Modeling Prioritization of Health Care for Complex Patients Using Archimedes

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Complex Patients Require Complex Treatments

- Optimize Treatment
  - There are many interventions; which should be done first?
- Diminishing Returns
  - How many interventions is too many?
- Optimizing Prevention and Healthcare Management for the Complex Patient FOA

Diabetes – complex patients

- There are several other health conditions that often accompany a diabetes diagnosis
  - Hypertension
  - Hypercholesterolemia
  - Poorly controlled blood sugars
  - High BMI
  - Smoking
- What is the best course of action for a patient with multiple health risks?

Diabetes – Global Burden of Disease

	Number of people (thousands)		Prevalence (percent)		Direct medical costs, 2003 (US$ million)			
Region	**2003**	**2025**	**2003**	**2025**	**Low estimate**	**High estimate**	**Deaths, 2001 (‘000)**	**DALYS 2001 (‘000)**
Developing countries	140,849	264,405	4.5	5.9	12,304	23,127	757	15,804
Developed countries	53,337	68,345	7.8	9.2	116,365	217,760	202	4,192
World	194,186	332,750	5.1	6.3	128,669	240,887	959	19,996

Modeling Outcomes in Diabetes

- There are several computer models available that predict health outcomes
- Most use clinical information and clinical trial outcomes to model disease outcomes
- Mount Hood Challenge

The Fourth Mount Hood Challenge, 2004

- Challenges
  - Simulate a clinical trial of type 2 diabetes (CARDS [Collaborative Atorvastatin Diabetes Study])
  - Simulate a clinical trial of type 1 diabetes (DCCT [Diabetes Control and Complications Trial])
  - Calculate outcomes for a hypothetical, precisely specified patient prototype

The Fourth Mount Hood Challenge, 2004

- 8 modeling groups
  - Cardiff Diabetes Model (discrete event)
  - Sheffield Diabetes Model
  - UKPDS Outcomes Model (discrete event)
  - UKPDS Risk Engine (regression equation)
  - EAGLE (Monte Carlo)
  - CORE Diabetes Model (Monte Carlo)
  - CDC/RTI Type 2 Diabetes Progression Model
  - Archimedes

Prototype - **Mount Hood Patient 3**

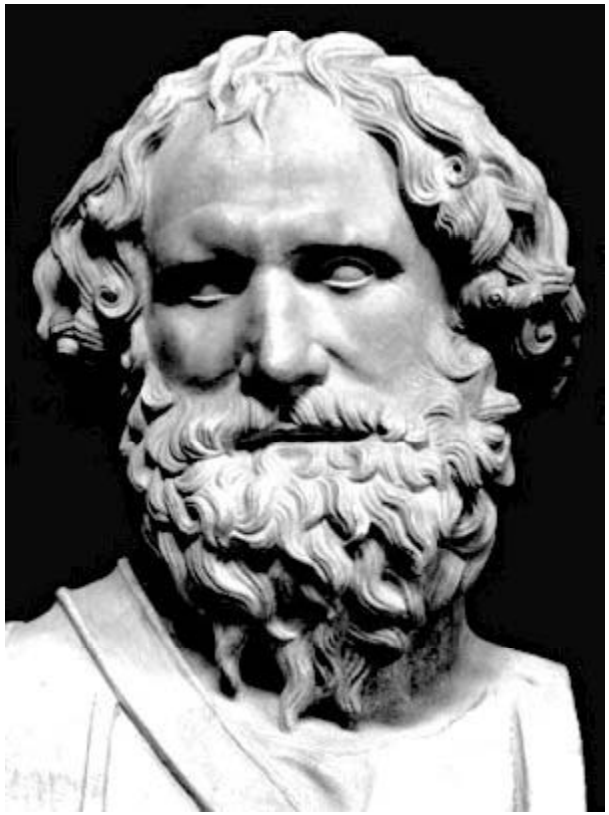
- **Demographics Values**
  - Sex = Male
  - Race = White European
  - Age = 65 y
  - Hx of T2 DM = 5 years
- **Biological Risk Factors Values**
  - HbA1c = 10%
  - LDL = 120
  - HDL = 45
  - Triglycerides = 200
  - Total cholesterol = 205
  - Systolic BP = 140
  - Diastolic BP = 90
  - BMI = 27
- **Treatments/BehaviorsValues:**
  - Tobacco use = No
  - Prophylactic aspirin use = No
  - Intensive nutrition therapy =No
  - Intensive exercise therapy = No
  - ACE inhibition = No
- **History of Complications Values:**
  - Myocardial infarction = No
  - Other CVD = No
  - Diabetic retinopathy = No
  - Microalbuminuria = No

Collaborative Atorvastatin Diabetes Study (CARDS) Simulation Results

Study		Coronary Event	Stroke
CARDS	C	5.1	3.2
	I	3.2	1.4
Cardiff	C	6.7	2.5
	I	4.5	2.2
Sheffield	C	7.8	3.9
	I	5.7	3.5
UKPDS	C	5.3	2.3
	I	3.6	2.0
UKPDS R.E.	C	8.0	2.9
	I	5.2	2.5
EAGLE	C	3.9	0.8
	I	--	--
CORE	C	6.4	2.0
	I	4.5	1.7
CDC/RTI	C	6.4	1.7
	I	4.3	1.5
Archimedes	C	5.4	3.2
	I	3.4	2.7

Archimedes

- How it works
  - Object oriented programming
  - Differential equations to represent biological information
    - Anatomy and [patho]physiology
    - Signs and symptoms
    - Treatment
    - Behaviors and logistics
    - Treatments
- Diabetes PhD - a simplified version, is available on a public website through the American Diabetes Association



