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Critical Illness Definitions Working Party
Speakers: Adele Groyer & James Tait

Update from the Critical Illness Definitions working party

May 2012

Members of CI Definitions Working Party

Adele Groyer

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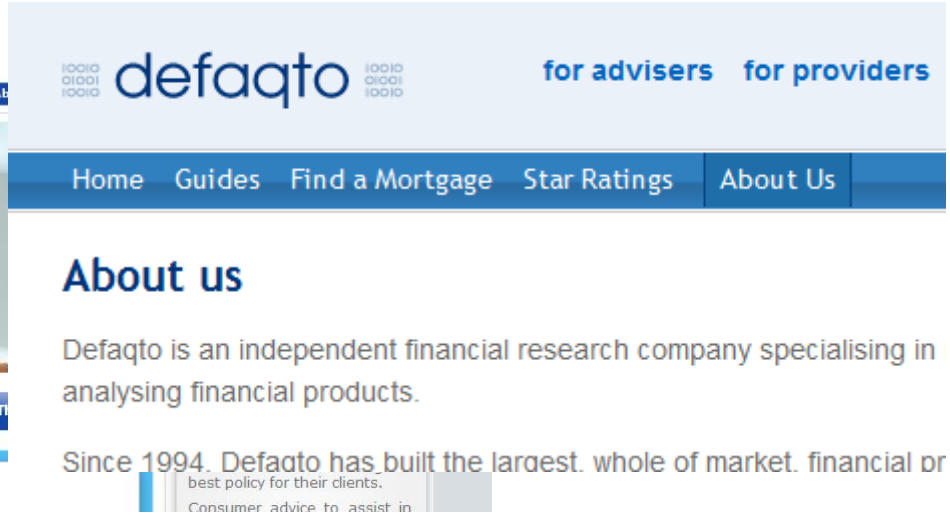
Agenda

- Recap of work to date – Cardiovascular focus
- Market developments since Health & Care 2011 (May)
- Overview of HES data
- Examples
  - Primary Pulmonary Hypertension
  - ABI+ Heart Attack

Objectives & Market Developments

	Aegon	Ageas	Aviva	Bright Grey	Friends Life	Legal & General	LV=	Scot Prov	Zurich
Full payment	41	41	34	43	45	39	48	43	40
Partial payment	1	2	2	2	8	1	7	2	0
ABI+	6	14	12	9	14	11	16	9	10



Working Party Objectives

- Estimate current population incidence of ABI+ & non-ABI conditions
- Suggest scenarios of how incidence may change in future
  - Trends
  - Shocks
- Highlight any special risks with offering cover on this basis

Recap – What's in scope?

- ABI+ & non-ABI conditions
- Start with heart-related conditions

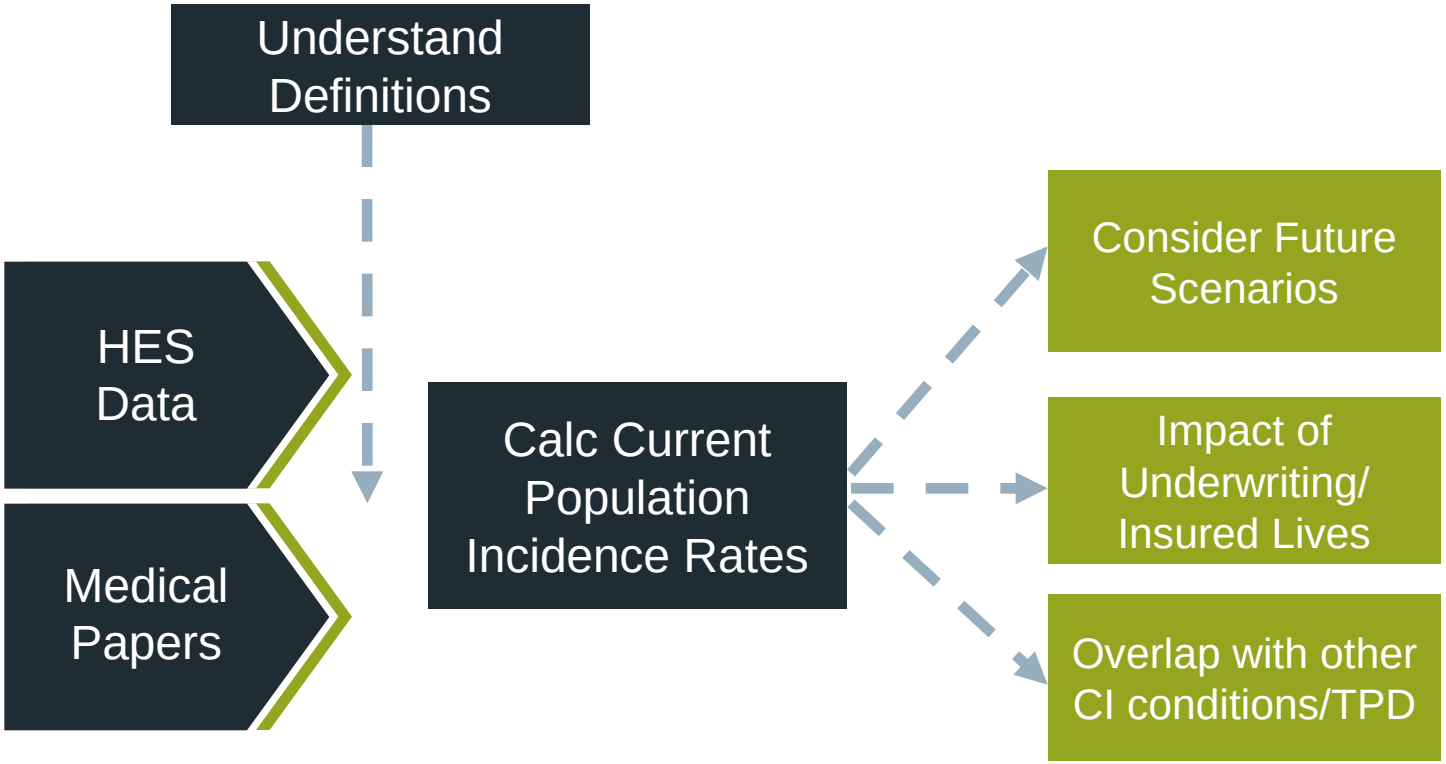
Presented at H&C 2011	Presented today
CABG (ABI+)	Heart attack (ABI+)
Angioplasty (non-ABI)	Primary pulmonary hypertension (non- ABI)
Heart valve replacement or repair (ABI+)	

What's in scope?
- HES Data vs Medical research papers

There are some conditions for which the HES data will not provide much practical insight ...

- Where future scenarios are key
- Where diagnosis may not result in hospitalisation
- Where the ICD code is not granular enough
- Where cause is important

Methodology



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An overview of the data we are using for the research

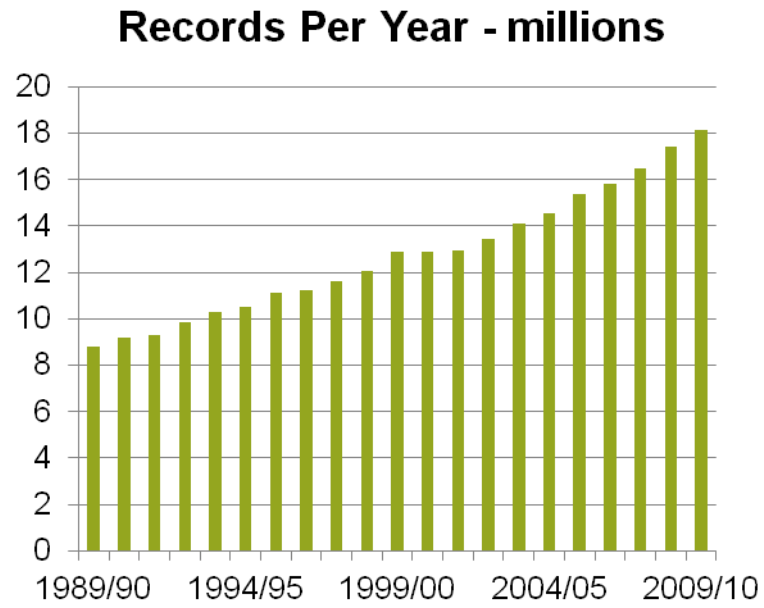
Hospital Episodes Data

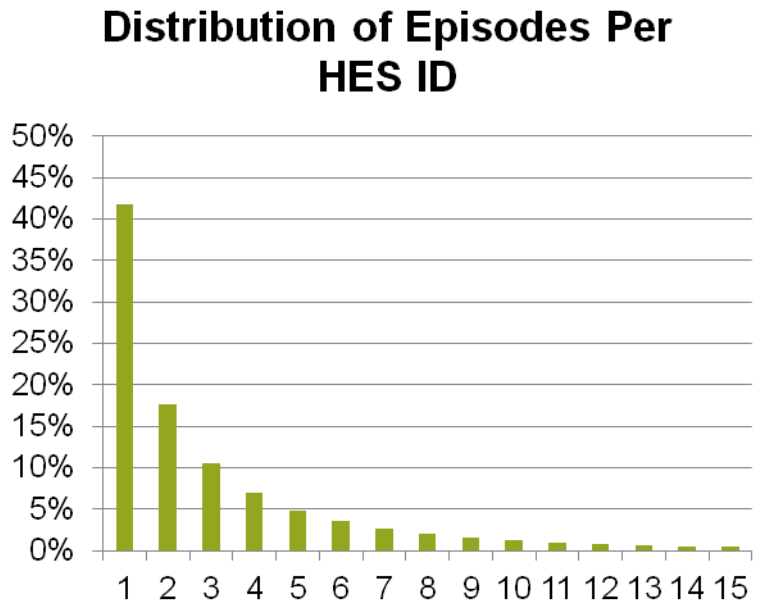
What the HES data looks like

Patient Identifier	Unique identifier by patient – 47m of these
Basic Patient Information	Age, gender
Basic Episode Information	Date started, date finished, admission method, current status etc
Diagnosis Information	Up to 20 different diagnoses
Procedure Information	Up to 20 different operations, with date of operation
Geographical Information	Postal district, Lower Super Output Area, IMD Rank, Mosaic Type, ACORN Type, Health ACORN type

Summary of HES Data

- Data years 1989/90 to 2009/10 received.
- Only 1997/98 to 2009/10 are coded with unique patient identifiers.





Example data

DIAG_01	DIAG_02	DIAG_03	DIAG_04	DIAG_05	DIAG_06	DIAG_07	DIAG_08	DIAG_09	DIAG_10	DIAG_11	DIAG_12	DIAG_13	DIAG_14
I423-	J439-	Z539-											
I499-	-												
I270-	I424-	I270-	J439-	I48X-	E039-								
S6250D	W198-A												
J181-													
J181-													
I423-	I48X-	I501-	J439-										
I423-	I48X-	I501-	J439-										
I48X-	I424-	J439-	I959-										
I270-	I509-	J449-	J90X-	J439-	I48X-								
I423-	I48X-	I501-	J439-										
R14X-	R060-	I423-	I48X-	I501-									
E876-	I500-	I48X-	E058-	Y522-									
J22X	I423	J439											
K621													
K602	E059	I424	I500										
I423	I48X	I10X	J439										
I424-	I48X-	I500-	I270-										
L918	D227												
I500-	S220-	X599-	I270-	I423-	I439-	J459-	Z950-	Z921-					
I424-	I500-	I270-	I081-	I48X-	E032-	Y522-	J439-	J459-					
K602	E059	I424	I500										
R074	I48X	J439	E039	J841	I423								
I423	I48X	I10X	J439										
I424	I500-	I48X-	J439-	Z877-									
I425	Z048												
I424-	Z450-	I500-	I48X-	T462-	Y522-	E079-	Z867-						
J22X-	R060-	T818-	Y831-	Z950-									
I500-	I429-	I48X-	I270-	J439-	K602-	K625-							
I424-	I48X-	I500-	T462-	Y522-	E079-	Z950-	Z867-						
M1097	I10X	I48X	I500	E059	J449								
I500-	I429-	I48X-	I270-	J439-	K602-	K625-							
I500-	I424-	I48X-	I270-	Z950-									
I500-	I424-	I48X-	I270-										
E876-	I424-	I517-	I48X-	I270-	Z950-								
E876-	I424-	I517-	I48X-	I270-	Z950-								
I081-	I424-	I517-	I48X-	I270-	I959-	J439-	M8190	Z950-					
I424-	I500-	I48X-	I270-	L52X-	L270-	K148-	R061-	Y041-	R55X-	I10X-	J439-	M8199	Z950-

