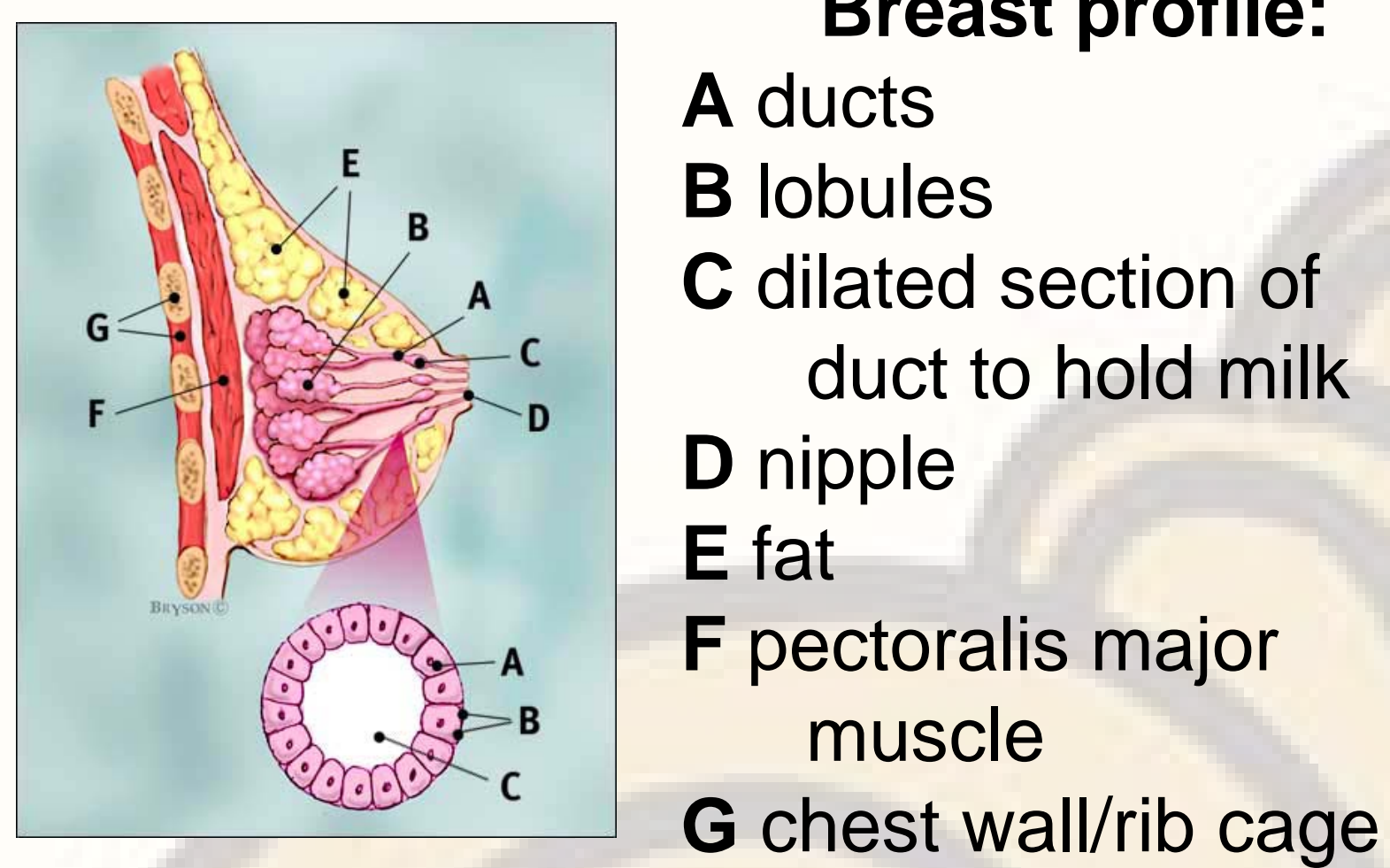


Superior Performance of Bayesian Networks in Predicting the Risk of Invasive Vs. In-Situ Breast Cancer in Older Women

Mehmet Ayvaci, MS; Oguzhan Alagoz, PhD; Houssam Nassif; Edward Sickles, MD; Elizabeth S Burnside, MD, MPh, MS

