Deriving Treatment Policies for Prostate Cancer Patients using Optimal Policy Trees

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Motivation

13 in every 100

Americans will get prostate cancer during their lifetime*

* https://www.cdc.gov/cancer/prostate/basic_info/risk_factors.htm

34,500 deaths

estimated in the US in 2022 alone*

* https://cancer.ca/en/cancer-information/cancer-types/prostate/statistics

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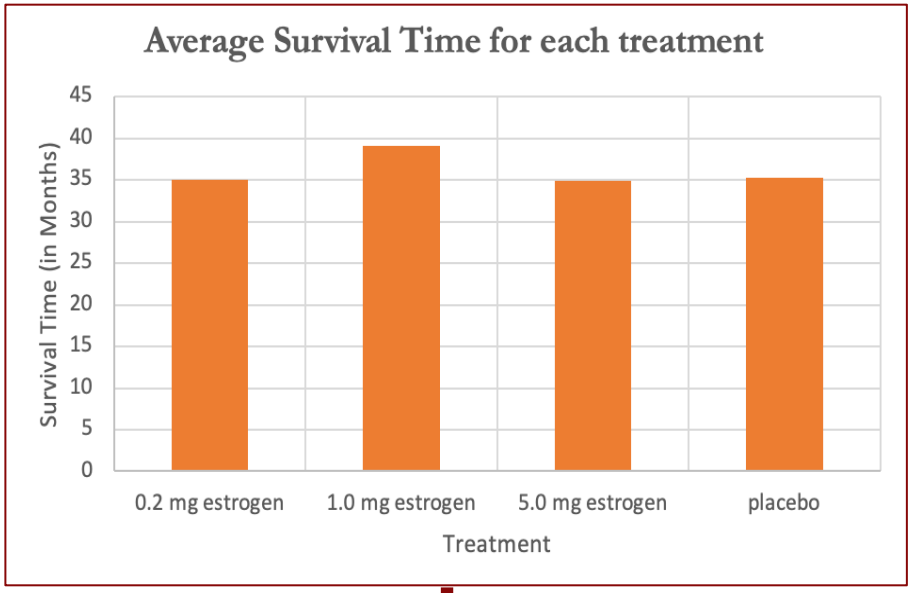
* https://www.cancer.org/cancer/prostate-cancer/about/key-statistics.html



Ineffective Treatment?

The Problem

"There may be an optimal treatment for each patient based on his individual characteristics"

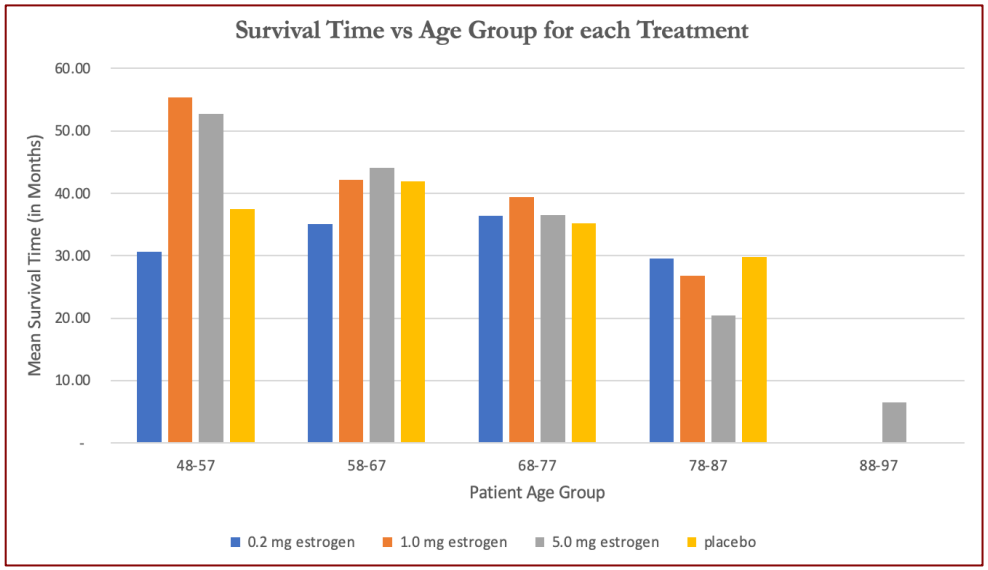
~ D P Byar, S B Green[1]

