James McCormack
BSc (Pharm), PharmD
Professor
Faculty of Pharmaceutical Sciences
University of British Columbia
Vancouver, BC, Canada

Objectives

1) outline the problem of lab test measurement and reporting and some of the ways it contributes to the overdiagnosis problem

2) demonstrate with some examples (BP, LDL, glucose)

3) hopefully offer some useful tips, and suggestions and simple charts for how to deal with this extremely important and relevant healthcare conundrum

4) INTERACTIVE
   Poll questions - internet access
   Play with virtual dice - work through a few scenarios

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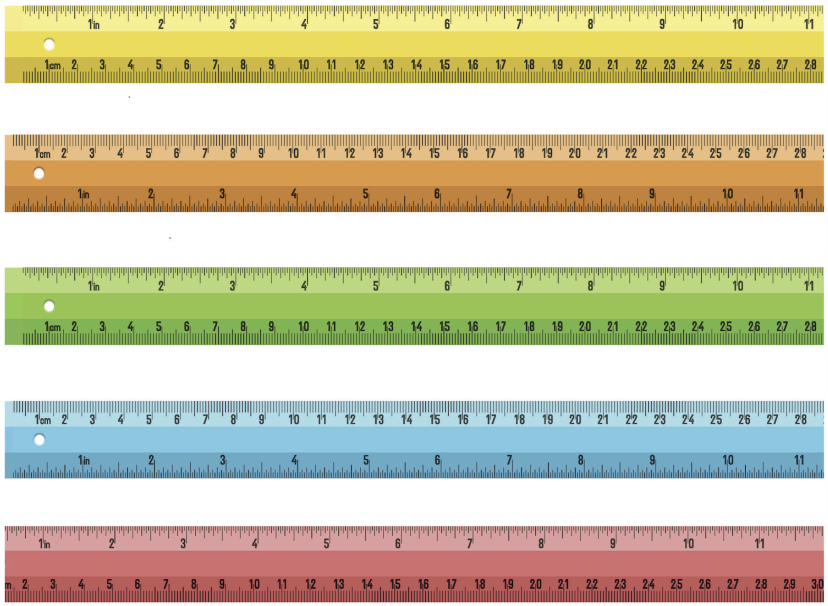
thebmj



YOUR RESULTS MAY VARY
The imprecision of medical measurements
James P. McCormack and Daniel T. Holmes
February 22, 2020

thebmj

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PRACTICE

Check for updates

PRACTICE POINTER

Your results may vary: the imprecision of medical measurements

James P McCormack *professor*[1], Daniel T Holmes *clinical professor*[2 3]

[1]Faculty of Pharmaceutical Sciences, University of British Columbia, Vancouver, BC, Canada; [2]St Paul's Hospital, Department of Pathology and Laboratory Medicine, Vancouver, BC, Canada; [3]Department of Pathology and Laboratory Medicine, University of British Columbia, Vancouver, BC, Canada.

Your results may vary

thebmj Interactive

A tool for visualising the variability of lab test results

Version 1.0
19 Feb 2020

Interpreting results can be challenging for patients and clinicians alike. Results can be affected by measurement uncertainty, and by variation caused by biological processes. This tool (based on data in the article below) is designed to help you decide if two consecutive results can be considered truly different after these kinds of variation have been taken into account.

1 Choose a test

HbA1c Healthy NGSP (%)

2 Adjust variables

These boxes are automatically populated with reasonable estimates of the analytic variation (authors' lab) and biologic variation (published research). These can be adjusted as needed.

HbA1c Healthy NGSP (%)

Analytic variation	Biologic variation	Normal range (reference interval)	
		Low	High
2.5%	1.6%	4.0	5.6

3 Enter lab results

Enter one or, if available, two serial lab results

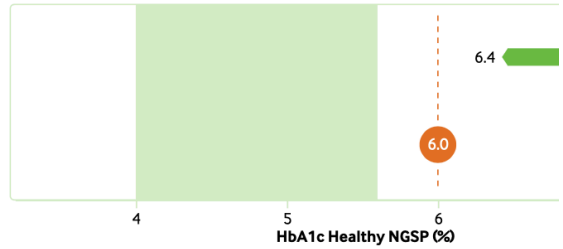
Result 1: 7.0

Result 2: 6.0

Show

4 View estimates

The minimum change required to conclude that two serial measurements are likel
"reference change value" (RCV). Arrows to the left and right of your first result show
For serial results, measurements can be considered different if the second is outsi

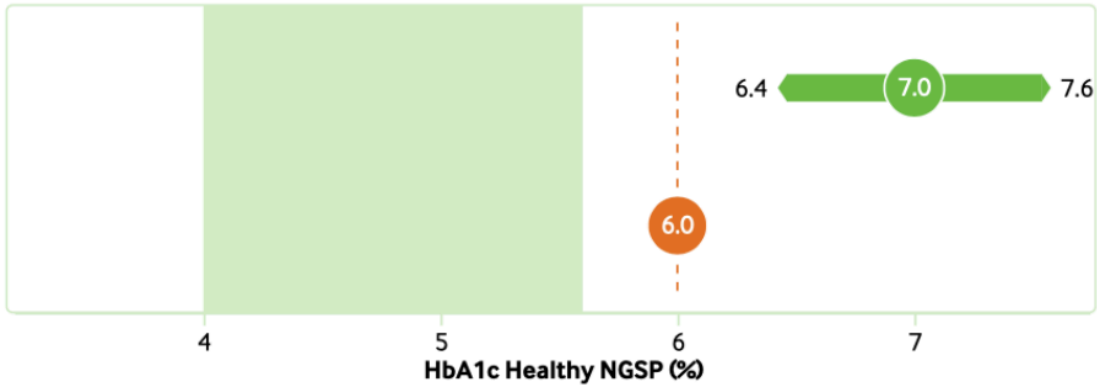


Normal range

Outside normal range

Result 2 is outside the RCV, so the difference is unlikely to be due to the combined effects of analytic and biological variation

The minimum change required to conclude that two serial measurements are likely different is called the "reference change value" (RCV). Arrows to the left and right of your first result show the RCV for this test. For serial results, measurements can be considered different if the second is outside the RCV of the first.



Normal range

Outside normal range

Result 2 is outside the RCV, so the difference is unlikely to be due to the combined effects of analytic and biological variation

