



**AFIR MUNICH**  
**LIFE 2009**

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

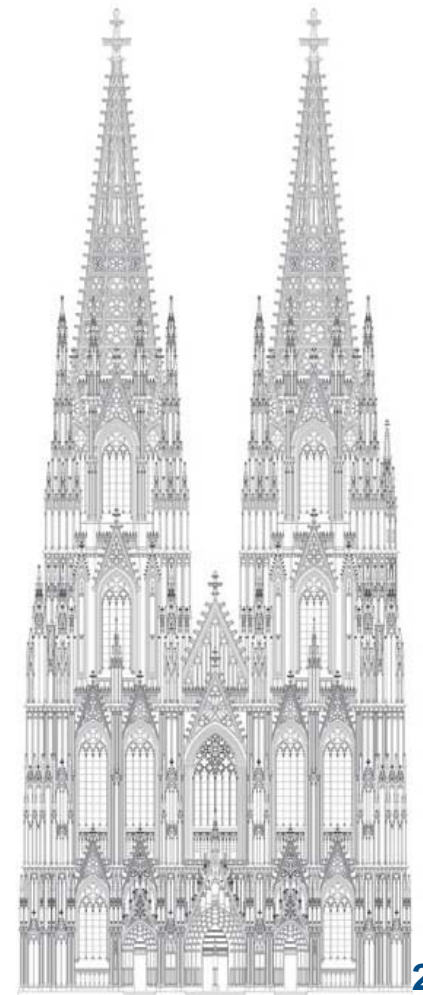
**Dr. Paul Triggs**  
**RISK-CONSULTING Prof. Dr. Weyer GmbH, Köln**



# 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<sup>®</sup>, 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

## Low Statistical Significance

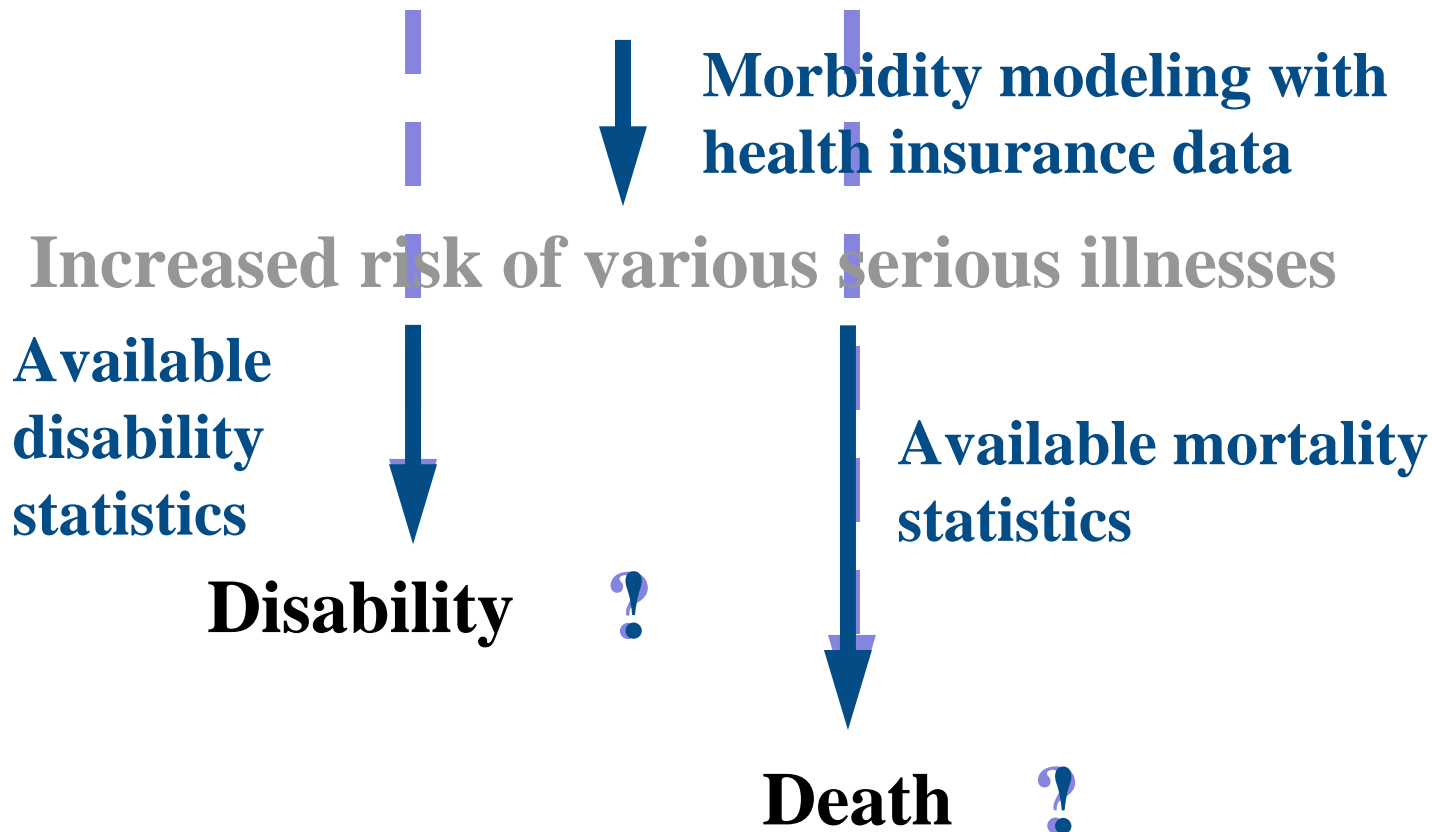
- Claims per year lies around 0.3%.
- Even largest insurers have only a few thousand claims per year.
- These have to be segmented by gender, age, occupation and medical condition.
- Trillions of different applicant profiles

