Reducing overtreatment by optimizing sequence of diagnostic tests ordering: FFT approach to analysis of clinical management strategies

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Irreducible uncertainty, inevitable error, unavoidable injustice: the inverse relationship between underuse & overuse

FP and FN errors are inevitable and inextricably linked: as FP decreases, FN increases and vice versa; it is impossible to simultaneously decrease FP (regret of commission) and FN errors (regret of omission). The right threshold is a function of values (which belongs to a class of problems where no technical solution is possible).

Many factors affect the optimal choice of a cut-off between underuse & overuse

• Evidence (in support one view/decision over another)
• The way we make decisions/integrate evidence (decision theoretical framework)
  • Normative – Descriptive- Prescriptive
    • Real “large” world vs. idealized ‘small’ world decision theories
• The evaluation of prospective gains (benefits) vs. losses (harms)
  • analytically/deliberatively vs. intuitively/affect-based assessment
• The assessment of accuracy of our decisions
  • False positives vs. false negatives
  • Population vs. individuals
Disentangling the Problems of Too Much and Too Little Medicine: Signal Detection Problem

• “too much medicine” (overuse)
  • ordering tests/administering Rx when we shouldn’t → over-diagnosis/overRX
    • false positives errors

• “too little medicine” (underuse)
  • Failing to order tests/administer Rx when we should → under-diagnosis/underRx
    • false negative errors

• Many ways to make decisions....
  • Decisions that lead to overuse/underuse should be analyzed within a framework of signal detection theory (STD)
  • Many theories of decision-making
    • Normative – Descriptive- Prescriptive
    • Real, “large” world vs. idealized ‘small’ world decision theories
      • Gigerenzer, G. & Gaissmaier, W, 2011
Evidence accumulation theory → Fast-and-Frugal Trees

Evidence Accumulation Theory

Fast-and-Frugal Trees

Evidence 1 + Evidence 2 + Evidence 3 + ...

Action threshold/
decision re gains (benefits)
vs. losses (harm)

Assessment of decision
accuracy

Many ways to make decisions that can result in FP vs. FN errors… decisions related to “large” (real) world vs. idealized “small” world settings… that can be best understood if unified under a common theoretical umbrella.

Evidence Accumulation Theory → Fast-and-Frugal Trees

FFT–EAT proposes that evidence is accumulated sequentially after which decision is made when certain threshold is exceeded. Such a decision is inevitably associated with false-positive versus false-negative errors, which are best appreciated within SDT framework.

Fast-and-frugal trees (FFT)- an effective heuristics for problem-solving and decision-making

FFT- “less can be more”

• FFT- a simple decision tree composed of sequentially ordered cues (tests) and binary (yes/no) decisions formulated via series of if-then statements.

• FFT outperformed a complex logistic regression model (consisting of 50 variables) re decision whether to admit a patient with chest pain to CCU

• by ignoring information, FFTs can be more accurate than statistical multivariate regression models (‘less is more’) 

• This is because FFTs can be less susceptible to overfitting than the regression models

A relationship between SDT and FFT

The exit structure (and order of cues) of the FFTs determines its overall diagnostic accuracy.

Courtesy of Dr. Luan
A relationship between SDT and FFT and Threshold model

the exit structure (and order of cues) of the FFTs (FFTTs) determines its overall diagnostic accuracy [discriminability (d’) and decision criterion (c)] .
Improving population health by avoiding overtreatment

• If the goal is to avoid overtreatment in a large segment of population, a clinician should use the FFT with the lowest number of false-positives (FPs) findings.

• Converting clinical management strategies into FFTs
  • Example (“Statin FFT”)
Use of statins for primary prevention of heart disease—a poster child for over-diagnosis and over-treatment?

• Cardiovascular disease (CVD) is the leading cause of mortality and morbidity in the United States

• Statins are highly effective drugs for both primary and secondary prevention

• In 2014, ACC/AHA recommends statins if the 10-year risk of CVD is ≥7.5%

• If the ACC/AHA are adhered to more than 1 billion people worldwide would receive statin therapy; many adults without CVD would unnecessary be treated

Stone et al JACC 2014; 63:2289-2934; Ioannidis JAP JAMA 2014;311:363-464
“Statin FFT”: a tool to help optimize management of CAD

- A busy clinician does not have enough time for meaningfully engaged shared decision-making
- Large body of evidence shows that decisions can be guided by simple, ready available clinical characteristics → FFT
- The existing evidence (data sets) can be used to generate “statin FFT” to optimize treatment of CAD
  - help avoid use expensive and invasive testing such as CT, MRI etc
Creating Statin FFT
- Framingham Heart Study Data Set restricted to readily available data ("cues")

Cue1 = "Diabetic"
Cue2 = "Blood pressure Rx"
Cue3 = "Age>=44"
Cue4 = "Systolic>120 mmHg"
Cue5 = "Total Cholesterol >=250 mg/dl"

FFT-3 cues: 3! x 2^2 exits=3*2*1*4= 24 permutations
FFT-4 cues: 4!=24 x 2^3 exits= 192 permutations
FFT-5 cues:5!x 2^4 exits= 1920 permutations

We determined the accuracy of the FFT by changing the order in which these questions were asked

Statin FFT (3 cues)
Effect of sequence of diagnostic tests (cues)

The worst combination: FFTyy (diabetes-age-BpRx)
(FP=19.2%)
Best
FFTnn (diabetes-BpRx-age)
FP=0.2%

FP=18.5%
FP=1.6%
FP=0.2%

pCVD (NoRx)=2.75%
pCVD (Rx)=10.8%
pCVD (NoRx)=4.4%
pCVD (Rx)=17.3%
pCVD (NoRx)=4.71%
pCVD (Rx)=35.6%
Effect of sequence of diagnostic tests (cues)

The worst combination:
FFTyy (diabetes-age-BpRx) (FP=19.2%)
Best
FFTnn (diabetes-BpRx-age) FP=0.2%

Treatment according to this FFT will lead to Rx of 26% vs. No Rx in 74% of patients.
pCVD (NoRx)=2.75%
pCVD (Rx)=10.8%

Treatment according to this FFT will lead to Rx of 4% vs. No Rx in 96% of patients.
pCVD (NoRx)=4.4%
pCVD (Rx)=17.3%

Treatment according to this FFT will lead to Rx of 0.24% vs. No Rx in 99.76% of patients
pCVD (NoRx)=4.71%
pCVD (Rx)=35.6%
Effect of diagnostic tests ordering

FP=18.5%

pCVD for paths: NN (73% of population)=2.7%; NYN :7.6% (0.96% of pop); NYY: 7.7% (0.5% of pop); Y:10.8% (26% of pop)

Treatment according to this FFT will lead to Rx of 26% vs. No Rx in 74% of patients.

FP=1.6%

pCVD for paths: NN (73% of population)=2.7%; NYN :9.8% (23% of pop); NYY: 28.3% (0.27% of pop); Y:16.3% (2.9% of pop)

Treatment according to this FFT will lead to Rx of 4% vs. No Rx in 96% of patients.

FP=0.2%

pCVD for paths: N (99.4% of population)=4.7%; YN :23.8% (0.38% of pop); YYN: 7.6% (0.05% of pop); YYY:35.6% (0.24% of pop)

Treatment according to this FFT will lead to Rx of 0.24% vs. No Rx in 99.76% of patients.
How does the sequence of test ordering affect the overall accuracy of various FFTs?

- **FFT-cues**
  - Small changes in the accuracy when answers to all questions is “yes”, or “no”
  - Unpredictable and potentially dramatic changes when “yes”/”no” alternate
Statins for prevention of CAD
The overall accuracy of various management strategies: the effect of threshold (FFT)
Comparison of FFTyn (age-BpRx-diabetes) vs FFTnn (diabetes-BpRx-age):
The effect of differential weighting of false negatives (regret of omission) vs. false positives (regret of commission) on discriminability ($d'$) and decision criterion ($c$)
Conclusions

• Much of clinical decision-making is dominated by heuristics resembling FFTs
  • Clinical pathways, clinical algorithms, guidelines \(\rightarrow\) easily converted into FFTs \(\rightarrow\) improve decision-making
  • The accuracy of our clinical management strategies can formally be assessed
    • provide more accurate evaluation of the extent of underuse vs. overuse
• FFT(T) offers an attractive theoretical solution how to optimally handle the issue of “too little” vs. “too much” medicine
• Much of over-treatment can be reduced if we pay attention how to sequentially order cues (tests) that are routinely available to us at the same time.