Just a few of the diagnoses that are solely or partially lab-based dependent

Acid-Base Disorders
Acidosis and Alkalosis
Acidosis/Alkalosis
aCL Syndrome
ACS
Acute DIC
Acute Idiopathic Polyneuritis
Acute Inflammatory Demyelinating Polyneuropathy
Acute Kidney Injury
Acute Myocardial Infarct
Acute Renal Failure
AD
Addison Disease
Adrenal Insufficiency
Adrenal Insufficiency and Addison Disease
AKI
Albuminuria
Alcohol dependence
Alcoholism
Allergies
Alzheimer Dementia
Alzheimer Disease
AMI
Anemia
Anencephaly
Angiitis
Angina
Angina pectoris
Ankylosing Spondylitis
Anthrax
Anticardiolipin Antibody Syndrome
Antiphospholipid Antibody Syndrome
Antiphospholipid Syndrome
aPL Syndrome
APLS
APS
ARF
Arteritis
Arthritis
AS
Asthma
Atypical Mycobacteria
Atypical Pneumonia
Autoimmune Diseases
Autoimmune Thyroiditis
Avian Flu
Bacillus anthracis infection
Bacterial Arthritis
Bacterial Vaginosis
Benign Prostatic Hyperplasia
Benign Prostatic Hypertrophy
Biological Warfare
Bioterrorism Agents
Bleeding Disorders
Blood in the urine
Bone Marrow Disorders
Borrelia burgdorferi Infection
Borrelia mayonii Infection
BPH
Breast Cancer
CAH
Cancer
Candidiasis
Carbohydrate Intolerance
Cardiovascular Disease
Celiac Disease
Celiac Sprue
Cervical Cancer
CF
CFIDS
CFS
CHF
Chlamydia
Chronic Fatigue and
Immune Dysfunction Syndrome
Chronic Fatigue Syndrome
Chronic Kidney Disease
Chronic Thyroiditis
Circumscribed Scleroderma
Cirrhosis
CKD
Coagulopathy
Cobalamin Deficiency
Colon Cancer
Colorectal Cancer
Community-Acquired Pneumonia
Congenital Adrenal Hyperplasia
Congenital Alactasia
Congestive Heart Failure
Conn Syndrome
Consumption Coagulopathy
Copper Storage Disease
CREST
Crohn Disease
Cushing Syndrome
Cutaneous anthrax
CVD
Cystic Fibrosis
Degenerative Joint Disease
Dehydration
Dermatosclerosis
Diabetes
Diabetes mellitus
Diarrhea
DIC
Diffuse Cutaneous Scleroderma
Diffuse Thyrotoxic Goiter
Disaccharidase Deficiency
Discoid Lupus
Disseminated Intravascular Coagulation
Disseminated Intravascular Coagulopathy
Disseminated Lupus Erythematosus
DJD
Double Pneumonia
Down Syndrome
Drug-induced Lupus
DS
Dysmetabolic Syndrome
Ebola Hemorrhagic Fever
Ebola Virus Disease
Ebola Virus Infection
Encephalitis
End Stage Renal Disease
Endocrine Syndromes
Endocrine System and Syndromes
Epilepsy
ESRD
EVD
Excessive Clotting Disorders
Extraosseous Plasmacytoma
Fibromyalgia
Flu
Folate Deficiency
Folic Acid or B9 Deficiency
Food and Waterborne Illness
Food Poisoning
Fungal Infections
Gastroenteritis
Gluten-Sensitive Enteropathy
Gonorrhea
Gout
Gouty Arthritis
Graves Disease
GSE
Guillain-Barré Syndrome
H1N1
H3N2
H5N1
H7N9
Hashimoto Thyroiditis
HBP
HD
Healthcare-Associated Pneumonia
Heart Attack
Heart Attack and Acute Coronary Syndrome
Heart Disease
Heart Failure
Hematuria
Hemochromatosis
Hemoglobin Abnormalities
Hemoglobin Barts
Hemoglobin C Disease
Hemoglobin E Disease
Hemoglobin S
Hemoglobin Variants
Hemoglobinopathy
Hepatic Disease
Hepatitis
Hepatolenticular Degeneration
Hereditary Persistence of Fetal Hemoglobin
Herpes
Herpes Zoster
High Blood Pressure
HIV
HIV Infection and AIDS
HL
Hodgkin Disease
Hodgkin Lymphoma
Hospital-Acquired Pneumonia
HPFH
HPV
Hughes Syndrome
Huntington Disease
Huntington's Chorea Disease
Hypercoagulable Disorders or States
Hyperparathyroidism
Hypersensitivity
Hypertension
Hyperthyroidism
Hypoparathyroidism
Hypothyroidism
IBD
Icterus
Infectious Arthritis
Infectious Polyneuritis
Infertility
Inflammatory Bowel Disease
Influenza
Influenza A
Influenza B
Inhalation anthrax
Inherited Copper Toxicity
Insulin Resistance
Insulin Resistance Syndrome
Iron Overload Disease
Iron Storage Disease
Jaundice
JIA
JRA
Juvenile Idiopathic Arthritis
Juvenile Rheumatoid Arthritis
Keratoconjuntivitis Sicca
Kidney Disease
Lactase Deficiency
Lactose Intolerance
Landry's Ascending Paralysis
LE
Lead Poisoning
Leukemia
Limited Cutaneous Scleroderma
Linear Scleroderma
Liver Disease
Lobar Pneumonia
Localized Scleroderma
Lower Respiratory Tract Infection
Lung Cancer
Lung Diseases
Lupus
Lupus Anticoagulant Syndrome
Lupus Erythematosus
Lyme Disease
Lymphocytic Thyroiditis
Lymphoma
Malabsorption
Malaria
Malignancy
Malignant tumor
Malnutrition
MDS
ME
Melanoma
Meningitis and Encephalitis
Meningococcal Meningitis
Menopause
Metabolic Syndrome
MG
MI
Morphea
MOTT
MPDs
MPNs
MRSA
MS
Multiple Myeloma
Multiple Sclerosis
Myalgic Encephalomyelitis
Myasthenia Gravis
Mycobacteria other than tuberculosis
Mycoses
Myelocele
Myelodysplasia
Myelodysplastic Syndrome
Myelomeningocele
Myeloproliferative Disorders
Myeloproliferative Neoplasms
Myocardial Infarct
Neonatal Lupus
Nephrotic Syndrome
Neural Tube Defects
Neuropathy
NHL
Non-Hodgkin lymphoma
Non-Small Cell Lung Cancer
Nontuberculous Mycobacteria
Nontuberculous Mycobacteria Infections
NTD
NTM
OA
Obesity Syndrome
Osteoarthritis
Osteoarthrosis
Osteoporosis
Ovarian Cancer
PA
Pancreatic Cancer
Pancreatic Diseases
Pancreatic Insufficiency
Pancreatitis
Parathyroid Cancer
Parathyroid Diseases
PCOS
Pelvic Inflammatory Disease
Peptic Ulcer
PID
Pituitary Disorders
Plasma Cell Dyscrasia
Plasma Cell Myeloma
Plasma Cell Neoplasm
Plasmacytoma
Plasmacytoma of Bone
Pneumonia
Polycystic Ovary Syndrome
Porphyria
Post-infectious Arthritis
Pre-eclampsia
Pregnancy
Pregnancy-induced Hypertension
Presenile Dementia
Primary Aldosteronism
Primary Hyperaldosteronism
Prinzmetal's angina
Prostate Cancer
Protein in urine
Proteinuria
RA
Reactive Arthritis
Reaven Syndrome
Renal Disease, Kidney Failure
Rheumatoid Arthritis
Rheumatoid Spondylitis
Sarcoidosis
SCD
Scleroderma
SEID
Seizure Disorder
Sepsis
Septic Arthritis
Sexually Transmitted Diseases
Sexually Transmitted Infections
Shingles
Sicca Syndrome
Sickle Cell Anemia
Sickle Cell Disease
Sjögren Syndrome
SLE
Small Cell Lung Cancer
Spina bifida
Spinal dysraphism
Spinal Meningitis
SSc
Stable angina
Staph
Staph aureus
Staph Infections
Staph Infections and Methicillin-Resistant
Staphylococcus aureus
Staphylococcus aureus
STDs
Stein-Leventhal Syndrome
Sticky Blood Syndrome
STIs
Stomach Flu
Stroke
Subacute Cutaneous Lupus
Swine Flu
Syndrome X
Syphilis
Systemic Exertion Intolerance Disease
Systemic Lupus Erythematosus
Systemic Scleroderma
Systemic Sclerosis
TB
Testicular Cancer
Thalassemia
Thrombophilia
Thyroid Cancer
Thyroid Diseases
Toxemia
Toxic Diffuse Goiter
Travelers' Diseases
Trich
Trichomonas
Trichomoniasis
Trisomy 21
Tuberculosis
Types of Liver Disease
Ulcerative Colitis
Unstable angina
Urinary Tract Infection
UTI
Vaginal Infection
Vaginitis and Vaginosis
Vaginitis/Vaginosis
Variant angina
Vasculitis
VD
Venereal Diseases
Vitamin B12 and Folate Deficiencies
Vitamin B12 Deficiency
Vitamin K Deficiency
Vulvovaginitis
Walking Pneumonia
West Nile Virus
Wilson Disease
WNV
Wound and Skin Infections

“It is commonly thought that laboratory tests provide two-thirds to three-fourths of the information used for making medical decisions. If so, test results had better tell the truth about what is happening with our patients.”