 **Direct statistical analysis impossible.**

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

# Predicting death and disability by using morbidity modeling

## Current Medical Condition



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# Available Data Sources in Germany

## Mortality

- DESTATIS ([www.gbe-bund.de](http://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](http://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](http://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 Geschl

#### 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
<b>A00-T98</b>	<b>Insgesamt</b>	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	
<b>A00-B99</b>	<b>KAPITEL I: Bestimmte Infektiöse und parasitäre Krankheiten</b>	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	
<b>A15-A19</b>	<b>Tuberkulose</b>	m	209	-	-	-	-	1	-	2	1	1	
		w	135	-	-	1	-	-	-	-	-	2	
		z	344	-	-	1	-	1	-	2	1	3	
<b>C00-D48</b>	<b>KAPITEL II: Neubildungen</b>	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	
<b>C00-C97</b>	<b>Bösartige Neubildungen</b>	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	
<b>C15-C26</b>	<b>Bösartige Neubildungen der Verdauungsorgane</b>	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	
<b>C30-C39</b>	<b>Bösartige Neubildungen der Atmungsorgane und sonstiger intrathorakaler Organe</b>	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	
<b>C50</b>	<b>Bösartige Neubildung der Brustdrüse (Mamma)</b>	m	249	1	-	-	-	-	-	-	1	1	
		w	16.780	-	-	1	-	1	1	14	54	198	
		z	17.029	1	-	1	-	1	1	14	55	199	
<b>C51-C58</b>	<b>Bösartige Neubildungen der weiblichen Genitalorgane</b>	w	10.645	-	-	-	-	-	5	10	32	108	
<b>C60-C63</b>	<b>Bösartige Neubildungen der männlichen Genitalorgane</b>	m	11.769	1	-	1	-	3	11	7	8	18	
<b>C81-C96</b>	<b>Bösartige Neubildungen des lymphatischen, blutbildenden und verwandten Gewebes</b>	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	
<b>D50-D89</b>	<b>KAPITEL III: Krankheiten des Blutes und der blutbildenden Organe sowie bestimmte Störungen mit Beteiligung des</b>	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