Outline of the Research

- Create simulated patient prototypes with varying severities of hypertension, dyslipidemia, glucose control, etc.
- Determine their risk of specified outcomes expected at 10, 20 and 30 years
- Compare the outcomes of patients with better prototypes to the patients with worse prototypes
- Determine the risk reduction for different interventions

Implications

- Pre-policy analysis
  - What if?
- Clinical
  - Competing demands
  - League Tables

As an example, below is the league table for the National Hockey League's Northeast Division, as of March 31, 2004:

Team	GP	W	L	T	OL	GF	GA	Pts
x-Boston	79	40	18	14	7	201	179	101
x-Toronto	80	43	24	10	3	234	204	99
x-Ottawa	79	41	22	10	6	254	178	98
x-Montreal	79	40	28	7	4	201	182	91
Buffalo	79	36	32	7	4	213	210	83

x - clinched playoff spot
y - clinched division championship

Patient Prototype

Patient Prototype Variables	
VARIABLE	**VALUES**
Gender	Male, female
Age	40, 50, 60, 70, 80
Race, ethnicity	WNH, H, B, A, AI
BMI	25, 27, 30, 35
Systolic BP / Diastolic BP	130/80, 140/90, 160/100, 180/110
LDL	70, 100, 130, 160, 190
HDL	30, 40, 50, 60
Triglycerides	100, 150, 300, 500
Cholesterol	Calculated
HbA1c	7, 8, 9, 10, 12
Smoking	Current, past, never
Physical activity	Sedentary, light, moderate, vigorous
Conditions, macrovascular	None, MI, Stroke, [Angina, bypass, angioplasty/stent], heart failure
Conditions, microvascular eye	None, retinopathy, blindness due to diabetes, laser surgery
Conditions, microvascular renal	None, microalbuminuria, proteinurea, dialysis/renal or transplant
Conditions, vascular extremities	None, foot ulcers, partial foot amputation, above foot amputation

Interventions

VARIABLE	VALUES
Tobacco use cessation	Yes, no
Physical activity	Sedentary, light, moderate, vigorous
Intensive dietary modification (BMI)	25, 27, 30
Systolic BP / Diastolic BP goals	130/80, 140/90, 160/100
LDL	70, 100, 130, 160
HDL	40, 50, 60
Triglycerides	150, 300, 500
Angiotensin II Receptor Blockers	Yes, no
Aldosterone Receptor Blockers	Yes, no
Alpha Blockers	Yes, no
Beta blocker	Yes, no
Calcium Channel Blockers	Yes, no
Combined Alpha and Beta Blockers	Yes, no
Diuretics	Yes, no
Alpha-Glucosidase Inhibitors	Yes, no
Biguanides	Yes, no
Meglitinides	Yes, no
Sulfonylureas	Yes, no
Insulin	Yes, no
HMG-CoA Reductase Inhibitors	Yes, no

Output variables

Risk (10, 20, 30 years)

- MI
- Stroke
- Renal failure
- Blindness
  - Eye problems, i.e., Retinopathy
- Amputation
  - Foot problems, i.e., foot ulcers

Challenges

- Amount of time required for data input and collection - iMacro
- Variation in calculated risks based on the same inputs
  - Diabetes PHD applies the input values to a hypothetical 1,000 pt cohort and yields a mean
  - Some parts of the model are probabilistic
  - It is only feasible to run each prototype once
- Possible combinations
  - Basic prototypes – 69,120
  - Interventions – 109,276
  - Total - 7,553,157,120

Simulated patient

- All prototypes were 50 year-old white males with a 4 year history of Type 2 diabetes

- Prototype variable values:
  - BP: 130/80, 180/110
  - LDL: 70, 190
  - HDL: 30, 60
  - Triglyceride: 100, 500
  - A1c: 7%, 12%
  - BMI: 25, 35
  - Smoker (16yo), non-smoker, former smoker (just quit)
  - Sedentary, vigorous exercise

Interventions

- Screening [eye (E) and foot (F)] (scr)
- Aspirin (ASA)
- Beta blocker (BB)
- Angiotensin converting enzyme inhibitor (ACE)
- Rosuvastatin [Crestor] (ST)

