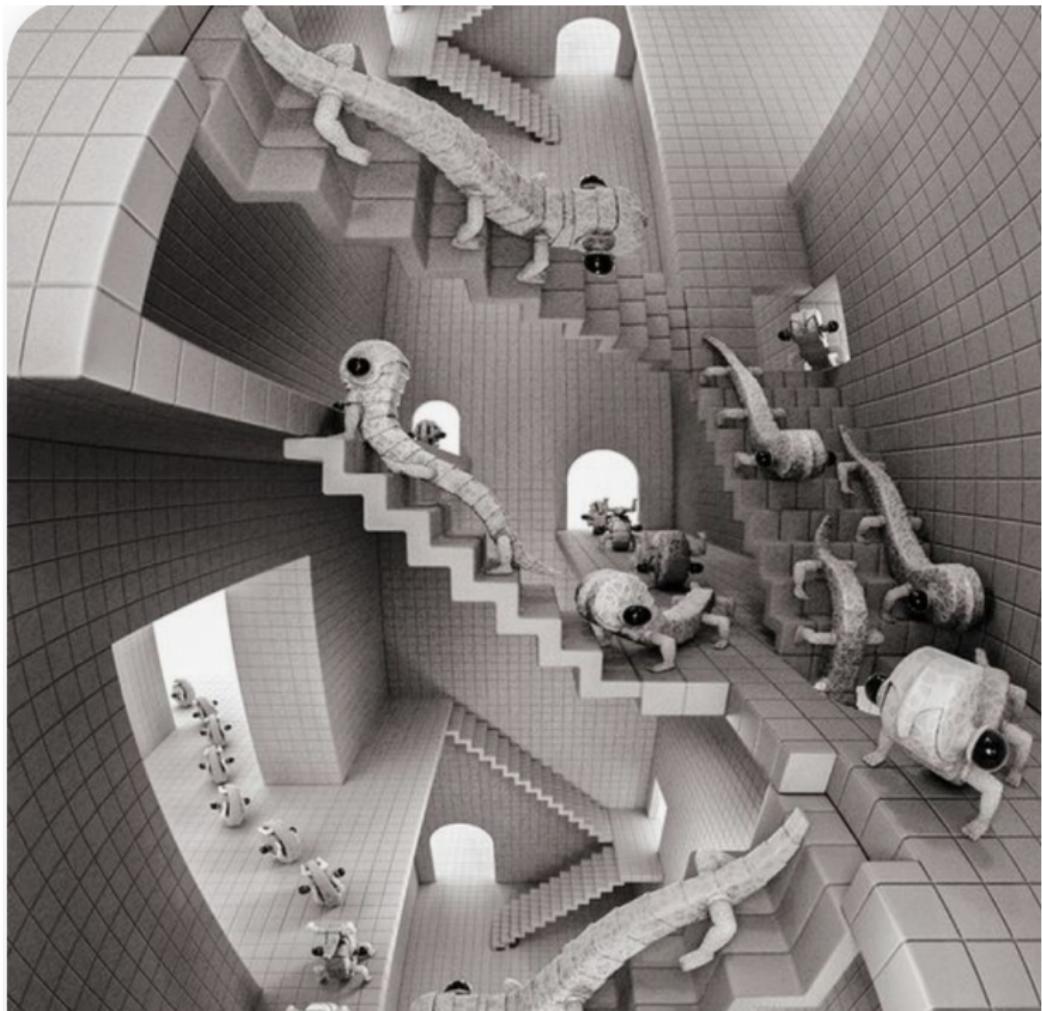


# Outcome versus Exposure Adjustment

Christian Torp-Pedersen

December 10, 2023



# Smoking is good for you??

**"Give your throat a vacation..."**

**Smoke a  
FRESH  
cigarette™**

**I**f the cigarette you have been smoking stings or burns your throat, switch to Camels and see the difference.

It's the peppery dust left in tobacco by inefficient cleaning methods that makes you cough.

**It's the unkindly hot smoke of harsh, dried-out tobacco that burns and irritates your throat.**

There is no peppery dust in Camels—that's whisked away by a special vacuum-cleaning process.

There are no stale, crumbly, parched tobaccoos—the fine Turkish and mild Domestic tobaccoos of which Camels are blended come to you in prime, factory-fresh condition, thanks to the Humidor Pack.