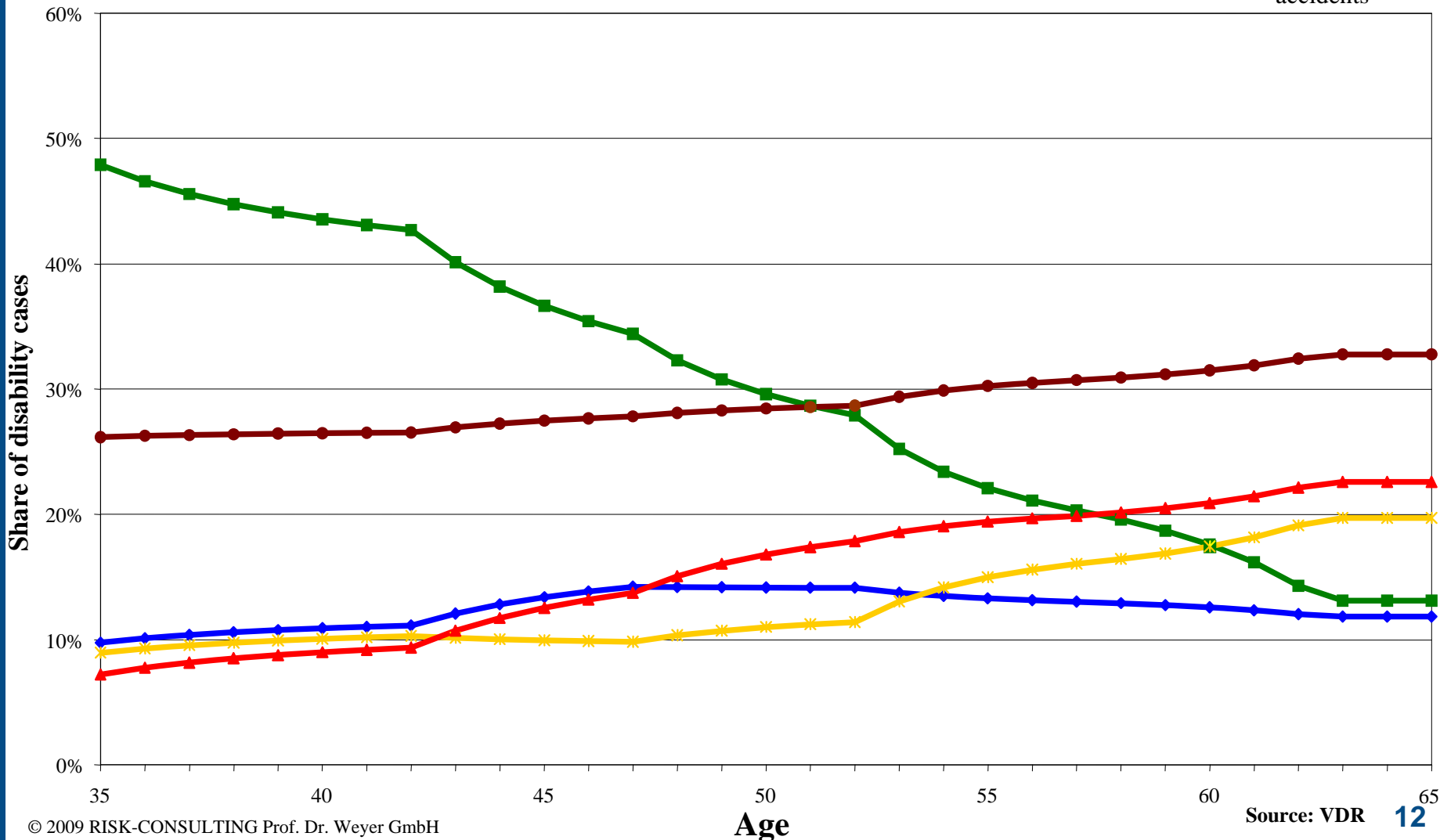
Rentenzugänge 2007, Renten nach SGB VI wegen verminderter Erwerbsfähigkeit

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

Diagnoseschlüsselzahl	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	60 und höher
			Anzahl							
		1	2	3	4	5	6	7	8	9
<b>A00-B99</b>	<b>Bestimmte infektiöse und parasitäre Krankheiten</b>	<b>577</b>	<b>9</b>	<b>16</b>	<b>55</b>	<b>109</b>	<b>146</b>	<b>106</b>	<b>111</b>	
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	