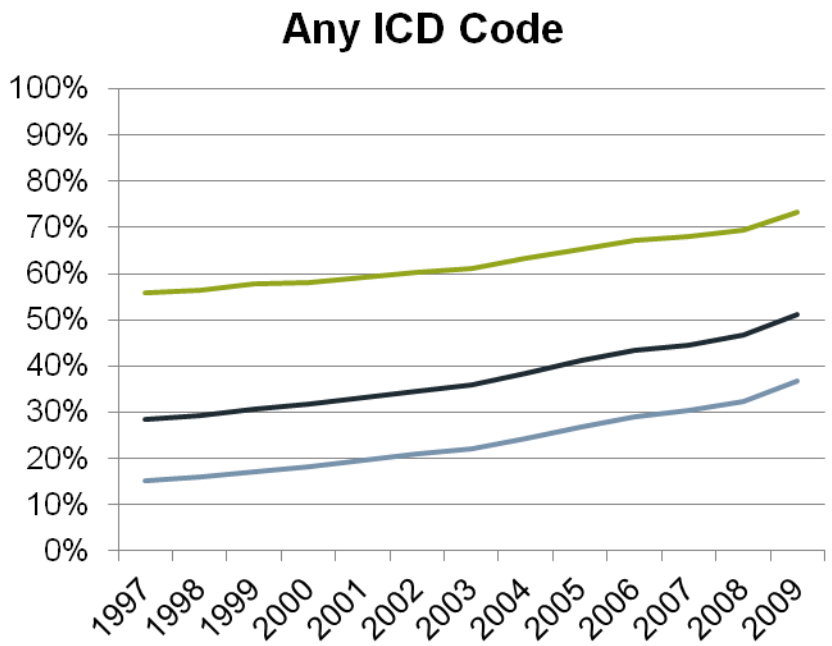
20 Diagnosis codes

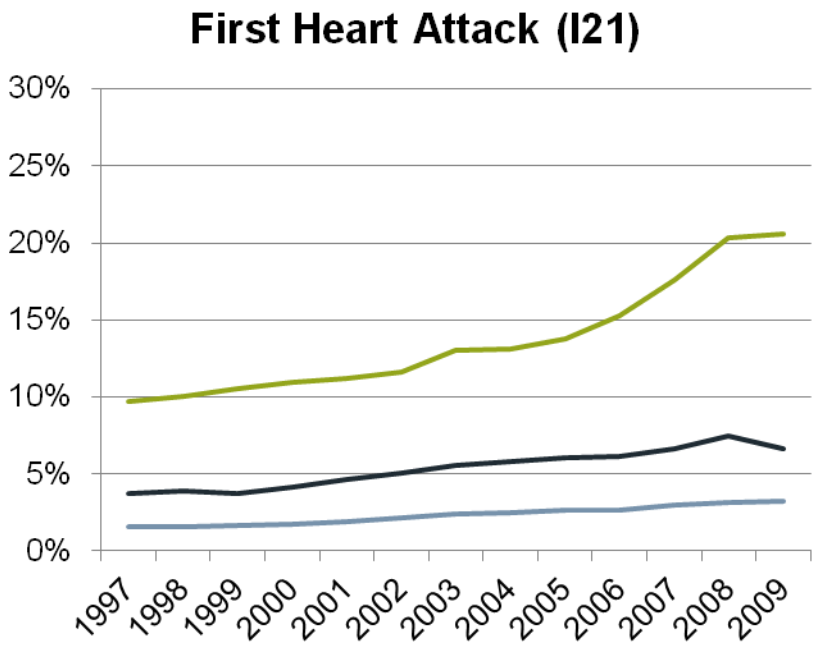
Each record is an individual episode

Each ICD code could appear multiple times as a primary diagnosis (DIAG_01) or in secondary diagnosis fields

Increases in Multiple Codings

Proportion of Episodes with 2nd, 3rd,4th Diagnosis fields being populated by year.





Data checks and Reconciliations

- Check of values in each field
  - Key fields have values corresponding to HES Data dictionary;
  - Some minor fields have unknown values;

- Reconciliations to freely available data
  - Primary Diagnosis, Finished Consultant Episodes;
  - Main procedures and interventions;
  - Total Procedures and interventions.

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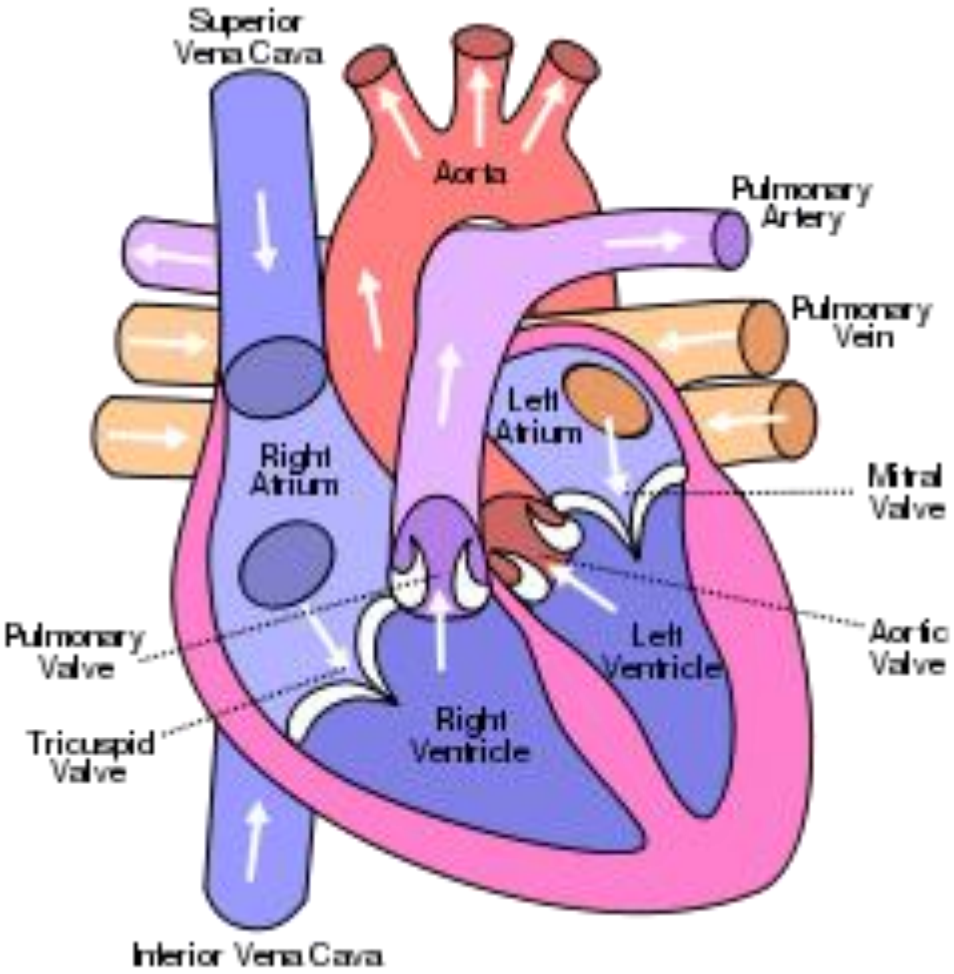
An example where publically available HES data is materially misleading

Primary Pulmonary Hypertension (non-ABI)

Pulmonary Hypertension



Pulmonary Hypertension
– Pathology

Pathology

•Syndrome

•Restricted blood flow through the pulmonary artery

•Increased pulmonary vascular resistance

•Right heart failure

Risk Factors
(Possible)

1. Drugs & toxins
2. Demographic
    1. Gender
    2. Pregnancy
    3. Hypertension
3. Disease
    1. HIV
    2. Liver disease
    3. Vascular disease
    4. Congenital disease

Symptoms

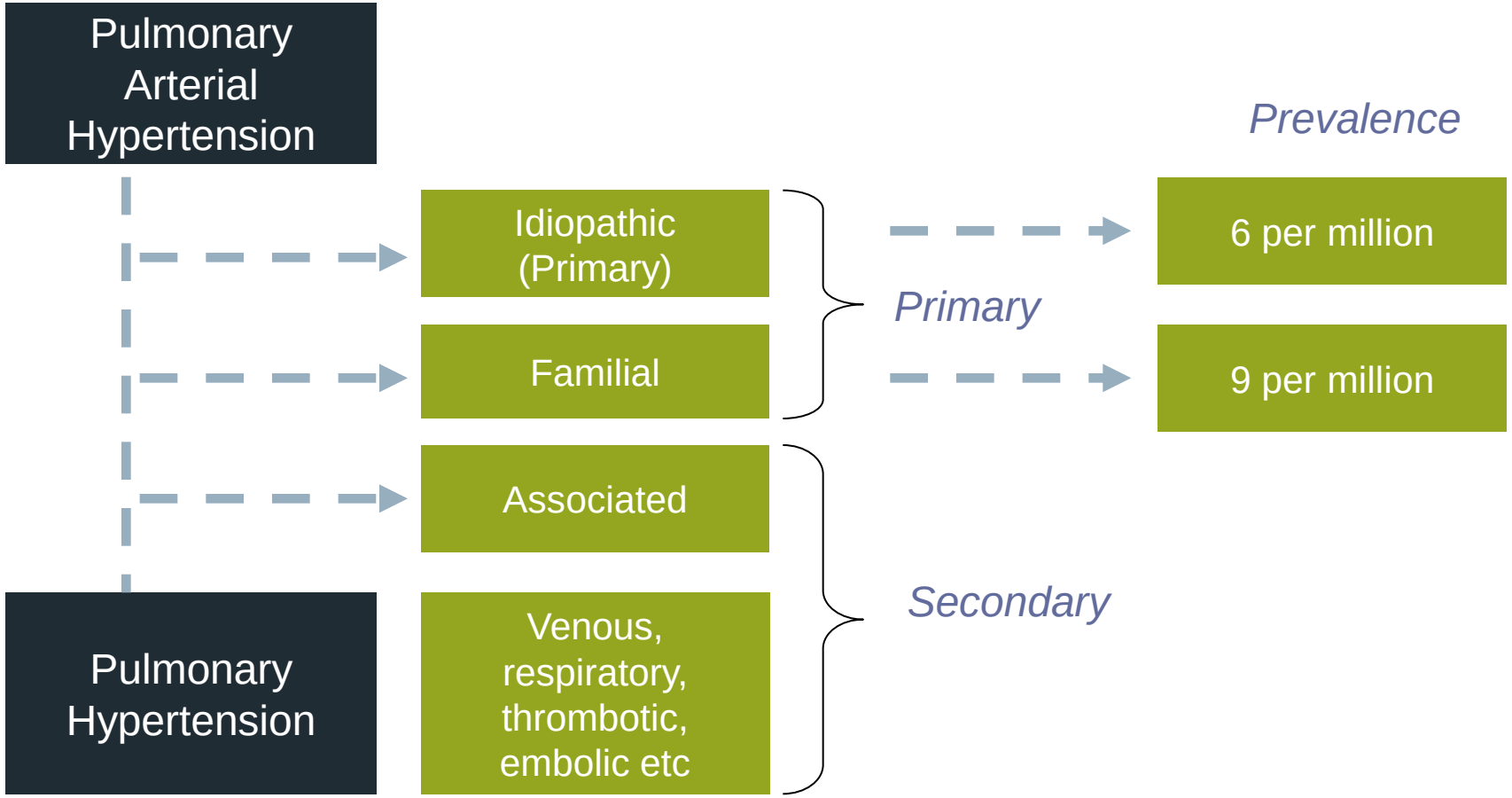
Shortness of breath
Dizziness
Fatigue
Chest pain
Swollen ankles