- Smoking cessation
- Sedentary -> Vigorous exercise

Intervention combinations

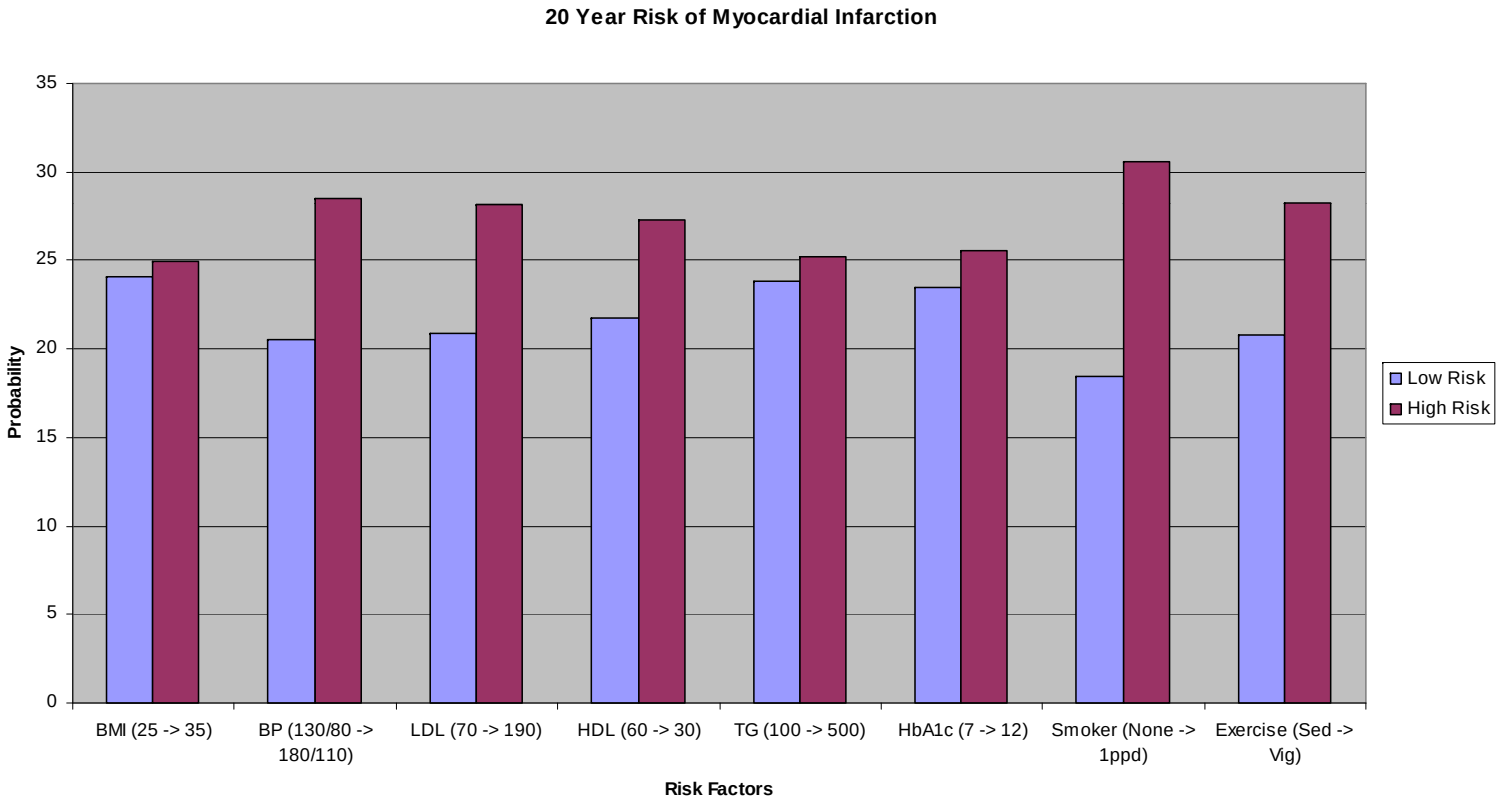
- F/E/ASA/ACE
- F/E/ASA/BB
- F/E/ACE/BB
- F/E/ASA/ACE/BB
- F/E/ST
- F/E/ASA/ST
- F/E/BB/ST
- F/E/ACE/ST
- F/E/ASA/ACE/ST
- F/E/ASA/BB/ST
- F/E/ACE/BB/ST
- F/E/ASA/ACE/BB/ST

(12 from possible 27)

