

# Hospital variation in FFR

## *Implications for cost-effective physiology*

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# Disclosure Statement of Financial Interest

Within the past 12+ months, Nils Johnson has had a financial interest/arrangement or affiliation with the organization(s) listed below.

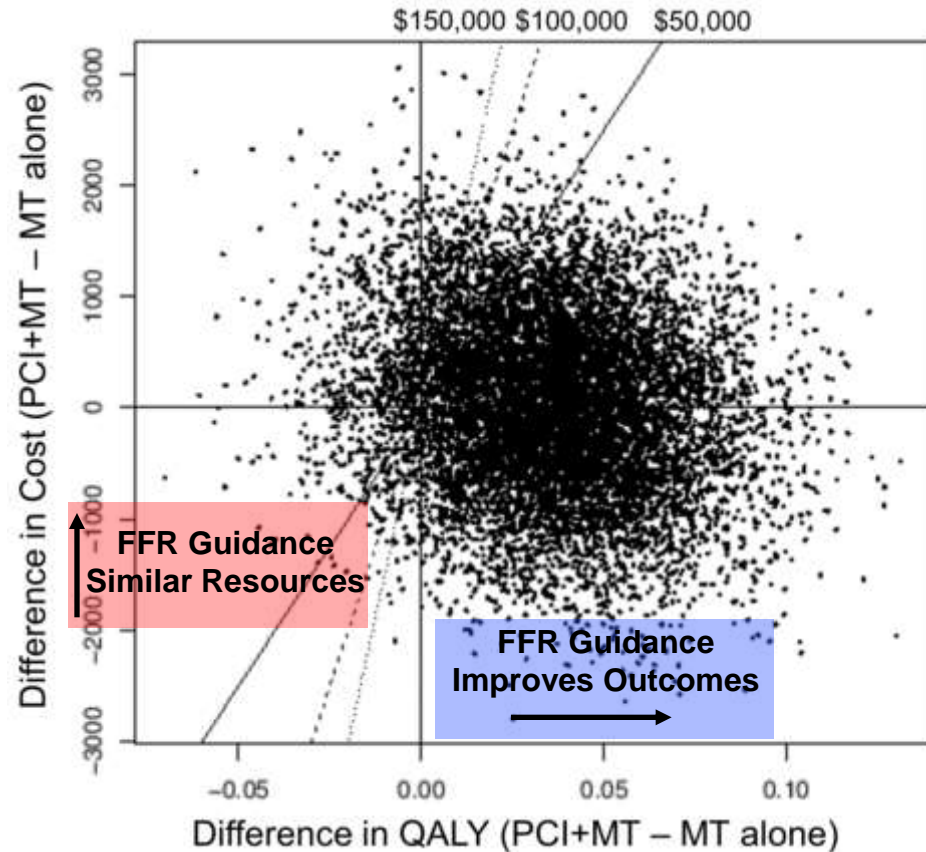
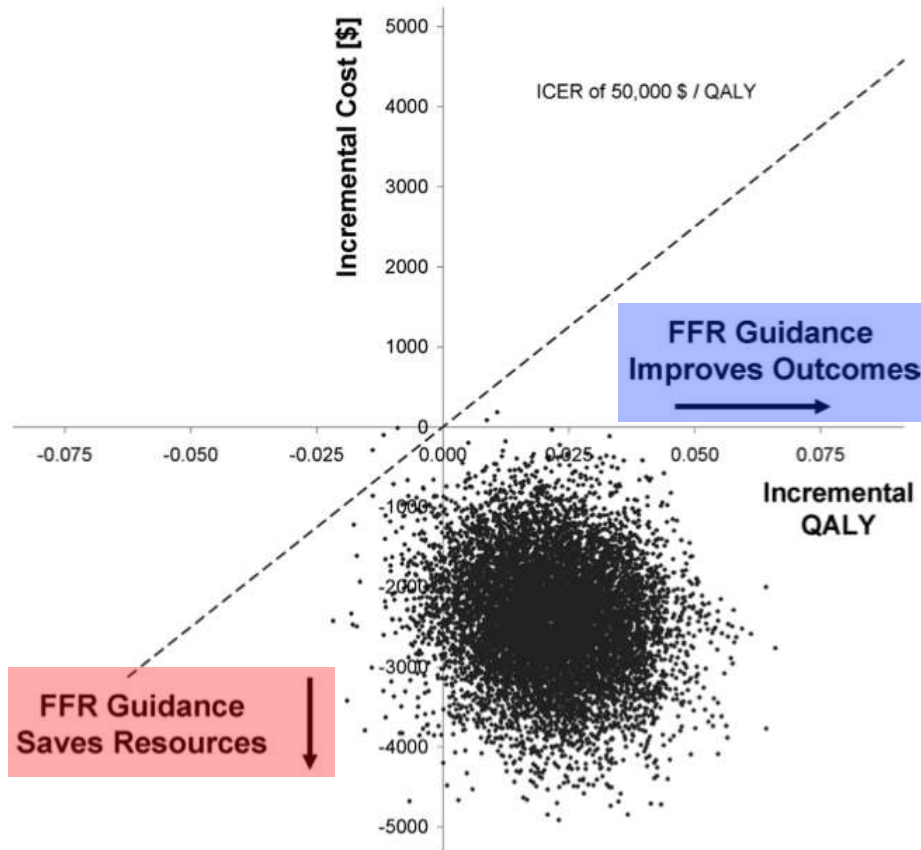
## Affiliation/Financial Relationship

- Grant/research support  
(to *institution*)
- Licensing and associated consulting  
(to *institution*)
- Support for educational meetings/training  
(honoraria/fees donated to *institution*)
- PET software 510(k) from FDA  
(application by Lance Gould, to *institution*)
- Patent pending  
(USPTO serial number 62/597,134)

## Organizations (alphabetical)

- St Jude Medical (for CONTRAST study)
- Volcano/Philips (for DEFINE-FLOW study)
- Boston Scientific  
(for smart-minimum FFR algorithm)
- Various, including academic and industry
- K113754 (cfrQuant, 2011)
- K143664 (HeartSee, 2014)
- K171303 (HeartSee update, 2017)
- SAVI and  $\Delta P/Q$  methods

# Cost effectiveness of FFR



In FAME 1, FFR

improved outcomes (QALY)

and reduced cost

In FAME 2, FFR

improved outcomes (QALY)