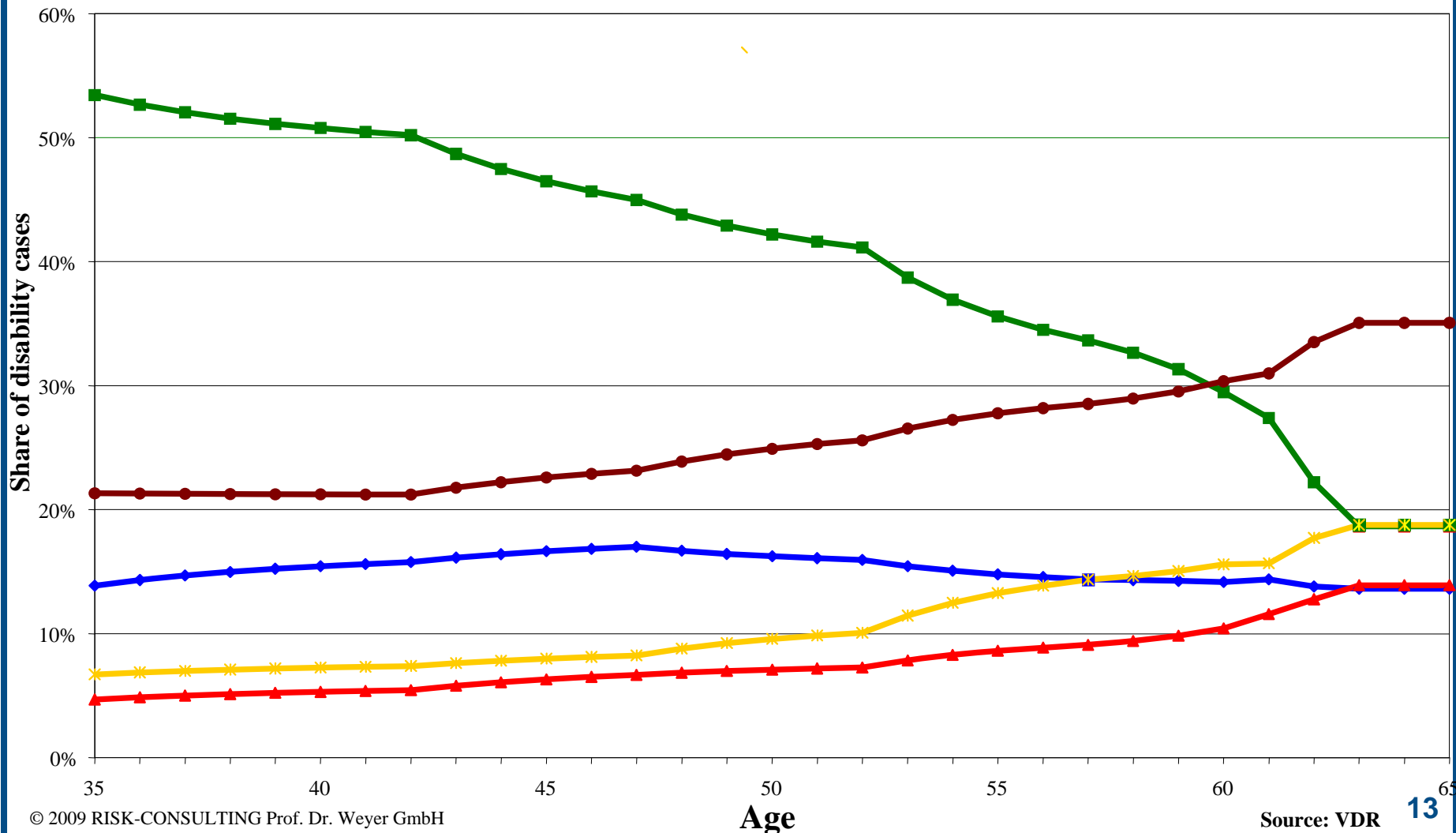
# Causes of Disability: Men

■ Psychological    
 ◆ Tumours    
 ✱ Spinal column/skeleton    
 ▲ Heart / circulation    
 ● Other, incl. accidents



# Causes of Disability: Women

■ Psychological   
 ◆ Tumours   
 ✱ Spinal column/skeleton   
 ▲ Heart / circulation   
 ● Other, incl. accidents