Treatment

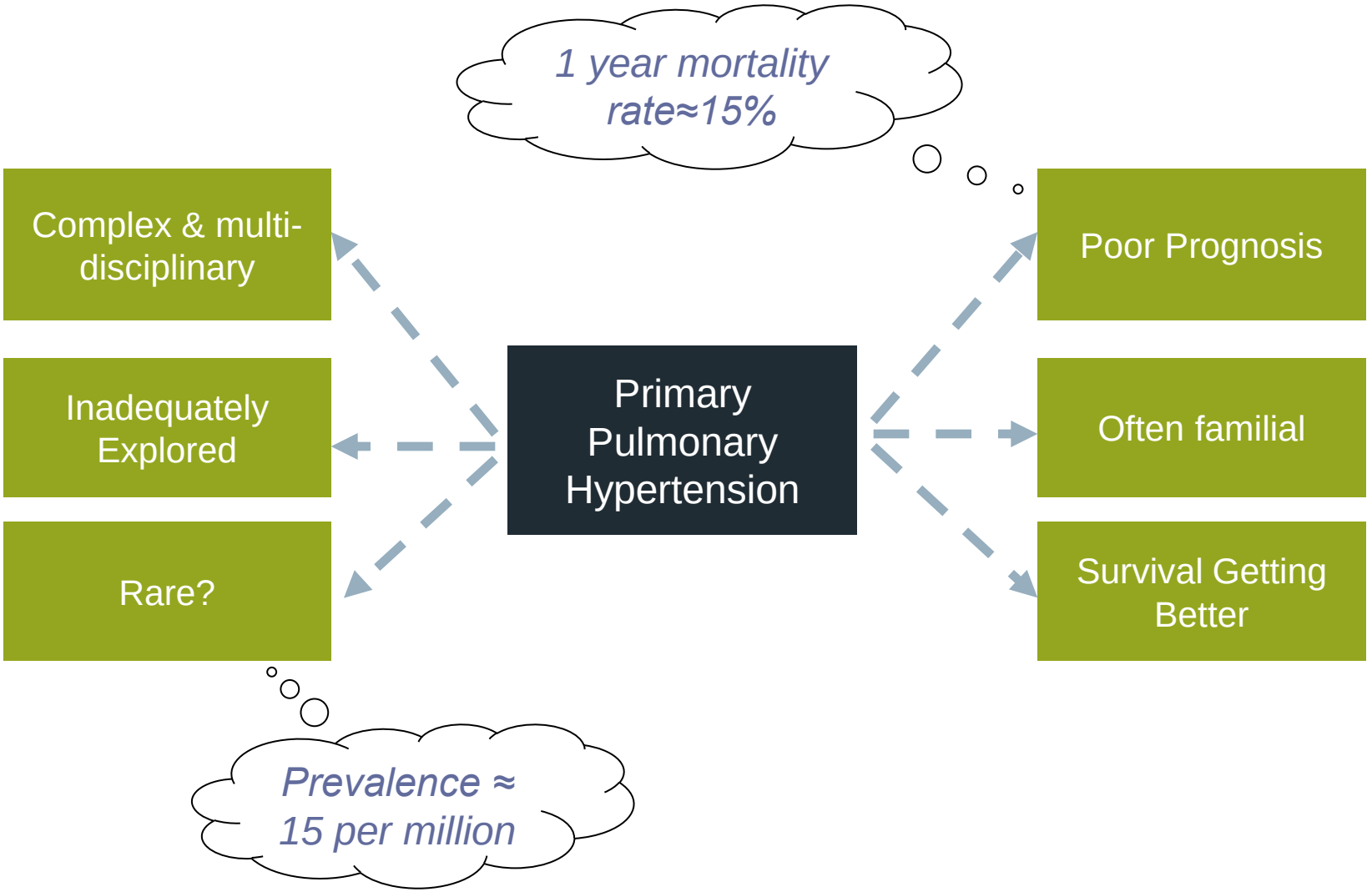
No cure

Evidence based treatment algorithm

Pulmonary Hypertension
– Classification & prevalence



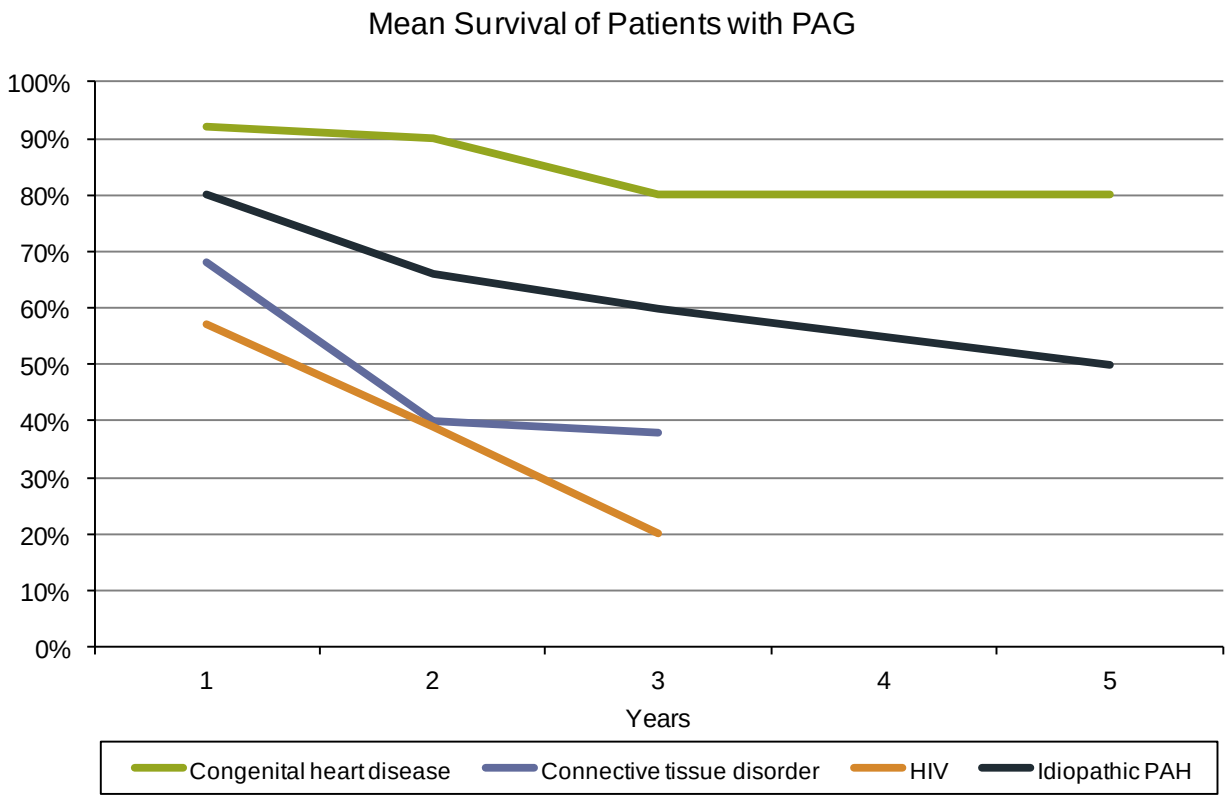
Primary Pulmonary Hypertension
– Introduction



Pulmonary Hypertension
– Survival

Prognostic indicators

1. Functional class
2. Exercise tolerance
3. Hemodynamics
4. Echocardiography
5. Imaging
6. Biomarkers



Expert consensus on PH: American College of Cardiology

Primary Pulmonary Hypertension
– Insured World

Insured definition is not an ABI standard but generally based around:

- Being at least class III on the NYHA scale of functional capacity
- Exclusion of secondary pulmonary hypertension

Pulmonary Hypertension
– Incidence

Estimating incidence can be tricky for such a rare disease

Incidence per million	IPH/FPH	CTD-PH	CHD-PH	Other
French National Registry	1.0	0.4	0.3	~ 0
Scottish Morbidity Records	3.3	2.1	1.7	~ 0
Scottish Pulmonary Vascular Unit	2.6	2.8	2.2	~ 0

Peacock, Murphy, McMurray, Caballero, Stewart (2007)

Pulmonary Hypertension
– Using Online HES data

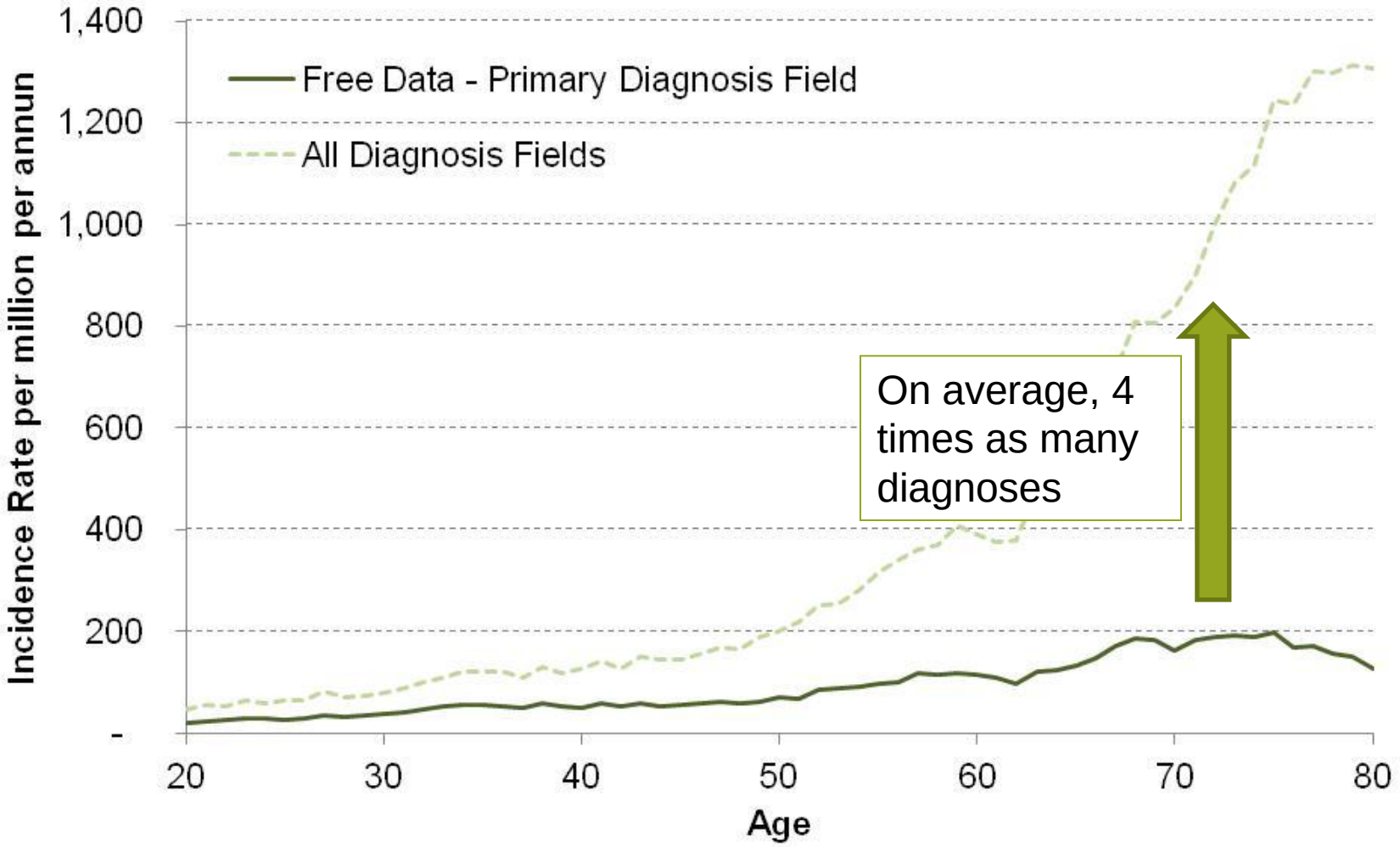
An example of the fallacy of using raw HES data

Incidence per million	0-14	15-59	60-74	76+	Total
HES Incidence	24.9	81.0	278.2	298.8	116.3
Medical Studies			1-3		

What's happening here?

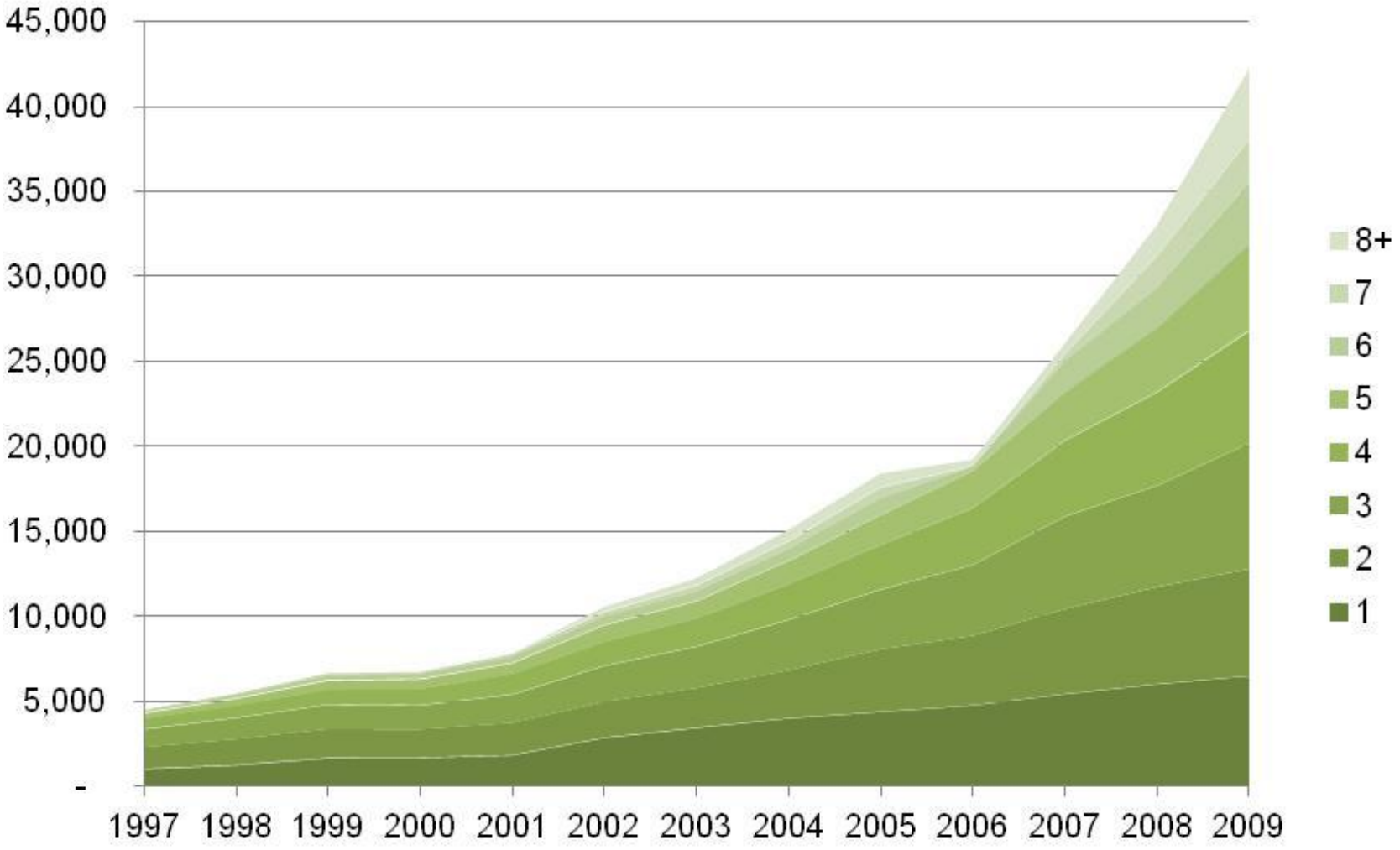
- Remove multiple hospital admissions
- Consider patient's medical history
- Apply severity adjustment