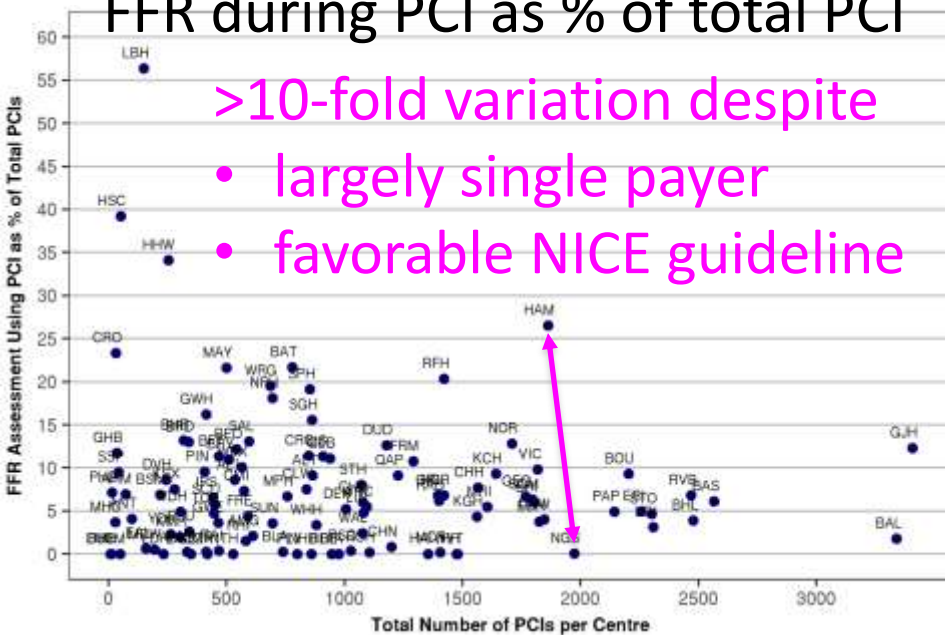
but slightly higher cost

Tradeoff: \$1,600/QALY

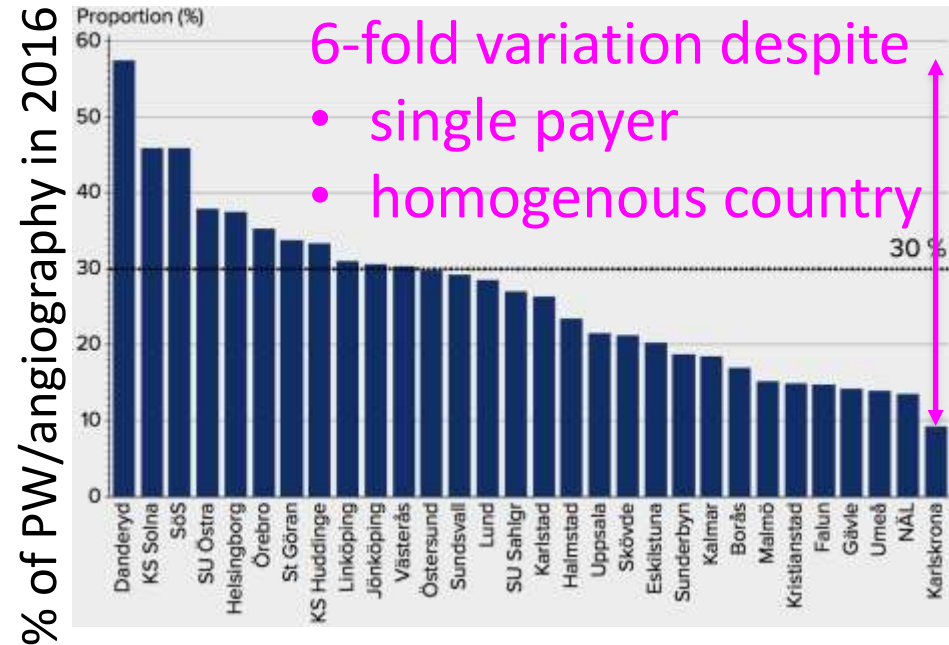
# Variation in FFR use

FFR during PCI as % of total PCI

- >10-fold variation despite
- largely single payer
- favorable NICE guideline

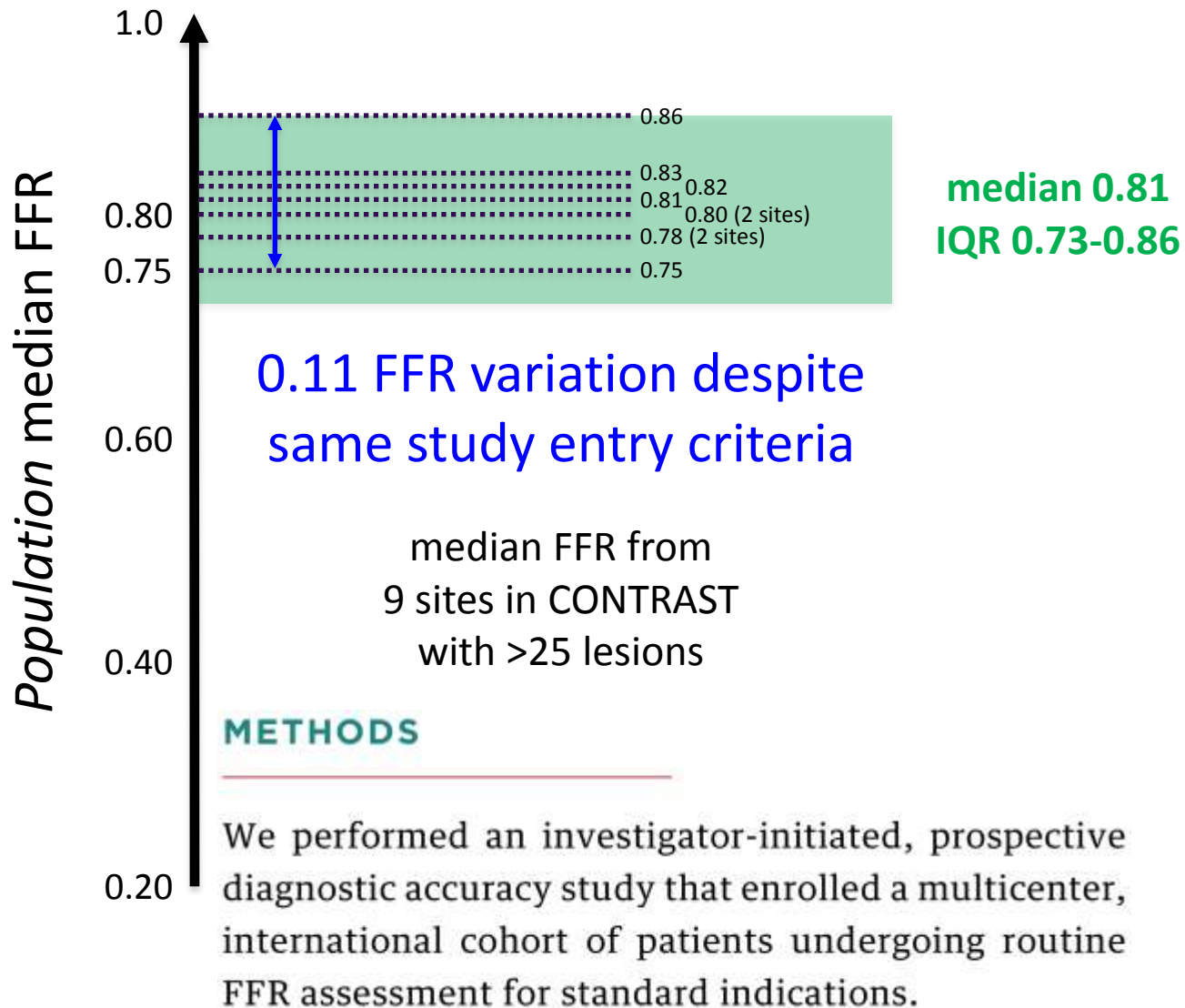


UK (BCIS registry)



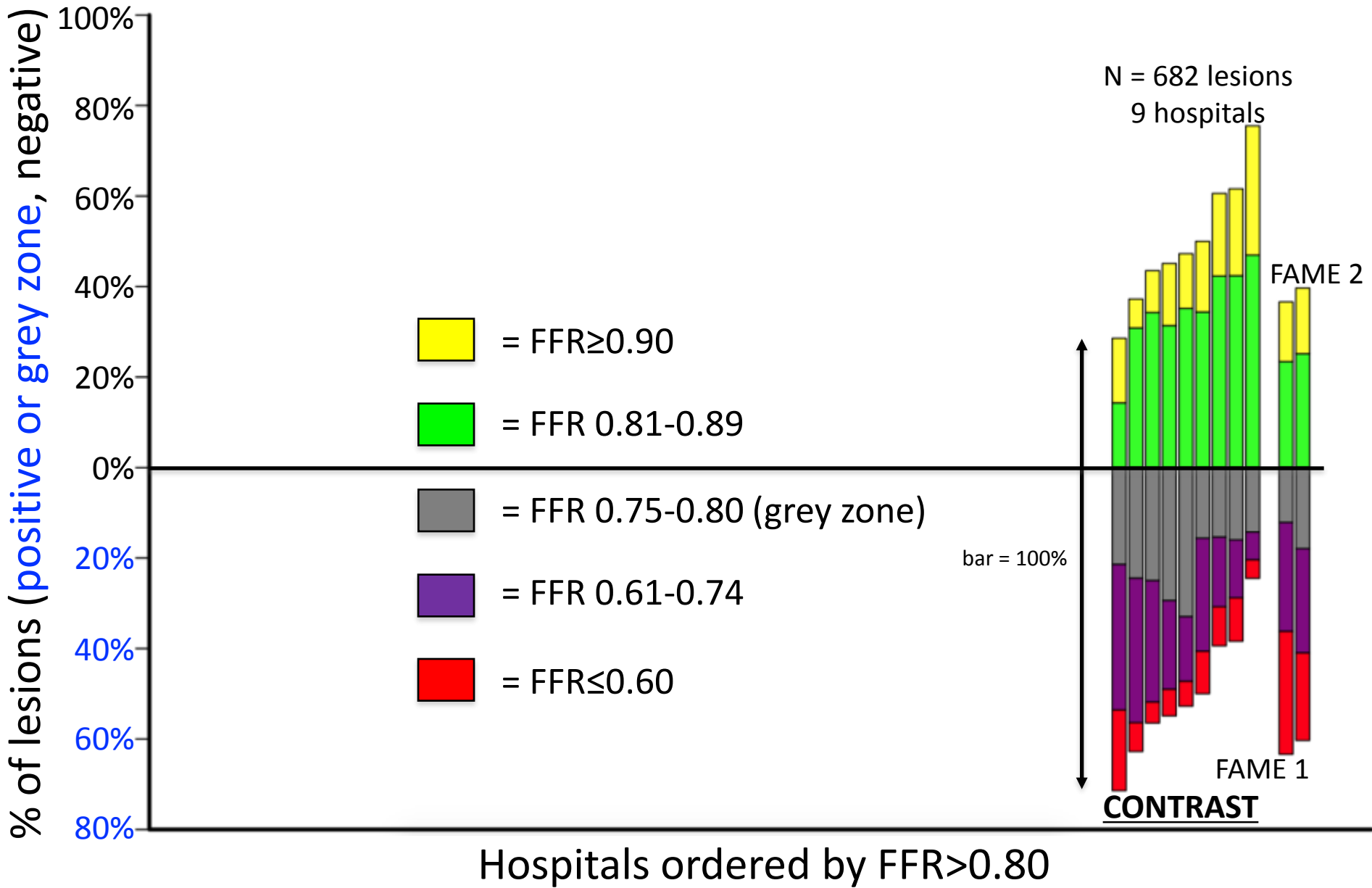
Swedish hospitals in rank order  
Sweden (SCAAR registry)