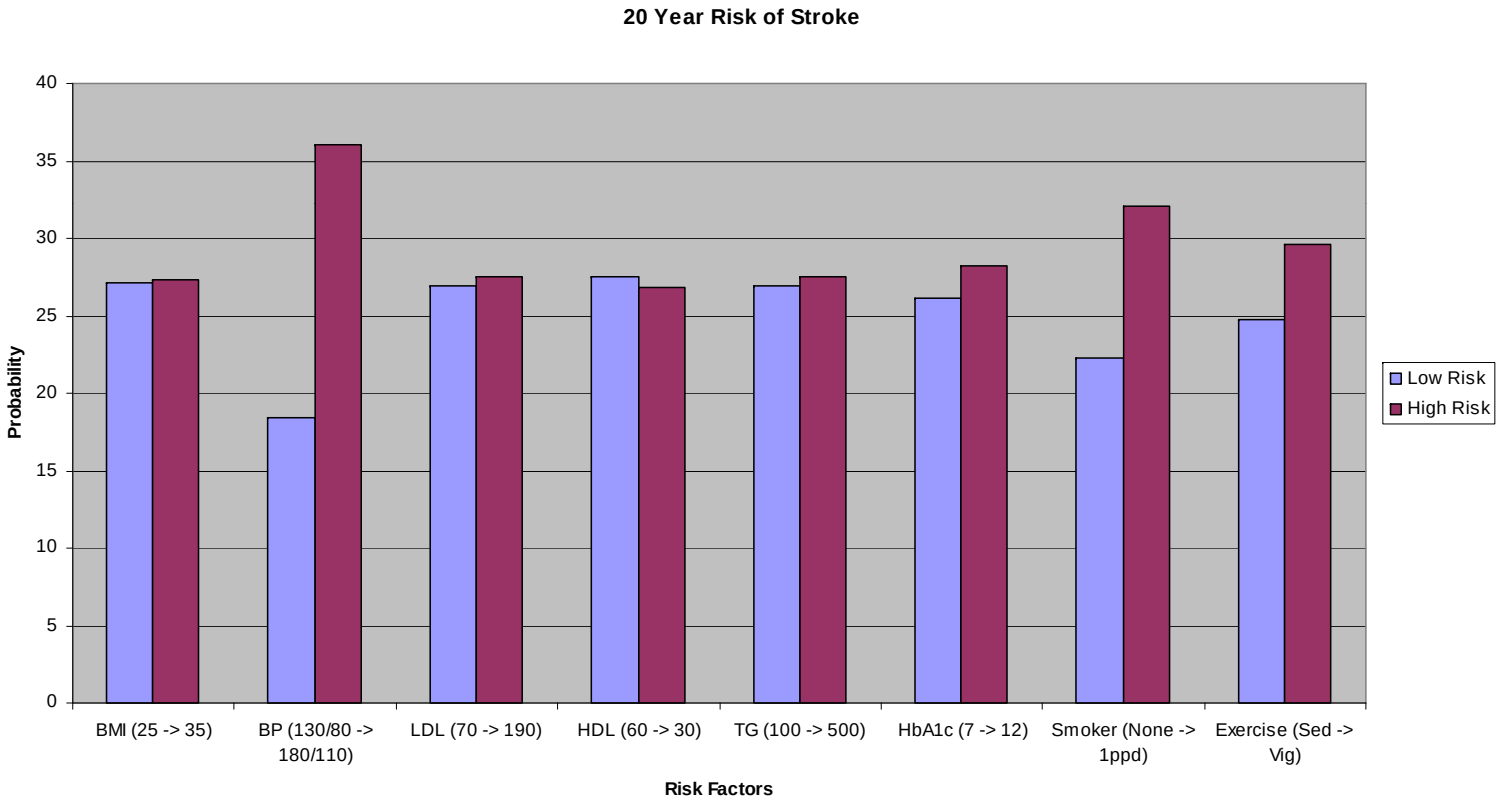
Analysis

- To begin, we used symmetrical data with only high and low values for each variable
- We examined each outcome variable independently and determined the risk for each input variable
- Compared risks for all prototypes for each outcome
- 20 year risks are presented prototype variables
- 10, 20, 30 year risks are presented for interventions

