–	2	5	3	4	9	
A50-A64	Infektionen vorwiegend durch GV übertragen	**9**	–	1	–	1	–	4	3	
A65-A69	Sonstige Spirochätenkrankheiten	**18**	–	1	2	1	3	5	6	
A70-A74	Sonstige Krankheiten durch Chlamydien	**–**	–	–	–	–	–	–	–	
A75-A79	Rickettsiosen	**–**	–	–	–	–	–	–	–	
A80-A89	Virusinfektionen des Zentralnervensystems	**27**	–	–	1	2	9	5	7	
A90-A99	Durch Arthropoden übertragene Viruskrankheiten und virale hämorrhagische Fieber	**–**	–	–	–	–	–	–	–	
B00-B09	Virusinfektionen durch (Schleim)Hautläsionen gekennz.	**15**	1	1	–	2	5	4	1	
B15-B19	Virushepatitis	**125**	–	2	5	19	50	21	20	
darunter: B18	Chronische Virushepatitis	**107**	–	1	5	17	40	20	17	
B20-B24	HIV-Krankheit [Humane Immundefiz.-Viruskrankh.]	**224**	4	10	34	68	50	31	22	
B25-B34	Sonstige Viruskrankheiten	**3**	–	–	–	–	1	1	1	
B35-B49	Mykosen	**10**	–	–	2	1	1	2	4	
B50-B64	Protozoenkrankheiten	**6**	–	–	–	2	–	1	2	
B65-B83	Helminthosen	**7**	1	–	–	2	1	1	2	

Causes of Disability: Men



Source: VDR

Causes of Disability: Women



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Insured persons and claims 2007

Largest health insurers in Germany by number of insured

	Health Insurer	Insured persons[1)] (comprehensive) (thousands)	Insured persons with claim[2)] (thousands)	Payment items[3)] (thousands)
1.	Debeka	2,049	1,353	17,583
2.	DKV	804	531	6,897
3.	Allianz	737	486	6,323
4.	SIGNAL	481	317	4,127
5.	DBV-Winterthur	434	286	3,719
6.	Central	430	283	3,685
7.	Bayerische Beamten	373	246	3,196
8.	Continentale	365	241	3,127
9.	HUK-Coburg	334	220	2,861
10.	Barmenia	312	206	2,679

1) Source: Versicherungswirtschaft No. 9/2008,
2) Using average value of 66% of persons
3) Using average of 13 items per claimant

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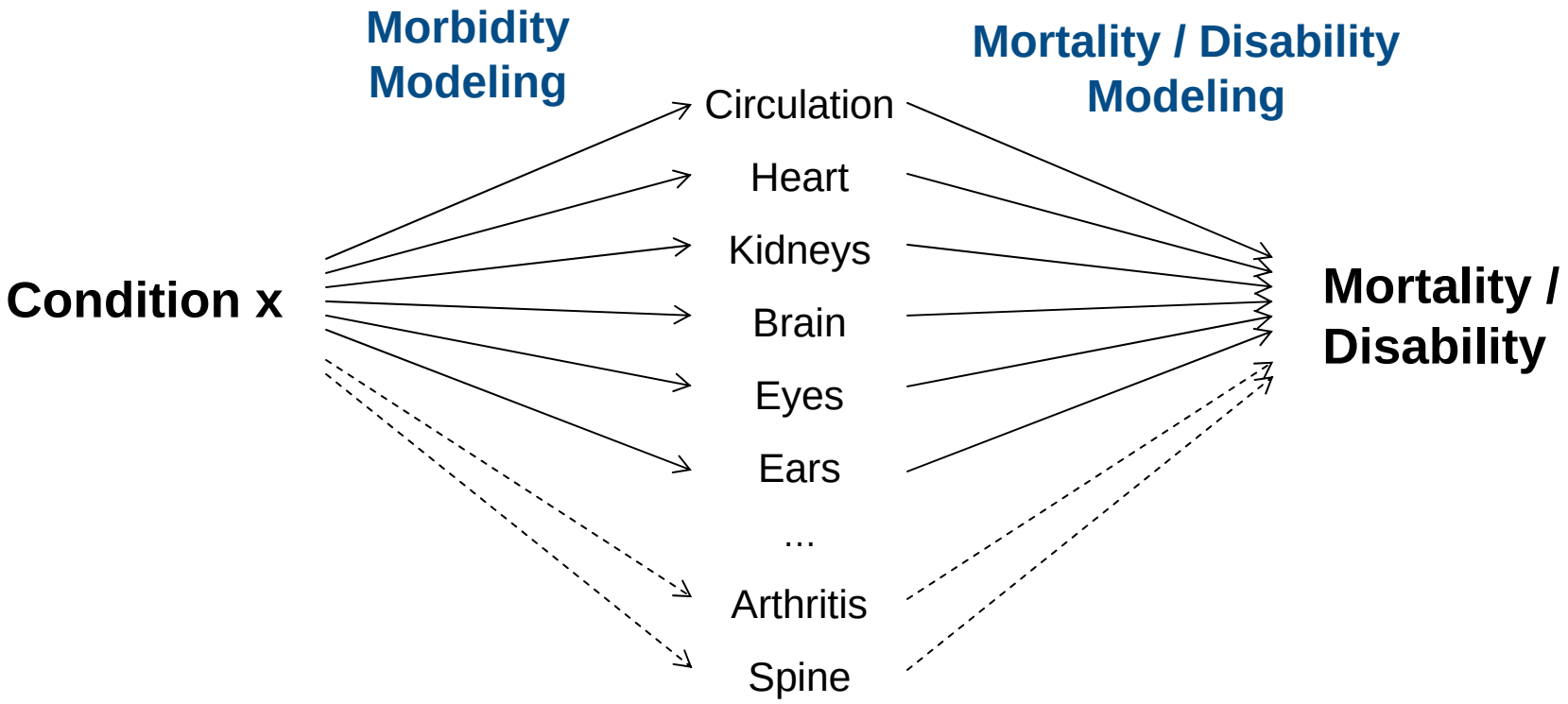
Principle of Calculation