# FFR severity in CONTRAST

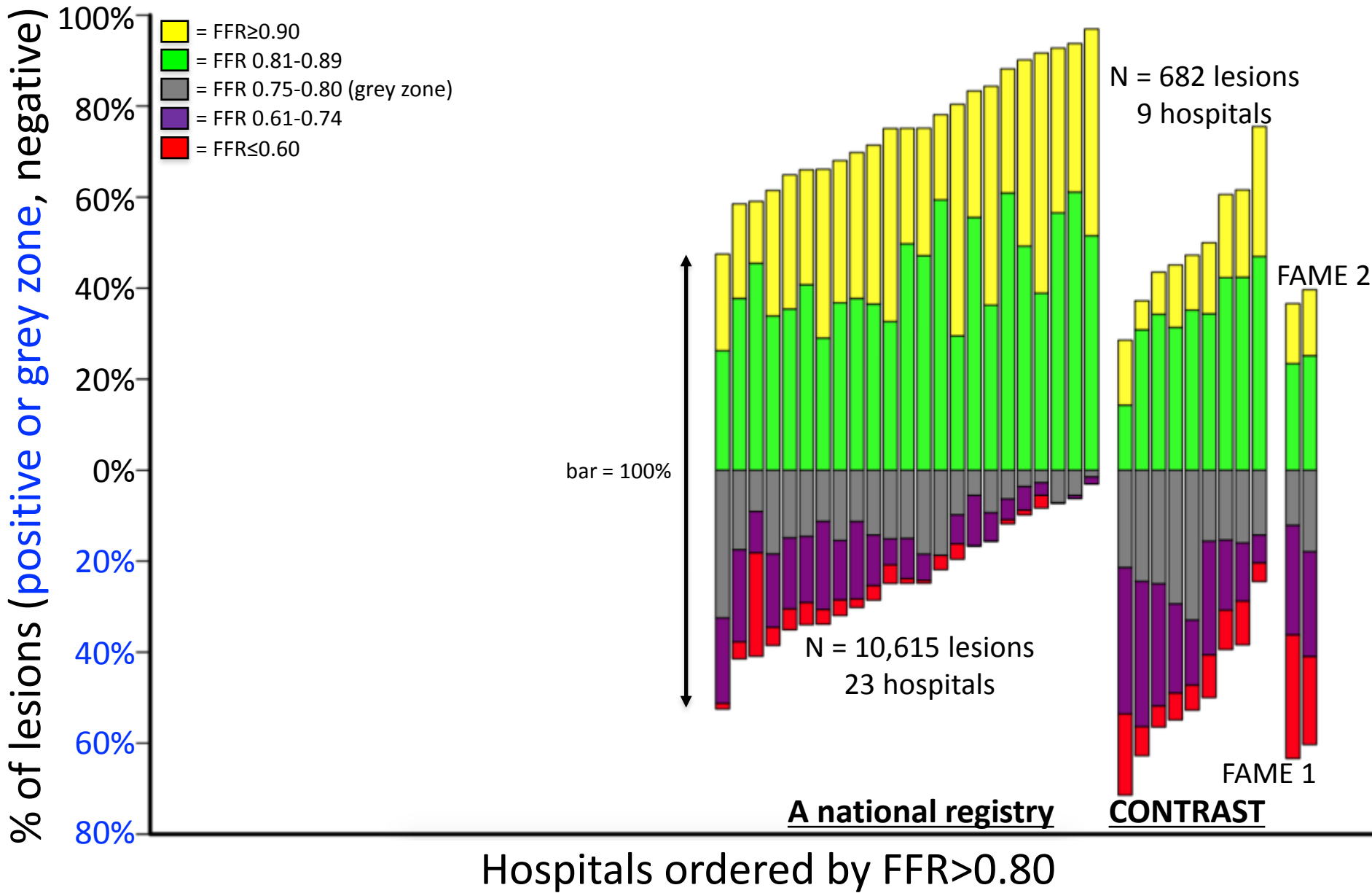


Preliminary, unconfirmed analysis (Nils Johnson)

Quote = Johnson NP, *JACC Cardiovasc Interv.* 2016 Apr 25;9(8):757-67. (Methods section)

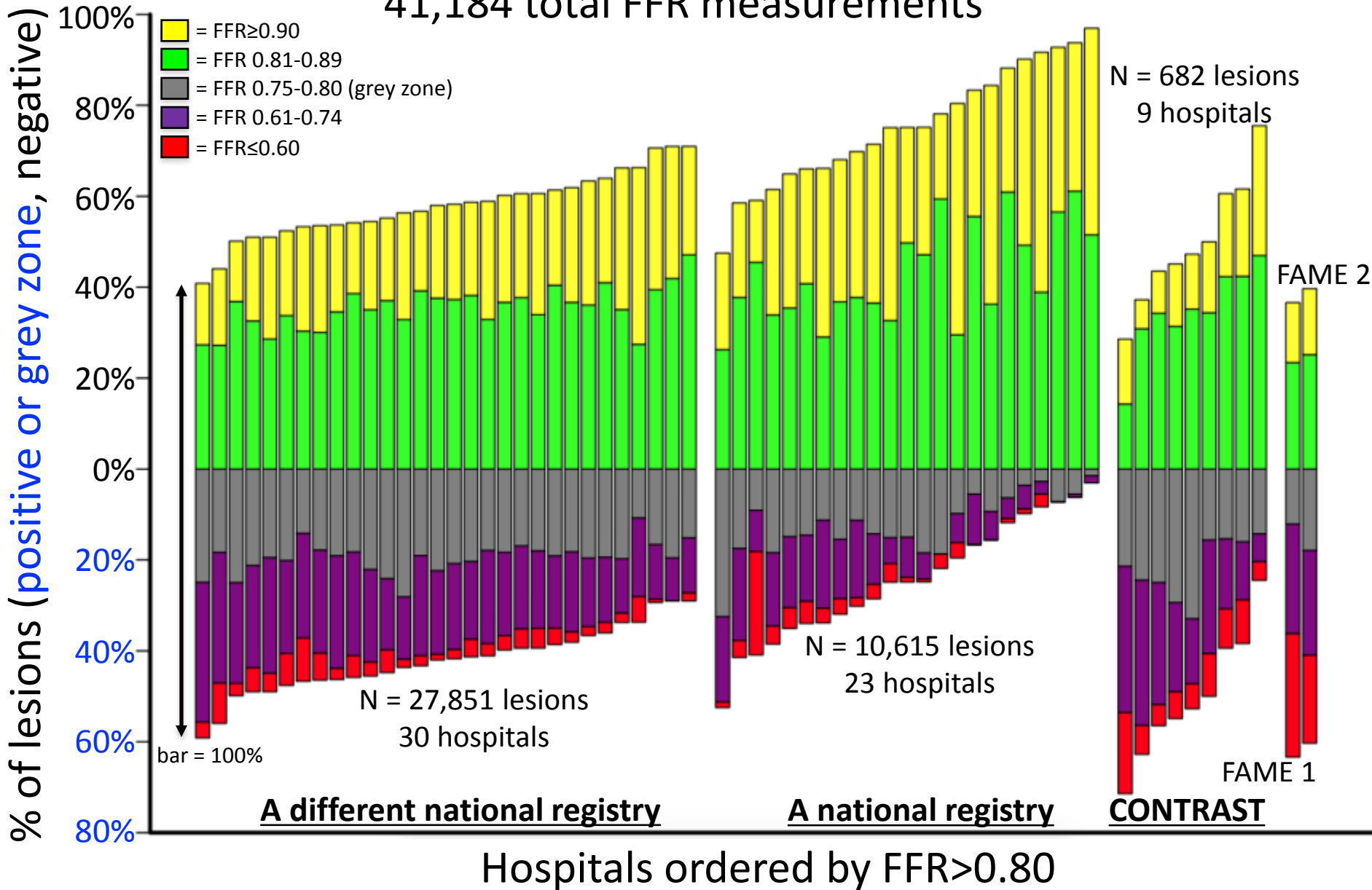


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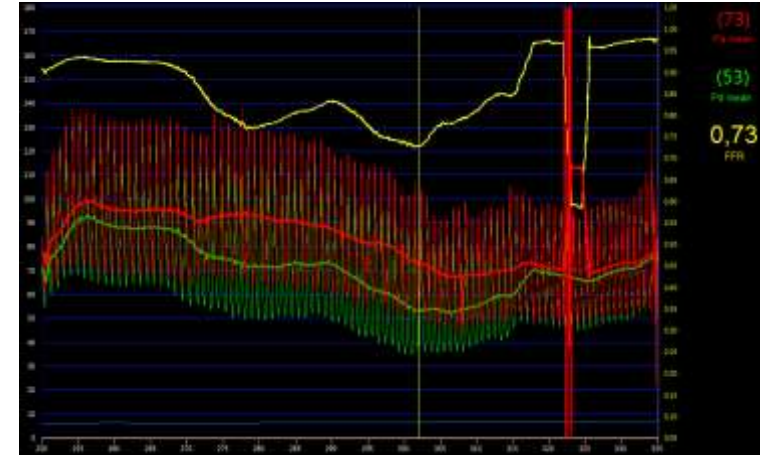
# 41,184 total FFR measurements