Introduction

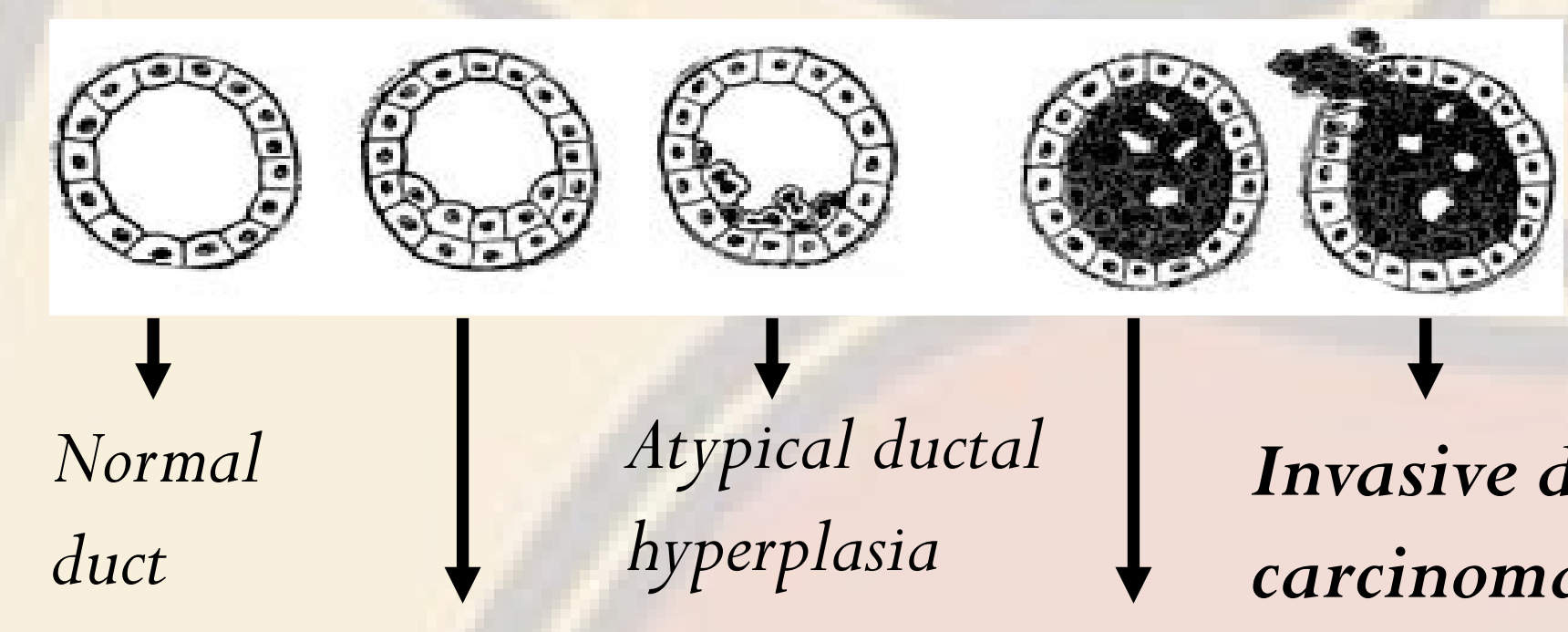
Breast Anatomy



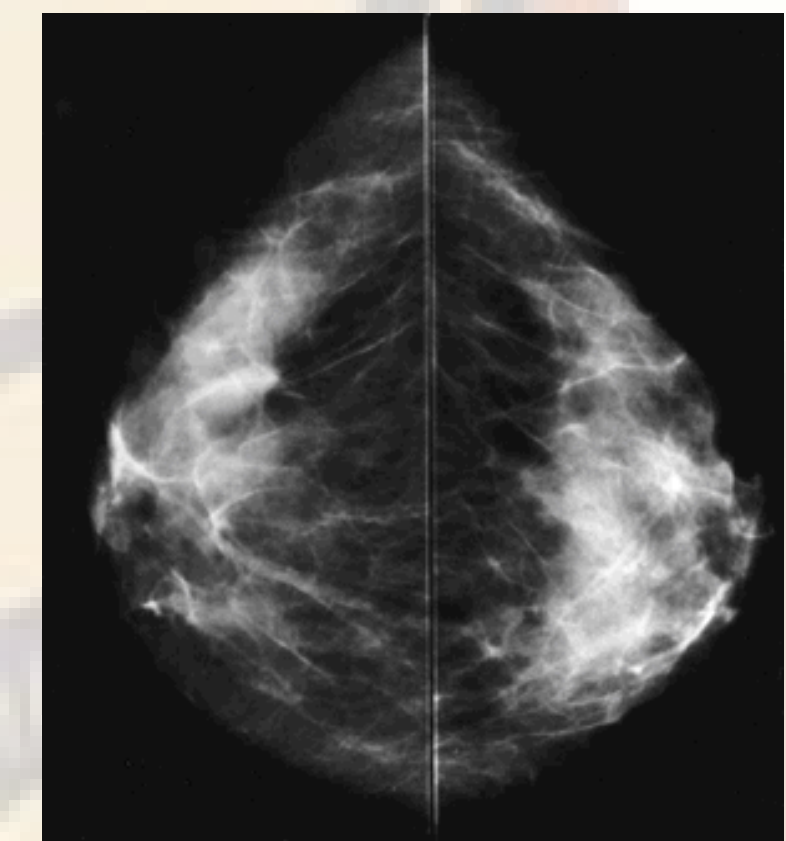
Breast profile:

Enlargement:
A normal duct cells
B basement membrane
C lumen (center of duct)

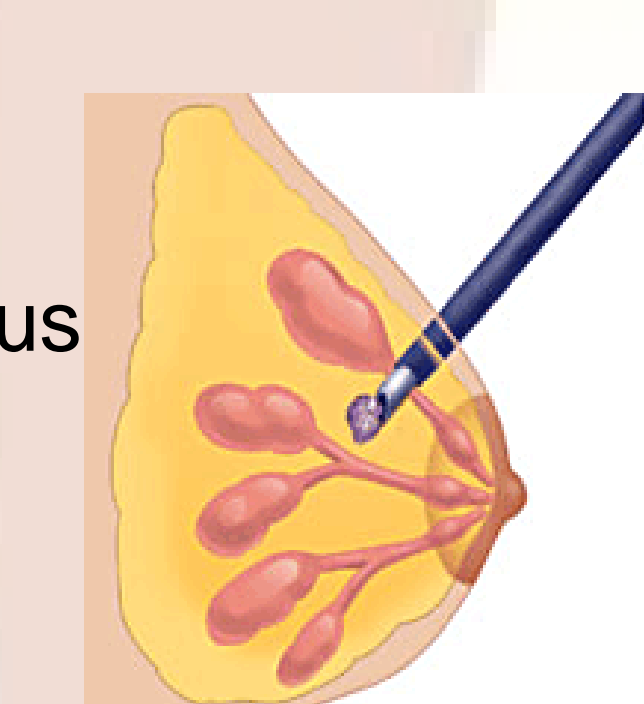
Breast Cancer Progression



Mammography



Biopsy



Sensitivity :

by Age

> <40 → 54%

> 40-49 → 77%

> 50-65 → 78%

> >65 → 81%

by Breast Density

> Younger women ~68%

> Older women ~85%

Aggressive Use

> To prove the benign etiology of micro-calcifications

> Result in PPV of 20%

> Annually 700,000 biopsies

> Estimated overspednig in biopsies:\$250M

Motivation

Why Invasive vs. DCIS?