## Insured persons and claims 2007

### Largest health insurers in Germany by number of insured

	Health Insurer	Insured persons <sup>1)</sup> (comprehensive) (thousands)	Insured persons with claim <sup>2)</sup> (thousands)	Payment items <sup>3)</sup> (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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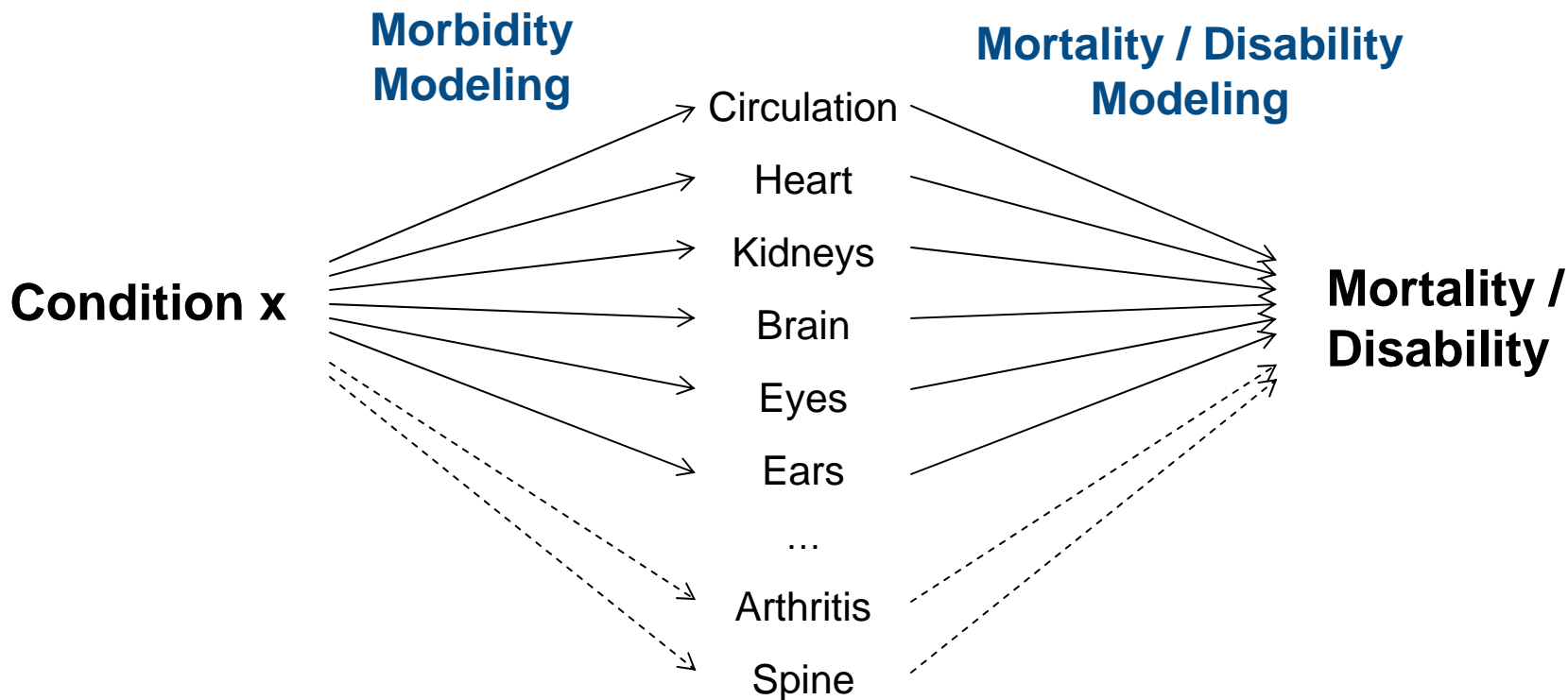
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# Principle of Calculation