Hospitals ordered by FFR > 0.80



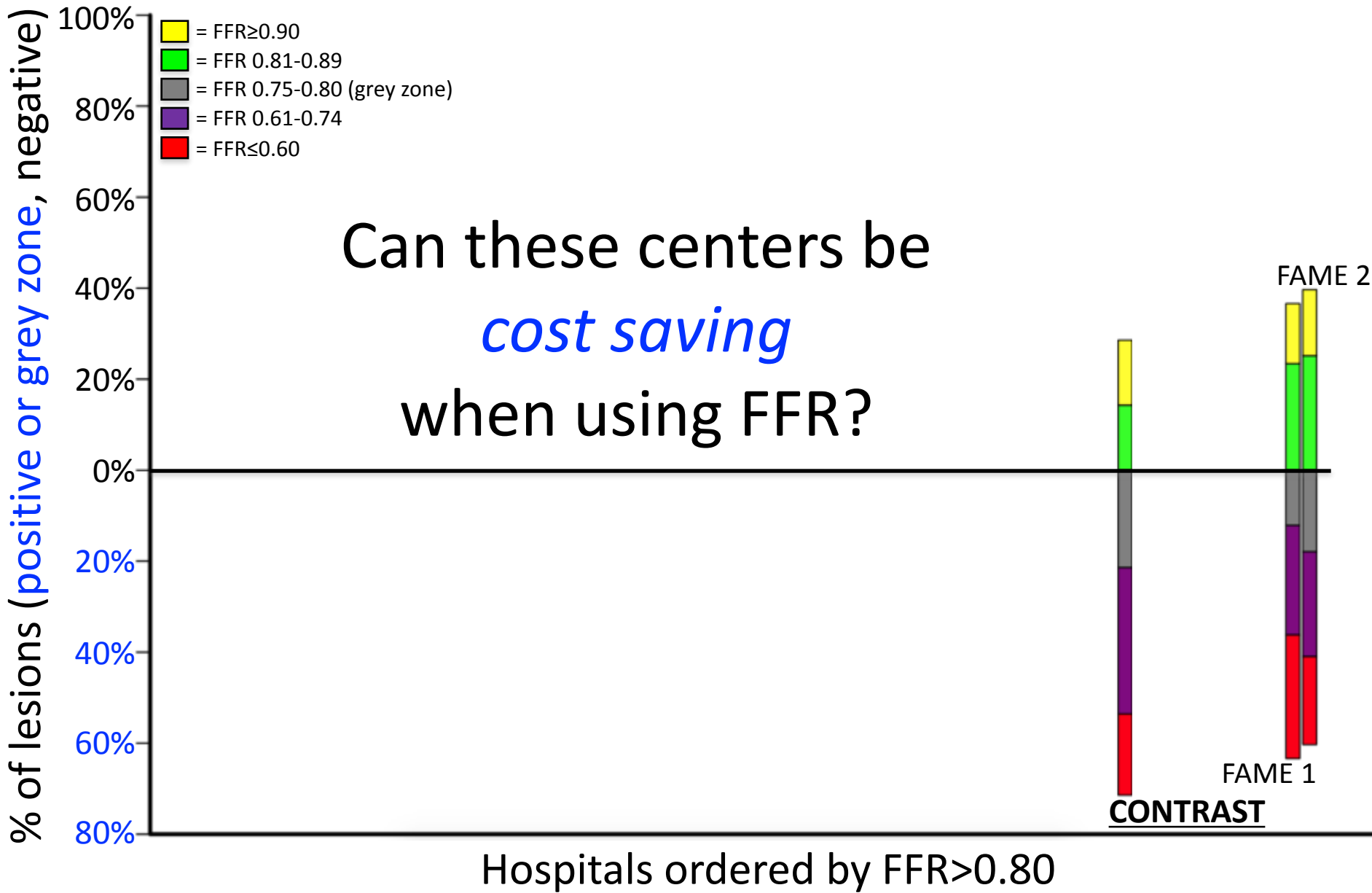
# Why variation in FFR severity?



- Who *gets into the cath lab*?  
(symptoms, non-invasive testing severity, practice patterns)
- Who *in the cath lab gets FFR*?  
(angiographic appearance, non-invasive results, practice patterns)

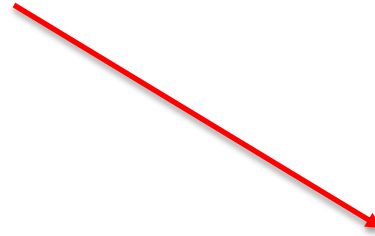
left = URL <https://rehabilitateyourheart.wordpress.com/2013/01/16/exercise-induced-angina/>, accessed April 28, 2018

middle = URL <http://orangeparkmedical.com/service/cath-lab>, accessed April 18, 2017



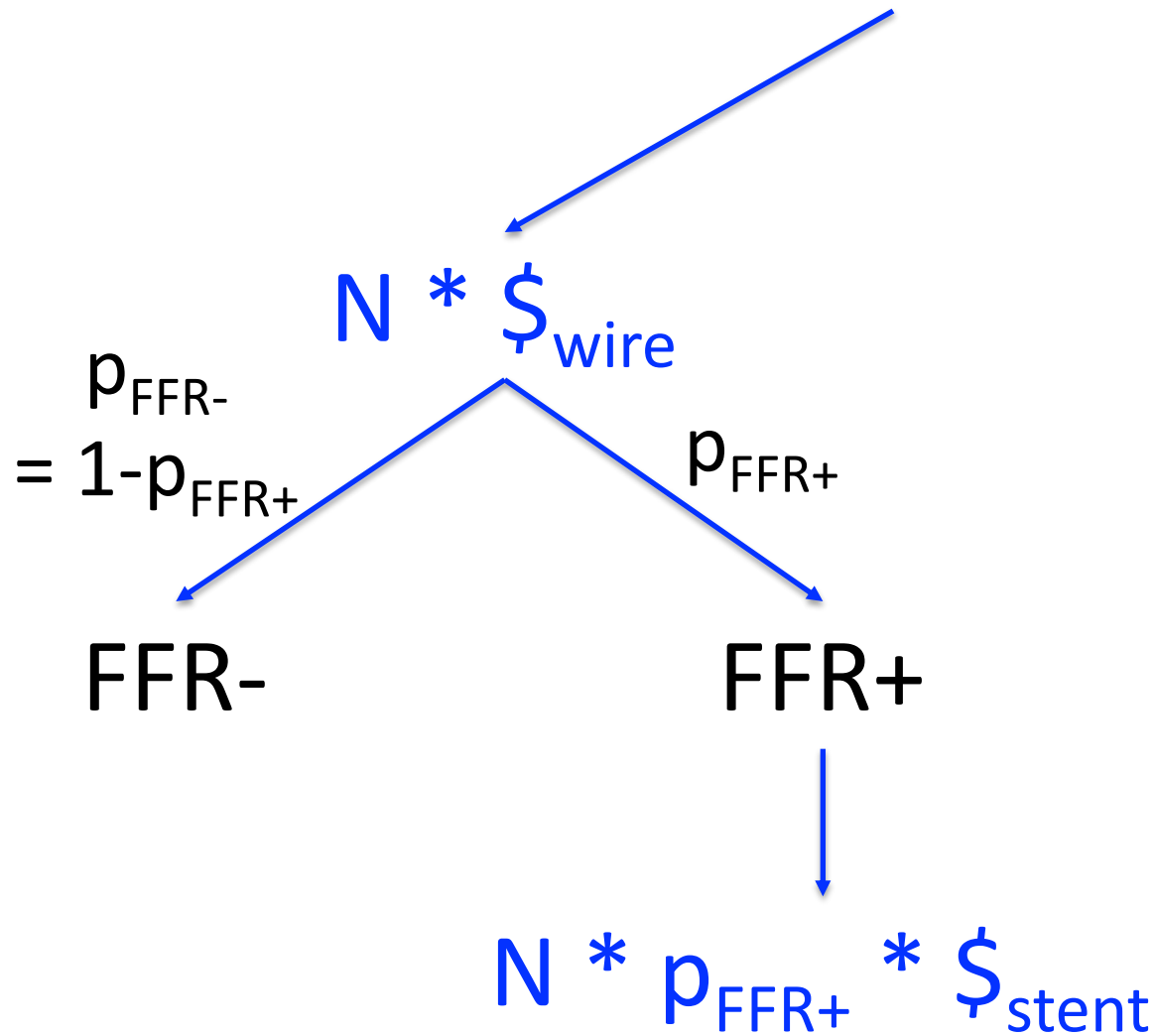
Preliminary, unconfirmed analysis (Nils Johnson)

Stent them all!