- Each requires different types of treatment
- DCIS is a non-invasive malignant condition with a favorable diagnosis
- DCIS will not cause mortality or morbidity for many years, if ever
- Risk factors partially differ

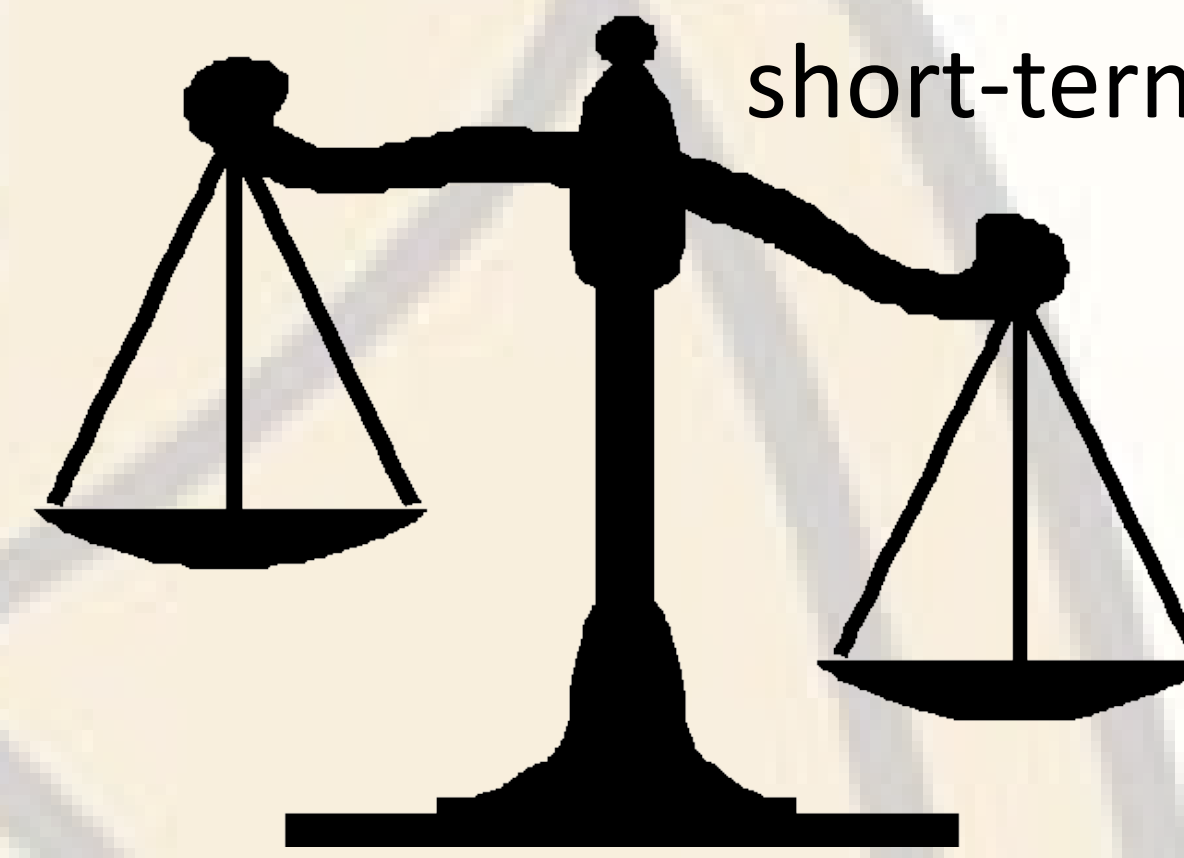
Why Age Stratification?

- Life expectancy difference in older and younger women
- Over diagnosis which does not correspond to reduced mortality
- Breast cancer less aggressive in older women
- Invasive procedures more risky in older women
- Resources could be better spent on more serious co-morbidities

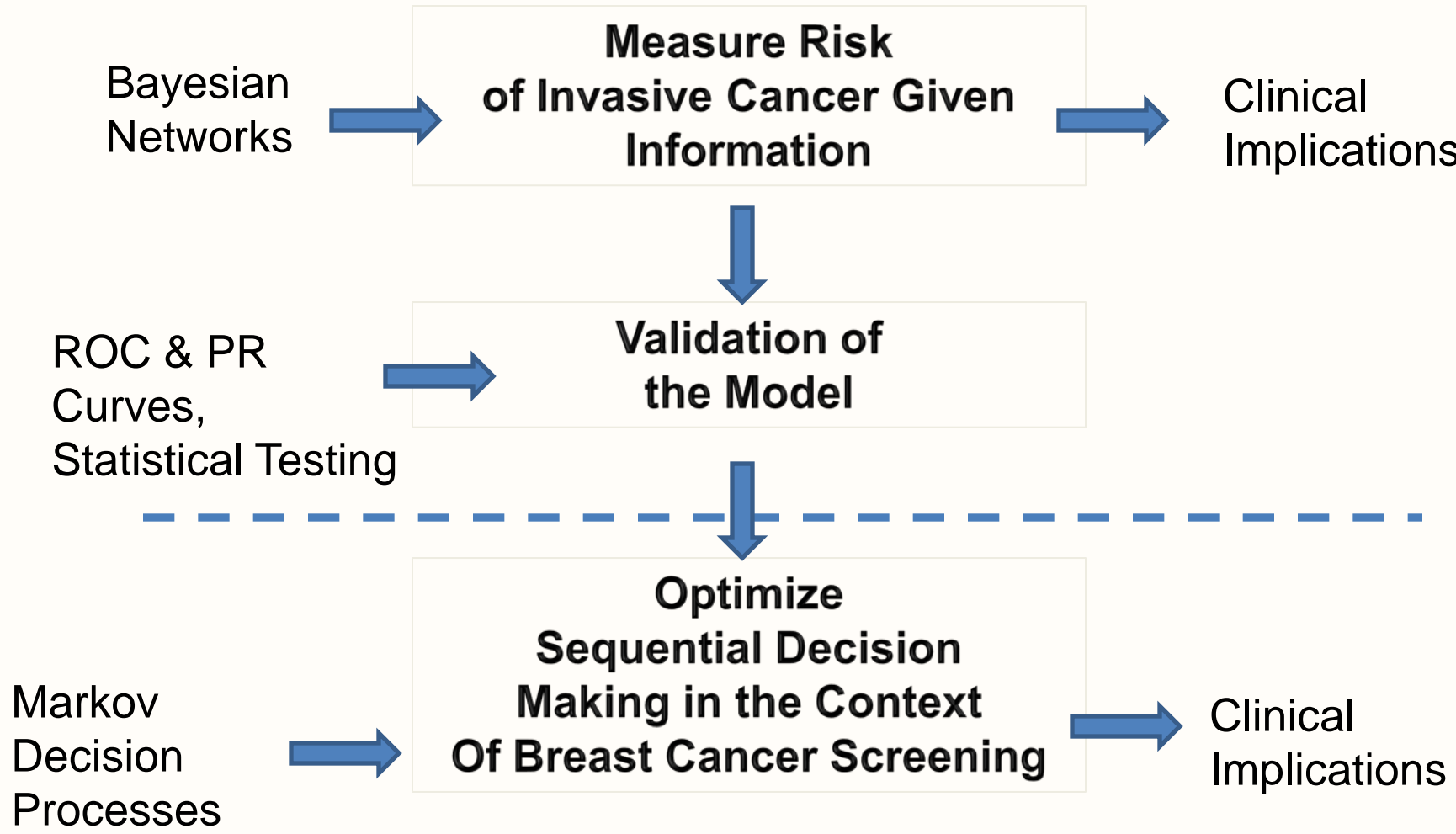
If Prob(Invasive|Old) is small:

Tolerate low PPV

Manage with short-term follow-up

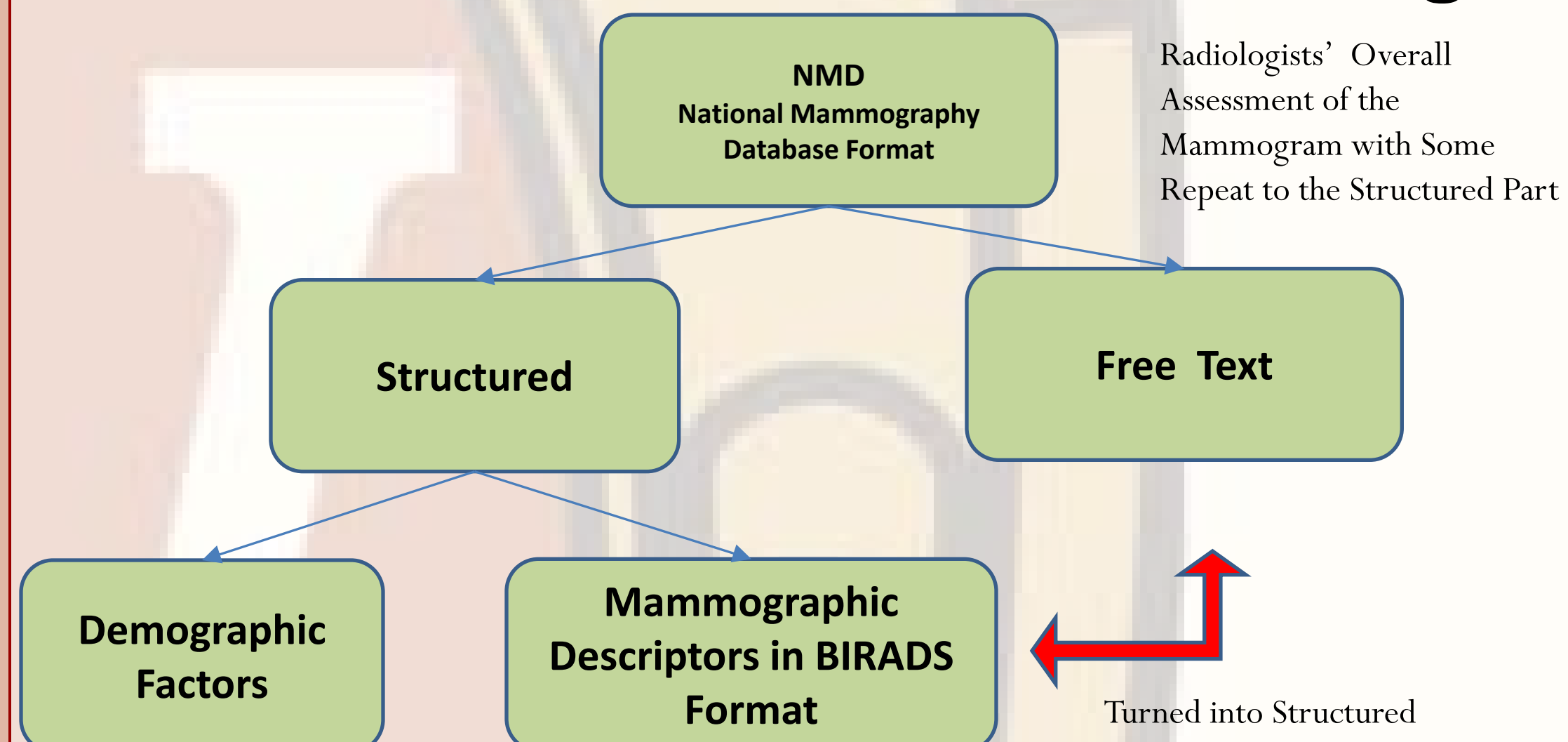


Research Framework



Data & Methods

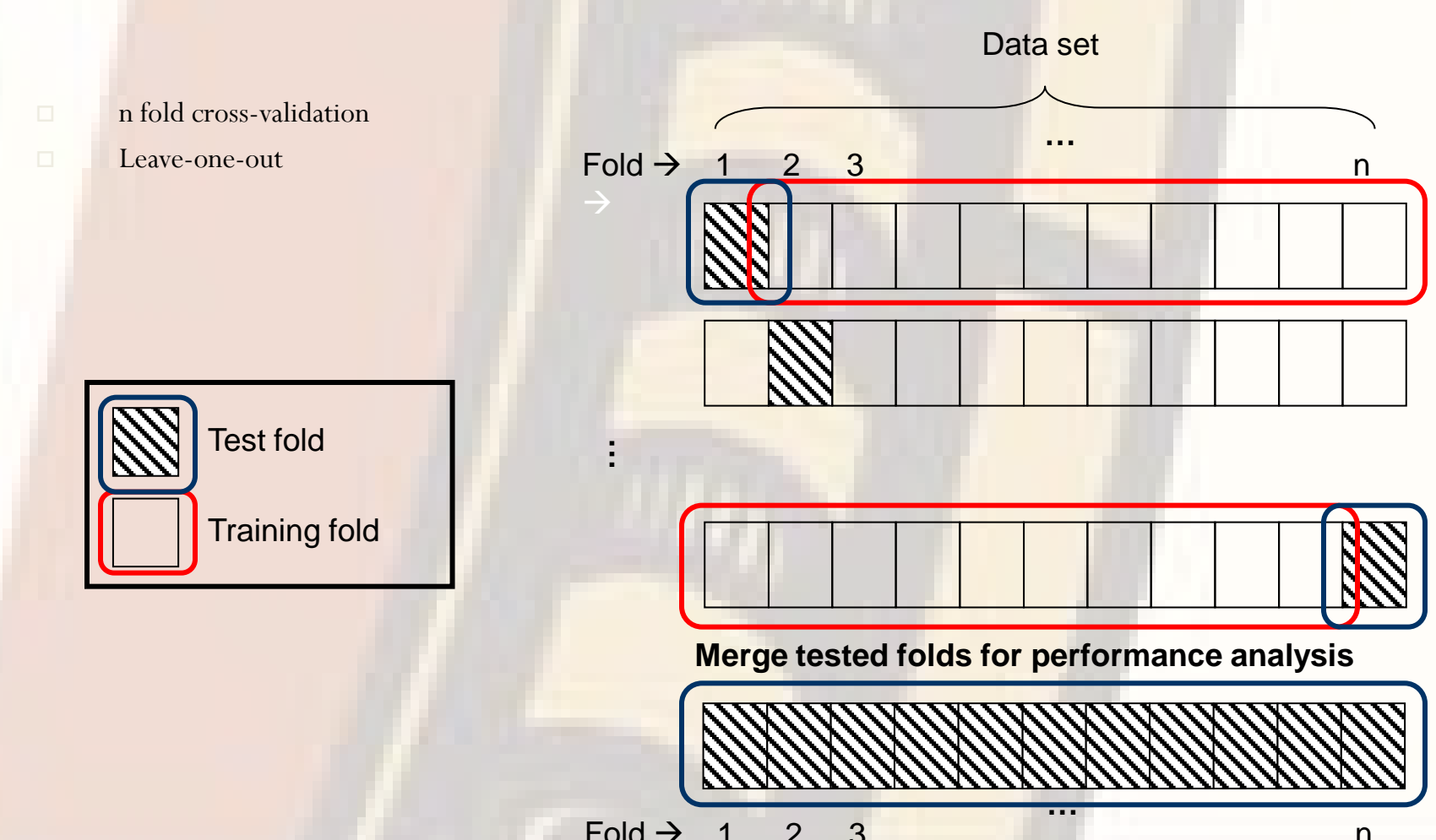
Structure of Data & Processing



Data in Detail

Structured	Free Text
<ul style="list-style-type: none"> • DEMOGRAPHIC <ul style="list-style-type: none"> • Age • Family History • Personal History • Prior Surgery • Palpable Lump • Interpreting Radiologist • Breast Density • Indication for Exam if Diagnostic 	<ul style="list-style-type: none"> • MAMMOGRAPHIC <ul style="list-style-type: none"> • BI-RADS Assessment • Principle Abnormal Finding <ul style="list-style-type: none"> o Architectural Distortion o Calcifications <ul style="list-style-type: none"> o Asymmetry (one view) o Focal asymmetry (two views) o Developing asymmetry o Mass o Single Dilated Duct o Both Calcifications and Something Else
<ul style="list-style-type: none"> • Associated Findings • Calcification Distribution • Calcification Morphology • Mass Margins • Mass Shape • Mass Density • Mass Size • Special Cases • Biopsy 	<ul style="list-style-type: none"> • Skin Retraction, Nipple Retraction, Skin Thickening, Trabecular Thickening, Skin Lesion, Axillary Adenopathy, Architectural Distortion • Clustered, Linear, Regional, Scattered, Segmental, Diffuse • Pleomorphic, Dystrophic, Lucent, Punctate, Vascular, Eggshell, Dermal, Fine-Linear, Round, Popcorn, Milk of Calcium, Rod Like, Suture, Amorphous, • Circumscribed, Obscured, Defined, Microlobulated, Spiculated • Irregular, Lobular, Oval, Round • Fat Containing, Low Density, Equal Density, High Density • <10mm, >10mm and <20mm, >20mm and <50mm, >50mm • Intra-mammary Lymph Node, Tubular Density, Asymmetric Breast Tissue, Focal Asymmetric Density • In situ, Invasive

Cross-Validation



- 1475 Diagnostic Mammograms → 1378 Patients
 - > 1298 patients with single mammogram
 - > 81 patients with two mammograms
 - > 5 patients with three mammograms