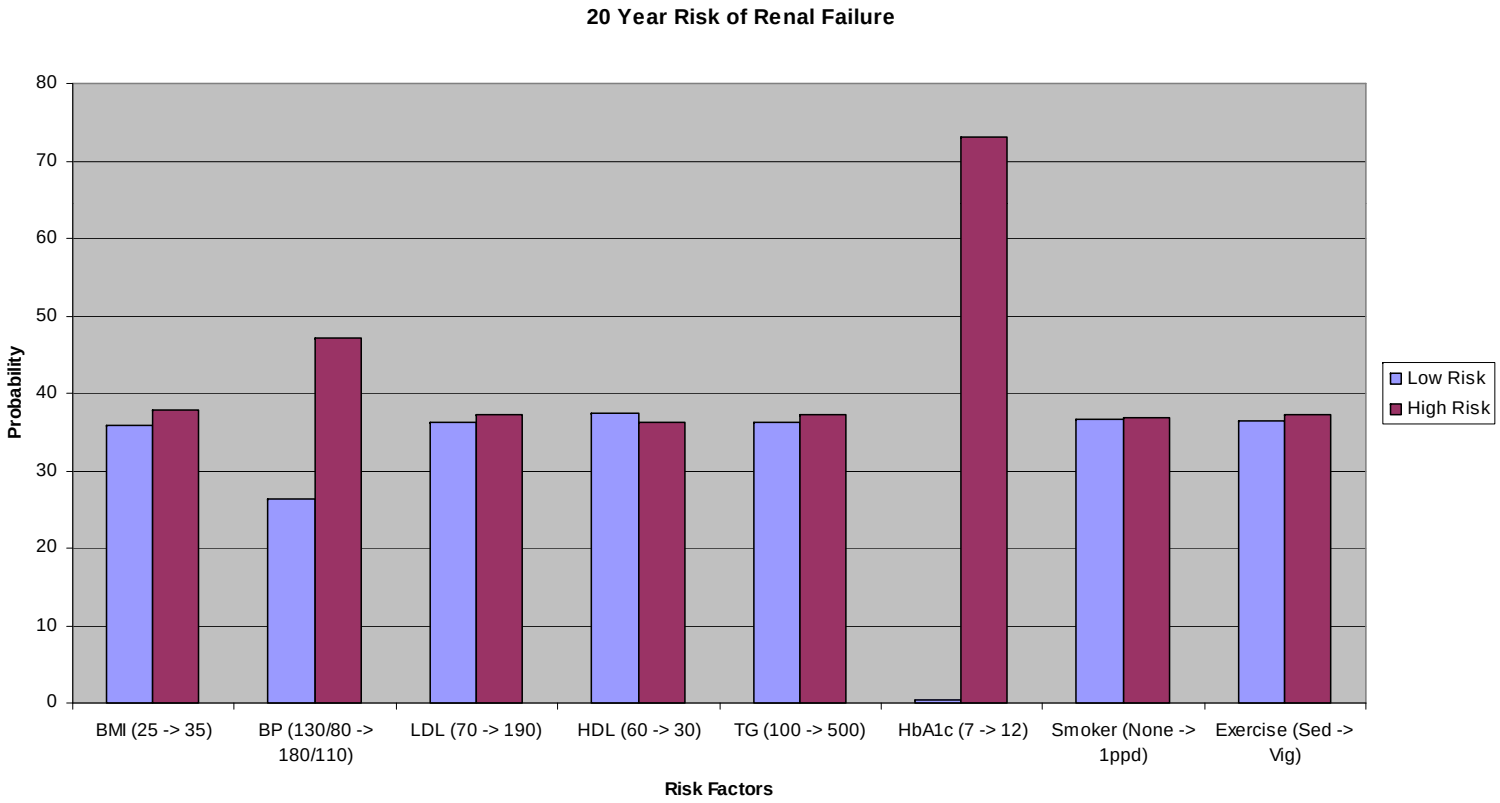
Risk of Myocardial Infarction



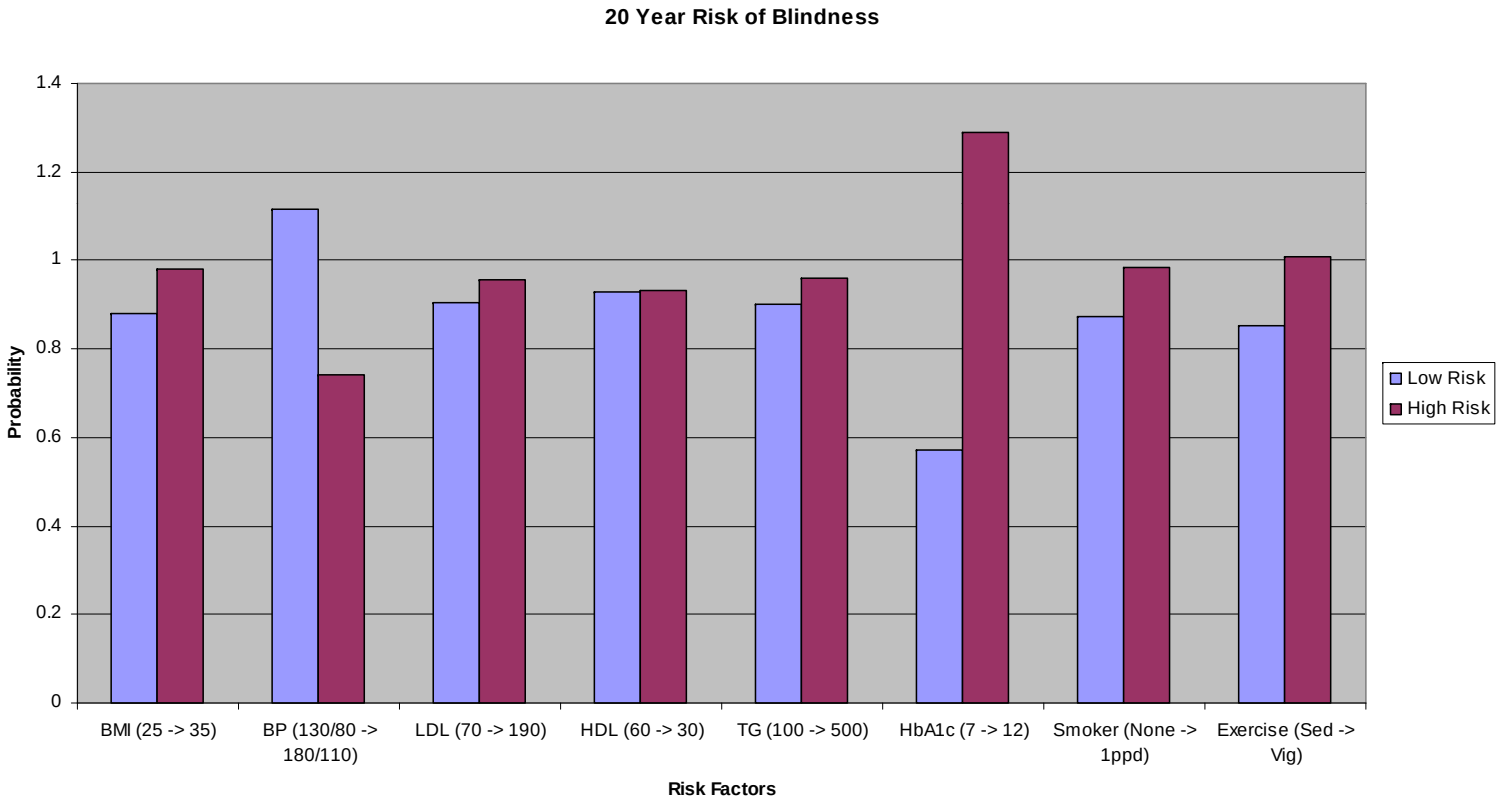
Risk of Stroke