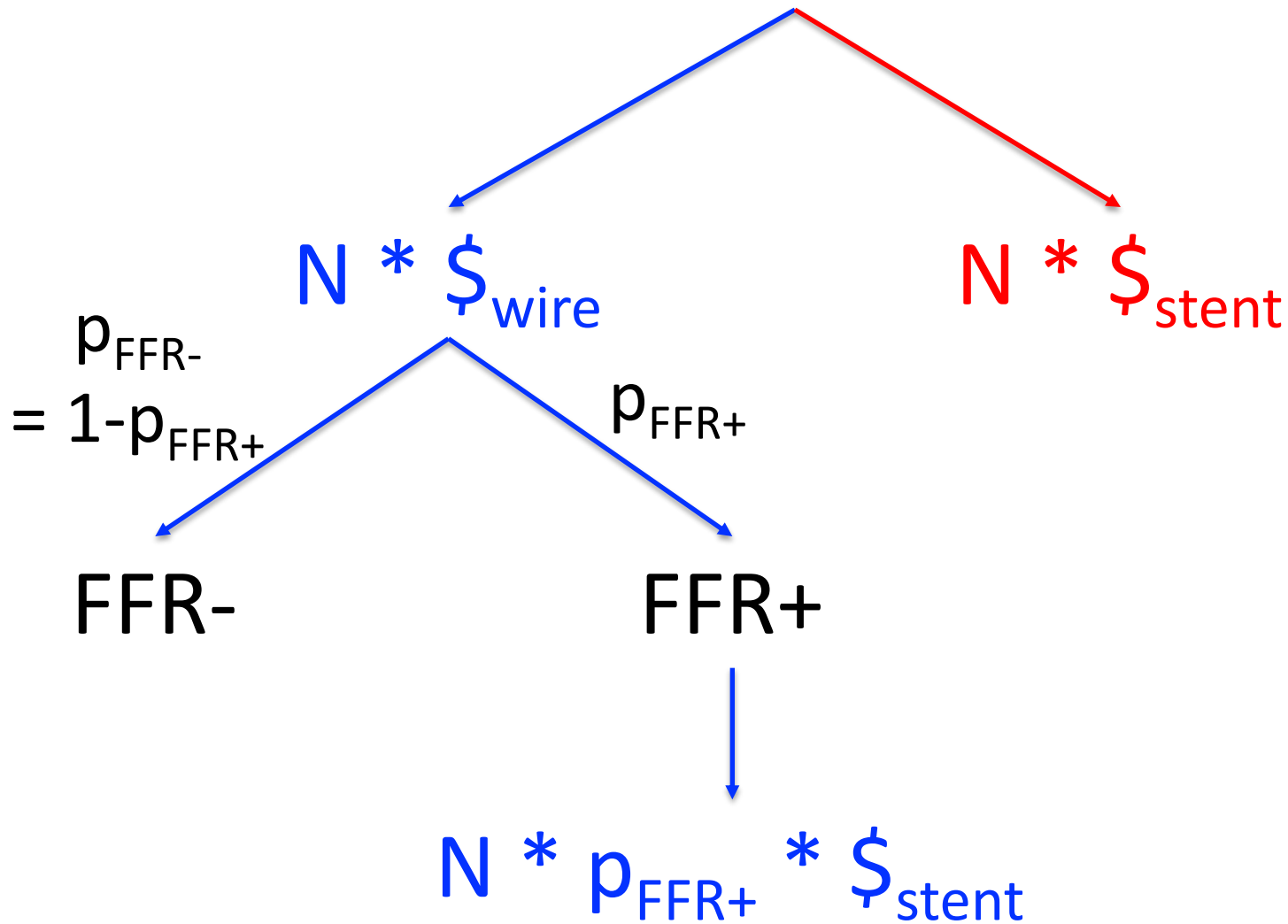


$N * \$_{\text{stent}}$

# FFR-guided strategy



# When is FFR cost saving?



# When is FFR cost saving?

$$N * \$_{\text{wire}} + N * p_{\text{FFR+}} * \$_{\text{stent}} < N * \$_{\text{stent}}$$

$$\$_{\text{wire}} / \$_{\text{stent}} + p_{\text{FFR+}} < 1$$

## Cost savings FFR

- Relative cost of pressure wire vs stent  
( $\$_{\text{wire}} / \$_{\text{stent}}$ )
- Frequency of finding FFR-positive lesion  
( $p_{\text{FFR+}}$ )

# FAME 1: Cost effectiveness

Table 2. Resources Used and Costs

| Resource (Cost)                    | Angiography Guided |                       | FFR Guided        |                       |
|------------------------------------|--------------------|-----------------------|-------------------|-----------------------|
|                                    | Resource Units, n  | Mean Cost/Patient, \$ | Resource Units, n | Mean Cost/Patient, \$ |
| Guide catheter (\$35)              | 2.2 (2.1–2.3)      | 77                    | 2.0 (2.0–2.1)     | 71                    |
| Guidewire (\$85)                   | 2.2 (2.0–2.3)      | 184                   | 1.2 (1.1–1.3)     | 95                    |
| Pressure wire (\$650)              | 0                  | ...                   | 1.3 (1.2–1.3)     | 819                   |
| Balloon catheter (\$150)           | 2.1 (1.9–2.2)      | 302                   | 1.7 (1.5–1.8)     | 245                   |
| Contrast agent (\$0.5/mL)          | 302 (291–314)      | 150                   | 272 (260–284)     | 135                   |
| DES (\$2100)                       | 2.7 (2.6–2.8)      | 5754                  | 1.9 (1.8–2.0)     | 4043                  |
| Bare metal stent (\$1000)          | 0.1 (0.06–0.14)    | 101                   | 0.06 (0.03–0.09)  | 59                    |
| Adenosine (\$150/vial)             | 0                  | ...                   | 1.5 (1.4–1.6)     | 222                   |
| GPI (\$500/vial)                   | 0.4 (0.3–0.5)      | 157                   | 0.3 (0.26–0.40)   | 137                   |
| Hospital day (floor bed, \$1696/d) | 2.1 (1.8–2.3)      | 3443                  | 2.1 (1.9–2.4)     | 3625                  |
| Hospital day (CCU, \$2877/d)       | 1.7 (1.4–2.0)      | 4710                  | 1.3 (1.0–1.6)     | 3731                  |
| Hospital day (total)               | 3.7 (3.4–4.0)      | 8153                  | 3.5 (3.2–3.7)     | 7356                  |
| Repeat PCI (\$12 780)              | 0.08 (0.05–0.11)   | 1005                  | 0.06 (0.04–0.09)  | 778                   |
| CABG (\$27 606)                    | 0.03 (0.01–0.04)   | 696                   | 0.01 (0.002–0.02) | 313                   |
| MI (\$4968)                        | 0.004 (0.001)      | 20                    | 0.002 (0–0.006)   | 10                    |
| MI with PCI (\$16 544)             | 0.0006 (0–0.01)    | 100                   | 0.002 (0–0.006)   | 33                    |
| Total 1-y costs, \$                | 16 700             |                       | 14 315            |                       |

DES indicates drug-eluting stent; GPI, glycoprotein inhibitor; CCU, cardiac care unit; and CABG, coronary artery bypass graft surgery. Values are mean number of resource units (95% confidence interval) or mean cost per patient.

| FFR-guided strategy  |    |                  |
|--|----|------------------|
| Lesions successfully measured for FFR — no./total no. (%)¶ | NA | 1329/1414 (94.0) |
| FFR  | NA | 0.71±0.18        |
| Ischemic lesions   | NA | 0.60±0.14        |
| Nonischemic lesions  | NA | 0.88±0.05        |
| Lesions with FFR ≤0.80 — no./total no. (%)                 | NA | 874/1387 (63.0)  |
| Lesions with FFR >0.80 — no./total no. (%)                 | NA | 513/1387 (37.0)  |

FAME 1

$$\$/_{\text{wire}} / \$/_{\text{stent}}$$

\$650 / \$2100 in 2006

$$\$/_{\text{wire}} / \$/_{\text{stent}} = 0.31$$

FAME 1

$$p_{\text{FFR}+} = 0.63$$

top = Fearon WF, *Circulation*. 2010 Dec 14;122(24):2545-50. (Table 2 with *annotation*)

bottom = Tonino PA, *NEJM*. 2009 Jan 15;360(3):213-24. (Table 2 portion with *annotation*)