- 1063 cases invasive vs. 412 DCIS

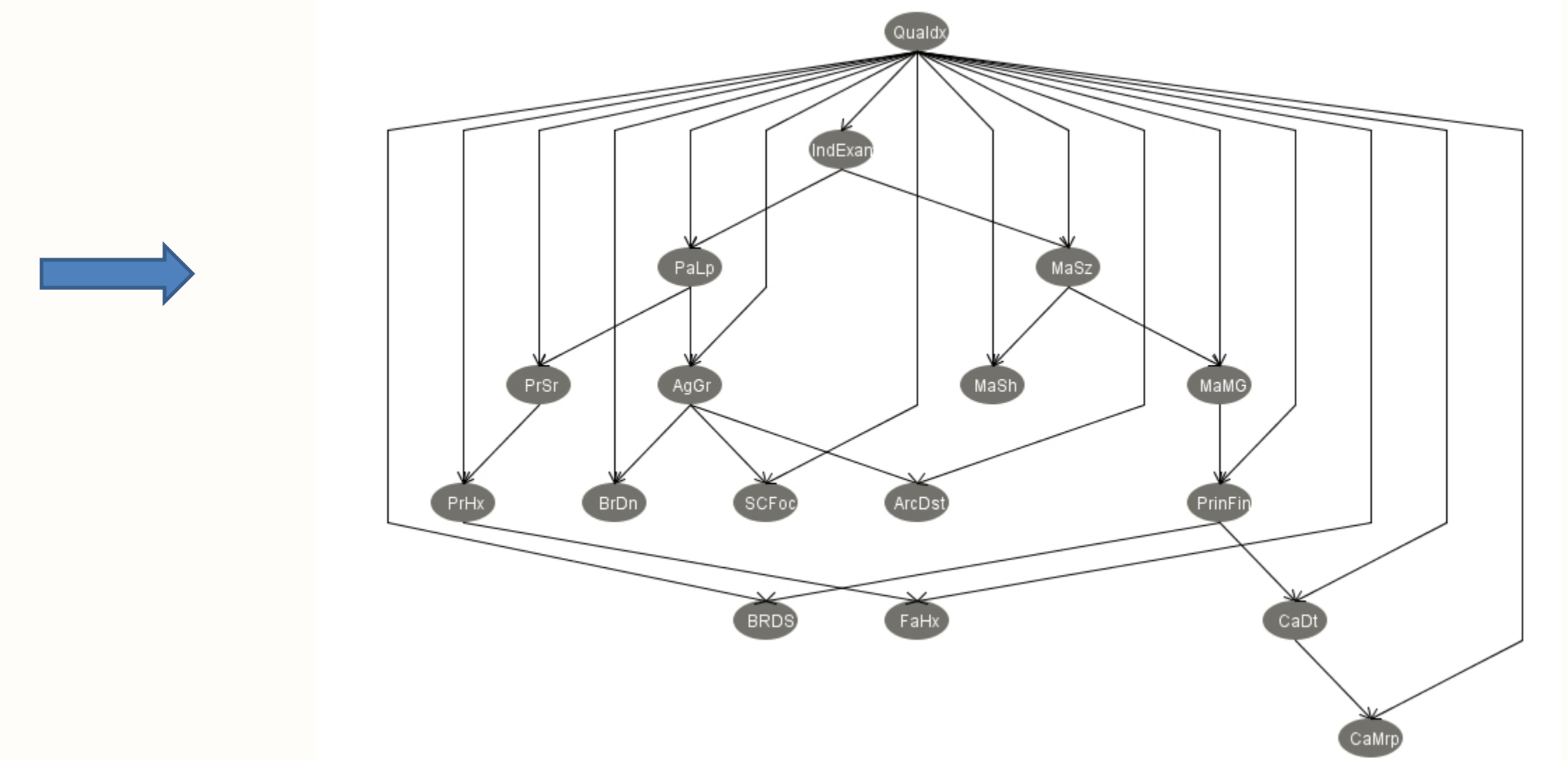
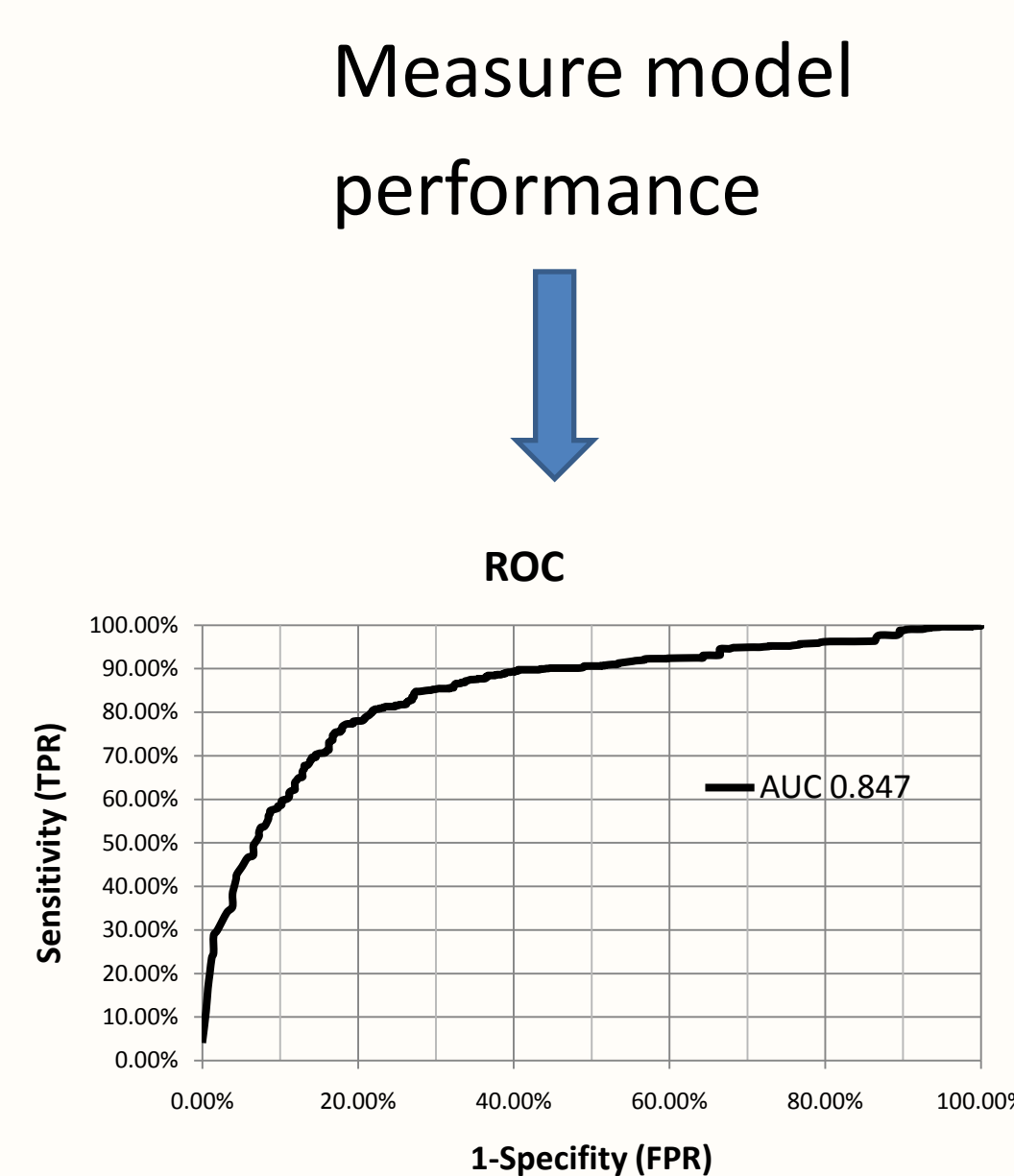
- Age range → 27 to 97 with
 - > Mean 59.7 and standard deviation 13.4