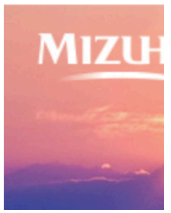
Clinica Chimica Acta 2004;346:3-11

New Rule Grants Patients Direct Access to Lab Results

By Melinda Beck

Feb. 3, 2014 1:05 p.m. ET

Clinical laboratories must give patients access to their own lab-test results upon request, without going through the physician who ordered them, according to a new federal rule announced Monday by the Department of Health and Human Services.



PROBLEM #1

It's typically the same report that goes to health care providers

PROBLEM #2

Many health care providers don't appreciate the key nuances of "lab" tests

MY THESIS

"For much in medicine, we knowingly sell preeminent precision even though we all know in our heart of hearts we can only deliver educated estimates. I believe most patients would be very understanding about this imprecision if we were just more open about it."

-James McCormack, Pharm D (1959 - hopefully not soon)

"We also CAN'T be precise about the imprecision"

I am speaking in general, and do realise there are always some exceptions

I am presenting concepts

I will be providing ball-park estimates

Two Problems with Faking Precision

FALSE BELIEFS

BELIEF #1 - the good/bad thresholds are relatively black and white

BELIEF #2 -when the numbers change these changes are real

These beliefs can potentially lead to inappropriate feelings of fear, happiness, frustration, confusion…

Both in patients AND clinicians

Sources of Imprecision

Lab Error

Analytic variation

Biologic variation

Actual LAB errors

Lab Error

0.3%

~60% pre-analytical
~15% analytical
~ 25% post analytical

Table 1. Laboratory errors in stat testing.

Defects: detection steps	Defects found No.	Frequency, %
Preanalytical		
Specimen collected from infusion route	3	1.9
Sample contaminated	1	0.6
Tube filling error	21	13.1
Empty tube	11	6.9
Inappropriate container	13	8.1
Nonrefrigerated sample	3	1.9
Missing tube	5	3.1
Digoxin test timing error	1	0.6
Patient identification error	14	8.8
Request procedure error	12	7.5
Data communication conflict	6	3.8
Physician's request order missed	3	1.9
Order misinterpreted	2	1.3
Check-in not performed (in the Laboratory Information Systems)	4	2.5
Subtotal	99	61.9
Analytical		
Instrument-caused random error	3	1.9
Analytical inaccuracy not recognized	21	13.1
Subtotal	24	15
Postanalytical		
Results communication breakdown	32	20
Lack of communication within laboratory	3	1.9
TAT excessive	2	1.3
Subtotal	37	23.1

Clinical Chemistry 2007;53:1338-42

Dispensing errors ~1-2%

Measurement Landscape

Assuming no pre-analytic issues - timing/labelling etc

Population-based reference intervals

Analytical Variation

Analytic variation

CVA - analytical variation

Biological Variation

Biologic variation

CVI - within subject

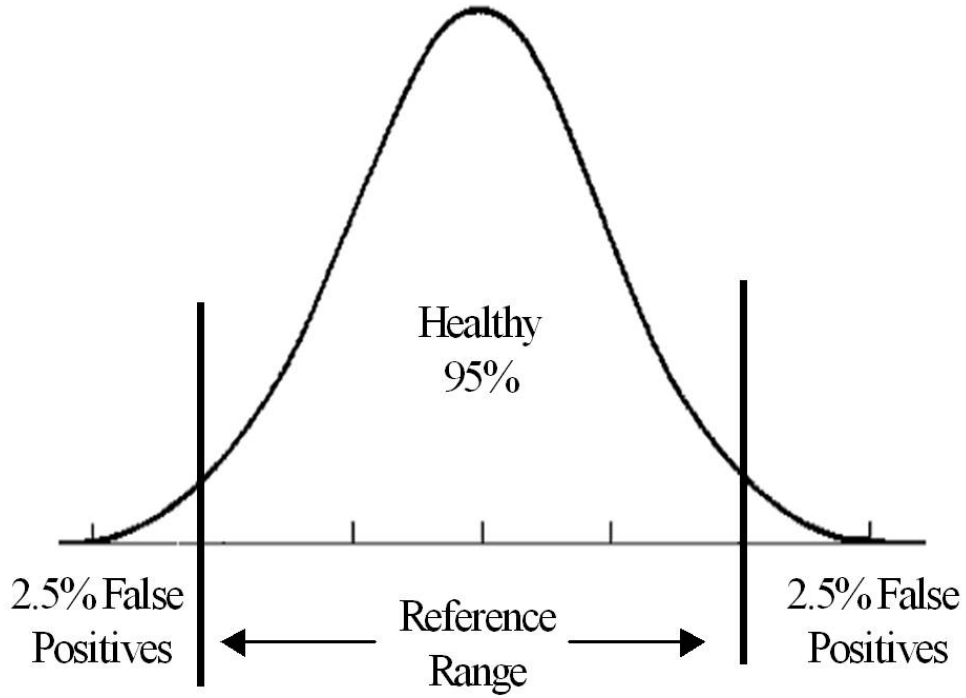
CVG - between subject

Reference change values (RCV)

Population-based reference intervals

Population-based reference intervals

The interval/range where 95% of healthy people fall



Lab results report
exact numbers
BUT
Every test result is
really only a range
that hopefully includes
the true result
+/- 1-2% up to
+/-20-30% or more

Number of Tests Ordered	Probability of at Least One Abnormal Test
1	5%
2	10%
5	23%
10	40%
15	54%
20	64%

When we do tests, typically we are wondering

what are the results NOW, and/or

have they changed from PREVIOUS measurements

Analytic variation

Biologic variation

Every “measurement” will be “different”

Analytic variability
Biologic variability

Nerd Alert

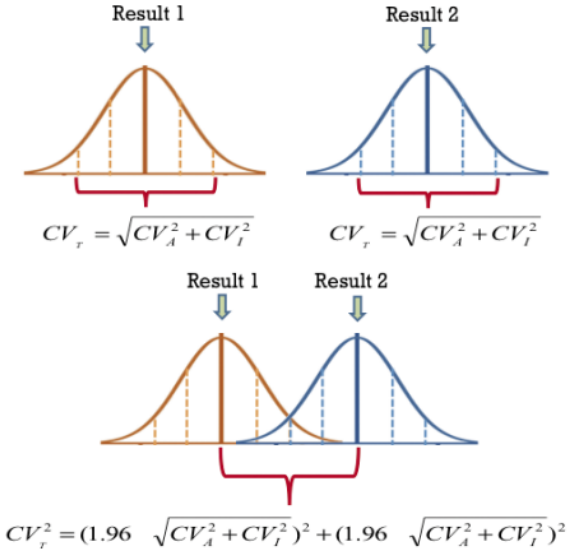
Reference Change Values (RCV)

a tool for assessment of the significance of differences
in serial results from an individual

Reference Change Values

Used with SERIAL results to help deal with the analytic imprecision and biologic variation