# FAME 1: Cost saving

$$\$_{\text{wire}} / \$_{\text{stent}} + p_{\text{FFR}+} < 1$$

$$0.31 + 0.63 = 0.94 < 1$$

## Cost analysis in FAME 1

- Pressure wire cheap vs DES  
( $\$_{\text{wire}} / \$_{\text{stent}} = 0.31$ )
- Frequently FFR-positive lesions  
( $p_{\text{FFR}+} = 0.63$ )



# What about DES costs now?

## PERSPECTIVE

### India and the Coronary Stent Market

#### Getting the Price Right

On February 13, 2017, India's National Pharmaceutical and Pricing Authority (NPPA) made a landmark decision to fix price ceilings for coronary stents at 7260 rupees for bare metal stents and 29600 rupees for drug-eluting stents (US equivalents of \$108 and \$444, respectively).<sup>1,2</sup>

Priya Wadhera, MS  
Thomas Alexander, MD  
Brahmajee K. Nallamothu,  
MD, MPH

India (Feb 2017)  
DES = \$444

### Top 10 Supply Items by Total Spend - November 2016

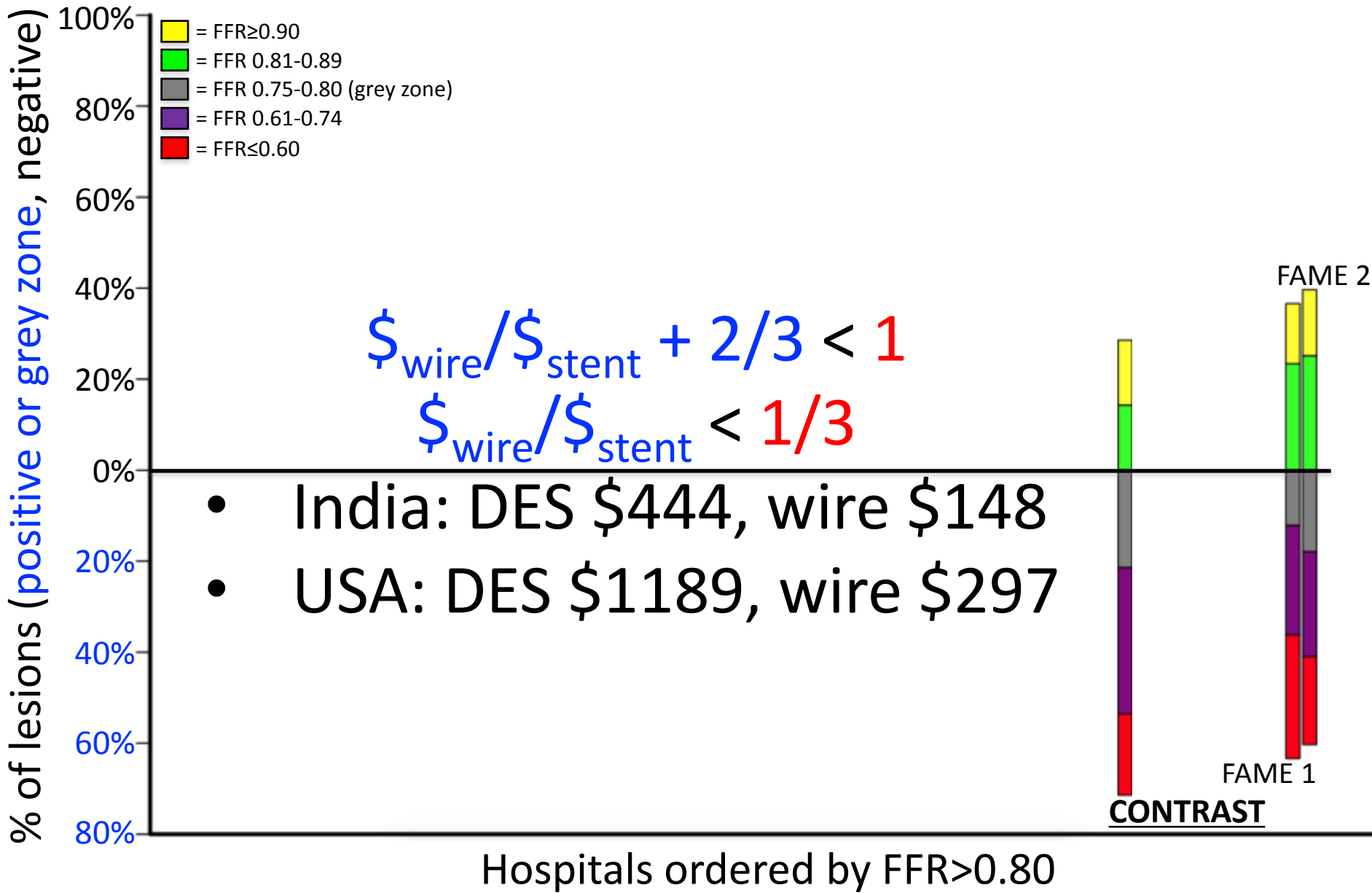
Tracks 10 supply items, often known as "physician preference items," based on total amount spent on those items during the month by hospitals and other provider organizations.

| Common Name                        | Category   | Avg. Cost | One Month Change | 12 Month Change |
|------------------------------------|--|-----------|------------------|-----------------|
| Implantable Pacemaker              | Pacemakers Cardiac Implantable                           | \$3,820   | 0.7%             | -3.6%           |
| Biological Heart Valve             | Prostheses Cardiac Valve Biological                      | \$6,628   | 0.0%             | -0.3%           |
| Hip Implant - Acetabular Shell     | Prostheses Joint Hip Acetabular Component Shell          | \$1,073   | -0.1%            | 2.2%            |
| CRT-P                              | Pacemakers Cardiac Implantable Resynchronization         | \$6,553   | -0.2%            | -3.0%           |
| Knee Implant - Femoral             | Prostheses Joint Knee Femoral Component                  | \$1,970   | -0.2%            | 1.1%            |
| Spinal Cord Stimulator - Analgesic | Stimulators Electrical Spinal Cord Analgesic             | \$18,805  | -0.5%            | -0.1%           |
| Cochlear Implants                  | Stimulators Electrical Auditory Cochlear                 | \$17,178  | -1.2%            | -1.5%           |
| IVD End Plate                      | Prostheses Intervertebral Disk                           | \$5,555   | -1.3%            | 2.5%            |
| Drug-eluting Stents                | Stents Vascular Coronary Balloon-Expandable Drug-Eluting | \$1,189   | -1.3%            | -4.7%           |
| Shoulder Implant - Humeral         | Prostheses Joint Shoulder Humeral Component              | \$2,069   | -2.8%            | -4.7%           |