Primary Pulmonary Hypertension

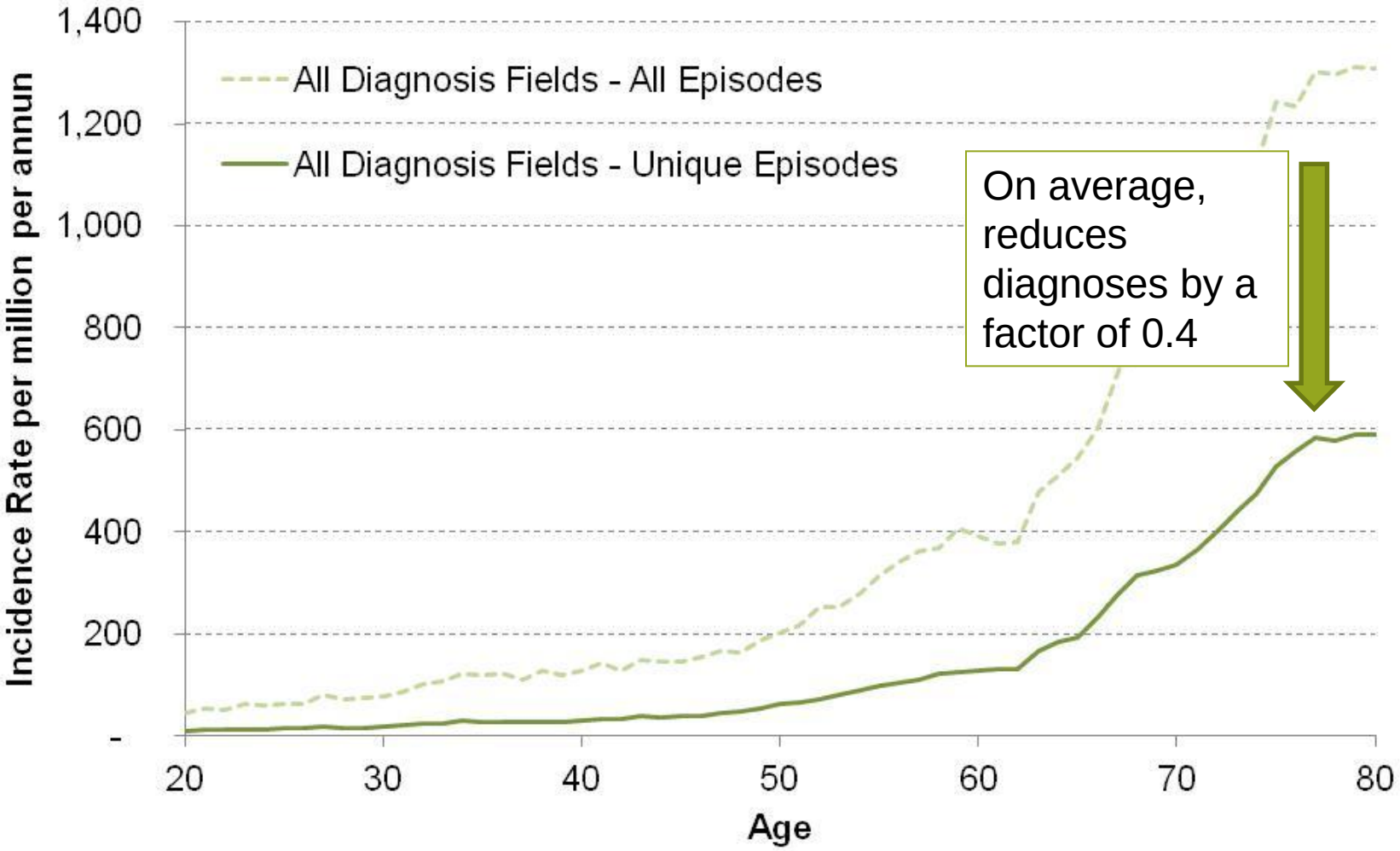


Primary Pulmonary Hypertension

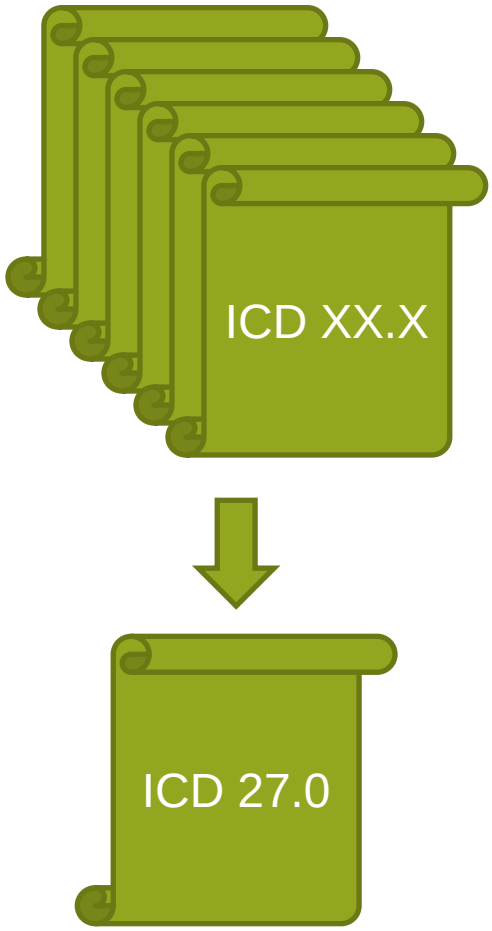
- Increase in the use of secondary diagnosis fields



Primary Pulmonary Hypertension



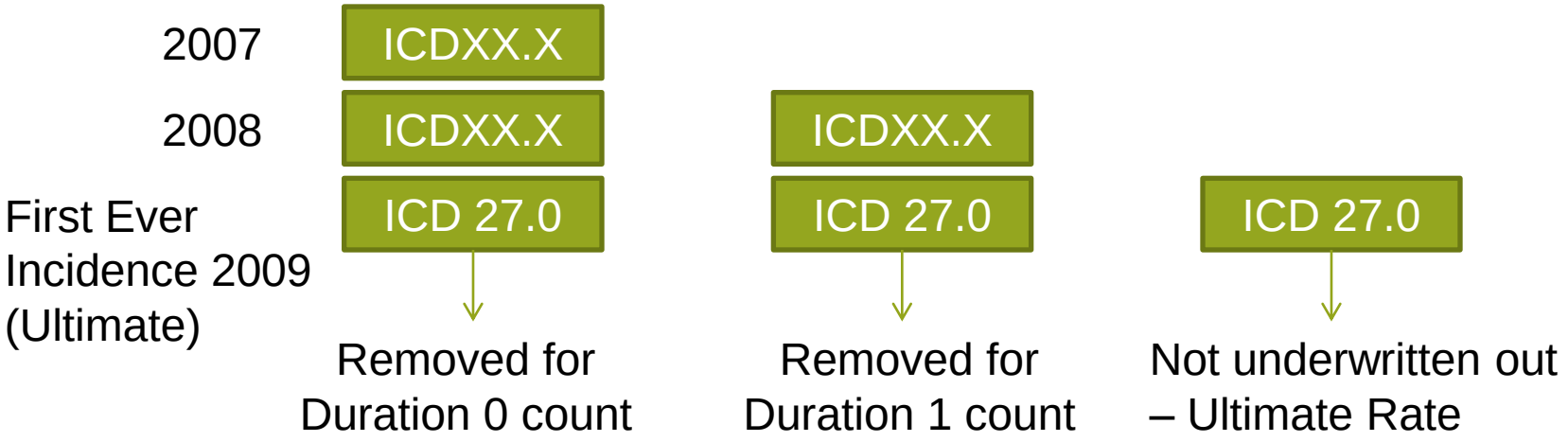
Primary Pulmonary Hypertension
- Allowing for the effects of underwriting



Process:

1. Extract all records with a particular ICD code
2. Include the multiple diagnosis fields, not just primary diagnosis contained in the publically available data
3. Order by date to obtain a first ever incidence of the condition