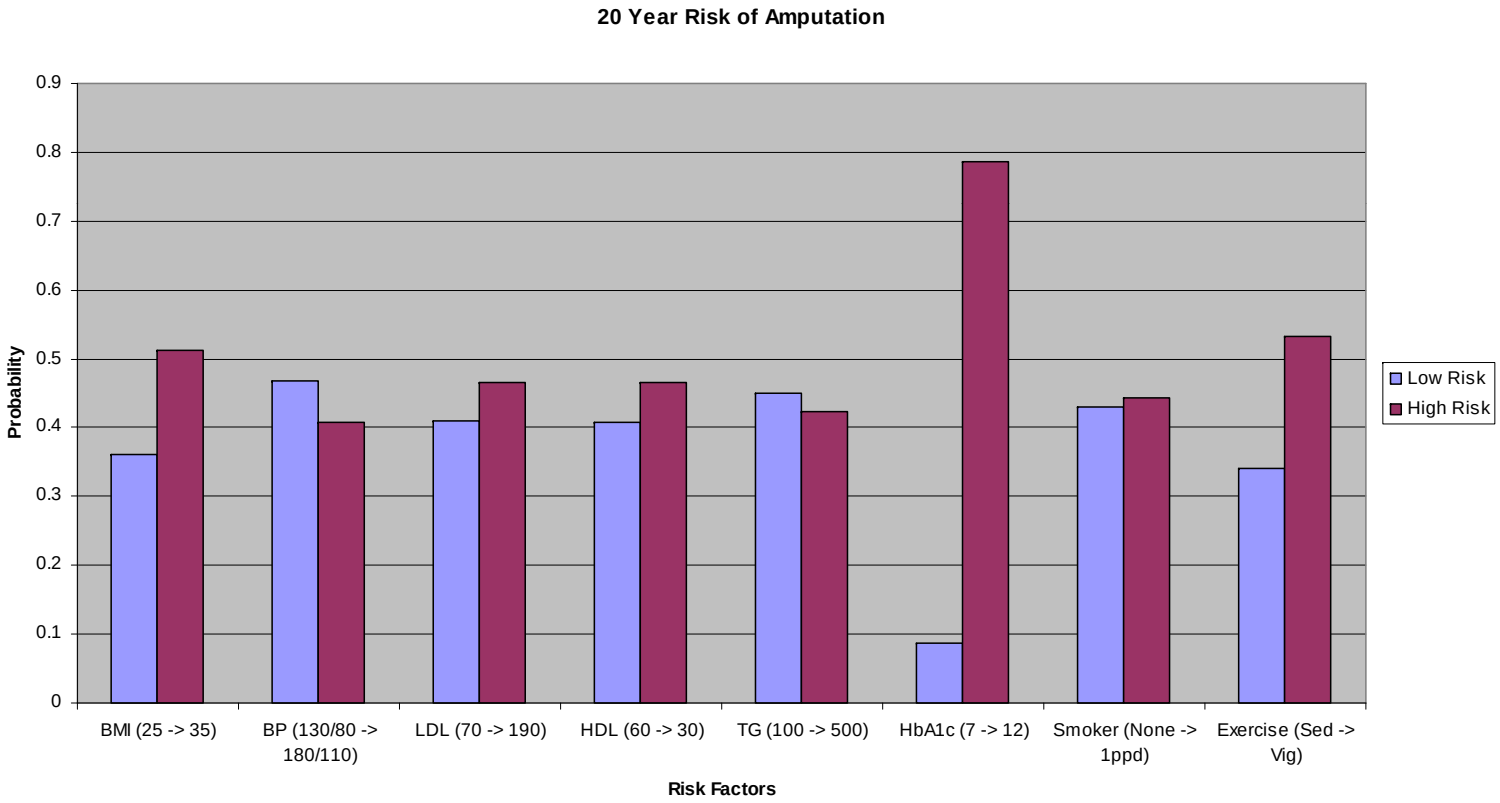
Risk of Renal Failure



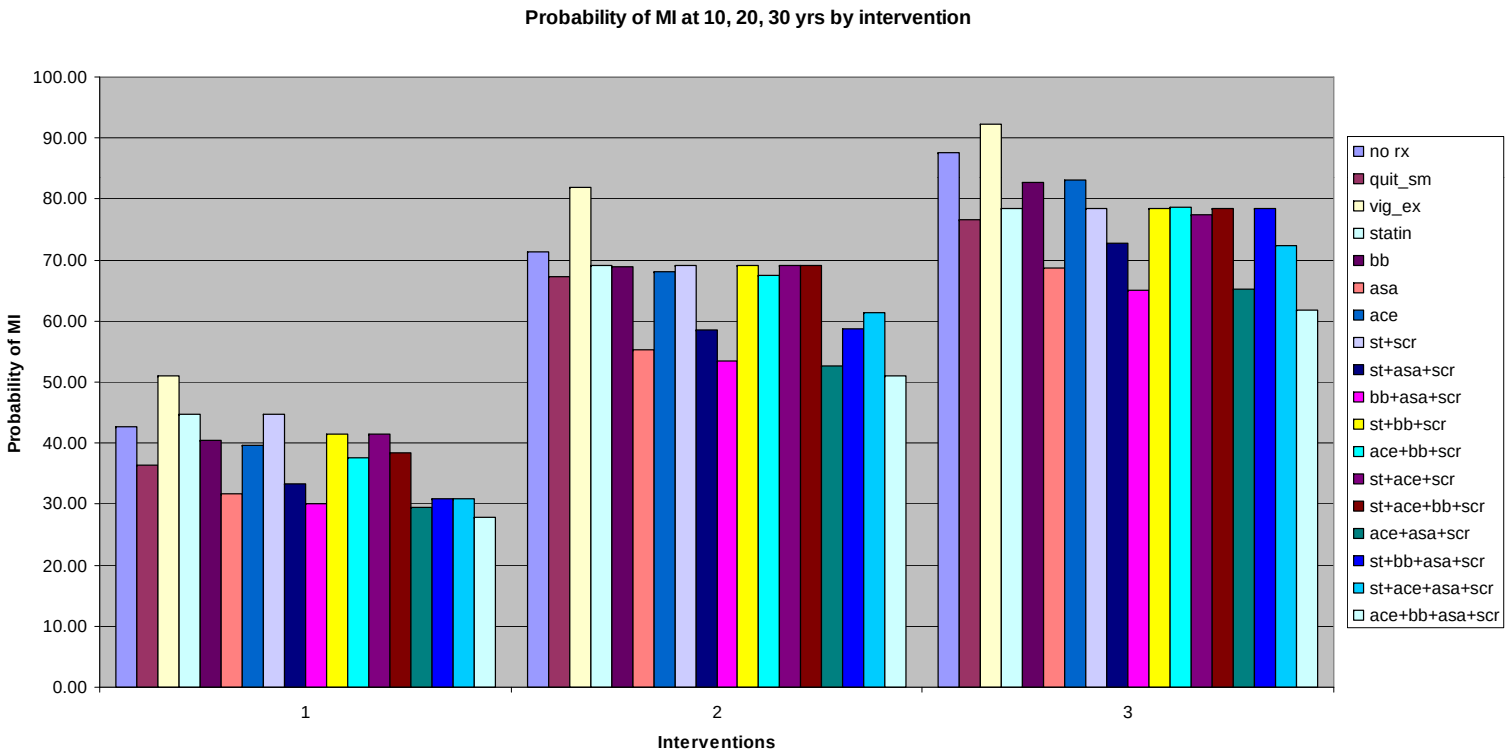
Risk of Blindness