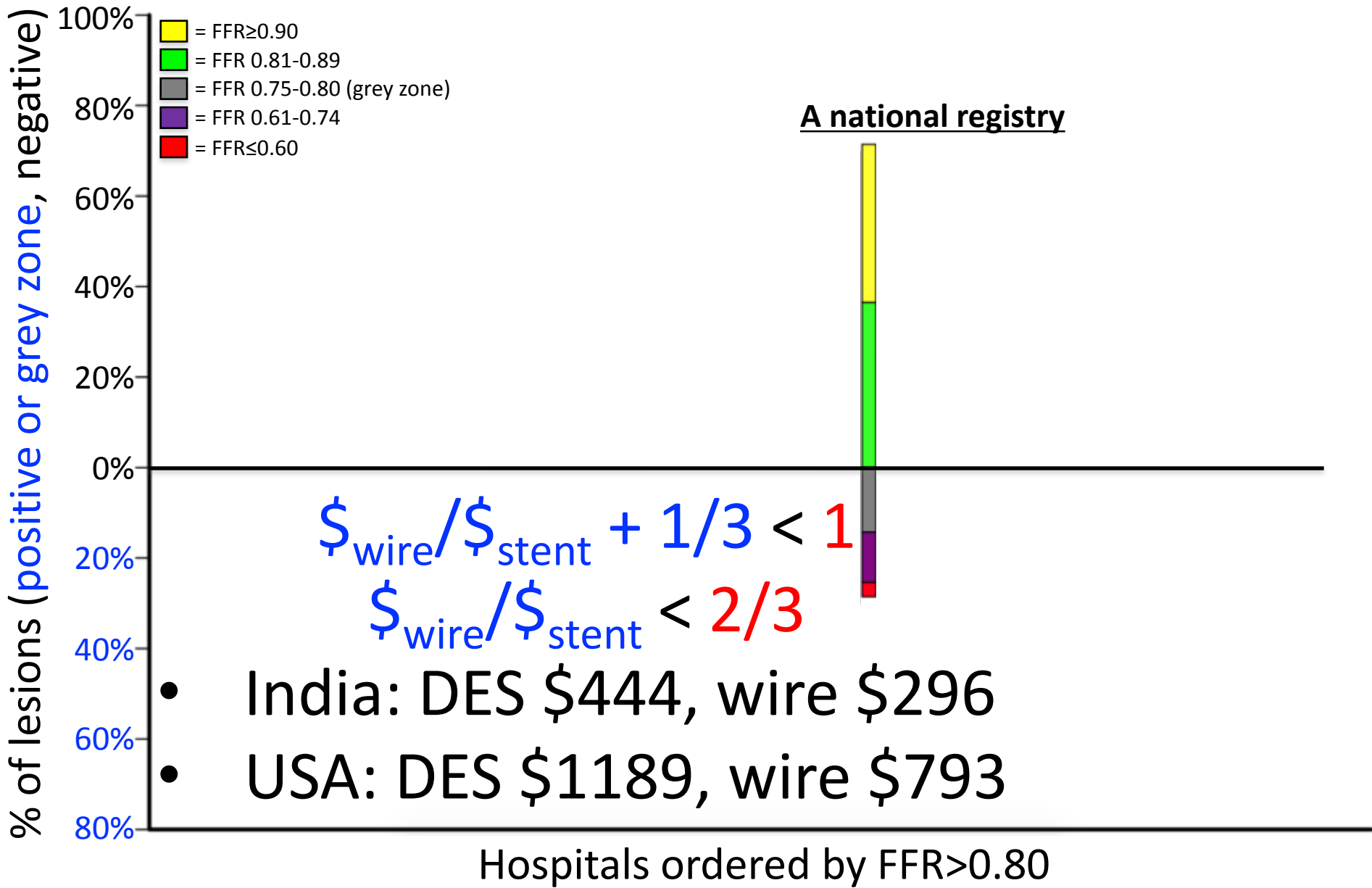
USA (Nov 2016)  
DES = \$1189

left = Wadhera P, Circulation. 2017 May 16;135(20):1879-1881.

right = URL <http://www.modernhealthcare.com/section/technology-price-index>, accessed April 28, 2018.

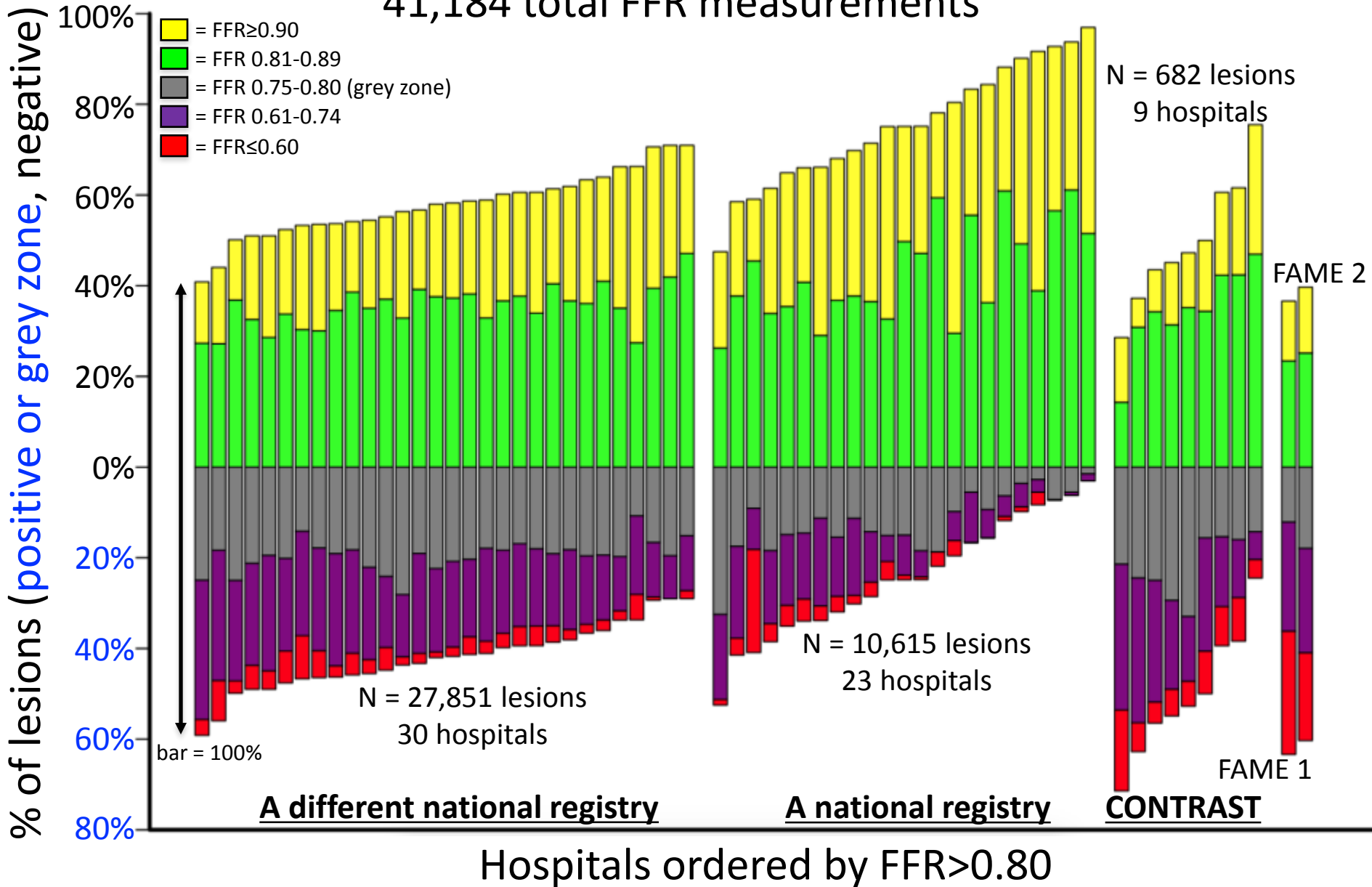


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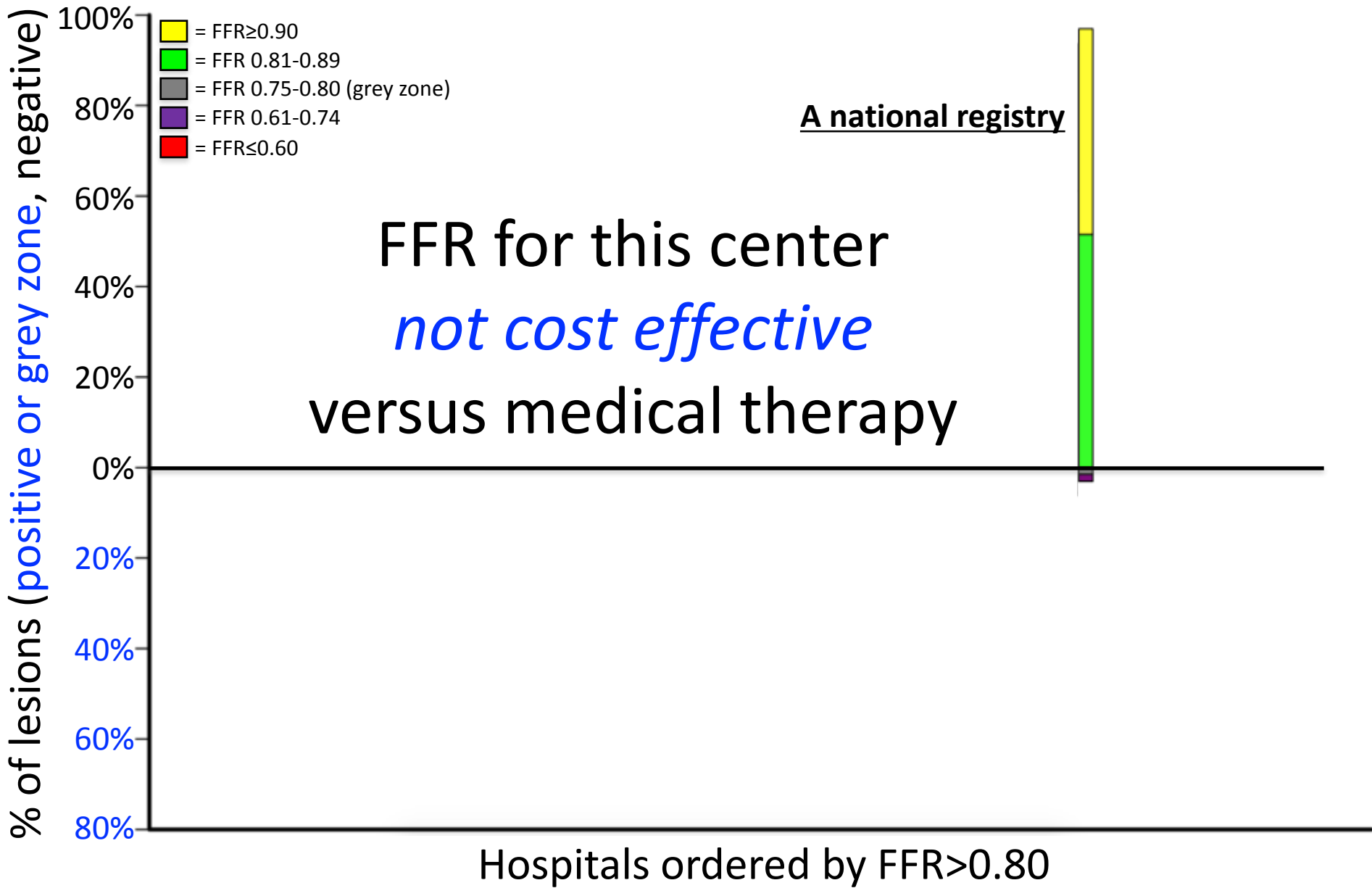