Primary Hypertension
- Allowing for the effects of underwriting

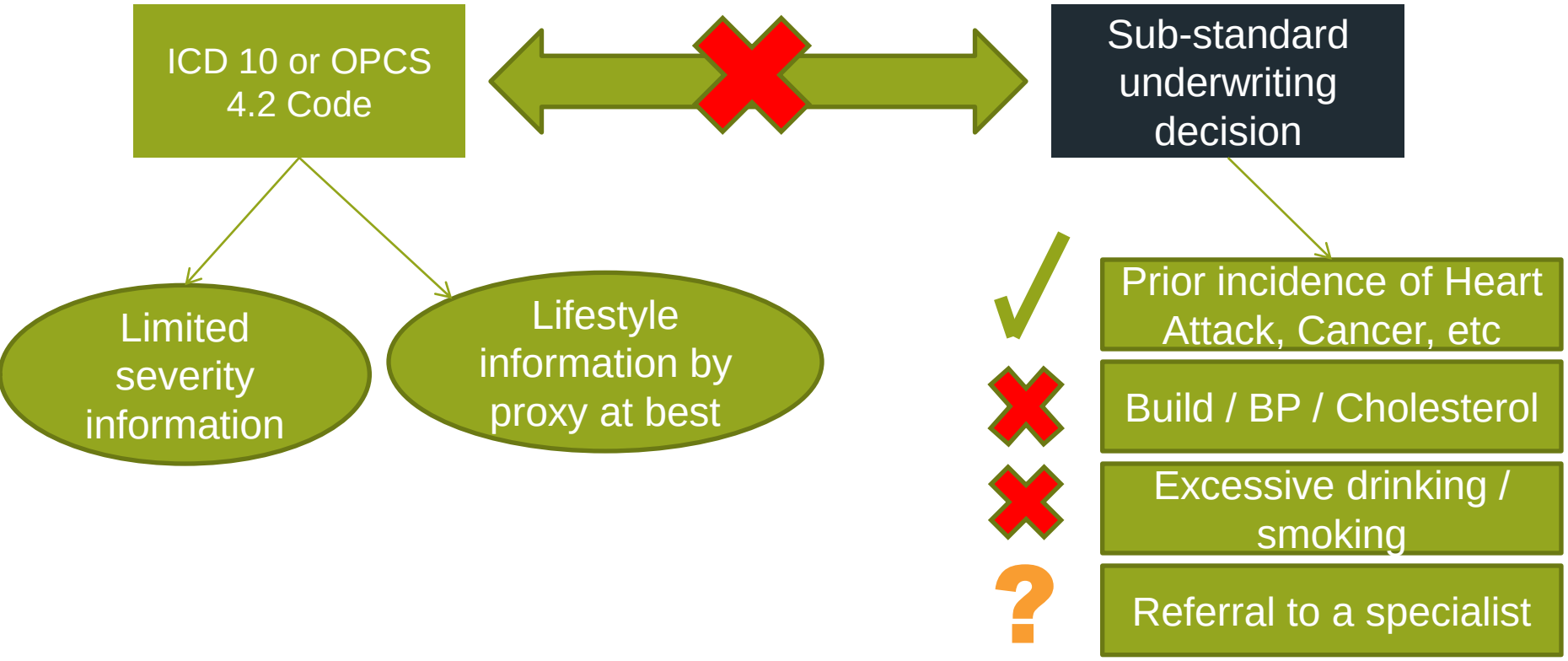


1. Pick an underwriting year – needs to be reasonably recent in order to obtain sufficient medical history

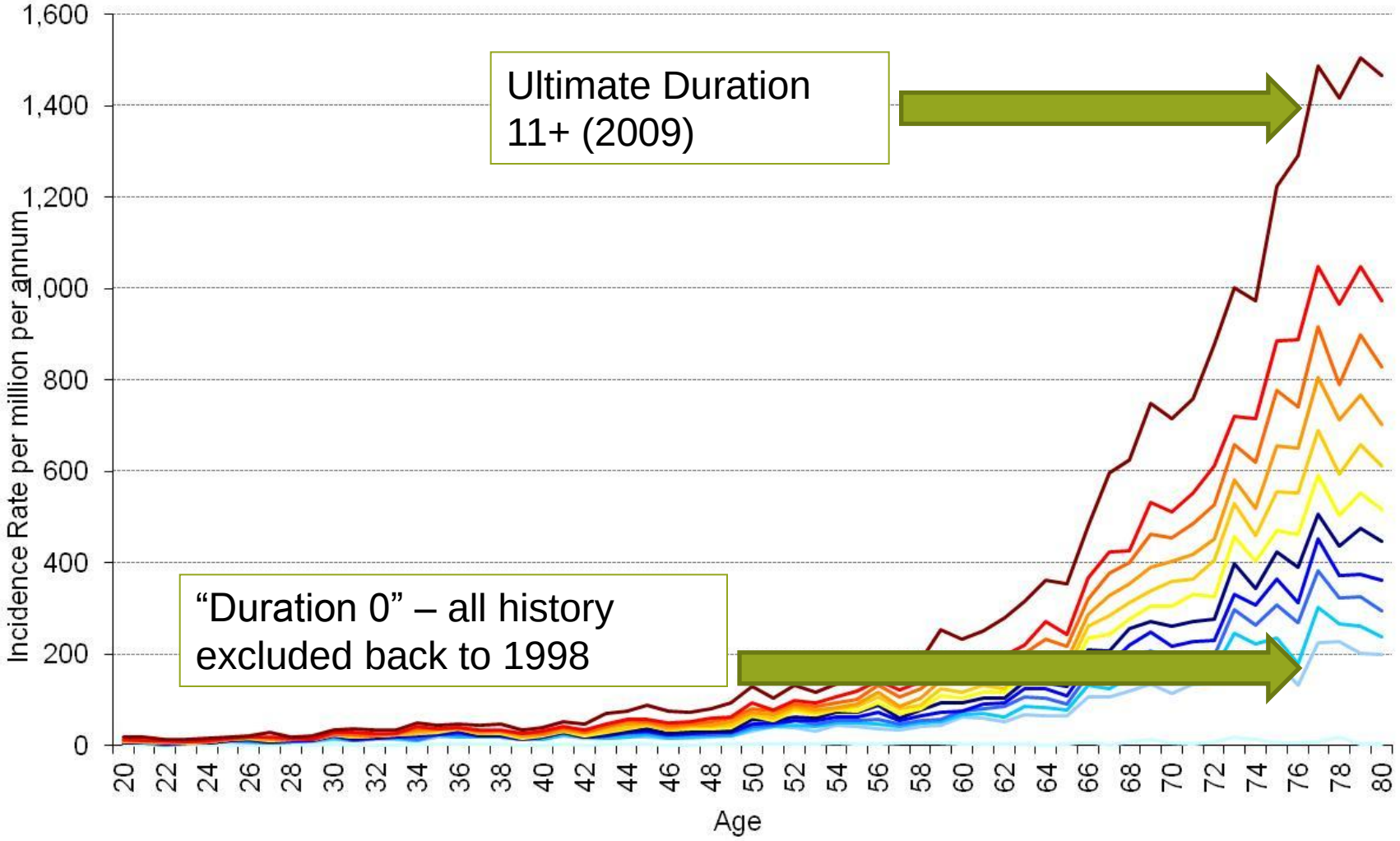
2. Filter out records with a previous incidence of an ICD code that would have been underwritten out

3. Therefore get a standard rates incidence of the condition

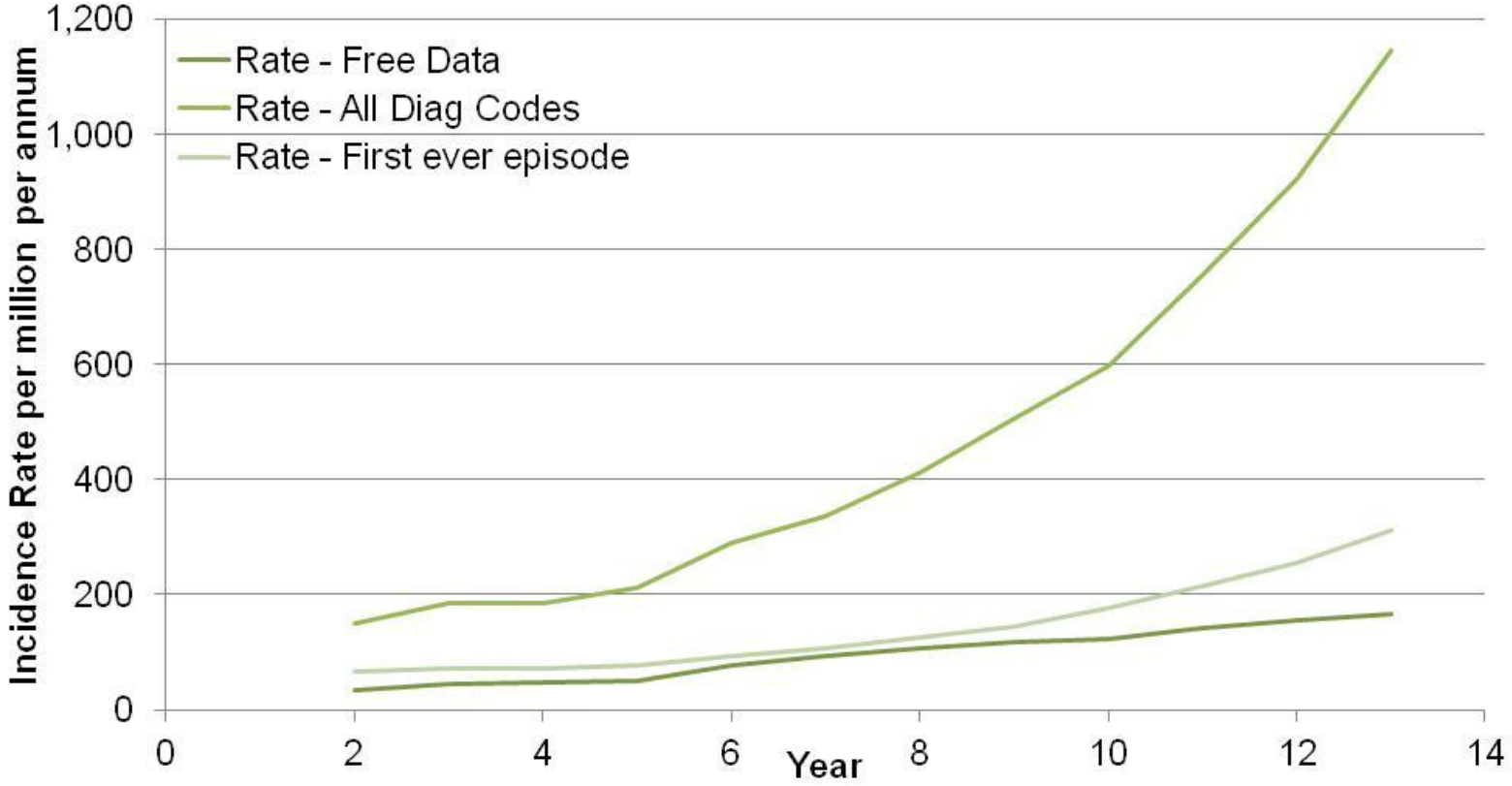
Primary Hypertension
- Allowing for the effects of underwriting



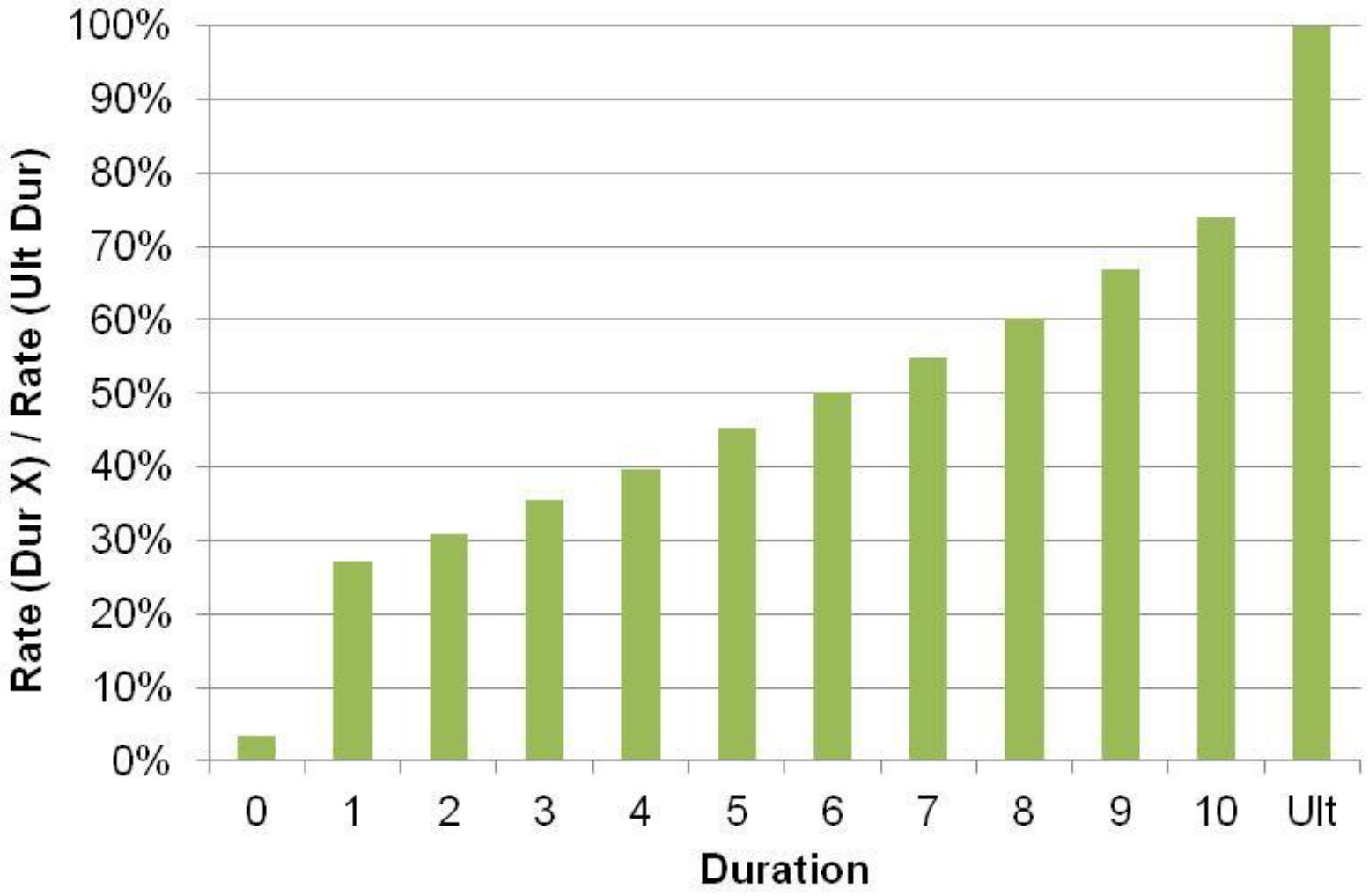
Pulmonary Hypertension



Pulmonary Hypertension
- Trend by diagnosis year first episode



Pulmonary Hypertension
- Durational "underwriting" impact



Pulmonary Hypertension
- Next steps

- Appropriateness of use of secondary diagnosis fields
- Overlap with other conditions
- Similar analysis for each condition, which conditions does the duplicate/multiple episode issue have the biggest impact on?
- Which conditions does our underwriting proxy approach create the biggest discounts for?