Medical condition at application time

Increased risk for (severe) diseases in disease-groups

Biometric risk to be predicted



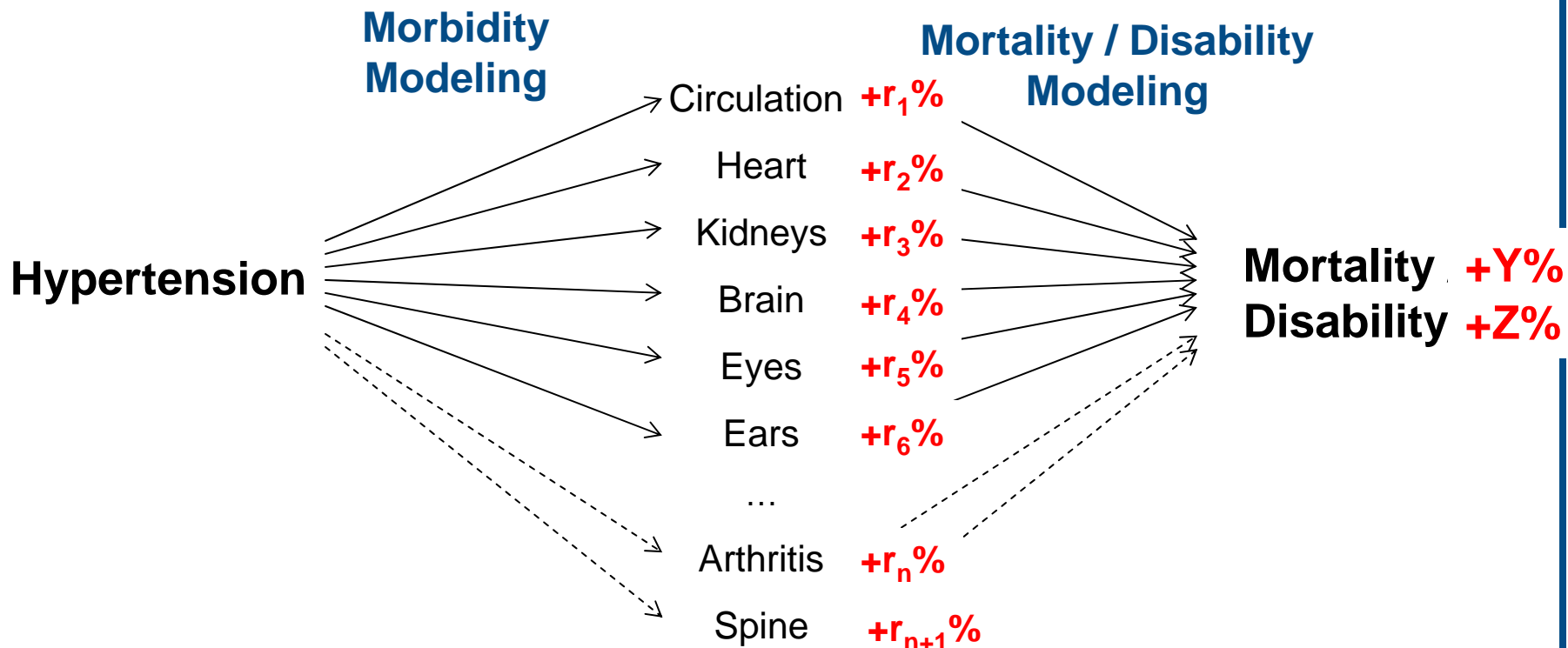


# Principle of Calculation

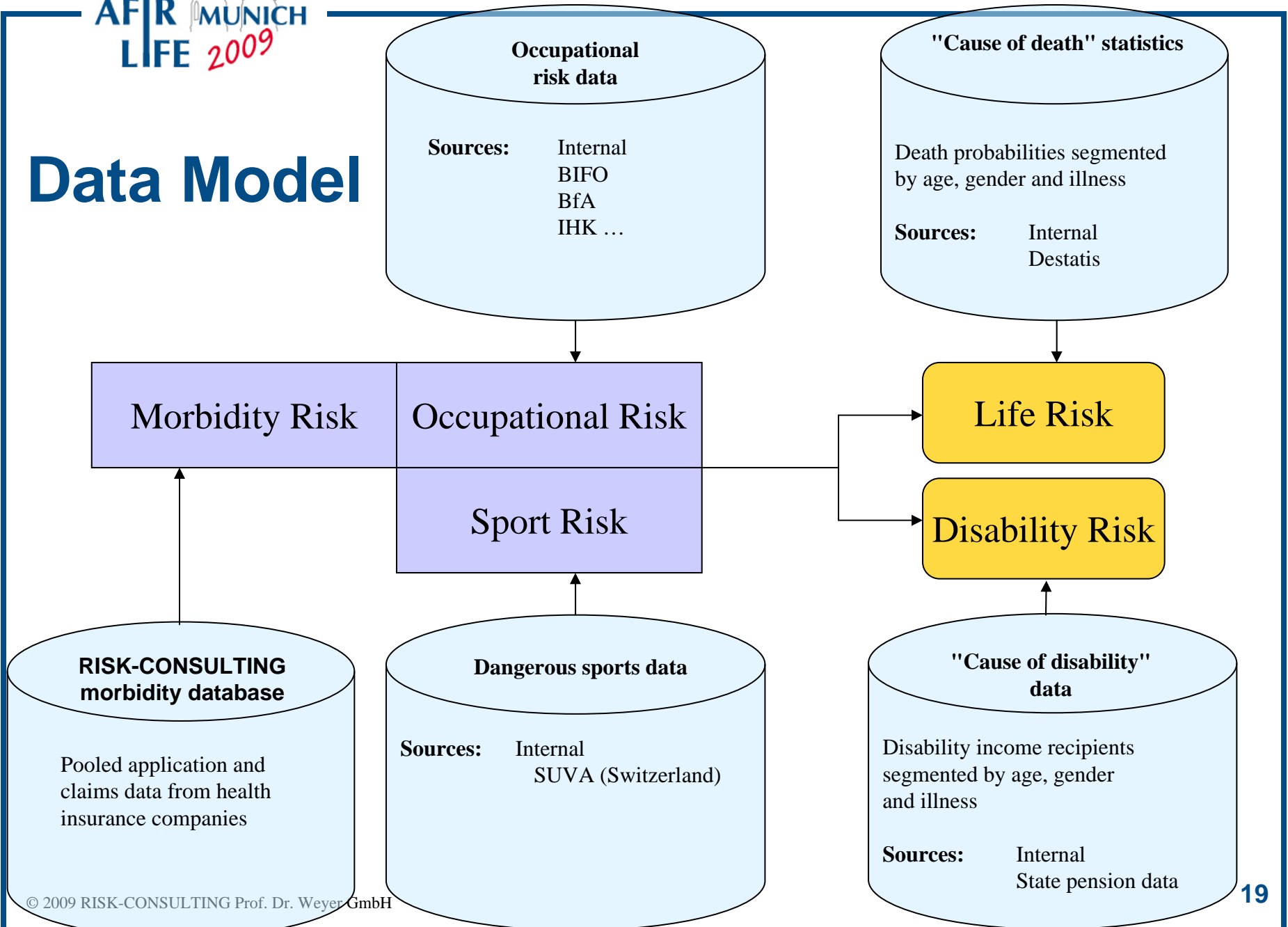
Medical condition at application time

Increased risk for (severe) diseases in disease-groups

