Optimizing Surveillance of Low Risk Prostate Cancer

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Can we build a statistical model that integrates all the available data to inform clinical decision-making in a way that improves health outcomes in the long term?

Can we communicate results with doctors and patients in a way that effectively informs their decision-making process?
1. Given my personal characteristics, conditions, and preferences, what should I expect will happen to me?

2. What are my options, and what are the benefits and harms of those options?

3. What can I do to improve the outcomes that are most important to me?

4. How can the health care system improve my chances of achieving the outcomes that I prefer?

(Washington and Lipstein 2011)
Active Surveillance of Prostate Cancer
Active Surveillance of Prostate Cancer

**Keys to Success**

1. Identify potentially lethal cancer when present
2. Identify indolent cancer as such
3. Maintain patient engagement
Active Surveillance of Prostate Cancer

Keys to Success
1. Identify potentially lethal cancer when present
2. Identify indolent cancer
3. Maintain patient engagement
Active Surveillance of Prostate Cancer

Keys to Success
1. Identify potentially lethal cancer when present
2. Identify indolent cancer
3. Maintain patient engagement
Active Surveillance of Prostate Cancer

Keys to Success
1. Identify potentially lethal cancer when present
2. Correctly diagnose indolent cancer
3. Maintain patient engagement

Patient Priorities
1. Avoid negative side effects of curative intervention
2. Limit the number, frequency of painful biopsies
3. Reduce anxiety

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Age (years)

PSA (ng/mL)

Reclassification

Yes
No
Probability of biopsy result given true cancer state

- **Indolent Biopsy**
  - True Indolent: 94%
  - True Lethal: 38%

- **Lethal Biopsy**
  - True Indolent: 6%
  - True Lethal: 62%
Individualized Risk Assessment of Prostate Cancer
PCPTRC 2.0

Enter Your Information

Race
Age
PSA Level
Family History of Prostate Cancer
Digital Rectal Examination
Prior Prostate Biopsy

Calculate Cancer Risk  Clear Fields

PCPTRC 2.0 and Adjusted Risk Calculators
PCPTRC 2.0
%freePSA
Download the R Code

PCPTRC 1.0 and Adjusted Risk Calculators
BMI
PCA3
Finasteride
%freePSA
[-2]proPSA
%freePSA and [-2]proPSA
Prostate Volume and Number of Biopsy Cores
AUA Symptom Score
Finasteride with Volume
Finasteride with AUA Symptom Score
Download the R Code

Patient Priorities

1. Avoid negative side effects of curative intervention
2. Limit the number, frequency of painful biopsies
3. Reduce anxiety
True Prostate Cancer Status

Random Variability

True PSA

Measurement Error

Observed PSA

Biopsy Results

Measurement Error
Latent Class

• Indolent
• Lethal

Random Variability

True PSA

Measurement Error

Observed PSA

Biopsy Results

Measurement Error

True Prostate Cancer Status

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Gold standard
Pathologic analysis observed in subset
True
Prostate
Cancer
Status

Random Variability

True
PSA

Measurement Error

Observed
PSA

Time-varying Biomarker

Biopsy
Results

Measurement Error
Repeated Outcome Measure

True Prostate Cancer Status

Random Variability

Measurement Error

True PSA

Observed PSA

Biopsy Results

- Histology (Gleason)
- # Positive Cores
- Maximum % Involvement
True Prostate Cancer Status

Random Effects

Observed PSA

Biopsy Results

Observed PSA

Biopsy Results

Observed PSA

Time

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\[
L_i = \prod_{k=1}^{K} \left[ P(\eta_i = k | V_i, \nu) f(Y_i | \eta_i = k, X_i, Z_i, b_i, \beta) \prod_{j=1}^{J_i} P(R_{ij} | \eta_i = k, W_{ij}, \gamma) \right]^{1[\eta_i = k]}
\]
\[ L_i = \prod_{k=1}^{K} \left[ P(\eta_i = k | \nu_i) f(Y_i | \eta_i = k, X_i, Z_i, b_i, \beta) \prod_{j=1}^{J_i} P(R_{ij} | \eta_i = k, W_{ij}, \gamma) \right]_{\eta_i = k} \]
\[ L_i = \prod_{k=1}^{K} \left[ P(\eta_i = k | V_i, \nu) f(Y_i | \eta_i = k, X_i, Z_i, b_i, \beta) \prod_{j=1}^{J_i} P(R_{ij} | \eta_i = k, W_{ij}, \gamma) \right]^{1[\eta_i = k]} \]
PSA Trajectories

Indolent Class

Lethal Class

Mean  Individual
Indolent Class

Lethal Class

With which group would this PSA trajectory be more consistent?
Can we build a statistical model that integrates all the available data to inform clinical decision-making in a way that improves health outcomes in the long term?

Can we communicate results with doctors and patients in a way that effectively informs their decision-making process?
Decision Support Tool

Prognosis for Active Surveillance Patients

These plots show your anticipated PSA trajectory (left) and risk of reclassification (right) based on your diagnostic characteristics. Green bands represent uncertainty in these estimates.

http://rycoley.shinyapps.io/prediction-app

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