Coefficients of Variation (total) = analytic PLUS biologic variation



MINIMUM DIFFERENCE between two consecutive results which needs to be EXCEEDED in order for one to state a STATISTICALLY SIGNIFICANT change has taken place

$$RCV = \sqrt{2} * 1.96 * \sqrt{(CV^2_{Analytical} + CV^2_{Intraindividual})}$$

How good, analytically speaking, does a “test” need to be

“The analytical CV (CVA) should be less than one-half the average within-subject biological variation (CVI)”

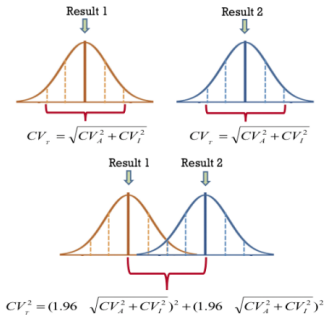
When it is, the CVA has almost no impact on the RCV - the RCV is pretty much determined by the CVI

Reference Change Values

findings of a “significant difference" JUST means we are ruling out that the difference seen is due to chance

NOT

THAT THE MAGNITUDE OF THE DIFFERENCE SEEN IS THE ACTUAL MAGNITUDE OF THE DIFFERENCE



We believe these two results are different

can’t necessarily quantify this difference with any precision

What about multiple measurements?

Table 1. RCV using multiple estimates of the initial and new set points, expressed as a fraction of traditional RCV from two singleton measurements.

		Number of results estimating initial set point				
		1	2	3	4	5
Number of results estimating new set point	1	1.00	0.87	0.82	0.79	0.77
	2	0.87	0.71	0.65	0.61	0.59
	3	0.82	0.65	0.58	0.54	0.52
	4	0.79	0.61	0.54	**0.50**	0.47
	5	0.77	0.59	0.52	0.47	0.45

with 4 measurements before and 4 afterwards
(vs 1 before and 1 after)
you can lower the RCV by 50%

Annals of Clinical Biochemistry 2016;53:413-4

Lab
Error

Analytic
variation

Biologic variation

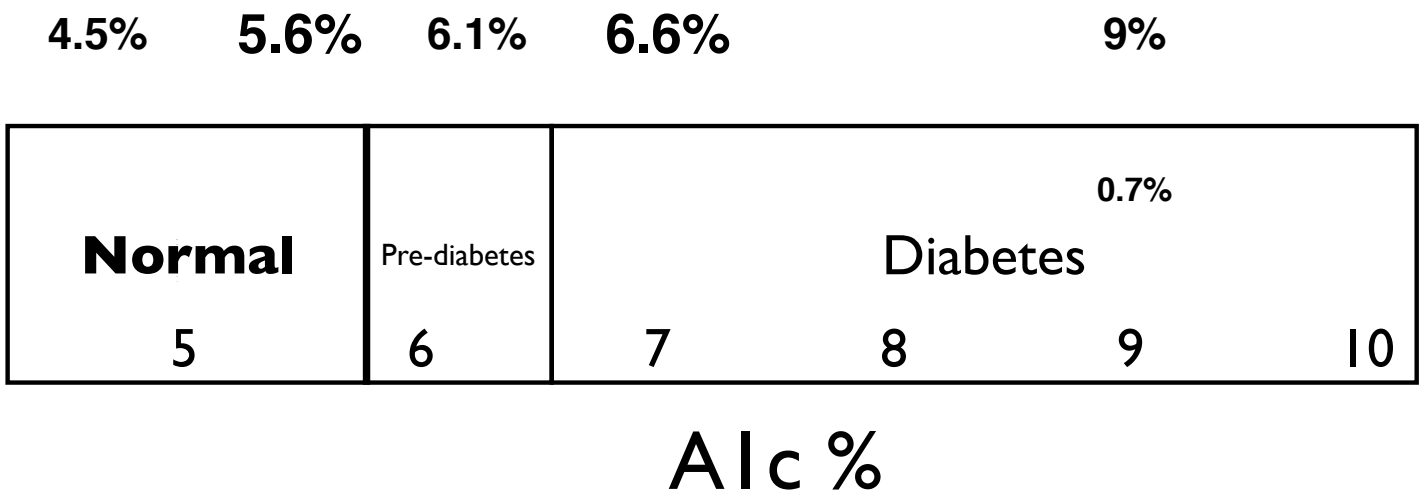
This is the problem
and it is
NOT fixable,
it is only
KNOWABLE