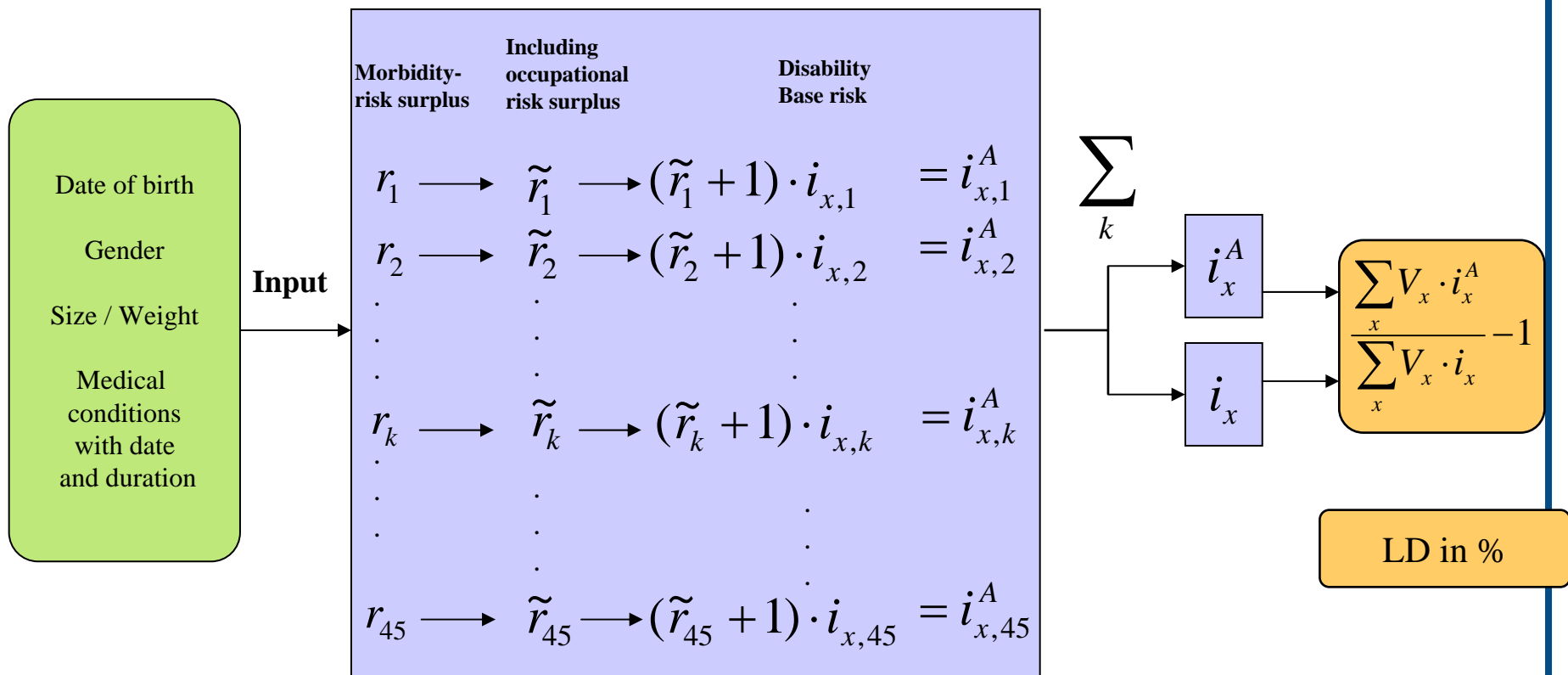
Biometric risk to be predicted



# Data Model



# Calculation of Risk Loadings



**k = disease groups:**

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

$V_x$  = 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	
	All treatments	Heart treatment	All treatments	Heart treatment
Hypertension				