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An example where HES data will be of limited use

ABI+ Heart Attack

Disease/Diagnosis – ABI+ Heart Attack

ABI SOBP DEFINITION

- Death of heart muscle, due to inadequate supply, that has resulted in all of the following evidence of acute myocardial infarction:
  - Typical clinical symptoms (for example characteristic chest pain)
  - New characteristic electrocardiographic changes.
  - The classic rise of cardiac enzymes or Troponins recorded at the following levels or higher;
    - Troponin T > 1ng/ml
    - AccuTnI > 0.5 ng/ml or equivalent threshold with other Troponin I methods.

  The evidence must show a definite acute myocardial infarction.

  For the above definition, the following are not covered:

  - Other acute coronary syndromes including but not limited to angina

Medical definition of heart attack: Classic WHO (1979)

- Any **two** of the following:
  - Typical chest pain **Symptoms**
  - Elevation of cardiac marker enzyme concentrations in the blood **Enzymes**
  - Typical electrocardiographic changes **ECG**

Universal Definition of Myocardial Infarction (2007)

- Detection of rise and/or fall of cardiac biomarkers (preferably Troponin) with one value above the 99th percentile of the URL together with at least one of the following:

(a) ischaemic symptoms; **Symptoms**

Enzymes

(b) ECG changes indicative of ischaemia (ST or T wave changes or Left Bundle Branch Block); **ECG**

(c) Development of pathologic Q waves in the ECG; **ECG**

(d) Imaging evidence **Imaging**

Scottish Intercollegiate Guidelines Network (SIGN) – Acute coronary syndromes

BIOCHEMICAL DIAGNOSIS	
C	**In patients with suspected acute coronary syndrome, serum troponin concentration should be measured on arrival at hospital to guide appropriate management and treatment.**
B	**To establish a diagnosis in patients with an acute coronary syndrome, a serum troponin concentration should be measured 12 hours from the onset of symptoms.**
☑	To establish a diagnosis in patients with an acute coronary syndrome when symptom onset is uncertain, serum troponin concentration should be measured 12 hours from presentation.
☑	When considering a diagnosis of ACS, serum troponin concentrations should not be interpreted in isolation but with regard to the clinical presentation of the patient.

Source: http://www.sign.ac.uk/pdf/qrgchd.pdf

Why are symptoms useful for MI diagnosis?

CHEST PAIN, NAUSEA, VOMITING, SHORTNESS OF BREATH, DIZZINESS, PALPITATIONS, SWEATING, ANXIETY

IN CLINICAL PRACTICE

- To establish whether the damage is new

  ECG **IMAGING**

- To differentiate between MI and other conditions

  ECG **ENZYMES**

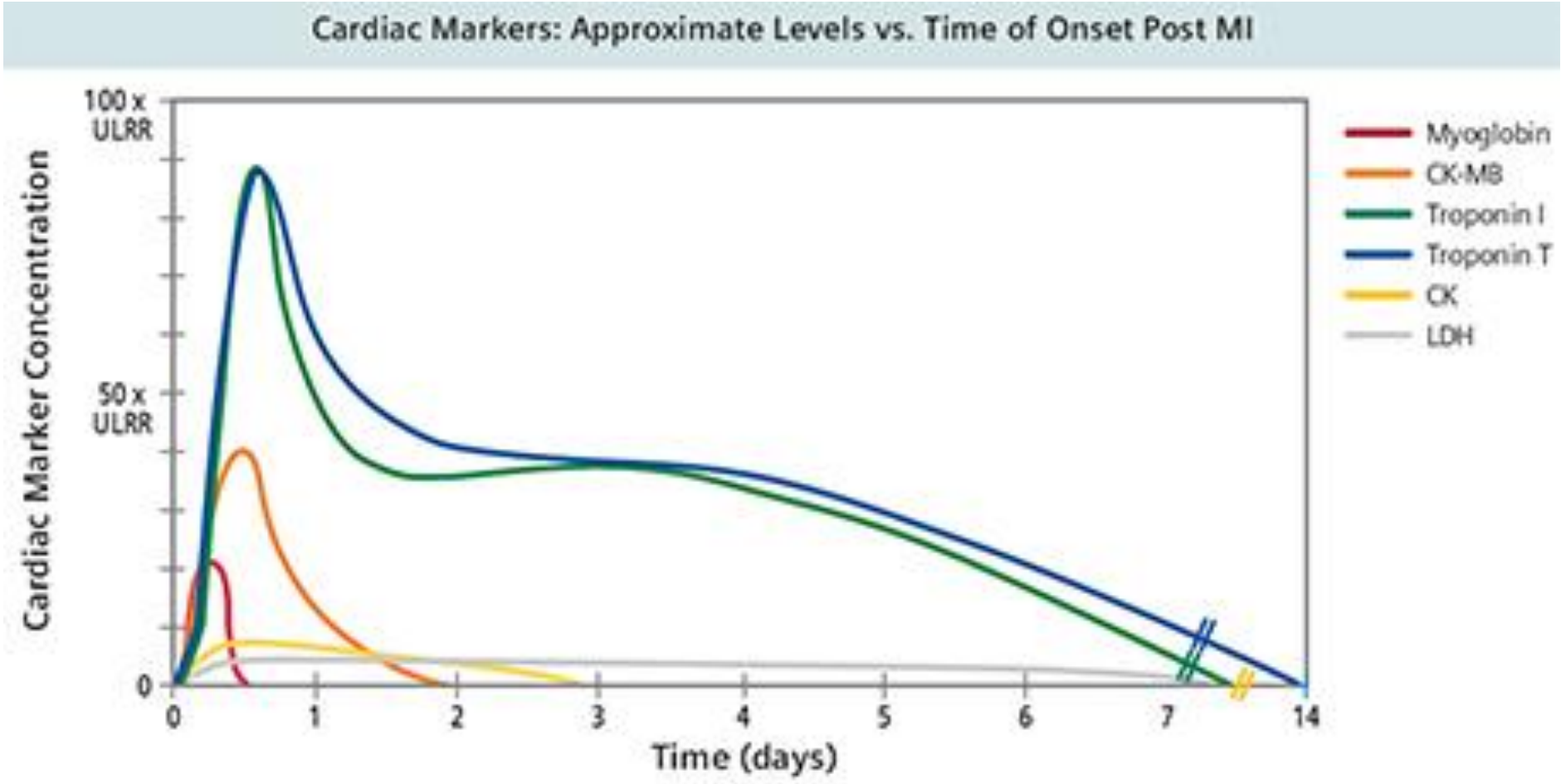
FOR CI INSURANCE

- To establish whether the MI took place while the policy was in force
- To establish whether the claimant has indeed suffered a “heart attack”

Preferred enzyme: Troponin

- Protein found in heart muscle
- Regulates muscle contraction
- TnT, TnI are specific to heart muscle
- Released into the blood when heart muscle is damaged
- Negligible background level in the blood in absence of heart damage

Cardiac marker concentration timing



Source: www.medical.siemens.com

Troponin testing

- First commercially available assay in 1997
- Roche has the patent for the only cTnT test
- Many manufacturers distribute cTnI tests
- Standardisation/comparability challenges
  - International Federation of Clinical Chemistry
- Bedside Troponin testing
  - +ve / -ve result only

Highly sensitive troponin

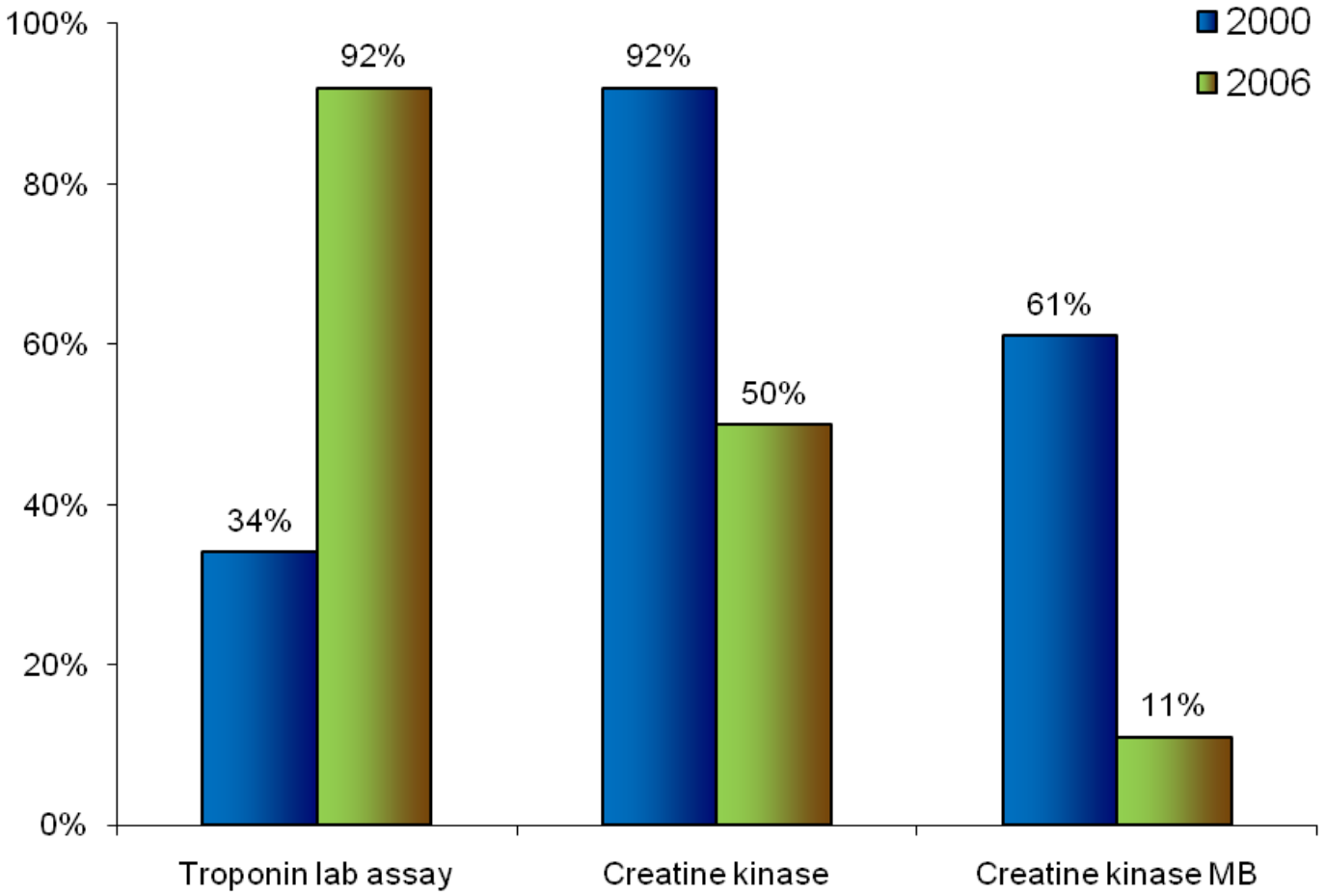
- ESC & ACC decision cut-off is the higher of:
  - the 99th percentile
  - the point at with the co-efficient of variation is <10%
- Historically most tests had a co-efficient >10% at the 99th percentile
- New sensitive tests meet requirements at 99th percentile
- Earlier diagnosis after onset of symptoms
- Possibly a 47% increase in population incidence
  - Based on Mills et al (2012) *BMJ 2012;344:e1533*
  - Incidence between 99th percentile and existing 10% co-efficient of variation cut-off

Troponin Testing

Test	99th percentile (ng/ml)	Limit of detection (ng/ml)	10% coefficient of variation point
Roche TnT 4th Generation	0.01 **ABI: 1.0**	0.01	0.03
Beckmann Coulter Access Accu TnI	0.04 **ABI: 0.5**	0.01	0.06
Abbott-Architect TnI	0.028	<0.01	**0.032**
Roche High-Sensitive TnT	0.014	0.005	**0.013**
Siemens Centaur Ultra TnI	0.04	0.006	**0.03**