Glucose
Blood pressure
Cholesterol

Glucose

Precisely Imprecise

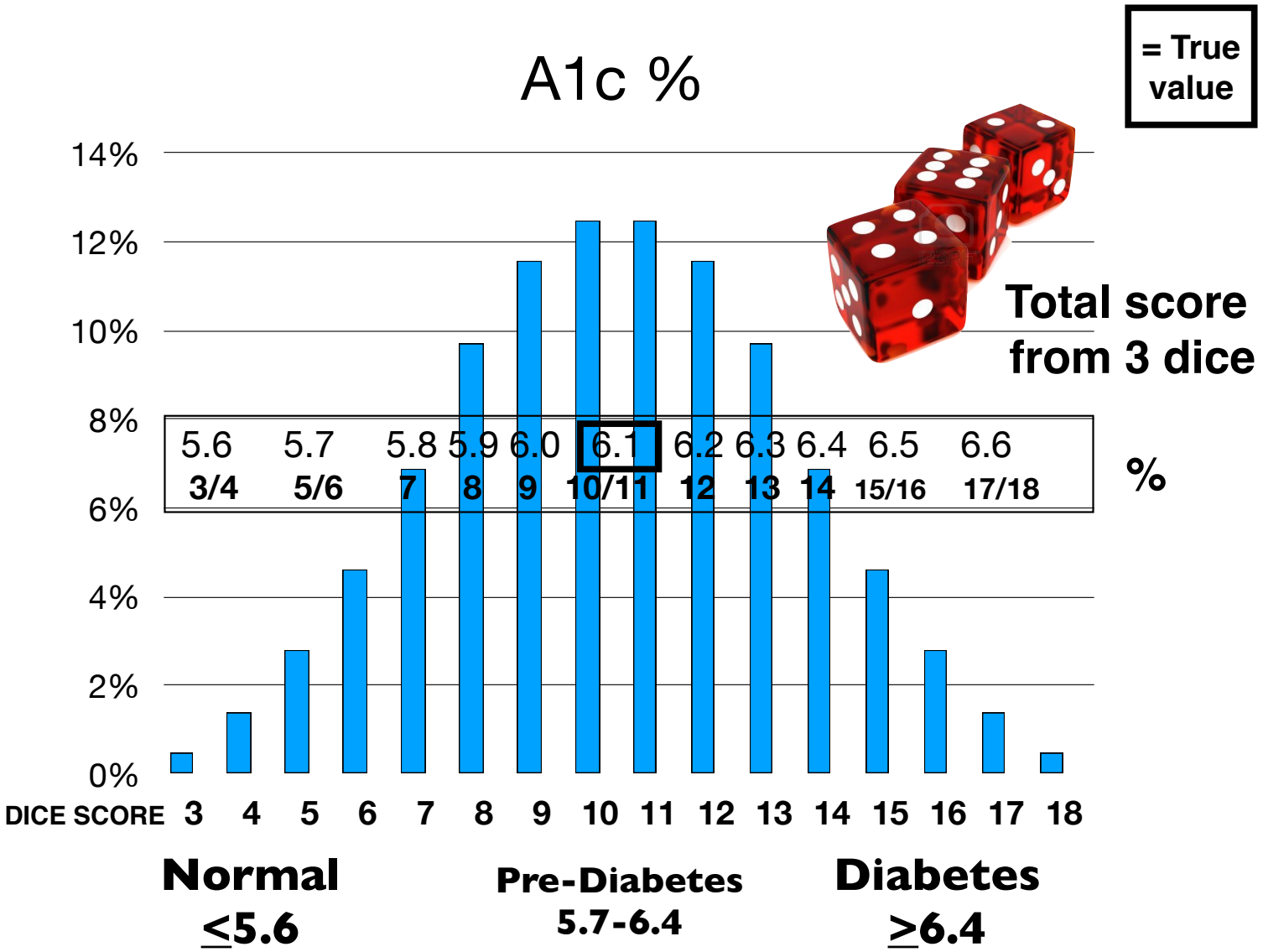
What an A1c result really means

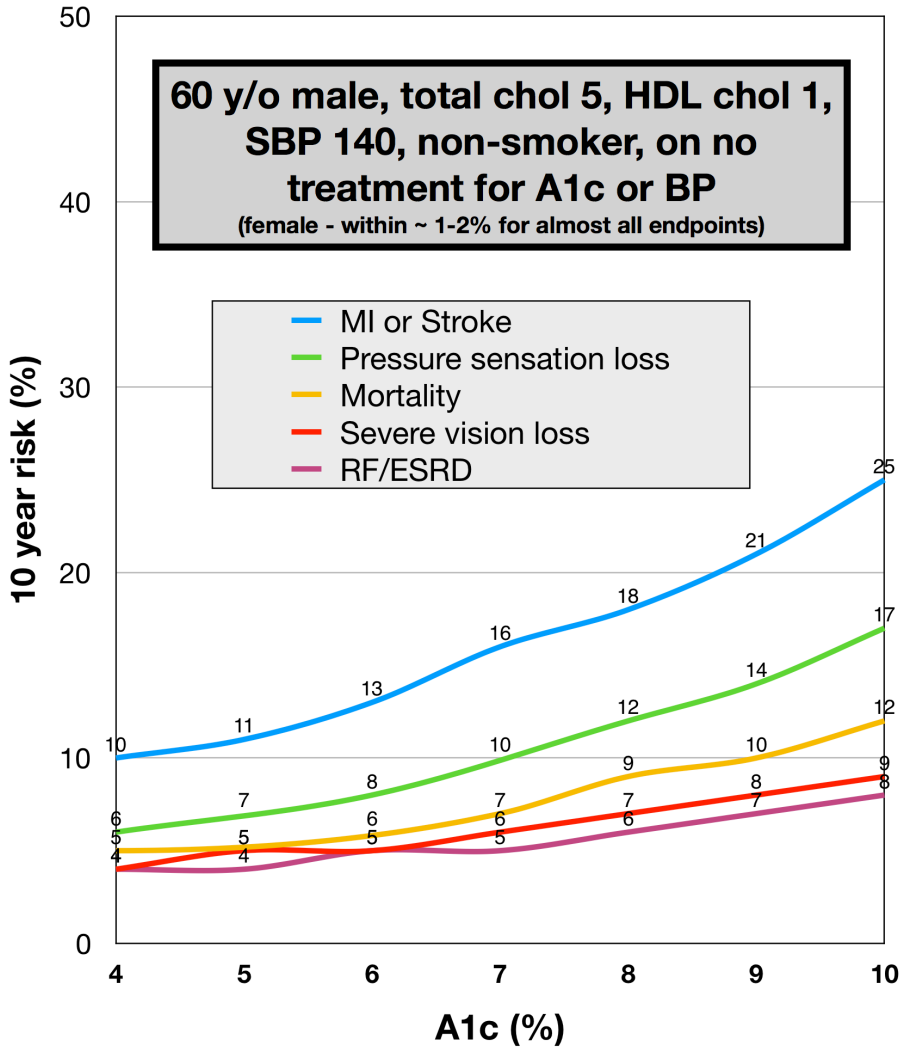


Typical A1c change seen with a medication = 0.7% ⬇

Seasonal variation 0.2-0.5%
Higher in the winter

Am J Epi 2004;161:565-74


A1c %
= True value
14%
12%
10%
8%
6%
4%
2%
0%
5.6 5.7 5.8 5.9 6.0 6.1 6.2 6.3 6.4 6.5 6.6
%
DICE SCORE 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
3/4 5/6 7 8 9 10/11 12 13 14 15/16 17/18
Total score from 3 dice
Normal ≤5.6
Pre-Diabetes 5.7-6.4
Diabetes ≥6.4



T2DM risk should not be categorized as YES or NO

https://sanjaybasu.shinyapps.io/recodesi/ - from the ACCORD study

Blood pressure

Systolic blood pressure

TYPICAL CHANGES SEEN

Start medication - avg 9 mmHg ⬇

Increase dose - avg 2-5 mmHg ⬇

Seasonal differences - avg 8 mmHg ⬇ when warm

Age related (per year) - avg 0.5-0.8 mmHg ⬆

Sample size calculation - 40 office measurements before and after treatment to be REASONABLY confident that a 5 mmHg change has occurred

BLOOD PRESSURE

Less than 135/85 “Despite a -4/-3 mmHg greater achieved reduction in systolic/diastolic BP, attempting to achieve “lower targets” instead of “standard targets” did not change total mortality, MI, stroke, CHF, major CV events or ESRD”

Cochrane Review 2009;Issue 3:CD004349

“the oft-cited <140 mm Hg systolic threshold used to define hypertension has admittedly been arbitrarily chosen as a 'compromise' and one could make a strong case for a lower threshold in high-risk patients and a higher threshold in those at lower risk”

“'treatment' refers to both lifestyle modifications and pharmacologic therapy”

Canadian Hypertension Education Program and Recommendations Task Force - Can Fam Physician January 2013 59: 19-21

AJH American Journal of Hypertension

Search This journal go Advanced search

Editorial

American Journal of Hypertension (2008) **21** 3–4; doi:10.1038/ajh.2007.20

Blood Pressure Variability: The Challenge of Variation

Tom P Marshall[1] (#aff1)

[1]Department of Public Health and Epidemiology, University of Birmingham, Edgbaston, Birmingham, UK

Correspondence: Tom P. Marshall, (T.P.Marshall@bham.ac.uk (mailto:T.P.Marshall@bham.ac.uk))

Need changes of at least 10/5 mmHg before you can say there has been a change

Am J Hyper 2008;21:3–4

"clinicians cannot identify individuals who have good or poor responses to drugs"

"coefficients of variation for systolic office, ambulatory, and self-monitored blood pressure, compared at baseline and 6 weeks, were 8.6%, 5.5%, and 4.2% respectively"

Br J Gen Pract 2010; 60: 675–80

"a single careful blood pressure measurement taken a few months after the start of treatment is not useful for monitoring"

BMJ 2009;338:b1492

Cholesterol

ARTICLE | Annals of Internal Medicine

Monitoring Cholesterol Levels: Measurement Error or True Change?

Paul P. Glasziou, MBBS, PhD; Les Irwig, MBBS, PhD; Stephane Heritier, PhD; R. John Simes, MBBS, MD; and Andrew Tonkin, MBBS, MD, for the LIPID Study Investigators

Background: Cholesterol level monitoring is a common clinical activity, but the optimal monitoring interval is unknown and practice varies.

Objective: To estimate, in patients receiving cholesterol-lowering medication, the variation in initial response to treatment, the long-term drift from initial response, and the detectability of long-term changes in on-treatment cholesterol level ("signal") given short-term, within-person variation ("noise").

Design: Analysis of cholesterol measurement data in the LIPID

of variation, 7%) to 0.60 mmol/L (23 mg/dL) (coefficient of variation, 11%), but it took almost 4 years for the long-term variation to exceed the short-term variation. This slow increase in variation and the modest increase in mean cholesterol level, about 2% per year, suggest that most of the variation in the study is due to short-term biological and analytic variability. Our calculations suggest that, for patients with levels that are 0.5 mmol/L or more (≥19 mg/dL) under target, monitoring is likely to detect many more false-positive results than true-positive results for at least the first 3 years after treatment has commenced.

Ann Intern Med 2008;148:656-61

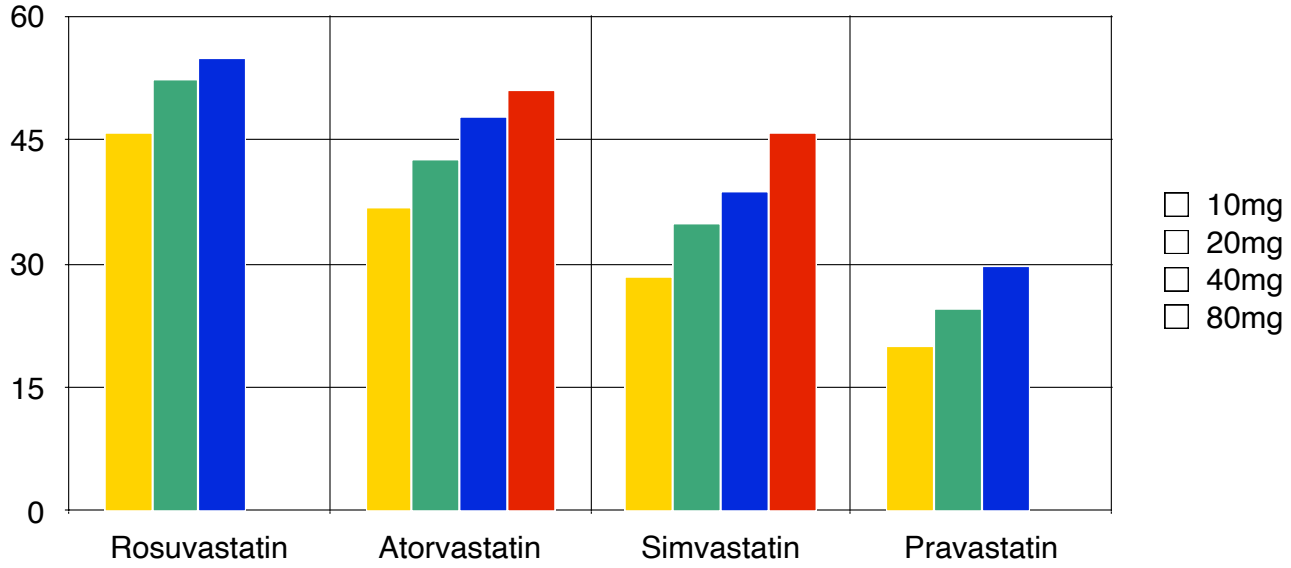
VARIATION
Total chol ~ - 0.80 to 0.80 mmol/L (~30 mg/dL) ~15%
LDL chol ~ - 0.5 to 0.5 mmol/L (~20 mg/dL)

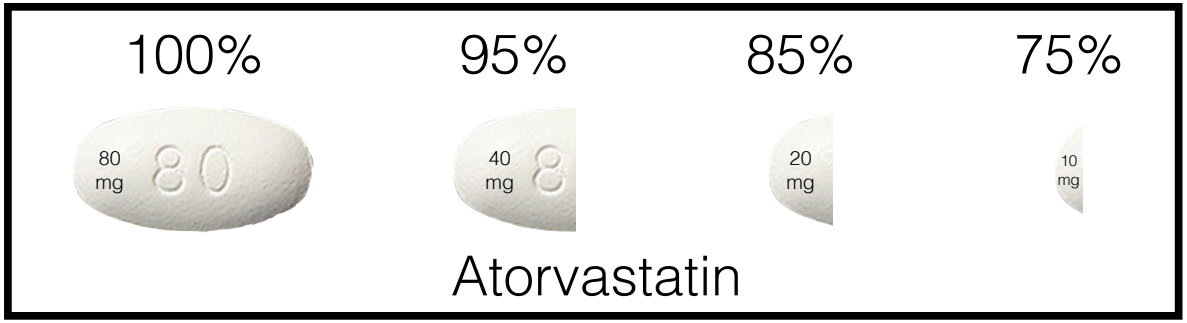
Average increase in cholesterol is 0.5-1%/year

"After initial change only measure every 3-5 years"

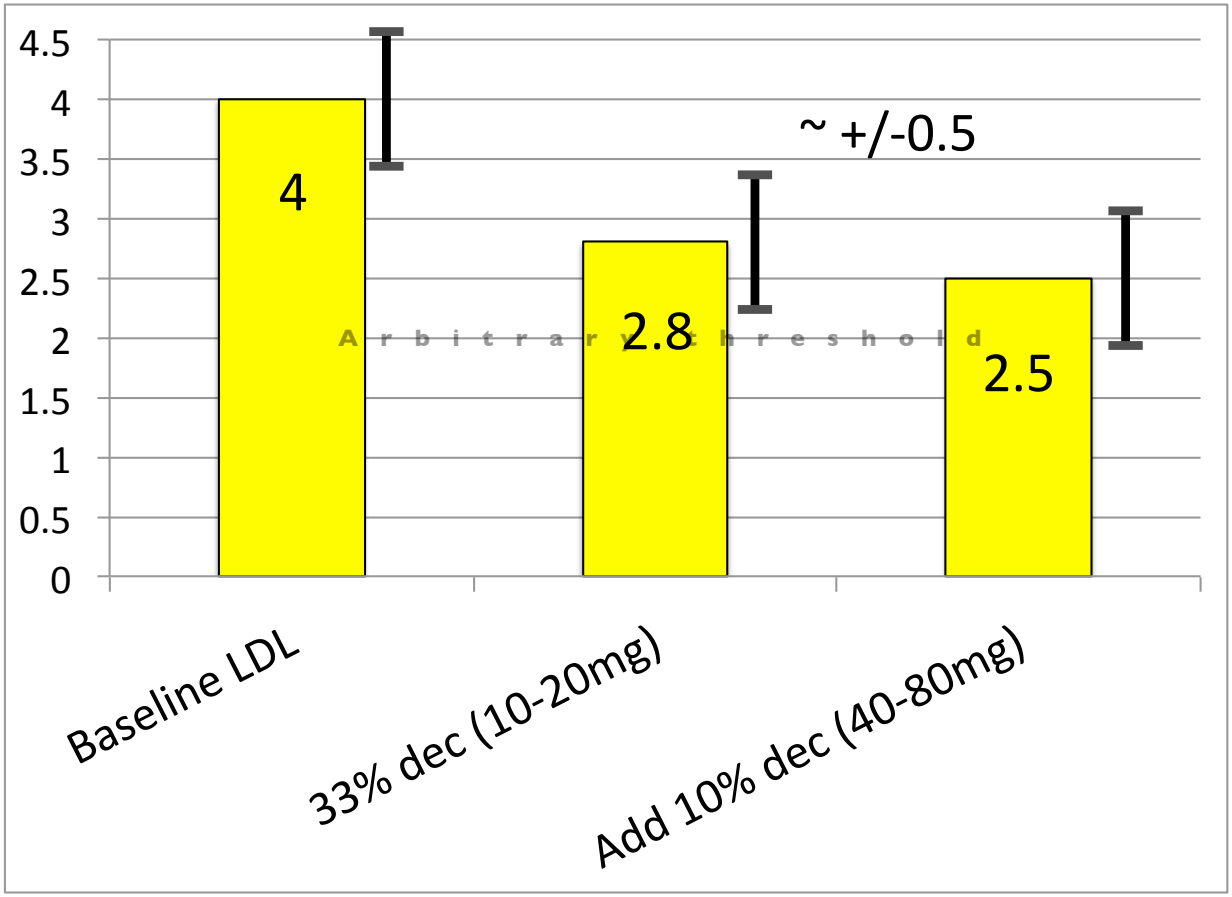
DOSE increases do not lead
to proportional EFFECT increases

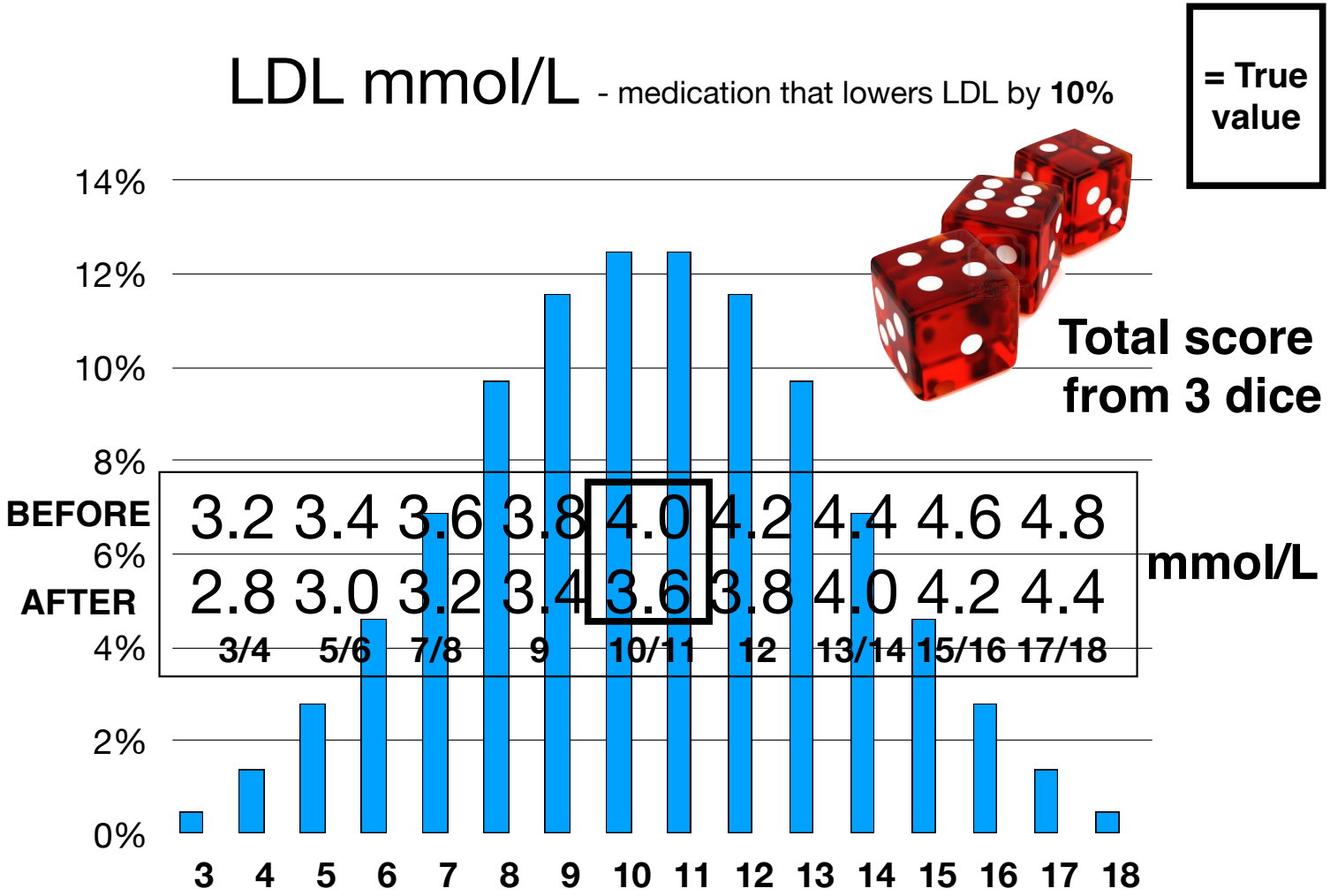
% reduction in LDL cholesterol





LDL cholesterol - 2 mmol/L ~80mg/dL





Trying to get to "target" by increasing the dose

LDL mmol/L - Average increase in cholesterol is 0.5-1%/year

= True value

Total score from 3 dice

When to remeasure

RESEARCH

When to remeasure cardiovascular risk in untreated people at low and intermediate risk: observational study