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]	
	Total	For Heart	Total	For Heart
Hypertension				

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
Coxarthrosis	0.12	2.629
Other conditions	...	...
Age	0.42	0.046
Occupation	0.09	0.126

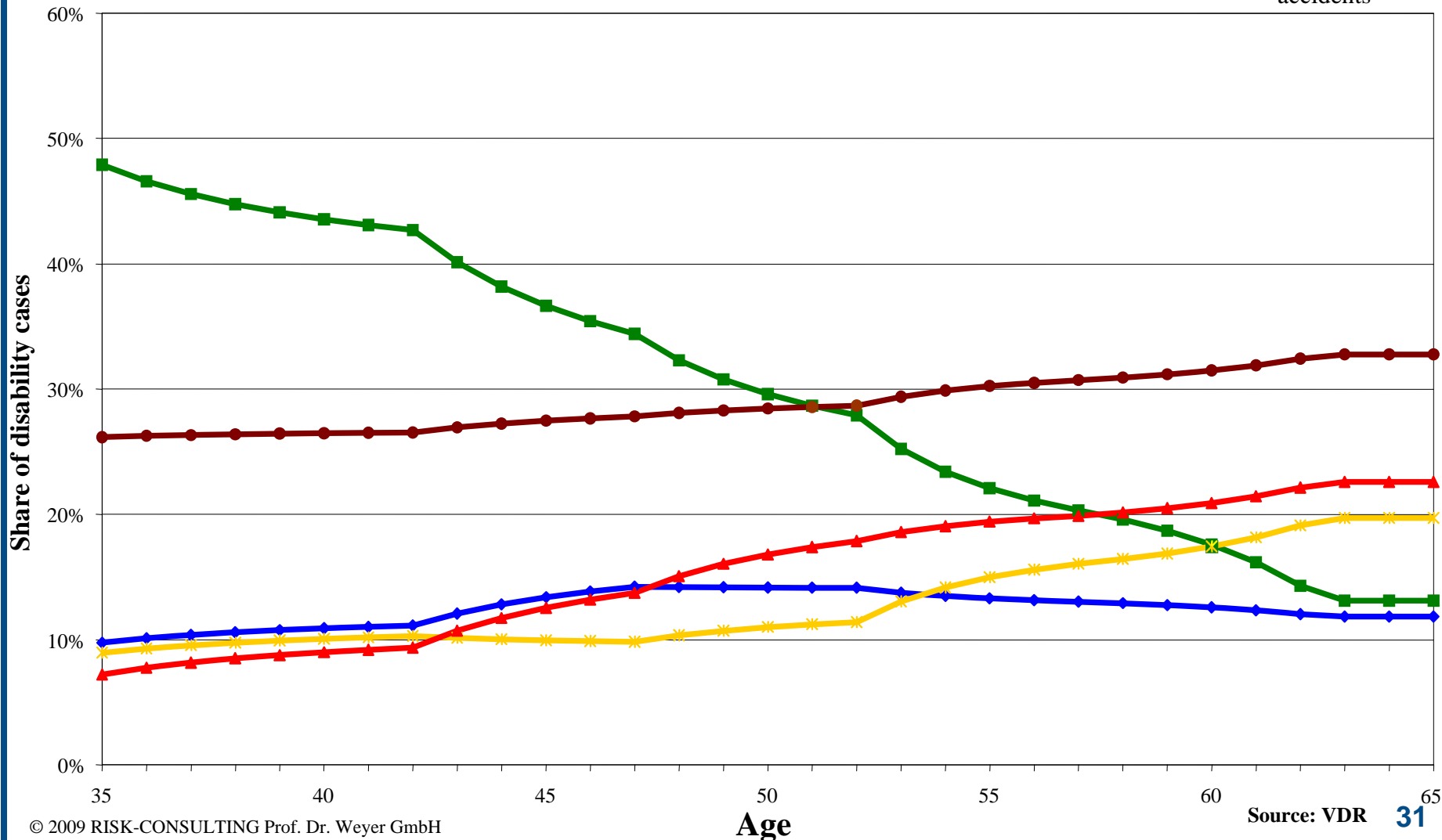
# Increased Morbidity Risk through Previous Medical Conditions

Average increase in morbidity risk for severe illness at age 45-50 (compared to persons of same age)

Previous condition at Application (Age 35)	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%		

# Causes of Disability: Men

■ Psychological    
 ◆ Tumours    
 ✱ Spinal column/skeleton    
 ▲ Heart / circulation    
 ● Other, incl. accidents



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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.**

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