Medical condition at application time

Increased risk for (severe) diseases in disease-groups

Biometric risk to be predicted



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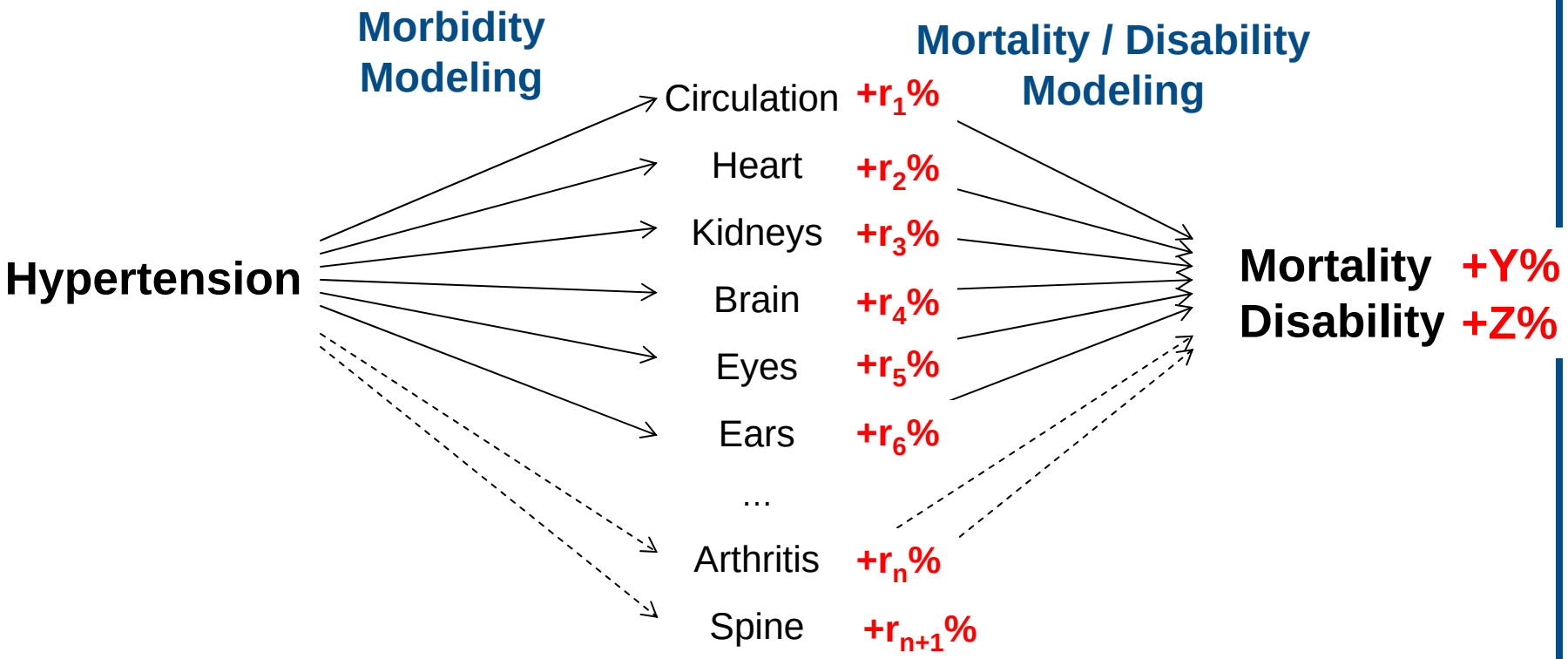
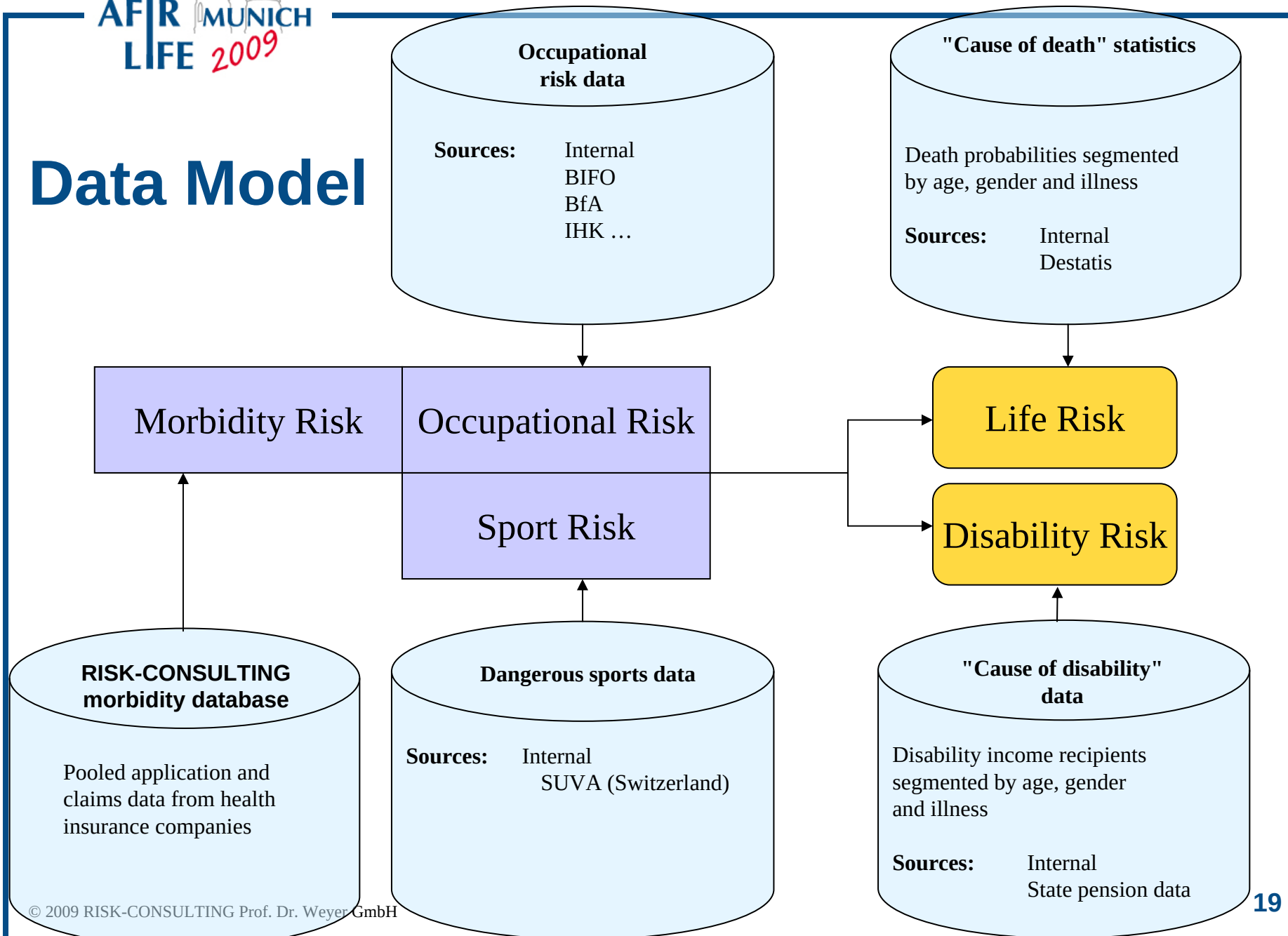