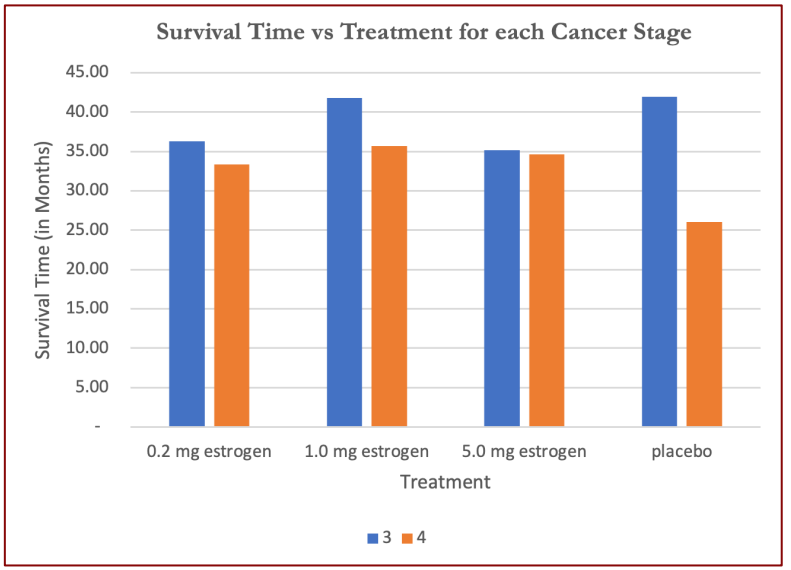
Treatment

Personalized Treatment

Optimal Personalized Treatment

The Data





PatNo	Stage	Treatment	Survival	Status	Age	Weight	pf	hx	sbp	dbp	ekg	hg	sz	sg	ap	bm	sdate	died
1	3	0.2 mg estrogen	72	alive	75	76	normal activity	0	15	9	heart strain	13.79882813	2	8	0.299987793	0	2778	0
2	3	0.2 mg estrogen	1	dead - other ca	54	116	normal activity	0	13	7	heart block or conduction def	14.59960938	42		0.699951172	0	2820	1
3	3	5.0 mg estrogen	40	dead - cerebrovascular	69	102	normal activity	1	14	8	heart strain	13.3984375	3	9	0.299987793	0	2933	1
4	3	0.2 mg estrogen	20	dead - cerebrovascular	75	94	in bed < 50% daytime	1	14	7	benign	17.59765625	4	8	0.899902344	0	2999	1
5	3	placebo	65	alive	67	99	normal activity	0	17	10	normal	13.3984375	34	8	0.5	0	3002	0
6	3	0.2 mg estrogen	24	dead - prostatic ca	71	98	normal activity	0	19	10	normal	15.09960938	10	11	0.599975586	0	3086	1
7	3	placebo	46	dead - heart or vascular	75	100	normal activity	0	14	10	benign	13	13	9	0.799926758	0	3099	1
8	3	placebo	62	alive	73	114	normal activity	1	17	11	heart strain	12.59960938	3	9	0.599975586	0	3100	0
9	3	1.0 mg estrogen	61	alive	60	110	normal activity	0	12	8	normal	14.59960938	4	10	0.699951172	0	3134	0
10	3	1.0 mg estrogen	60	alive	78	107	normal activity	1	13	8	old MI	13	21	6	0.399963379	0	3140	0
11	3	1.0 mg estrogen	60	alive	77	89	normal activity	0	15	8	normal	15.59960938	3	8	0.599975586	0	3141	0
12	3	5.0 mg estrogen	59	alive	74	105	normal activity	1	18	14	normal	13.59960938	6	8	0.399963379	0	3176	0
13	3	0.2 mg estrogen	59	alive	74	107	normal activity	0	14	9	old MI	14.3984375	6	9	0.299987793	0	3183	0
14	3	placebo	49	dead - prostatic ca	55	112	normal activity	1	16	9	heart strain	13.8984375	4	9	1	0	3183	1
15	3	5.0 mg estrogen	20	dead - cerebrovascular	73	88	normal activity	0	19	10	heart strain	12	15	10	0.599975586	0	3196	1
16	3	5.0 mg estrogen	3	dead - heart or vascular	87	81	in bed < 50% daytime	1	17	12	rhythmic disturb & electrolyte ch	13.3984375	3	9	0.399963379	0	3196	1
17	3	placebo	58	alive	64	90	normal activity	0	14	8	normal	16.19921875	6	9	0.699951172	0	3218	0
18	3	1.0 mg estrogen	29	dead - pulmonary embolus	79	104	normal activity	0	13	8	benign	15	5	8	0.5	0	3230	1
19	3	5.0 mg estrogen	26	dead - heart or vascular	62	90	normal activity	1	13	8	benign	14.3984375	2	9	0.699951172	0	3386	1
20	3	5.0 mg estrogen	52	alive	74	107	normal activity	0	13	8	heart strain	16.3984375	10	9	0.699951172	0	3400	0