This scientific germ-safe wrapping—not plain ordinary Cellophane, but moisture-



# CAMELS

MILD . . . NO CIGARETTE AFTER-TASTE



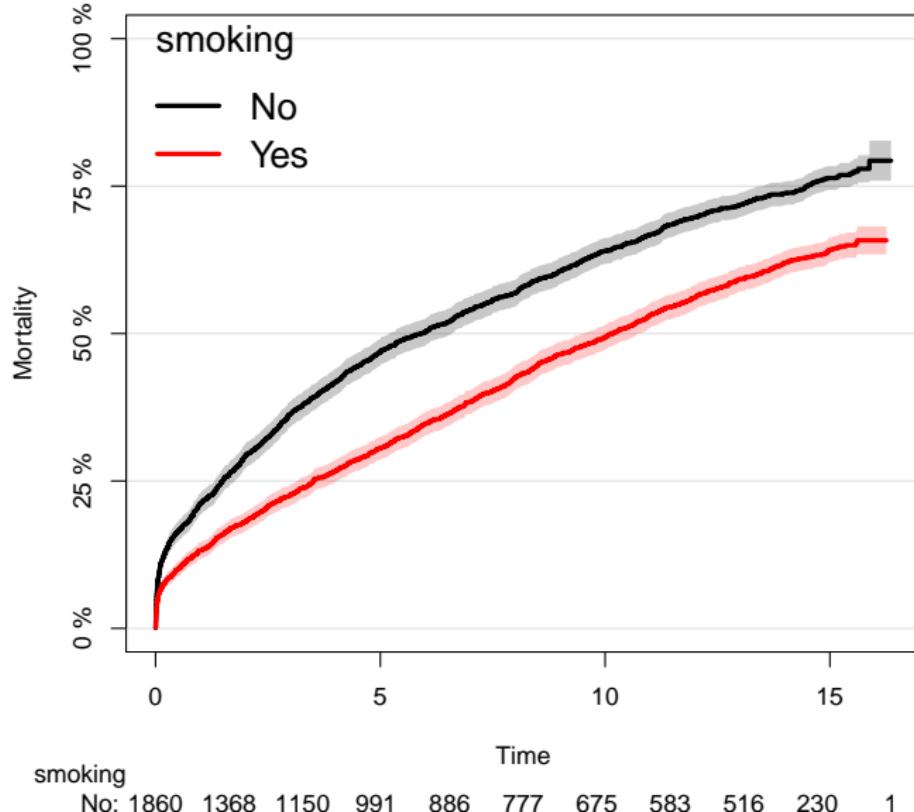
**Don't remove the moisture-proof wrapping from your package of Cansels after you open it. The Biscoidor Pack is protection against dust and germs. In offices and homes, even in the dry atmosphere of artificial heat, the Biscoidor Pack delivers fresh Cansels and keeps them right until the last one has been smoked.**

## TRACE screening data

- ▶ 6600 patients with AMI 1990-1992
- ▶ Follow up - 15 years
- ▶ 4000 cases with selected data and complete cases

European Heart Journal (2005)