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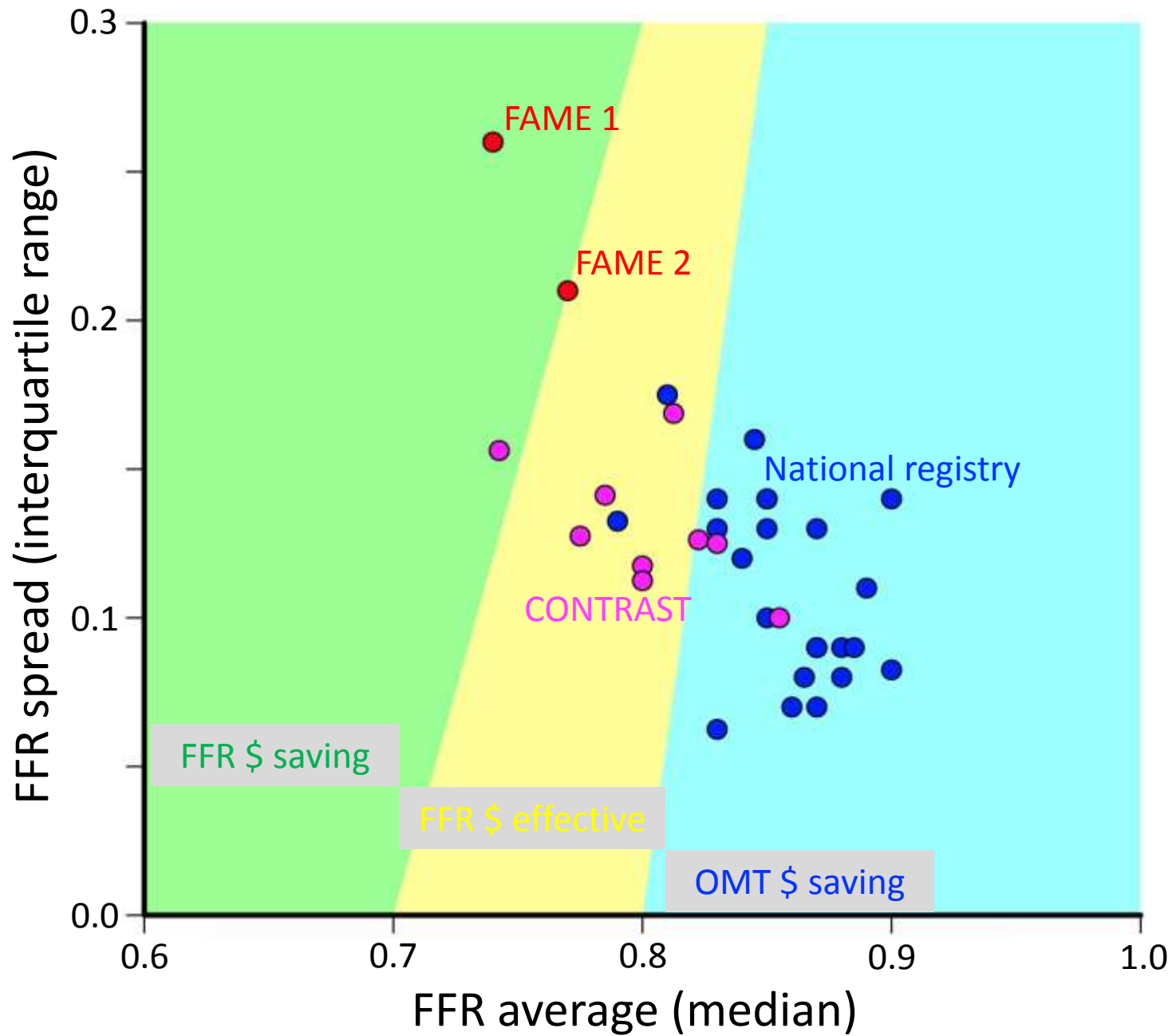
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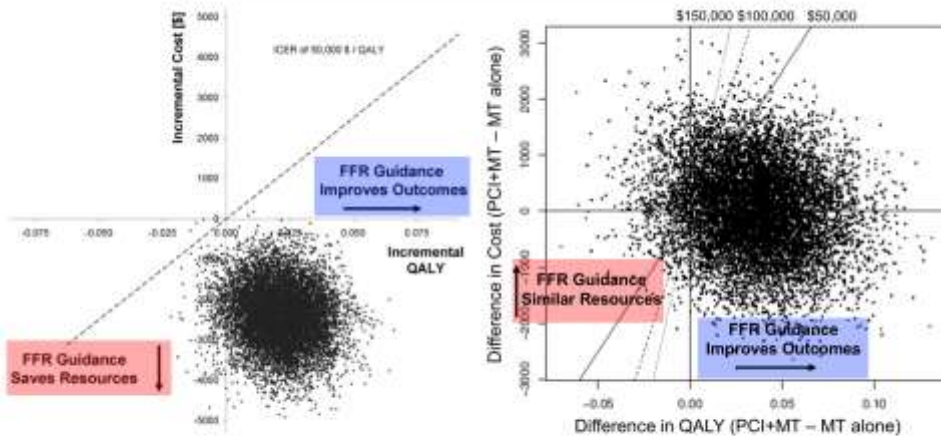


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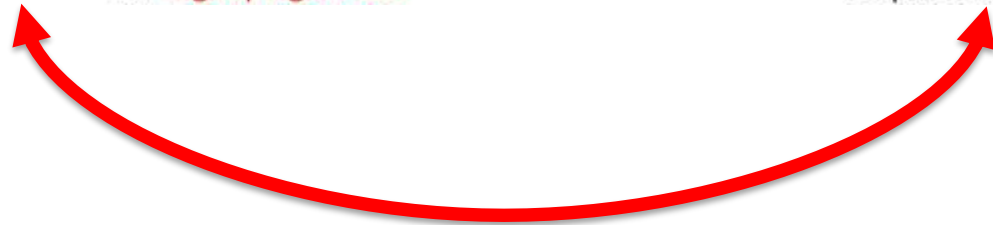
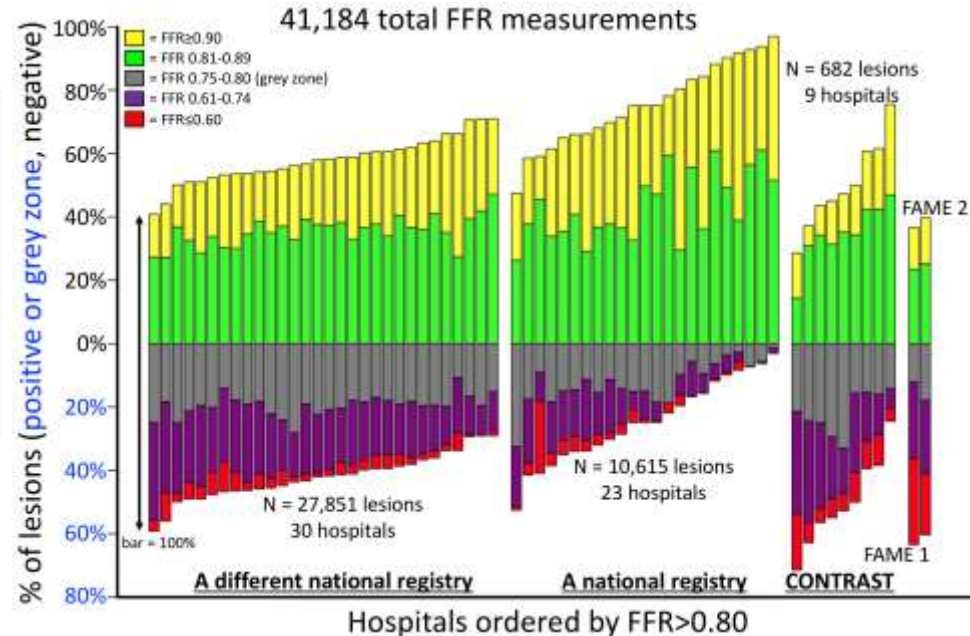
# Cost effectiveness $\leftrightarrow$ FFR severity

## Cost effectiveness of FFR



In FAME 1, FFR improved outcomes (QALY) and reduced cost

In FAME 2, FFR improved outcomes (QALY) but slightly higher cost



interdependent heterogeneous