Data Summary

Row Labels	Subject Count	Actual Invasive Count
AgeLT50	374	264
Age5064	568	398
AgeGTE65	533	401
Overall	1475	1063

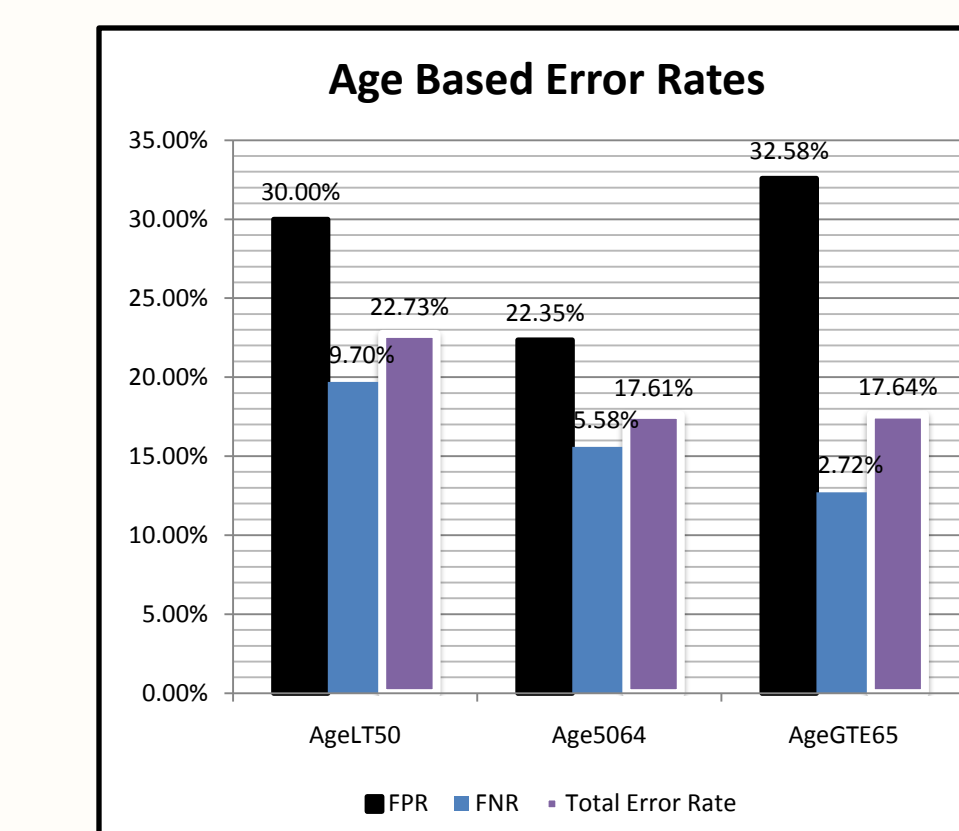
Results & Conclusion

Develop a risk prediction model for prospective differentiation of DCIS versus invasive breast cancer