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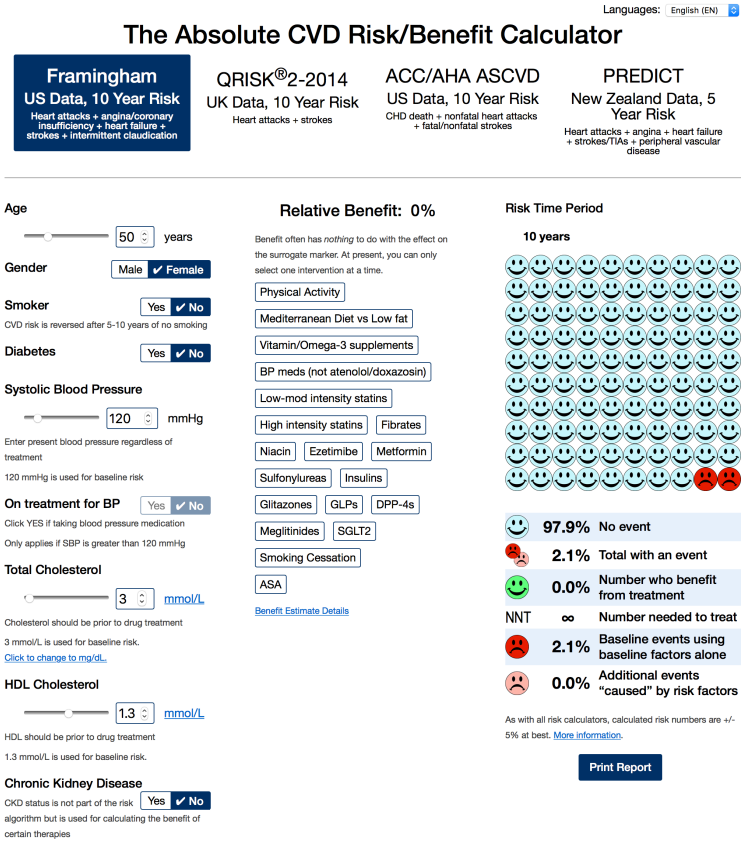
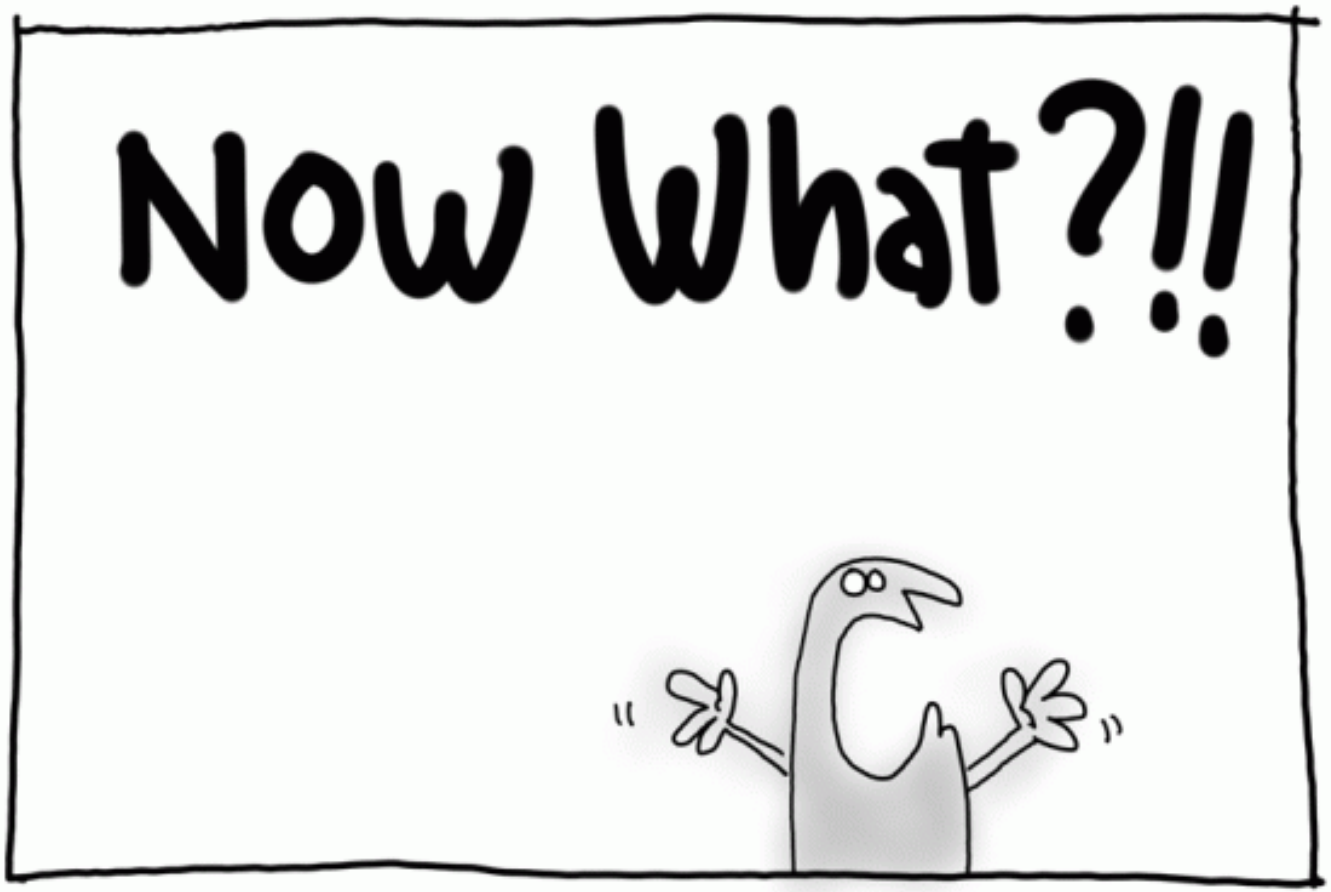
"Repeat risk estimation before 8-10 years is not warranted for most people initially not requiring treatment"



Calculate ballpark 5/10-yr risk of CVD - BP, chol, diabetes
Make estimate of benefit based on the best available evidence
Gives a list of adverse effects to discuss

cvdcalculator.com


Now What?!!

The Problem
is
NOT Fixable,
it is
Only
KNOWABLE

Approximate variability estimates for routine medical measurements

Test	Single measurement variability		Serial measurement variability
	Analytical variation†	Analytical and biological variation‡	Reference change value*
Bone density (spine, total hip)	<2%	2-5%	2-5%
Chloride	<2%	2-5%	2-5%
Osmolality	<2%	2-5%	2-5%
Sodium	<2%	<2%	2-5%
Bone density (femoral neck)	<2%	2-5%	6-10%
Albumin	2-5%	6-10%	6-10%
Calcium	2-5%	2-5%	6-10%
HbA_{1c} NGSP (%)	2-5%	6-10%	6-10%
Haemoglobin	2-5%	6-10%	6-10%
Total protein	2-5%	6-10%	6-10%
Transferrin	2-5%	6-10%	6-10%
Creatinine	2-5%	6-10%	11-20%
Glucose	2-5%	6-10%	11-20%
HbA_{1c} (diabetics) IFCC (mmol/mol)	2-5%	11-20%	11-20%
HbA_{1c} (diabetics) NGSP (%)	2-5%	6-10%	11-20%
HbA_{1c} IFCC (mmol/mol)	6-10%	6-10%	11-20%
Lactate dehydrogenase	2-5%	11-20%	11-20%
Magnesium	2-5%	6-10%	11-20%
PCO_2	2-5%	6-10%	11-20%
Potassium	2-5%	6-10%	11-20%
Total cholesterol	2-5%	11-20%	11-20%
Alanine aminotransferase	6-10%	11-20%	21-30%
Alkaline phosphatase	11-20%	11-20%	21-30%
Aspartate aminotransferase	6-10%	11-20%	21-30%
Gamma glutamyltransferase	6-10%	11-20%	21-30%
HDL cholesterol	2-5%	11-20%	21-30%
LDL cholesterol	2-5%	11-20%	21-30%
Phosphate	2-5%	11-20%	21-30%
Rheumatoid factor	11-20%	21-30%	21-30%
Uric acid	2-5%	11-20%	21-30%
Vitamin B_{12}	11-20%	11-20%	21-30%
25-hydroxy-vitamin D	6-10%	21-30%	31-40%
Holotranscobalamin	6-10%	21-30%	31-40%
Total testosterone (male)	6-10%	21-30%	31-40%
Urea	2-5%	21-30%	31-40%
Thyroid stimulating hormone	6-10%	31-40%	41-50%
Iron	2-5%	>50%	>50%
Lactate	2-5%	>50%	>50%
Total bilirubin	2-5%	41-50%	>50%
Triglycerides	2-5%	31-40%	>50%

*Change (%) required for two serial measurements to be considered different.
†Confidence interval (%) around a single measurement when only considering analytical variation.
‡Confidence interval (%) around a single measurement when considering both analytical and biological variation.
NGSP= National Glycated Haemoglobin Standardization. IFCC= International Federation of Clinical Chemistry.
HDL= high density lipoprotein. LDL= low density lipoprotein.

The calculations in the three columns help you interpret 3 different scenarios

Confidence interval (%) around a single measurement = analytic variation

Confidence interval (%) around a single measurement of something that might be on-going = analytic and biologic variation

Change (%) required for two serial measurements to be considered different

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Sodium	<2%	<2%	2-5%
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Start the presentation.

If I was the boss of “LAB” result reporting

All of this could be done today

Shift from a laboratory perspective to a patient-centered viewpoint

Using BALLPARK estimates

ALWAYS provide the imprecision

Provide MUCH more definitive guidance

Stop using terms like low, medium, high or significant

If they are “risk factor” measurements then they should only be provided with “risk” estimates

Do not do a test without discussion of a pre-test probability and then provide a post-test probability

Make many tests more “inconvenient”?

As much as possible

DO NOT use “flags”, adjectives, or mention SDs, Gaussian distributions, two-sided tests, Z-scores, T-scores, confidence intervals, or p-values.

Not sure if we even need point estimates

Lab Value thoughts

have you first looked at how the patient is clinically doing?

will the result of your test change what you would do?

does a “risk factor” test improve your assessment of risk?

how big a change do you expect from your treatment?

what is the sensitivity and specificity of the test? - pre-test and post-test probability

how long does that change take?

how big a change is needed to be confident a change has occurred?

When someone does something wrong, don’t forget all the things they did right.