Table: Details for 20 patients in the dataset with the prescribed treatment

Approach

1

Counterfactual Estimation

Direct Method
Inverse Propensity
Doubly Robust

2

Training Optimal Policy Trees

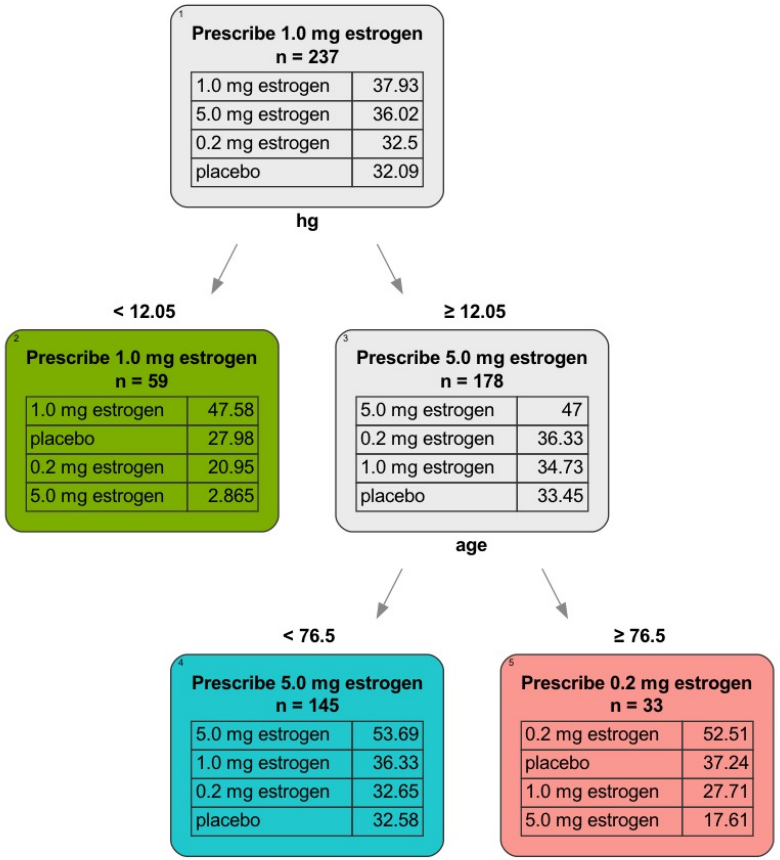
Grid Search + CV
Harrell C-Statistic

3

OCTs and Subset Analysis

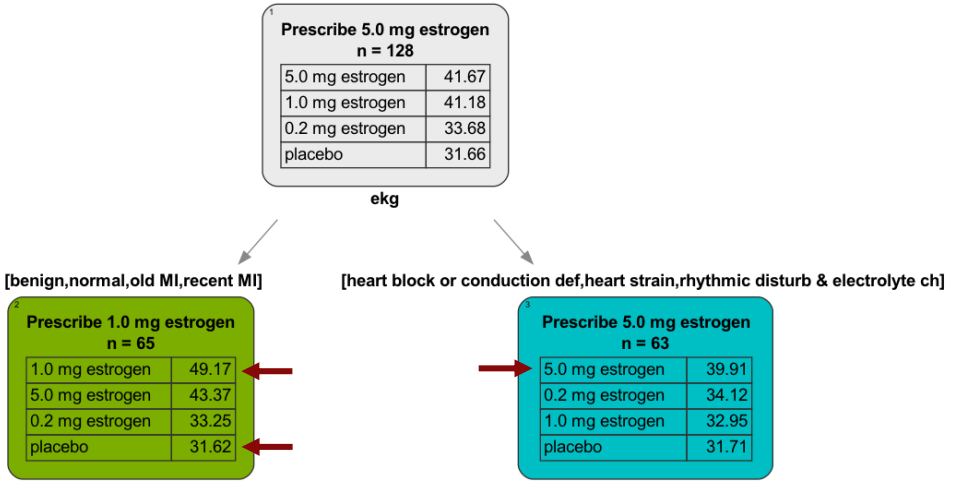
Where does OPT perform well?

Insights



Older patients harmed by stronger treatments

(Doubly Method)



Prescribe 5.0 mg estrogen for severe cases

(Patients with large tumors)