Measure model performance

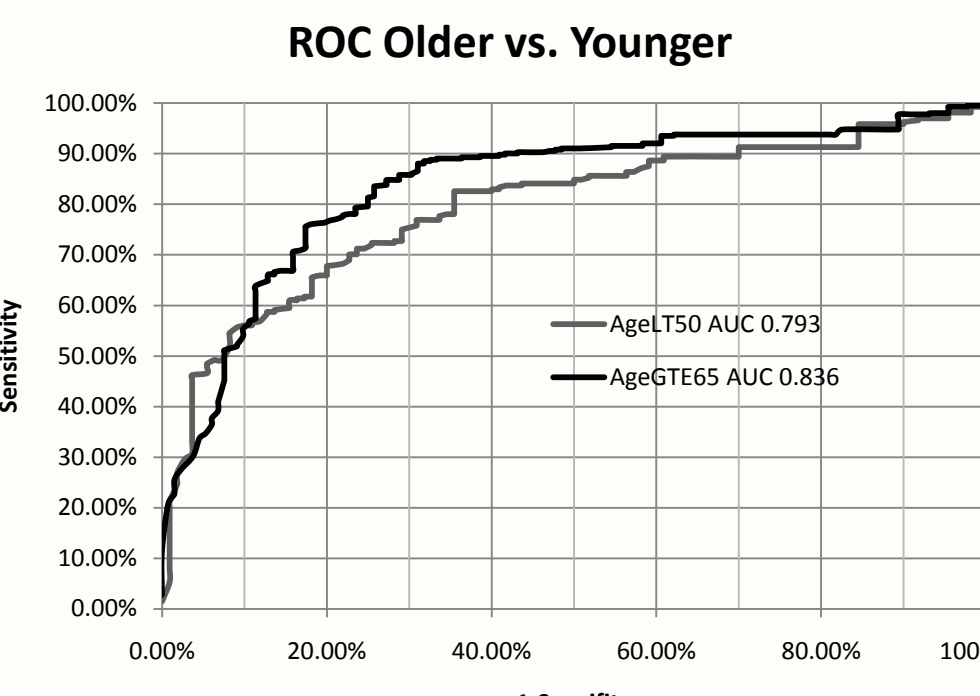
ROC



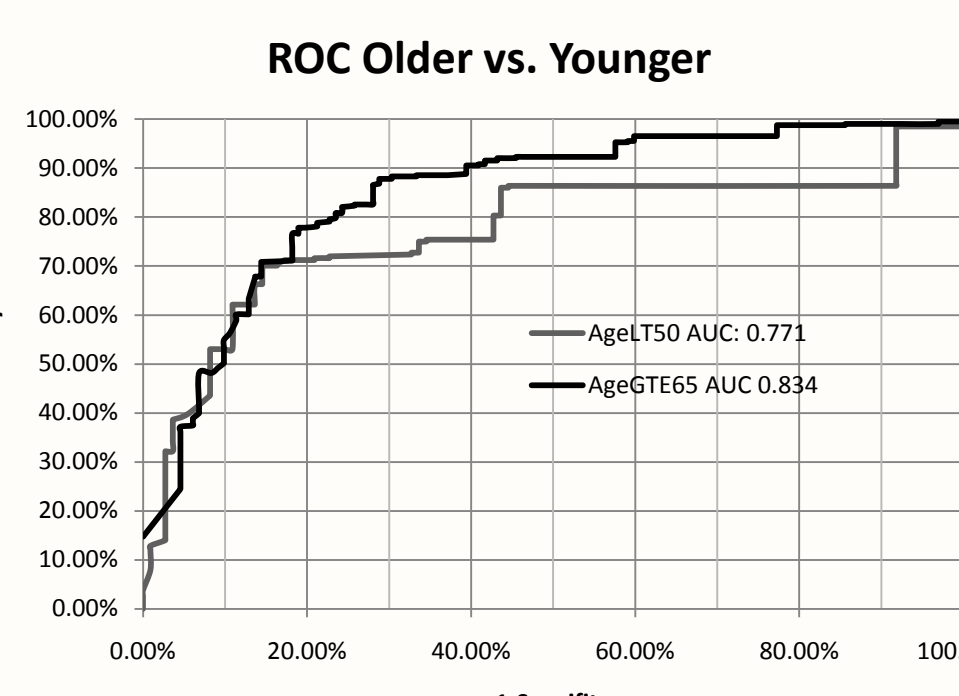
- > Acceptable ROC
- > Decreasing trend in Error rates

Measure and compare model performance for different age groups

With All Variables Included

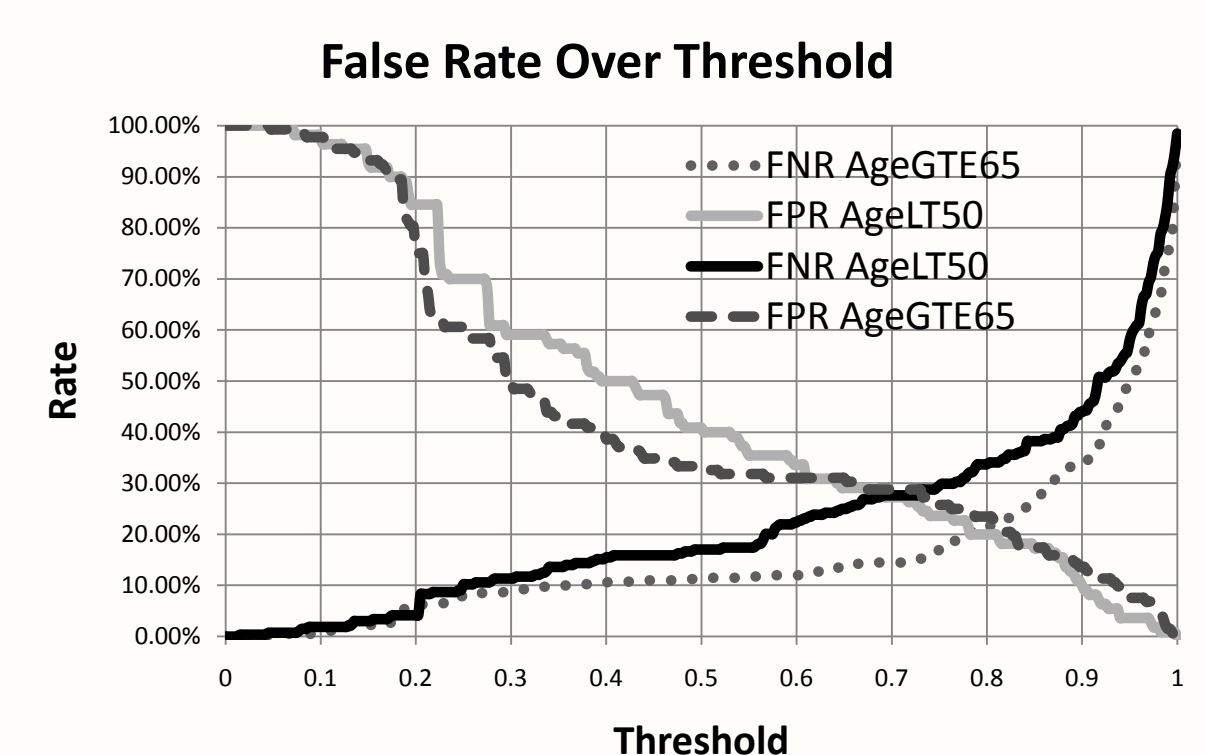


In order to avoid possible over-fitting Used Stepwise Regression to find the significant model



> Difference in AUC = 0.043
With p-value = 0.112

> Difference in AUC = 0.063
With p-value = 0.041



- > Improvement in False Negative Rates

Conclusion

- > Mammography is not perfect and performs better in older women.
- > There is a need for discriminating between invasive and DCIS to better manage the breast disease in the context of age and other comorbidities
- > An age based risk prediction model for assessing performance difference in discriminating invasive vs. DCIS is necessary
- > Such a model would enable physicians to make more informed decisions
- > Demonstration of performance difference and varying risk factors in different age cohorts justifies personalized treatment/management of invasive disease when biopsy decision is made