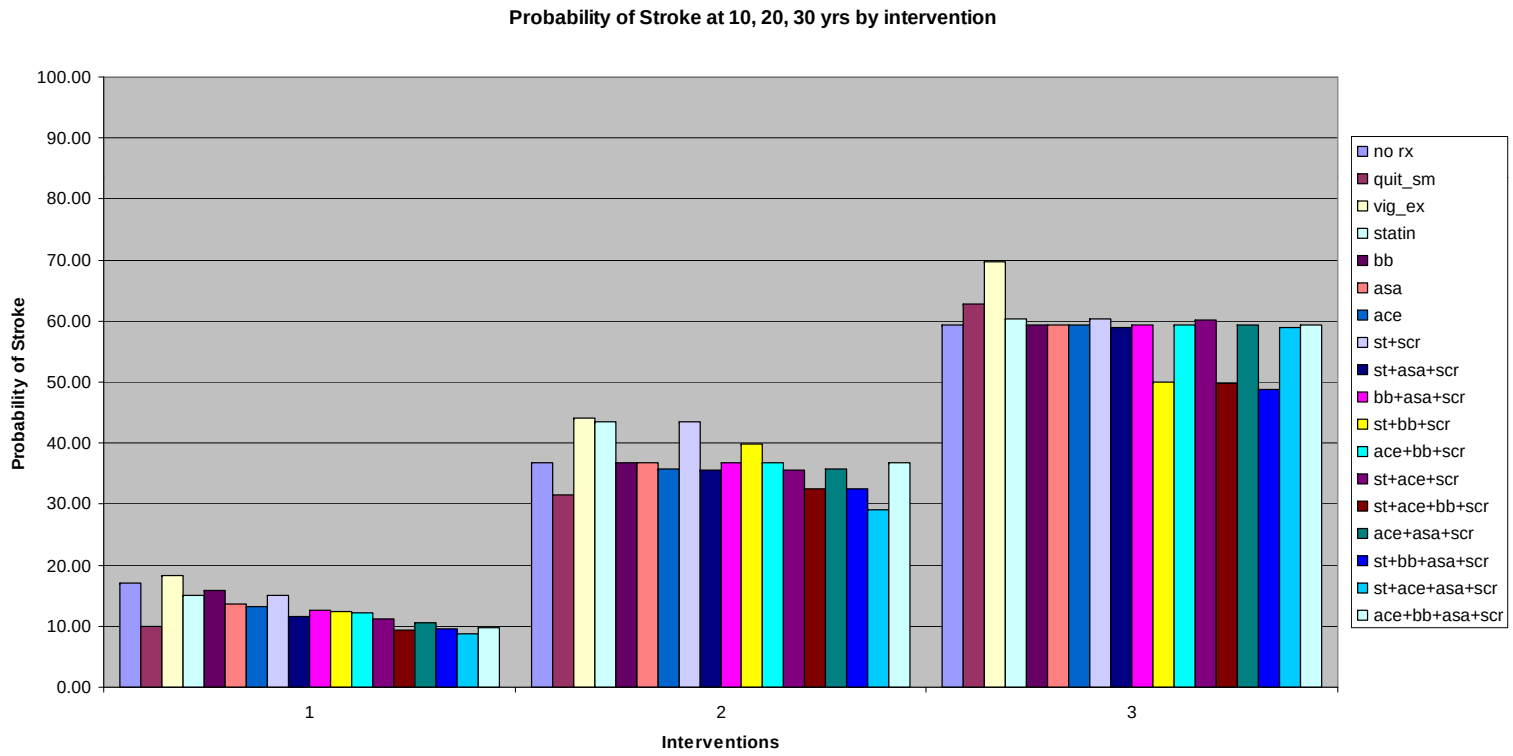
Risk of Amputation



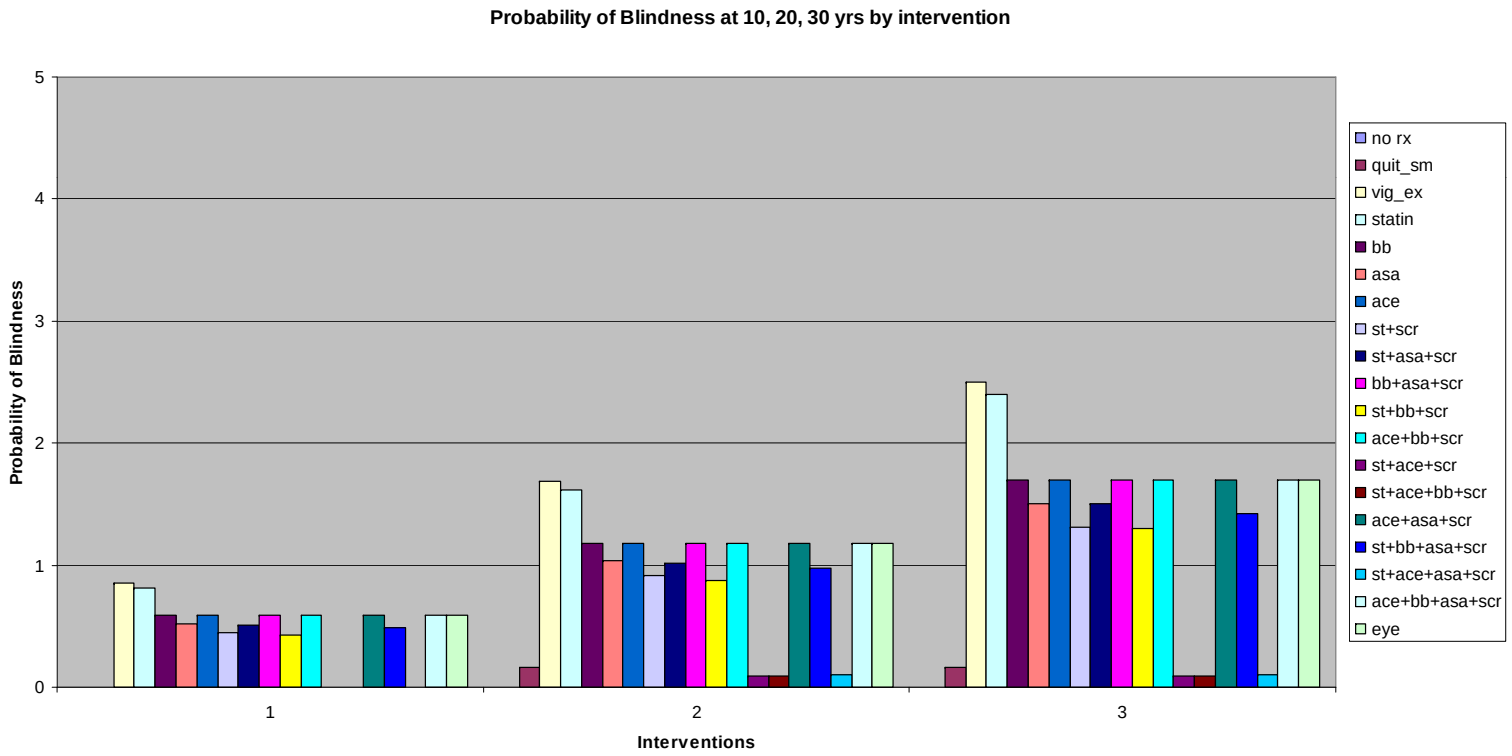
Risk of Myocardial Infarction by Intervention



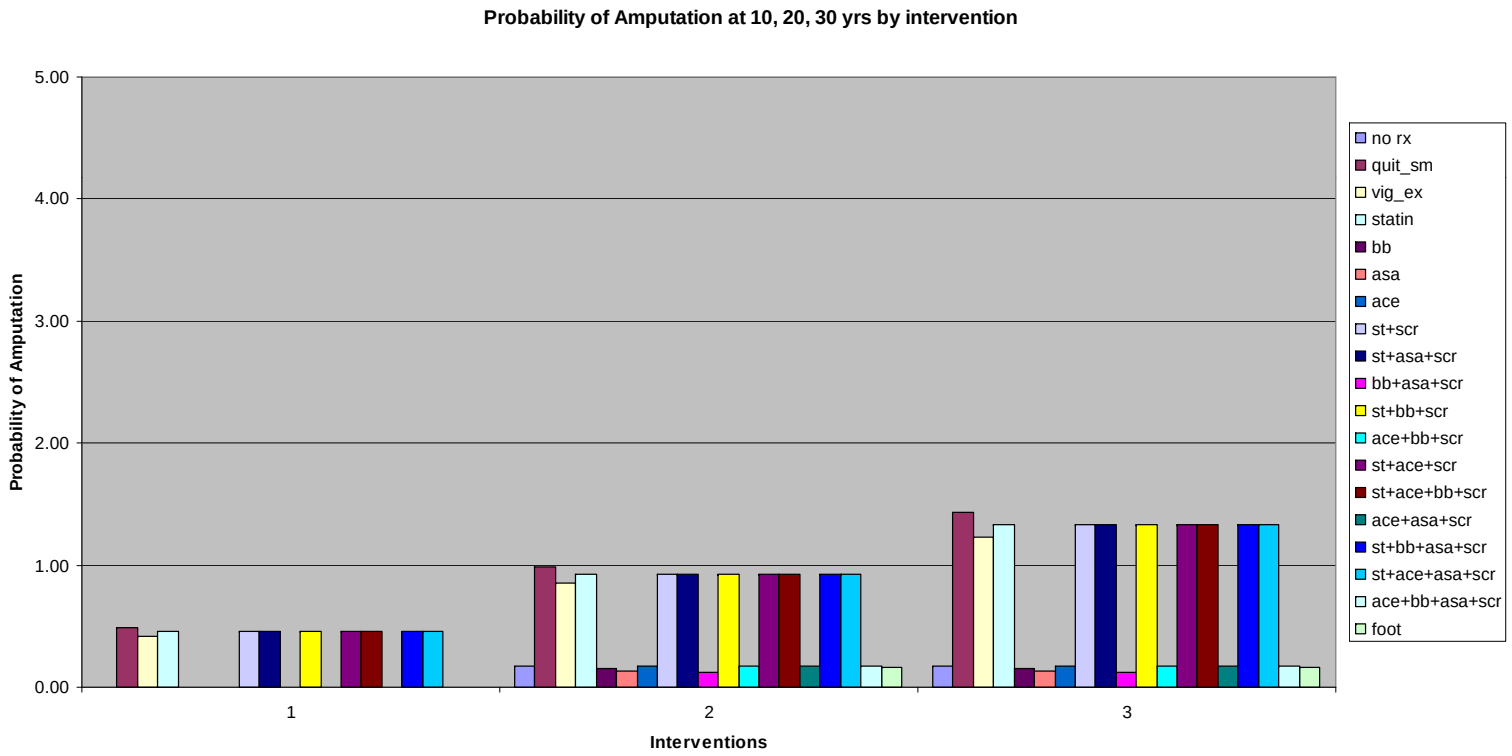
Risk of Stroke by Intervention



Risk of Blindness by Intervention



Risk of Amputation by Intervention



Future Steps

- Exercise: low and intermediate
- Outcomes when complications are present
- Outcomes for the older patients
- Data reduction?
  - Compare gender, race, Hi/Low?

Questions?