# Survival by smoking



# Descriptives by smoking

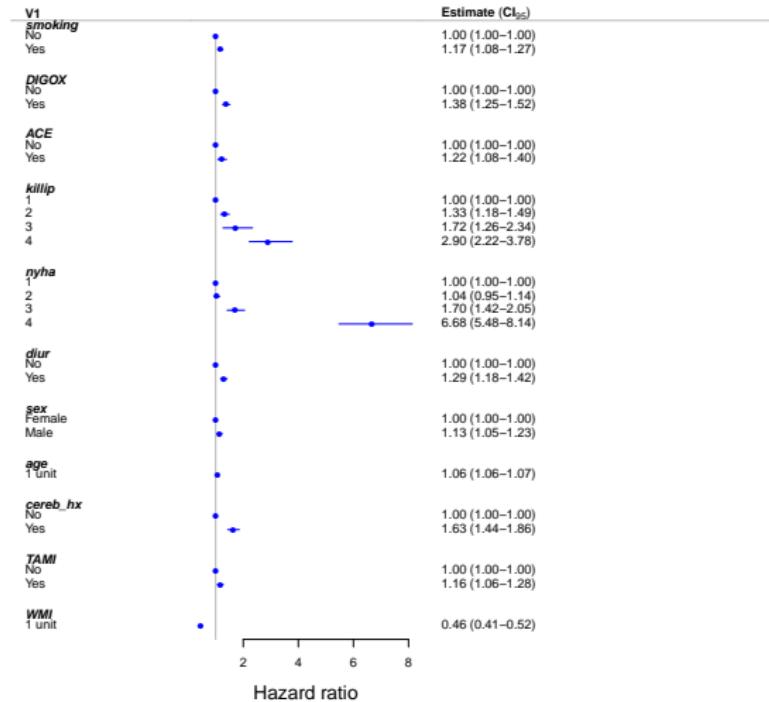
Variable	Level	No (n=1860)	Yes (n=2200)	Total (n=4060)	p-value
DIGOX	No	1445 (77.7)	1947 (88.5)	3392 (83.5)	< 1e-04
	Yes	415 (22.3)	253 (11.5)	668 (16.5)	
ACE	No	1668 (89.7)	2067 (94.0)	3735 (92.0)	< 1e-04
	Yes	192 (10.3)	133 (6.0)	325 (8.0)	
killip	1	1521 (81.8)	1945 (88.4)	3466 (85.4)	< 1e-04
	2	253 (13.6)	195 (8.9)	448 (11.0)	
	3	25 (1.3)	23 (1.0)	48 (1.2)	
	4	61 (3.3)	37 (1.7)	98 (2.4)	
nyha	1	1091 (58.7)	1488 (67.6)	2579 (63.5)	< 1e-04
	2	559 (30.1)	564 (25.6)	1123 (27.7)	
	3	92 (4.9)	62 (2.8)	154 (3.8)	
	4	118 (6.3)	86 (3.9)	204 (5.0)	
diur	No	981 (52.7)	1529 (69.5)	2510 (61.8)	< 1e-04
	Yes	879 (47.3)	671 (30.5)	1550 (38.2)	
sex	Female	716 (38.5)	620 (28.2)	1336 (32.9)	< 1e-04
	Male	1144 (61.5)	1580 (71.8)	2724 (67.1)	
age	mean (sd)	70.6 (10.7)	62.5 (11.5)	66.2 (11.9)	< 1e-04
cereb <sub>hx</sub>	No	1691 (90.9)	2074 (94.3)	3765 (92.7)	< 1e-04