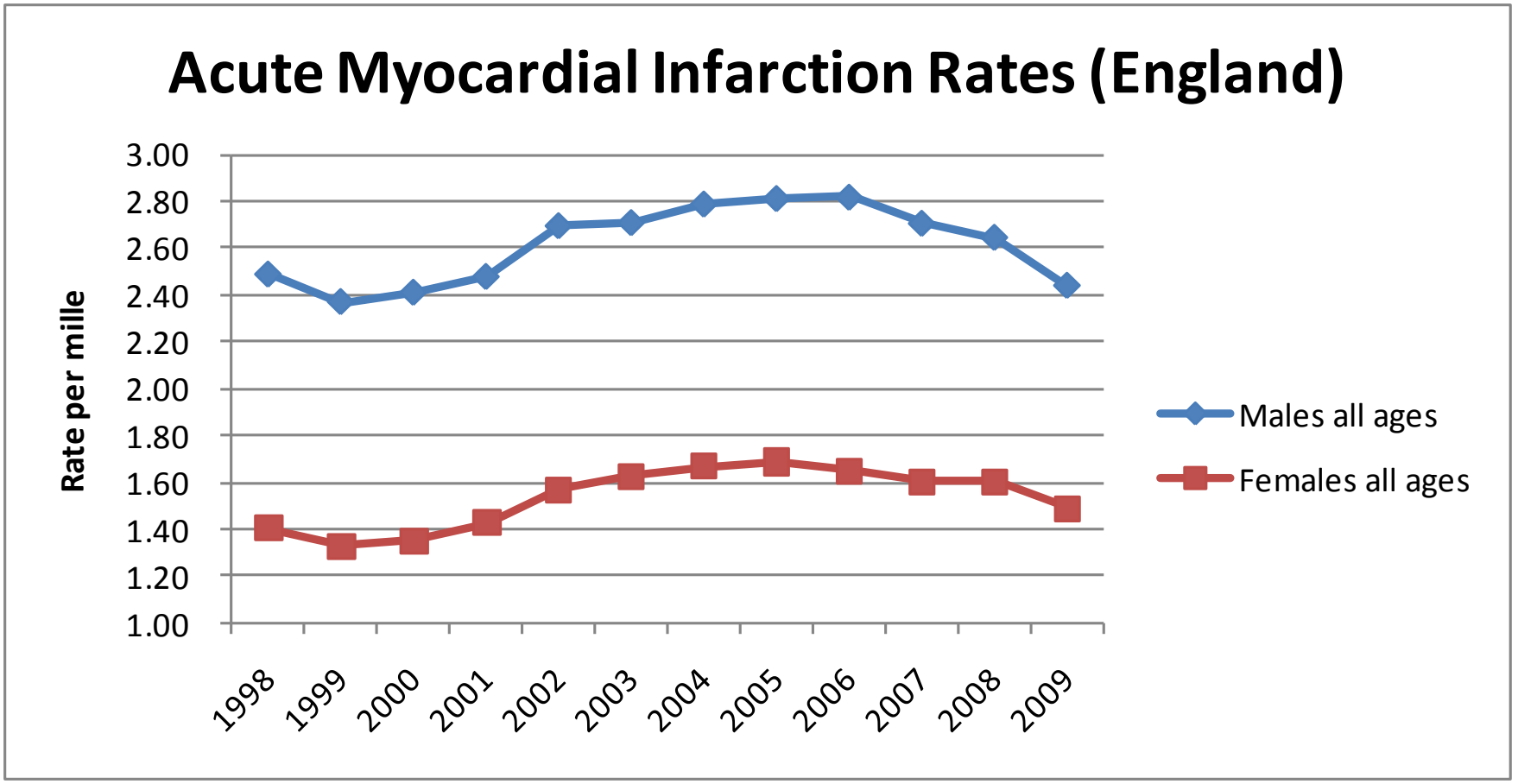
Source: www.ifcc.org

Use of Troponin in UK clinical practice



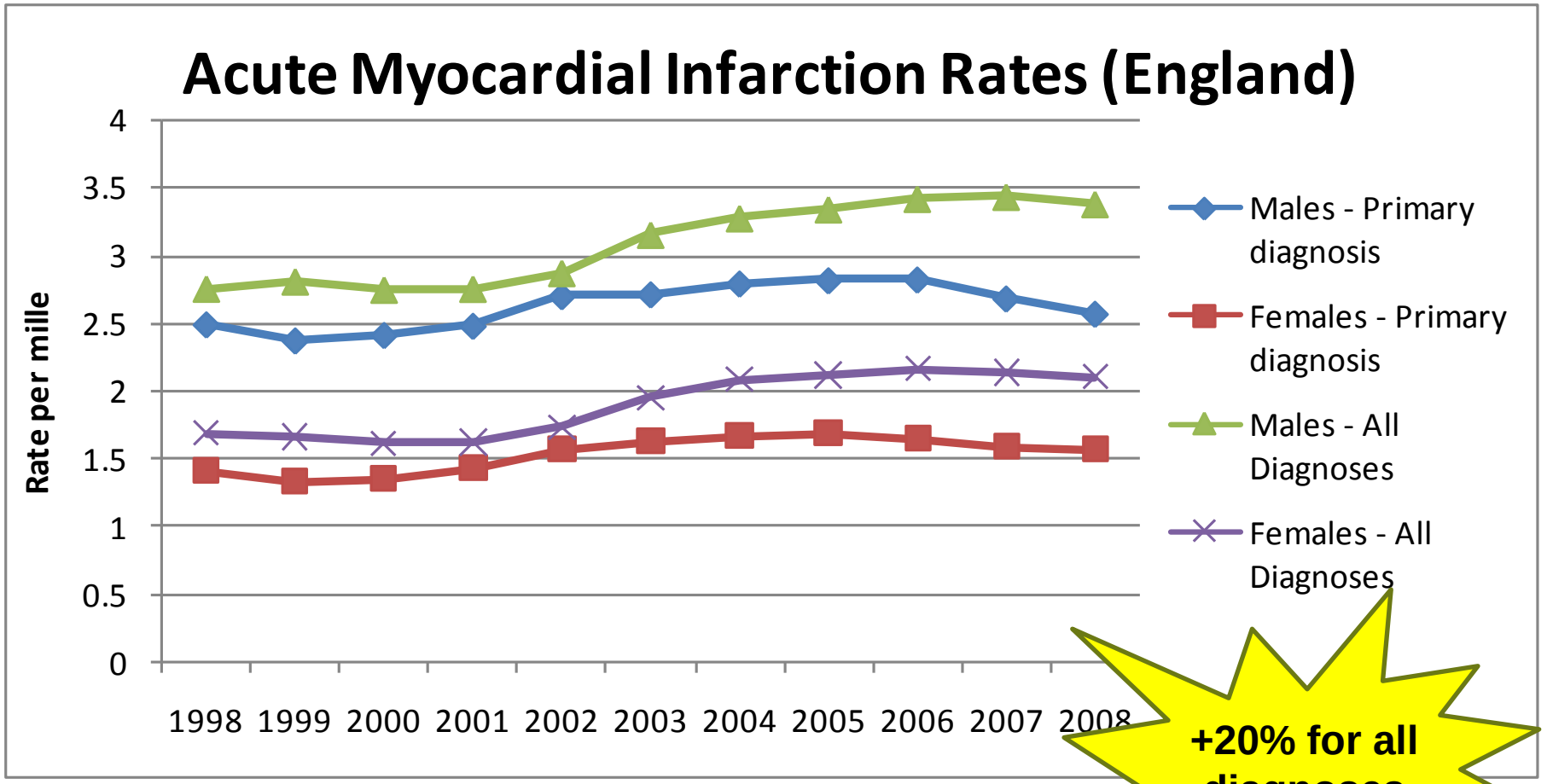
Source: National Audit of Myocardial Infarction Project (MINAP). Royal College of Physicians 2007.

Effect of change in definition



Source: HES Online data for ICD-10 code I21 & ONS mid-year population estimates

Effect of change in definition: all diagnosis fields

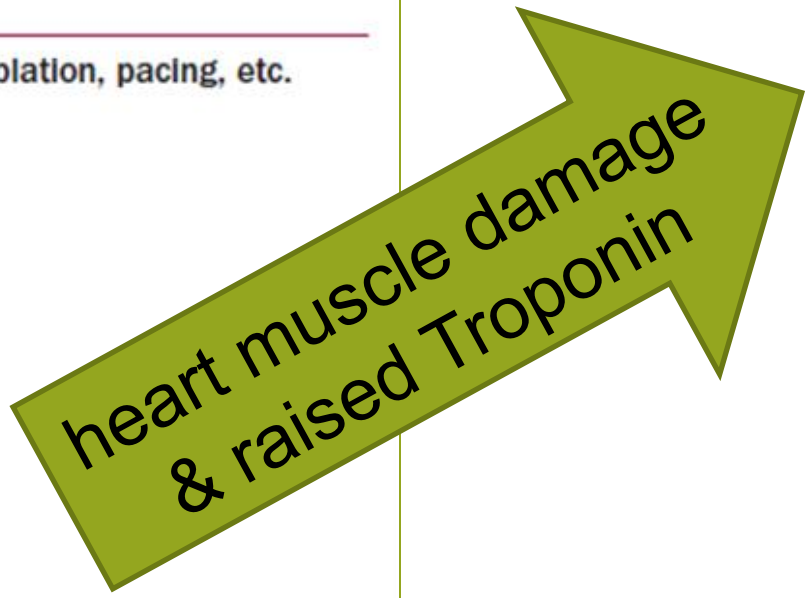


Sources: ONS mid-year population estimates;
HES Data - Copyright © 2011, Re-used with the permission of The Health and Social Care Information Centre. All rights reserved.

Other conditions exhibiting raised Troponin

Table 2. Elevations of Troponin in the Absence of Overt Ischemic Heart Disease

- Cardiac contusion, or other trauma including surgery, ablation, pacing, etc.
- Congestive heart failure—acute and chronic
- Aortic dissection
- Aortic valve disease
- Hypertrophic cardiomyopathy
- Tachy- or bradyarrhythmias, or heart block
- Apical ballooning syndrome
- Rhabdomyolysis with cardiac injury
- Pulmonary embolism, severe pulmonary hypertension
- Renal failure
- Acute neurological disease, including stroke or subarachnoid haemorrhage
- Infiltrative diseases, e.g. amyloidosis, haemochromatosis, sarcoidosis, and scleroderma Inflammatory diseases, e.g. myocarditis or myocardial extension of endo-/pericarditis
- Drug toxicity or toxins
- Critically ill patients, especially with respiratory failure or sepsis
- Burns, especially if affecting >30% of body surface area
- Extreme exertion



Source: Thygesen et al. Circulation. 2007; 166: 2634-2653

Sample Troponin elevations for non-cardiac conditions

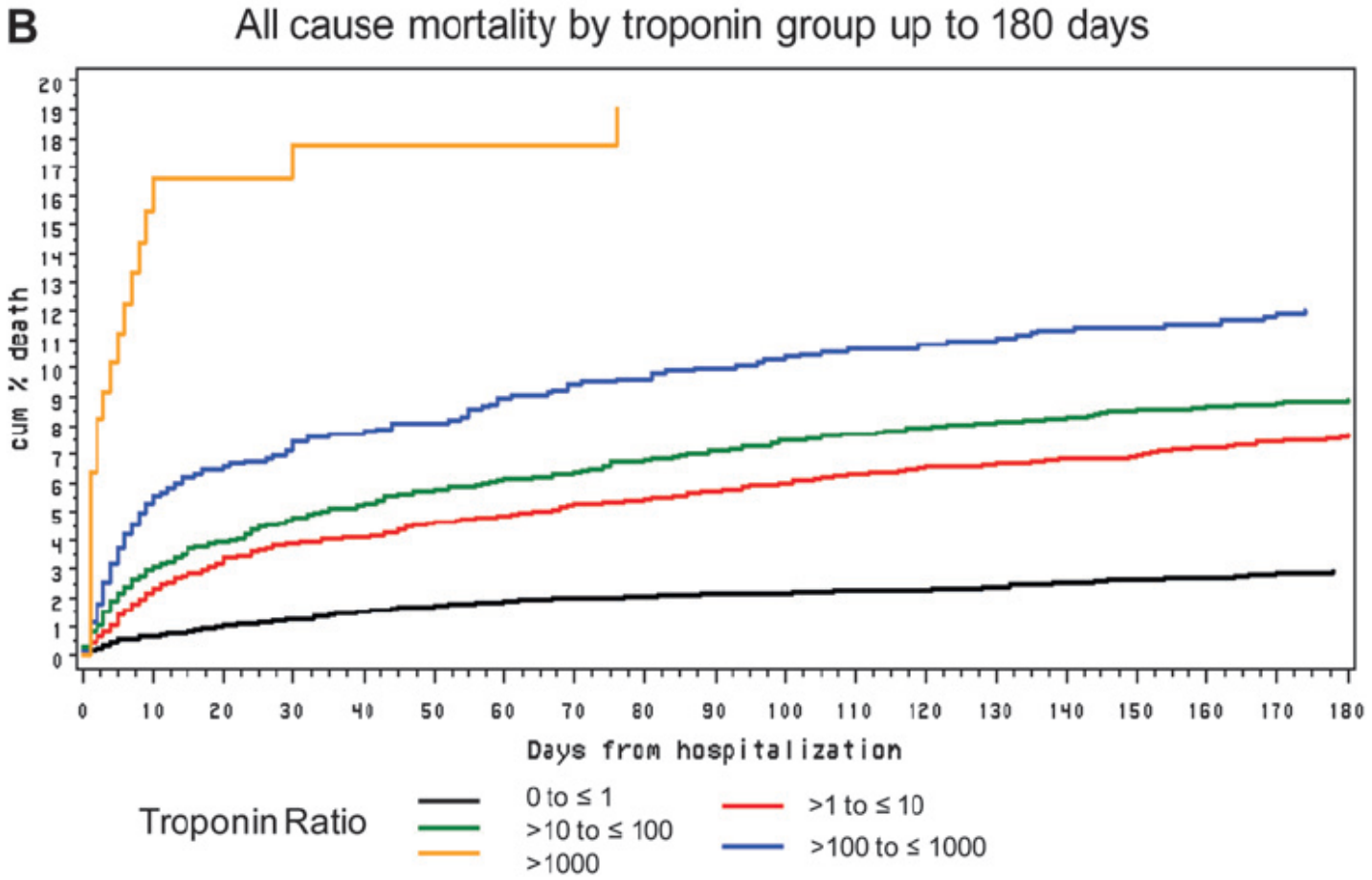
Condition	Cut-off (ng/ml)	% of cases	Incidence
Acute Pulmonary Embolism	0.1 (TnT)	32%	100 cases per 100,000 persons (acute MI = 600) 24% 1-year mortality rate http://emedicine.medscape.com
Acute Pericarditis ***Involves chest pain***	0.5 (TnI)	49%	1 per 1000 hospital admissions http://emedicine.medscape.com (from HES: MI = 3.3)
Acute or Severe Heart Failure (hospitalised)	1.0 (TnT)	3%	
Myocarditis	3.1 (TnI)	34%	1 – 10 cases per 100,000 persons (acute MI = 600) http://emedicine.medscape.com
Sepsis / Shock	0.4 (TnI)	50%	
Renal failure	0.4 (TnI)	1%	