Data Model



Calculation of Risk Loadings

Date of birth

Gender

Size / Weight

Medical conditions with date and duration

Input

Morbidity-risk surplus	**Including occupational risk surplus**	**Disability Base risk**	
r_1	$\longrightarrow \tilde{r}_1$	$\longrightarrow (\tilde{r}_1 + 1) \cdot i_{x,1}$	$= i^A_{x,1}$
r_2	$\longrightarrow \tilde{r}_2$	$\longrightarrow (\tilde{r}_2 + 1) \cdot i_{x,2}$	$= i^A_{x,2}$
⋮	⋮	⋮	
r_k	$\longrightarrow \tilde{r}_k$	$\longrightarrow (\tilde{r}_k + 1) \cdot i_{x,k}$	$= i^A_{x,k}$
⋮	⋮	⋮	
r_{45}	$\longrightarrow \tilde{r}_{45}$	$\longrightarrow (\tilde{r}_{45} + 1) \cdot i_{x,45}$	$= i^A_{x,45}$

$\sum_k$

i^A_x

i_x

$$\frac{\sum_x V_x \cdot i^A_x}{\sum_x V_x \cdot i_x} - 1$$

LD in %

k = disease groups:

Psychological / Nerves
Tumours
Spinal Column / Skeleton
Heart / Circulation
Injuries

$\mathbf{V_x}$ = Actuarial weighting

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Hypertension as Precursor for Claims for Heart Treatment

Condition		Treatment Rate first 4 years		Treatment Rate second 4 years	
Hypertension		All treatments	Heart treatment	All treatments	Heart treatment
Men	No	68%	4%	73%	6%
	Yes	89%	66%	90%	56%
Women	No	79%	3%	81%	5%
	Yes	91%	65%	91%	54%

Hypertension as Precursor for Claims for Heart Treatment Costs

Condition		Costs first 4 Years [€/Year]		Costs second 4 Years [€/Year]	
Hypertension		Total	For Heart	Total	For Heart
Men	No	850	5	925	6
	Yes	1.150	80	1.250	130
Women	No	1.550	4	1.600	4
	Yes	2.000	80	2.050	110

Even after grouping previous conditions into categories, the numbers are small

Disease Category	% Applicants
Diseases of the thyroid gland	1.2%
Neuroses / Psychoses	1.1%
High blood pressure	2.1%
Liver/ Gall bladder / Pancreas	1.5%
Spine / Joints	8.9%

Significance

Loss of significance by application of segmentation techniques

- Segments, that are characterized by several characteristics, are sparsely filled: (Women, age 30-35, weight 50-55 kg, previous illnesses: hay fever, kidney stones, disc prolapse)

- The cells of the n-dimensional space of characteristics are almost empty (n > 16,000)

Significance

Maintenance of significance by the use of Discriminant Analysis

- No building of segments
- "Neighboring" information is used
- Scoring provides a projection of the n-dimensional space of characteristics on the one-dimensional scale of scores
- High significance for low dimensional scores ($\alpha < 10^{-3}$ usually $\alpha < 10^{-20}$)

Example of Discriminant Analysis for Diseases of the Spine

Condition (men)	Standardized (relative influence)	Non-standardized (absolute influence)
Lumbar vertebral syndrome	0.48	0.428
Disc Prolapse	0.27	2.447
Scoliosis	0.25	1.251
Coxarthritis	0.12	2.629
Other conditions	...	...
Age	0.42	0.046
Occupation	0.09	0.126

Increased Morbidity Risk through Previous Medical Conditions

Previous condition at Application (Age 35)	Average increase in morbidity risk for severe illness at age 45-50 (compared to persons of same age)					
	Psychological		Spinal column / skeleton		Heart / circulation	
	men	women	men	women	men	women
Hypertension BMI normal			10%	10%	210%	150%
Hypertension BMI 30			40%	50%	680%	530%
Sciatica			540%	510%		
Cluster headache	590%	710%	20%	20%		

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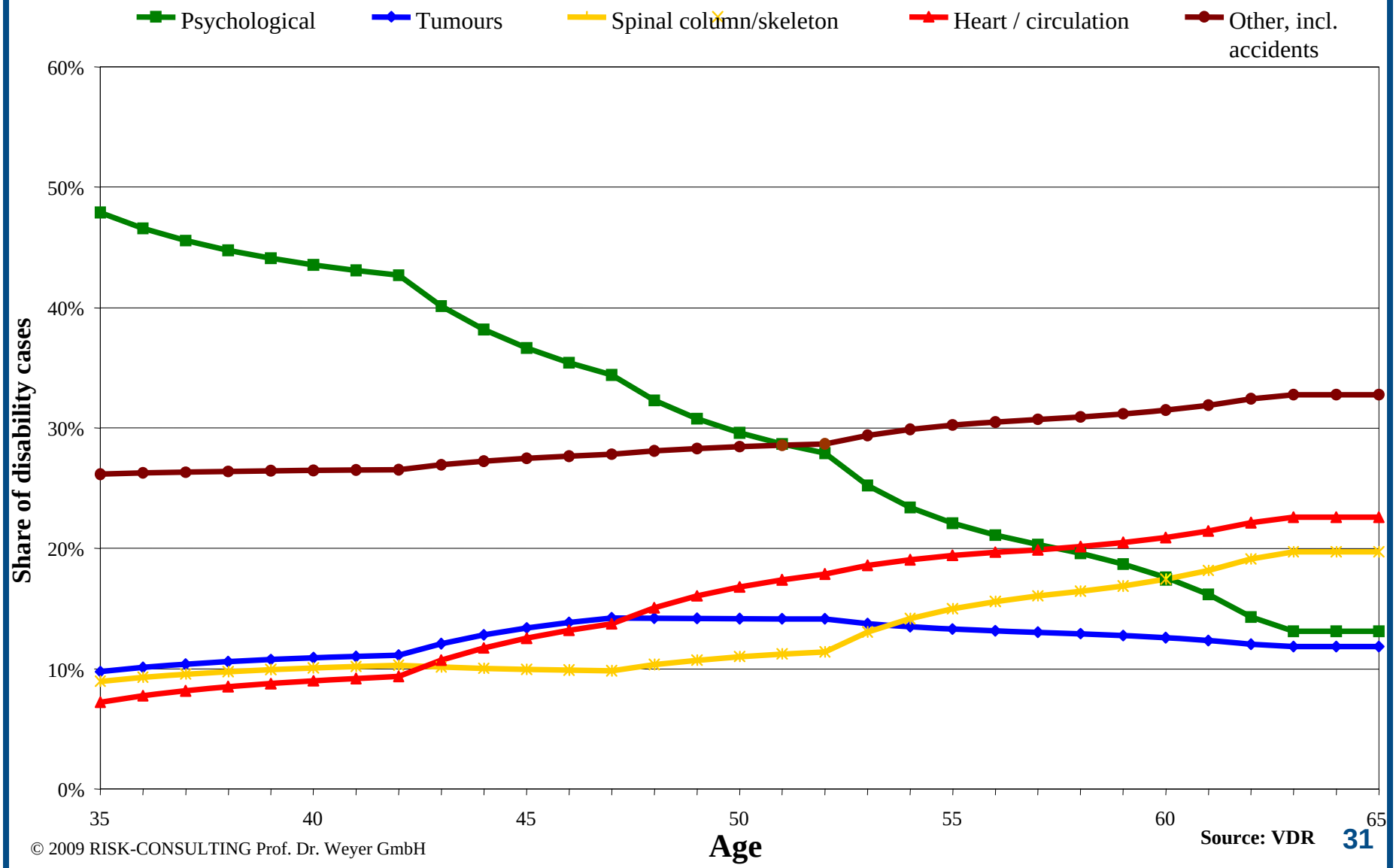

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Conclusion

- **Direct calculation of the increased risk due to medical conditions is not possible because of insufficient data.**

- **An indirect (two-step) method using morbidity (i.e. health insurance) data allows the accurate calculation of biometric risk, even when medical conditions are present.**

- **To analyse large volumes of morbidity data, multivariate techniques, especially Discriminant Analysis are recommended.**

Dr. Paul Triggs

RISK-CONSULTING
Prof. Dr. Weyer GmbH
Hatzfeldstr. 5
D-51069 Köln / Cologne
Germany

E-Mail: triggs@risk-consulting.de
Tel.: +49 (221) 96 84 79 - 20
Fax: +49 (221) 96 84 79 - 28