	Yes	169 (9.1)	126 (5.7)	295 (7.3)	
TAMI	No	1388 (74.6)	1872 (85.1)	3260 (80.3)	< 1e-04
	Yes	472 (25.4)	328 (14.9)	800 (19.7)	
WMI	mean (sd)	1.5 (0.4)	1.6 (0.3)	1.6 (0.4)	< 1e-04

$$h(t) = \lim_{\delta t \rightarrow 0} \frac{\text{Observed deaths in } [t, t + \delta t] / N(t)}{\delta t}$$

$$h(t) = h_0(t) e^{smoking\beta_1 + sex\beta_2 + age\beta_3.....}$$

$$hr_{smoking} = e^{\beta_1}$$

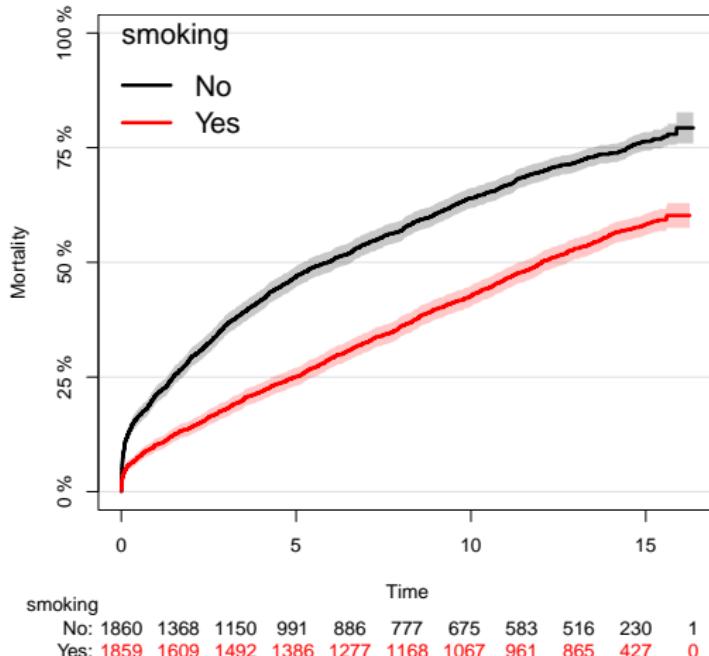
# Old fashioned Cox



## Propensity stratification / matching

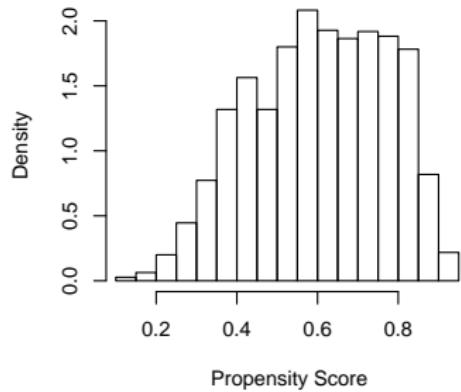
- ▶ Propensity is probability of smoking
- ▶ In propensity stratification analysis is stratified by multiple strata of this propensity to ensure that survival is compared for individual with similar propensity of smoking
- ▶ In propensity matching cases are matched with control that have similar probability of smoking. If it works nicely there is apparently a controlled trial.

# Propensity matching

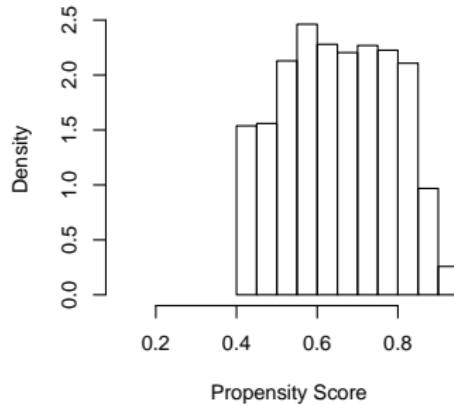


# Propensity plot

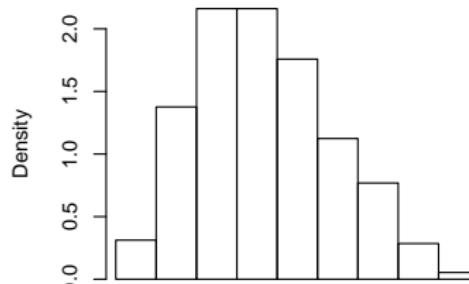
**Raw Treated**



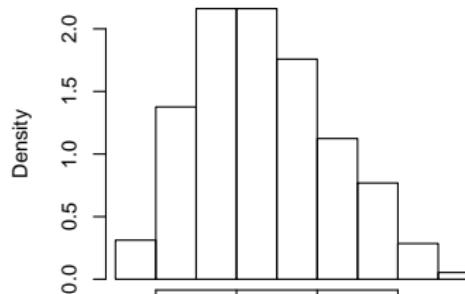
**Matched Treated**



**Raw Control**



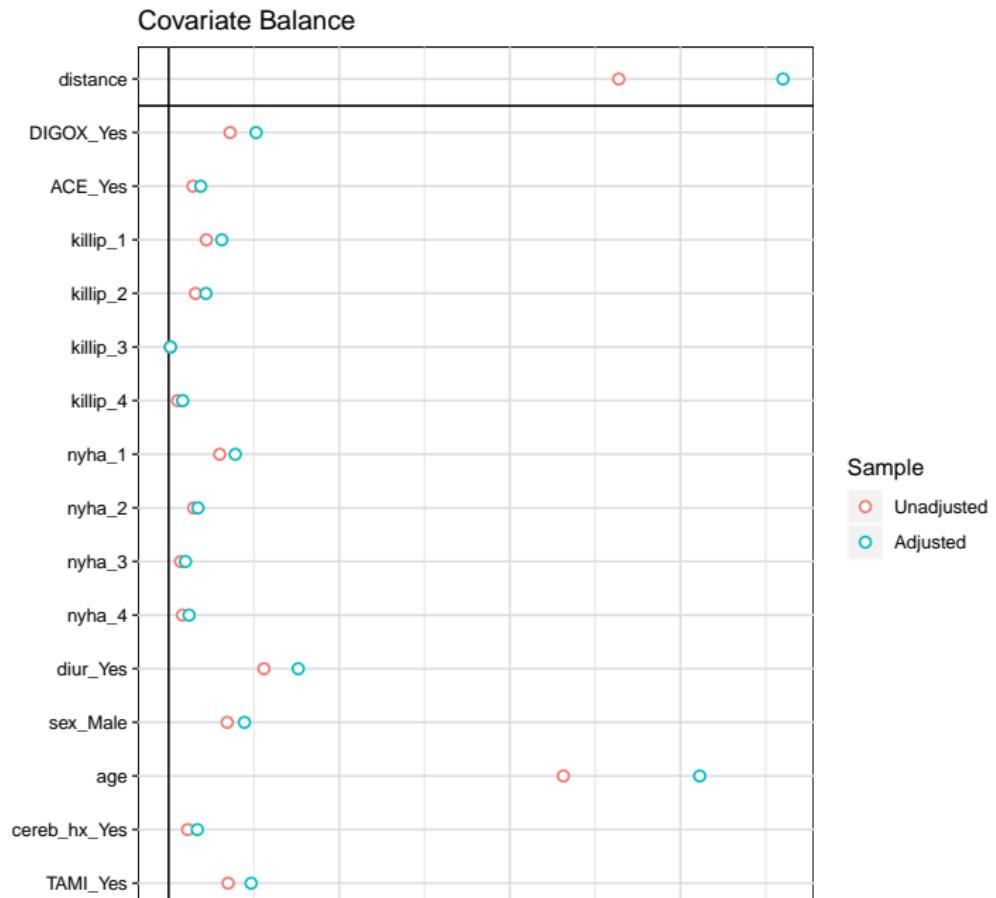
**Matched Control**



## Descriptives by propensity

Variable	Level	No (n=1860)	Yes (n=1860)	Total (n=3720)	p-value
DIGOX	No	1445 (77.7)	1731 (93.1)	3176 (85.4)	< 1e-04
	Yes	415 (22.3)	129 (6.9)	544 (14.6)	
ACE	No	1668 (89.7)	1773 (95.3)	3441 (92.5)	< 1e-04
	Yes	192 (10.3)	87 (4.7)	279 (7.5)	
killip	1	1521 (81.8)	1695 (91.1)	3216 (86.5)	< 1e-04
	2	253 (13.6)	131 (7.0)	384 (10.3)	
	3	25 (1.3)	19 (1.0)	44 (1.2)	
	4	61 (3.3)	15 (0.8)	76 (2.0)	
nyha	1	1091 (58.7)	1309 (70.4)	2400 (64.5)	< 1e-04
	2	559 (30.1)	463 (24.9)	1022 (27.5)	
	3	92 (4.9)	37 (2.0)	129 (3.5)	
	4	118 (6.3)	51 (2.7)	169 (4.5)	
diur	No	981 (52.7)	1405 (75.5)	2386 (64.1)	< 1e-04
	Yes	879 (47.3)	455 (24.5)	1334 (35.9)	
sex	Female	716 (38.5)	468 (25.2)	1184 (31.8)	< 1e-04
	Male	1144 (61.5)	1392 (74.8)	2536 (68.2)	
age	mean (sd)	70.6 (10.7)	59.8 (10.1)	65.2 (11.7)	< 1e-04
cereb <sub>hx</sub>	No	1691 (90.9)	1785 (96.0)	3476 (93.4)	< 1e-04
	Yes	169 (9.1)	75 (4.0)	244 (6.6)	
TAMI	No	1388 (74.6)	1658 (89.1)	3046 (81.9)	< 1e-04
	Yes	472 (25.4)	202 (10.9)	674 (18.1)	
WMI	mean (sd)	1.5 (0.4)	1.6 (0.3)	1.6 (0.3)	< 1e-04

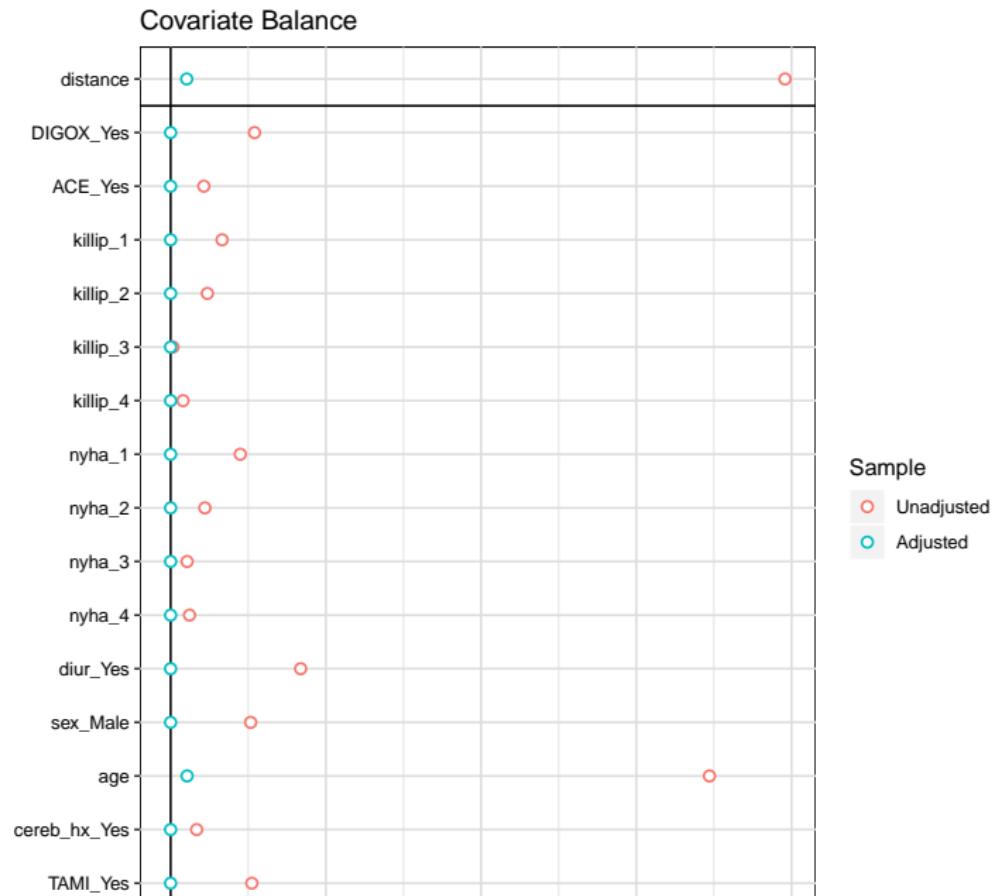
# Love plot



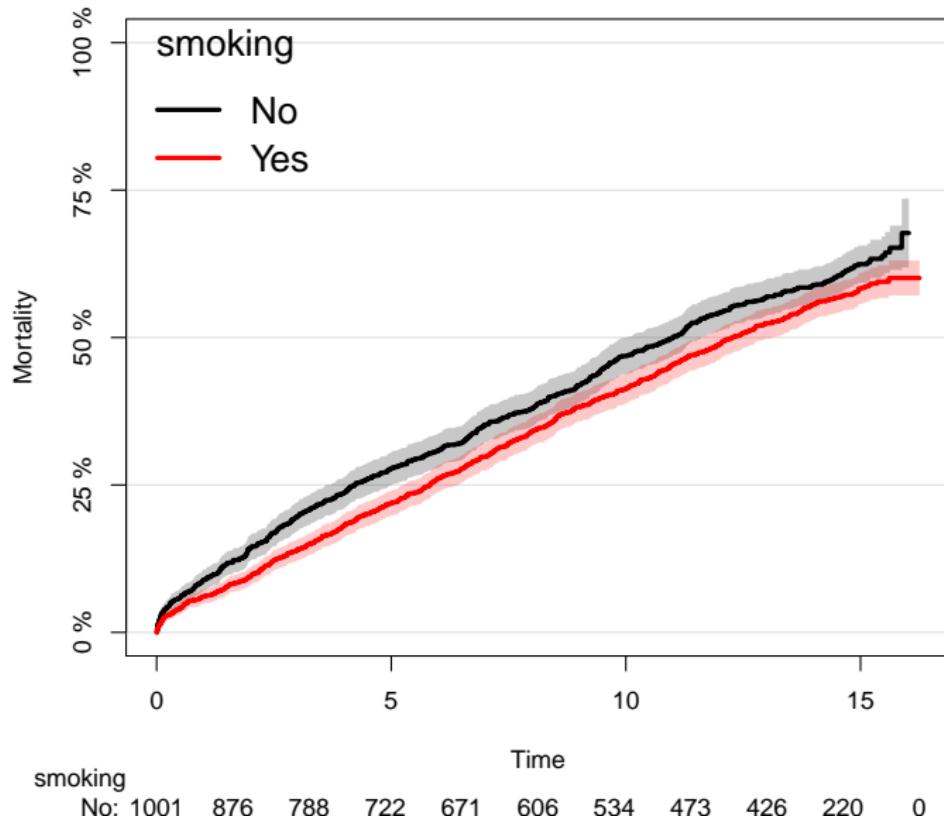
## Other Matching?



# Course Exact Matching



# Survival by CEM-matching



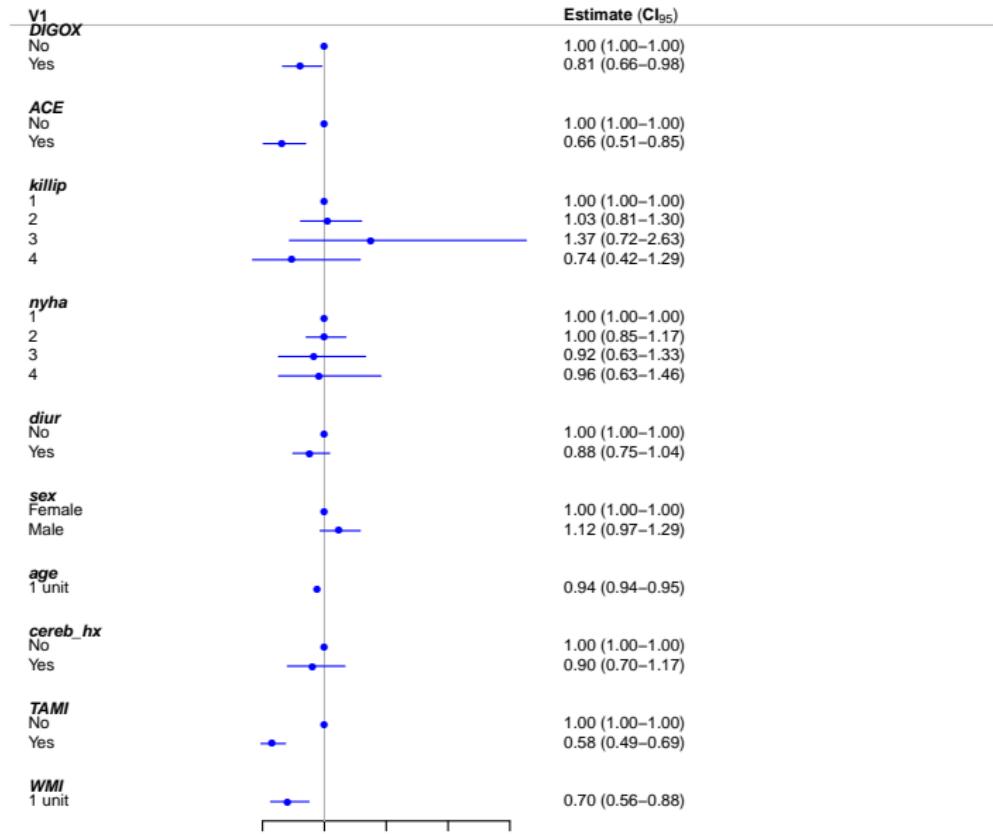
smoking

No: 1001 876 788 722 671 606 534 473 426 220 0

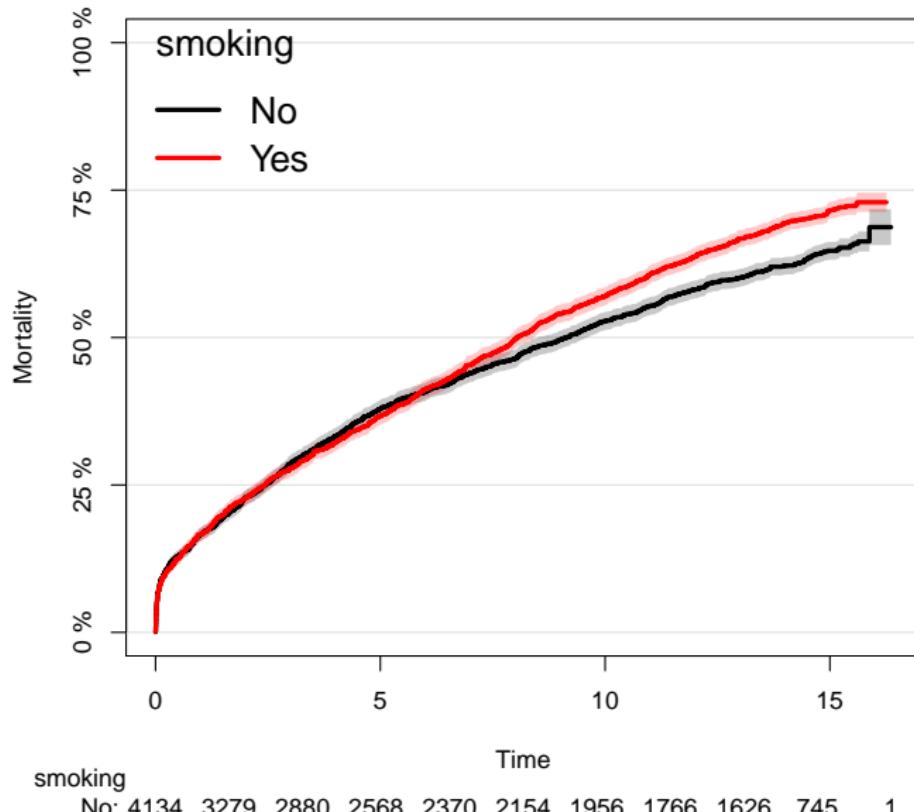
## Descriptives by CEM

Variable	Level	No (n=1001)	Yes (n=1462)	Total (n=2463)	p-value
DIGOX	No	927 (92.6)	1396 (95.5)	2323 (94.3)	0.0032658
	Yes	74 (7.4)	66 (4.5)	140 (5.7)	
ACE	No	991 (99.0)	1449 (99.1)	2440 (99.1)	0.9481526
	Yes	10 (1.0)	13 (0.9)	23 (0.9)	
killip	1	969 (96.8)	1428 (97.7)	2397 (97.3)	NA
	2	29 (2.9)	32 (2.2)	61 (2.5)	
	3	0 (0.0)	0 (0.0)	0 (0.0)	
	4	3 (0.3)	2 (0.1)	5 (0.2)	
nyha	1	770 (76.9)	1174 (80.3)	1944 (78.9)	0.1989648
	2	223 (22.3)	281 (19.2)	504 (20.5)	
	3	4 (0.4)	4 (0.3)	8 (0.3)	
	4	4 (0.4)	3 (0.2)	7 (0.3)	
diur	No	768 (76.7)	1210 (82.8)	1978 (80.3)	0.0002614
	Yes	233 (23.3)	252 (17.2)	485 (19.7)	
sex	Female	281 (28.1)	359 (24.6)	640 (26.0)	0.0564162
	Male	720 (71.9)	1103 (75.4)	1823 (74.0)	
age	mean (sd)	67.2 (10.4)	62.2 (10.9)	64.2 (11.0)	< 1e-04
cereb <sub>hx</sub>	No	983 (98.2)	1443 (98.7)	2426 (98.5)	0.4062322
	Yes	18 (1.8)	19 (1.3)	37 (1.5)	
TAMI	No	862 (86.1)	1317 (90.1)	2179 (88.5)	0.0030339
	Yes	139 (13.9)	145 (9.9)	284 (11.5)	
WMI	mean (sd)	1.7 (0.2)	1.7 (0.2)	1.7 (0.2)	0.9361005

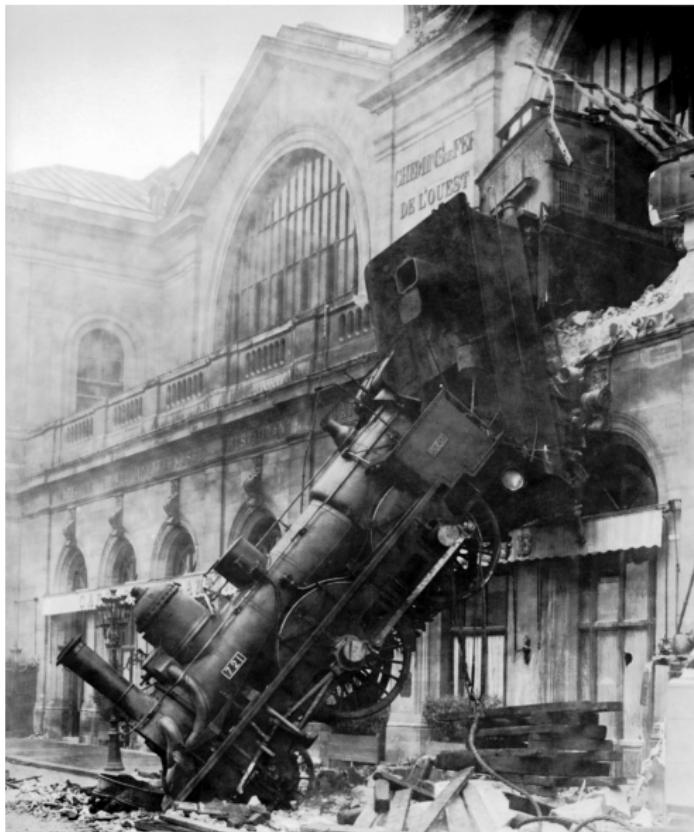
# Determinants of smoking



## Inverse probability score



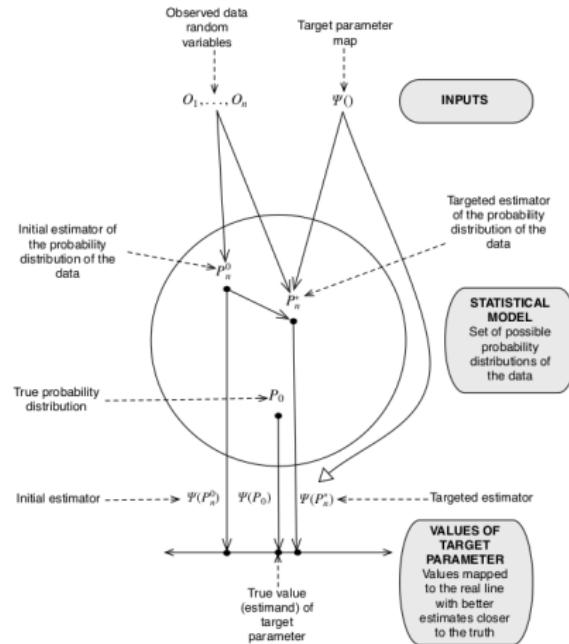
Navigate with care!



## Double Robust Methods



# Estimating and Targeting



Rose van der Laan, Targeted Learning 2011