Source: Roongsritong et al. Chest 2004; 125; 1877-1884

Non-MI causes of Troponin elevation

- Many exhibit only low Troponin elevations
  - below ABI cut-off
- Many are rare vs MI
- Many overlap with other CI conditions or death
- Some, such as myocarditis & pericarditis, produce similar symptoms to MI
  - So ABI+ does not introduce additional risk

Is Troponin level predictive of outcome?



Source: Jolly et al, Quantitative troponin and death, cardiogenic shock, cardiac arrest and new heart failure in pateints with non-ST-segment elevation acute coronary syndromes (NTSE ACS): insights from the Global Registry of Acute Coronary Events; Heart 2011 97: 197-202 (2010)

Typical ECG changes

- Myocardial ischaemia that may progress to MI
  - ST segment elevation
  - ST segment depression
  - T wave abnormalities
- Established MI
  - Q waves

ECG representation of a normal heartbeat (Wikimedia Commons)

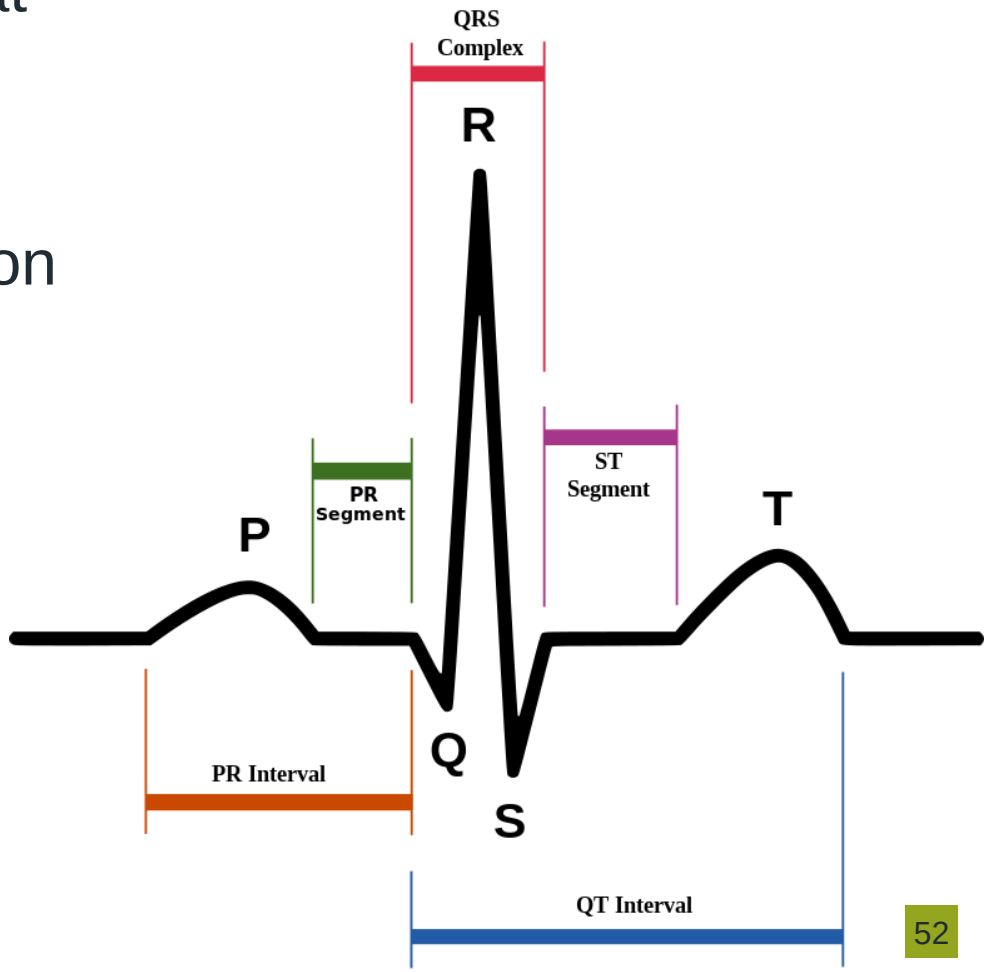


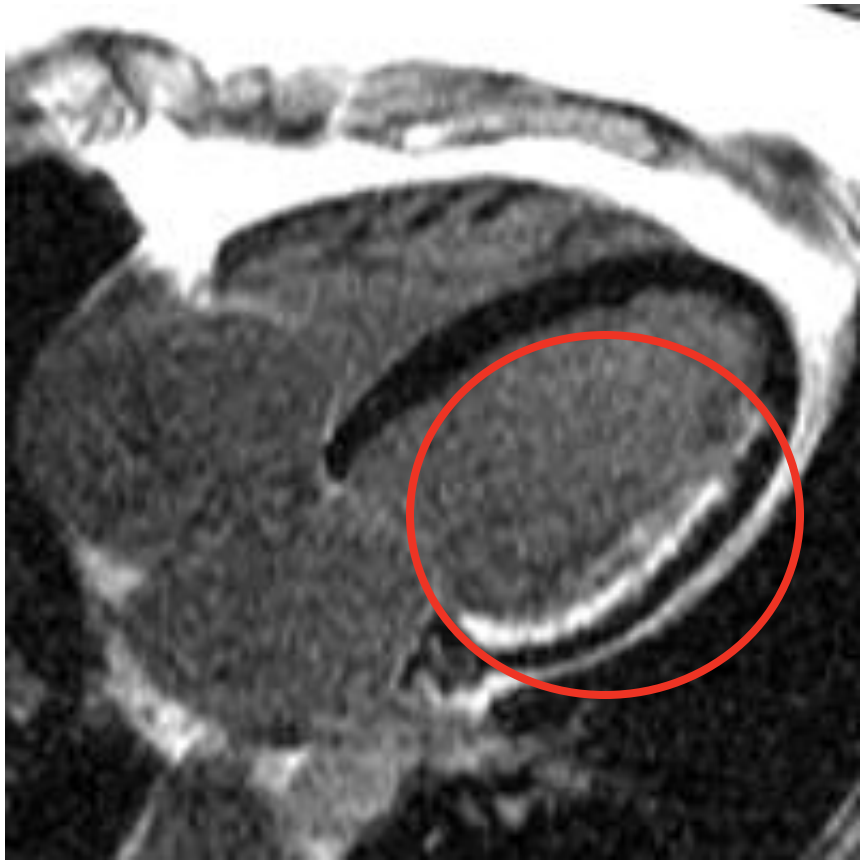
Table 5. Common ECG Pitfalls in Diagnosing Myocardial Infarction

False positives
Benign early repolarization
LBBB
Pre-excitation
Brugada syndrome
Peri-/myocarditis
Pulmonary embolism
Subarachnoid haemorrhage
Metabolic disturbances such as hyperkalaemia
Failure to recognize normal limits for J-point displacement
Lead transposition or use of modified Mason–Likar configuration (24)
Cholecystitis
False negatives
Prior myocardial infarction with Q-waves and/or persistent ST elevation
Paced rhythm
LBBB

Source: Thygesen et al. Circulation. 2007; 166: 2634-2653

Cardiac imaging

- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Increasing ability to see and date myocardial necrosis
- Confirmed myocardial necrosis but no Troponin measurement
  - *how to determine whether the severity hurdle has been met?*



Source: http://en.wikipedia.org/wiki/File:CMR_infarct.gif

Conclusion

EXISTING DEFINITION ISSUES

- Objective evidence (Troponin, ECG) carries more weight than subjective evidence (symptoms)

BUT sometimes ....

- Troponin values are unavailable (e.g. bedside testing)
- Troponin measurement is not taken at peak
- There are non-specific ECG changes / complicating conditions

*SO symptoms are often used to **justify** payment of claim when Troponin or ECG evidence is unclear*

Conclusion

ABI+ introduces a small risk of paying non-MI cases

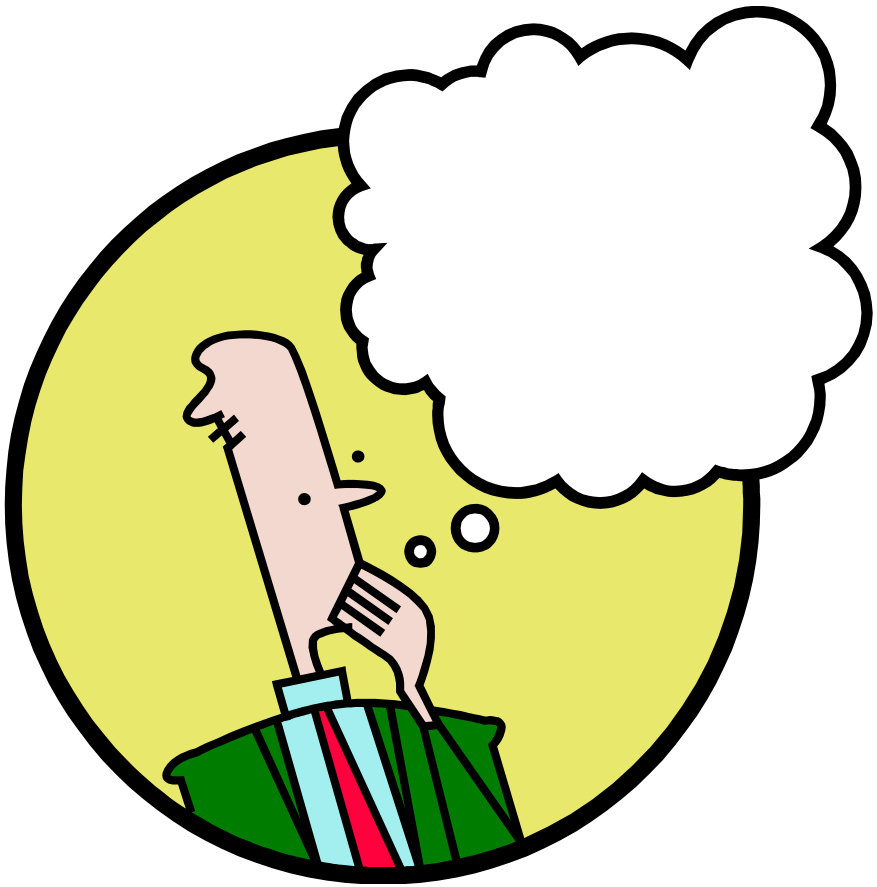
- Many non-MI causes of Troponin elevation exhibit lower elevations than ABI cut-off
  - BUT optimum measurements vs cut-off are sometimes unavailable
  - Comparable cut-offs may not be available in future
- Troponin AND new ECG changes are required
  - BUT in some cases one or more is missing
- *"The evidence must show a definite acute myocardial infarction"*
  - unlikely to meet definition if the diagnosis is a non-MI cause

Conclusion

EMERGING DEFINITION ISSUES

- Difficulty mapping to definition severity criteria
  - Unavailability of suitable Troponin measurement
    - *bedside testing / non-optimal timing*
  - New Troponin assays
  - Use of imaging
- Insurance definition increasingly out of sync with medical practice
  - client understanding & insurer reputation

Your thoughts



- What do you think of the proposed **methodology**?
- Can you think of any other **data sources or resources** that will aid this investigation?
- Would you like to **volunteer** for the CI Defintions Working Party?

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Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenters.