



Lifestyle diseases as Complex Adaptive Systems: Perspectives and Challenges

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CCS 17, Cancun, Mexico

17-20th September 2017



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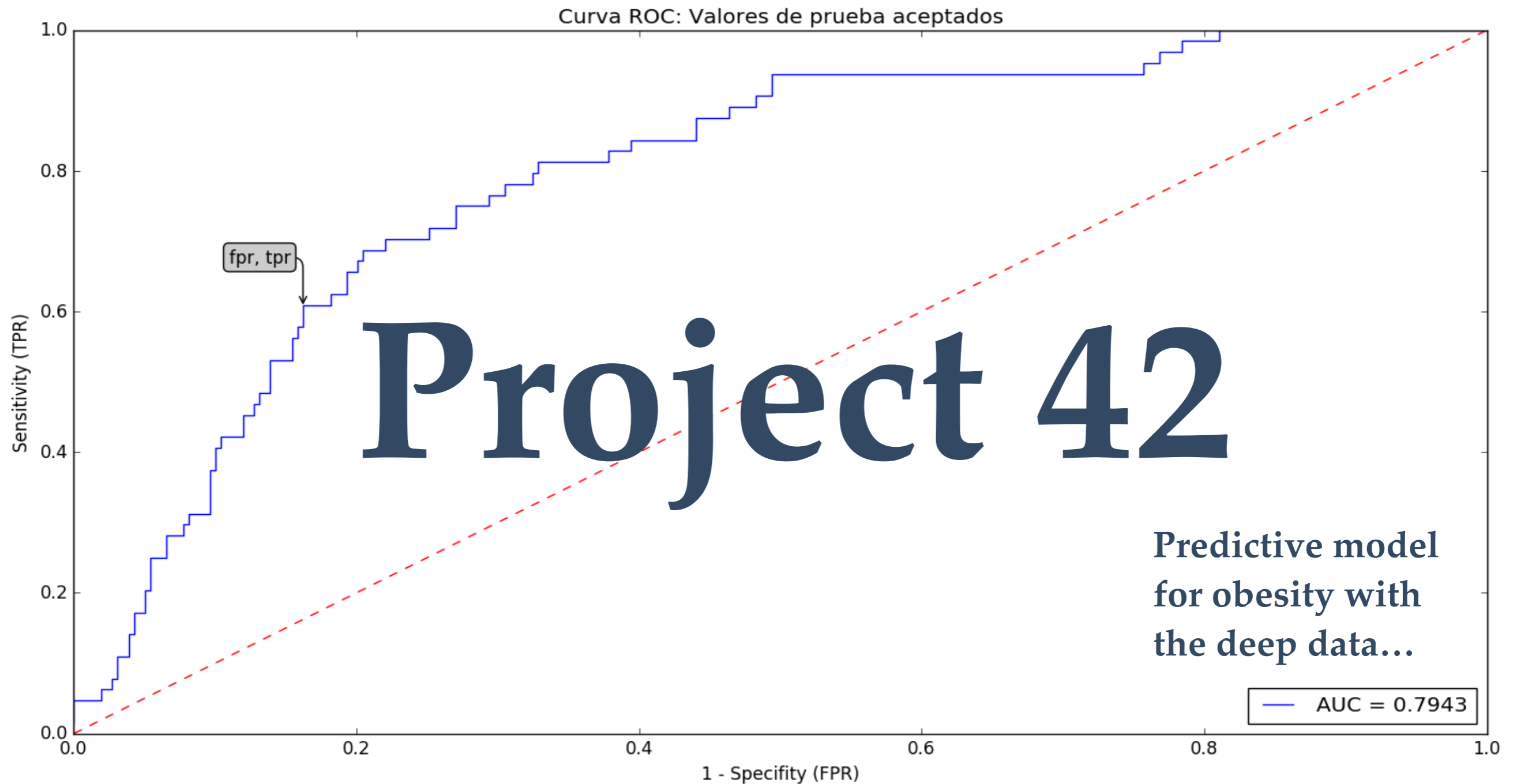
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CONACyT Fronteras-2015-2-1093

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**Predictive models for lifestyle diseases
based on the “deepest” datasets**

Lifestyle diseases are intimately associated with decision making: Your Prediction/ Decision Heuristic/Algorithm depends on...



**“Who” you are
What and how
you think
you “feel”**

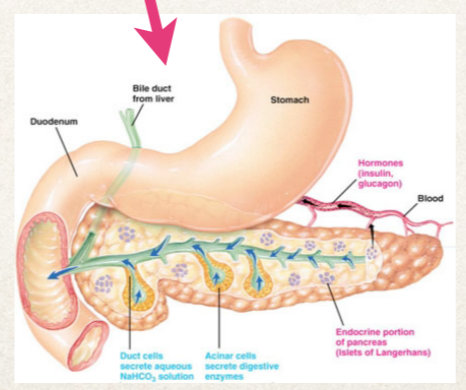
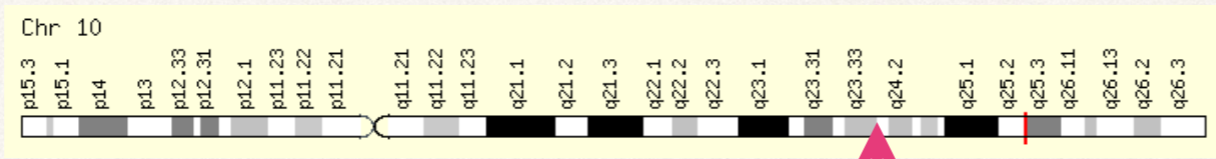
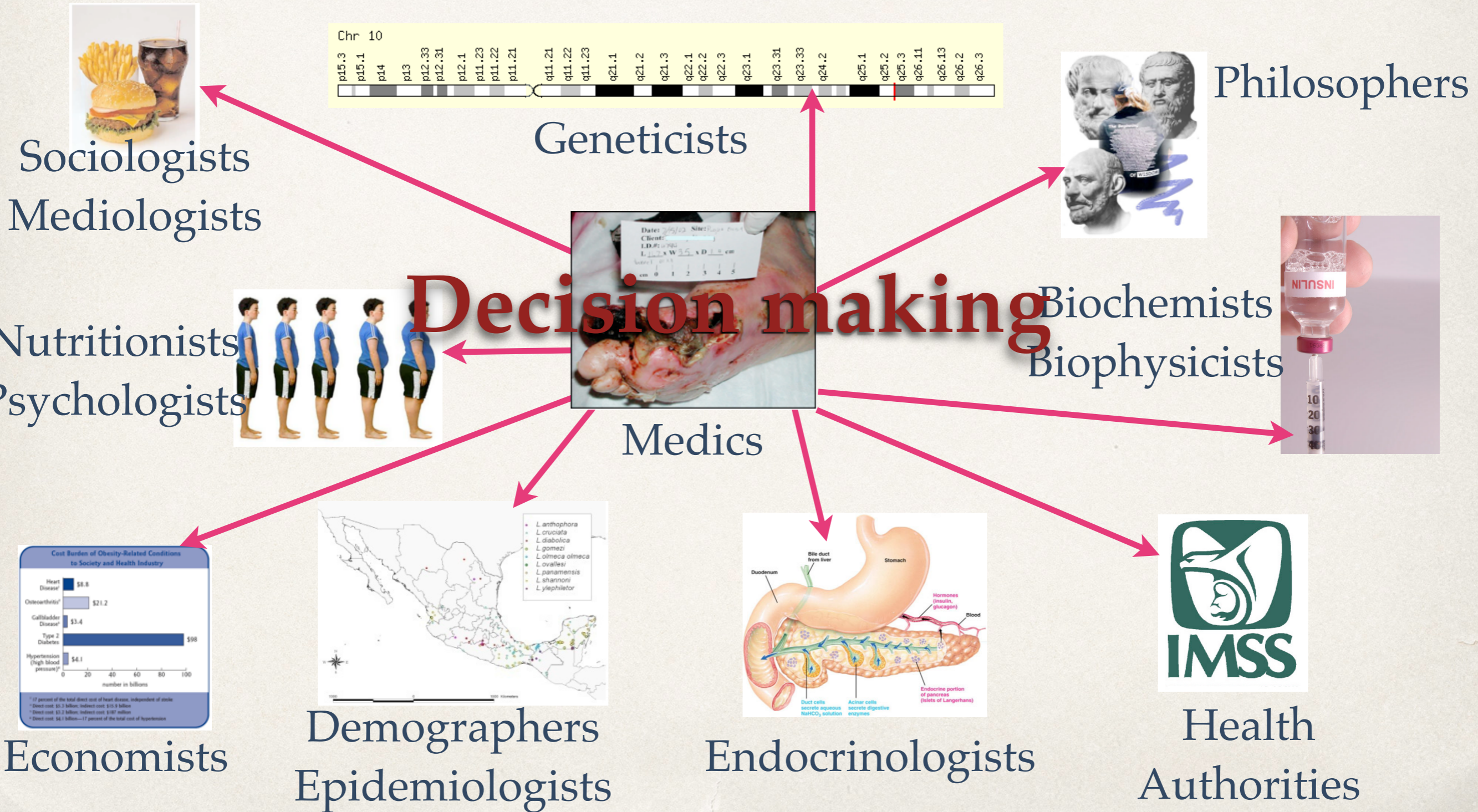


Your prediction/decision heuristic/algorithm then determines your behaviour - what you do



They are complex...

Multifactorial, Multi-scale, Multi-disciplinary



Economists

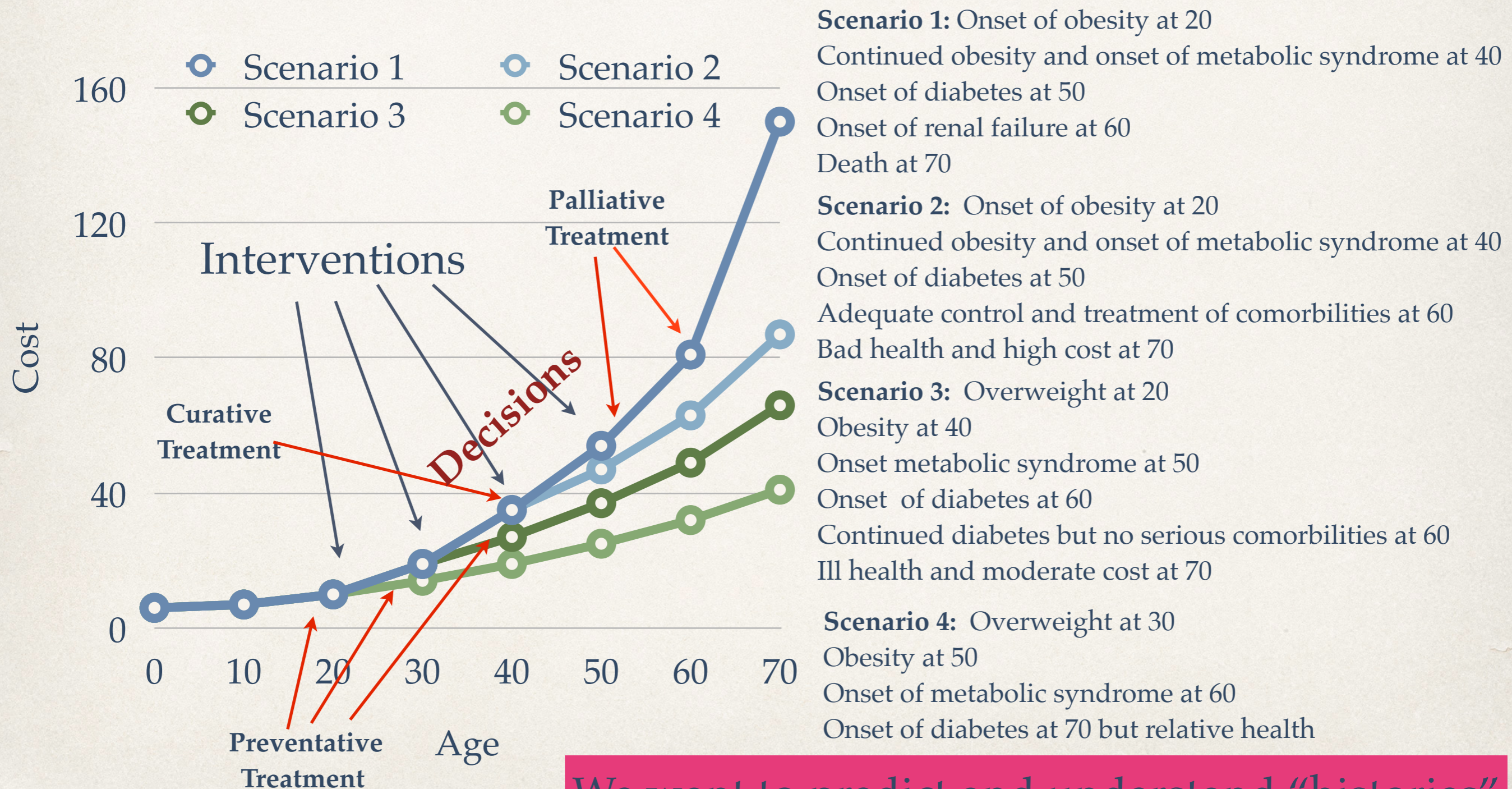
Demographers
Epidemiologists

Endocrinologists

Health
Authorities



They are dynamical and adaptive... evolving in a space of configurations and interventions that are a result of decisions



We want to predict and understand “histories”



What is a decision? Its based on a prediction

A "decision" Prediction $P(C | X(t))$ Probability of C given X

In the exact sciences, predictions

tend to be **algorithmic**



In medicine and public health, predictions

tend to be **heuristic**

Curative
Medicine
Less complex,
less adaptative

Preventative
Medicine
More complex,
more adaptative

$X(t)$ = the information used
to make the decision (predict)

How much information do you need or use to make a "good decision"?

What degree of multi-factoriality is there?

Preventative medicine requires a lot more data.

Where do we get that data...? from the data revolution



Project 42: Pilot

Results from predictive models * based on data from a study of 1,076 non-academics and academics from the UNAM: 2,524 variables - Genetic, epidemiological, physiological,...

Epidemiological: Personal (81), **Personal history** (130), **Family History** (548), Self-health evaluation (226), **Nutrition** (220), **Lifestyle** (390), Health knowledge (293)

Genetic (772)

Anthropometric and physiological (49)

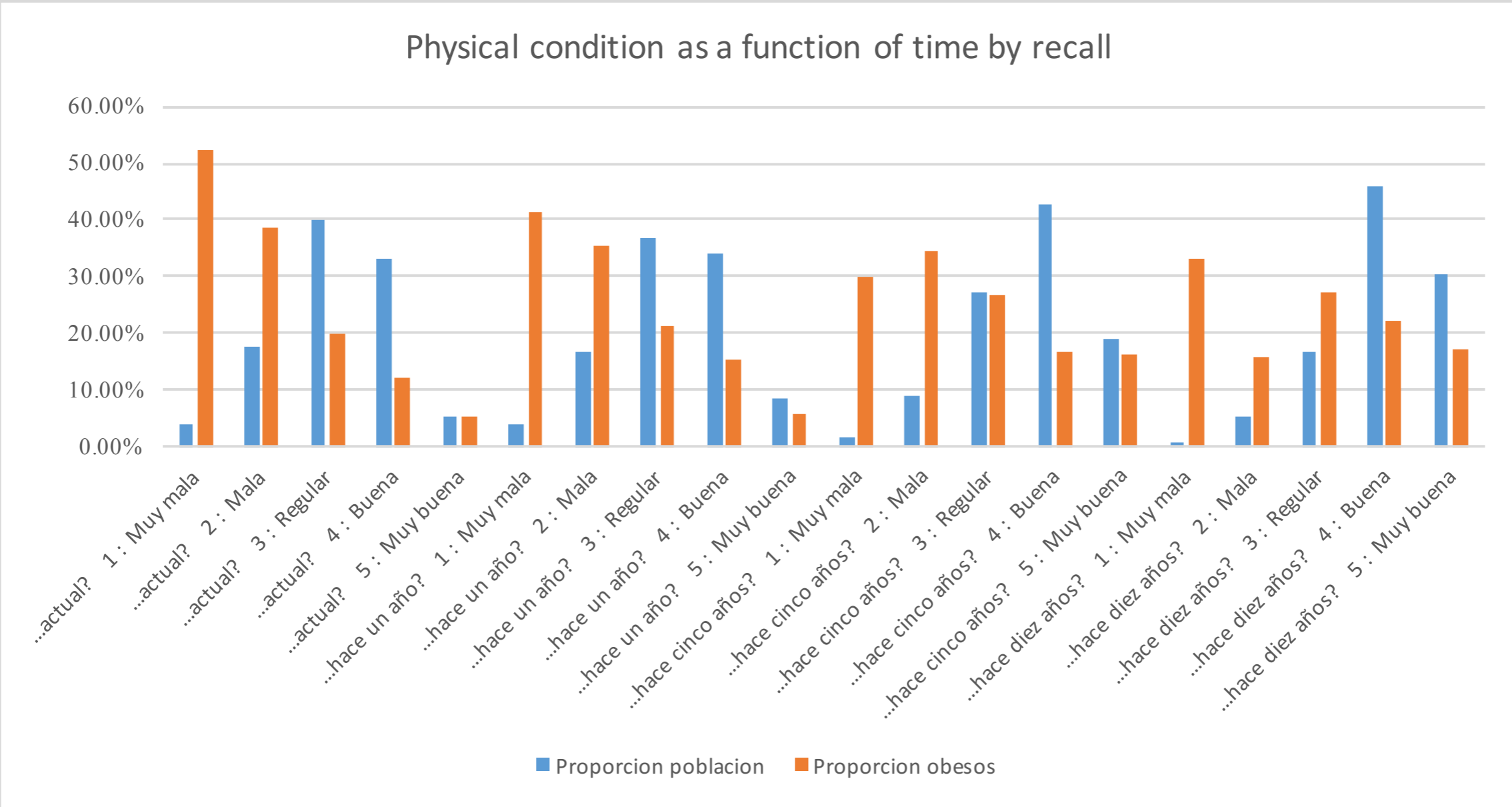
* Second phase now in progress: > 300 students and faculty of the Facultad de Medicina, UNAM, longitudinal study of previous populations: Extend to > 700,000 SNPs, psychological testing, EEG, ECG, actigraphy,...

Nutrition	
Specificity (TNR)	83.40%
1 – Specificity (SPC)	16.60%
Sensitivity (FPR)	29.69%
Accuracy (ACC)	72.76%
AUC ROC	0.63
Lifestyle	
Specificity (TNR)	84.17%
1 – Specificity (SPC)	15.83%
Sensitivity (FPR)	31.25%
Accuracy (ACC)	73.68%
AUC ROC	0.70
Lifestyle and Nutrition	
Specificity (TNR)	78.38%
1 – Specificity (SPC)	21.62%
Sensitivity (FPR)	46.88%
Accuracy (ACC)	72.14%
AUC ROC	0.71
Lifestyle and Nutrition and Personal and Family History	
Specificity (TNR)	81.08%
1 – Specificity (SPC)	18.92%
Sensitivity (FPR)	51.56%
Accuracy (ACC)	75.23%
AUC ROC	0.76

Epsilon	# participantes	# obesos	Proporcion obesos	Puesto	Epsilon	# participantes	Proporcion poblacion	# obesos	Probabilidad obesidad	Proporcion obesos
-2.81	23									
1.23	74									
0.19	54									
-1.64	10									
-2.38	52									
-3.58	81									

¿Cuántas calorías hay en un litro de agua?

No sabe el número de calorías que



¿Cómo es tu salud actualmente?

	Epsilon	# participantes	# obesos	obesos	Proporcion poblacion	# obesos	Probabilidad obesidad	Proporcion obesos
1: Muy mala	1.15	15	5	33.33%		190	45	23.68%
2: Mala								
3: Regular								
4: Buena	5.25	771	223	28.92%	71.65%	223	28.92%	97.81%
5: Muy buena	-7.54	239	3	1.26%	22.21%	3	1.26%	1.32%
Bajar de peso	-3.50	63	2	3.17%	5.86%	2	3.17%	0.88%
Esta contento con su peso	-0.90	3	0	0.00%	0.28%	0	0.00%	0.00%
Subir de peso								
No sabe								

¿Qué acciones le gustaría tomar respecto a su peso?

	Epsilon	# participantes	Proporcion poblacion	# obesos	Probabilidad obesidad	Proporcion obesos
Bajar de peso	5.25	771	71.65%	223	28.92%	97.81%
Esta contento con su peso	-7.54	239	22.21%	3	1.26%	1.32%
Subir de peso	-3.50	63	5.86%	2	3.17%	0.88%
No sabe	-0.90	3	0.28%	0	0.00%	0.00%



Do you become what you eat?

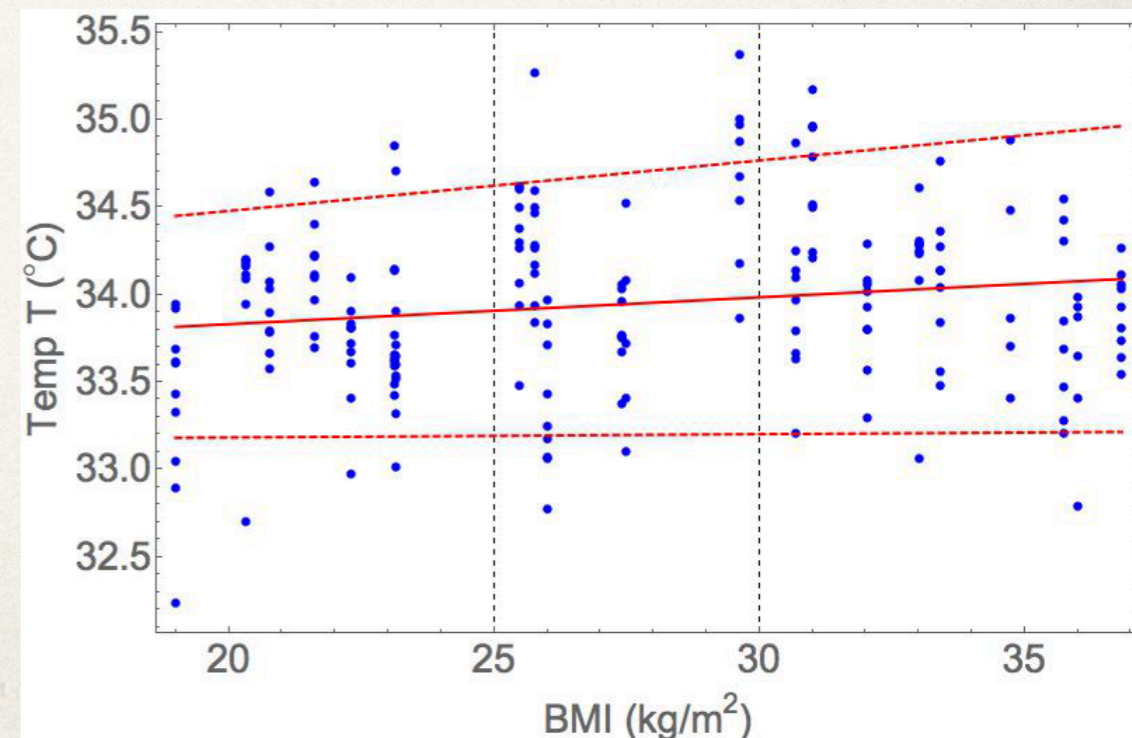
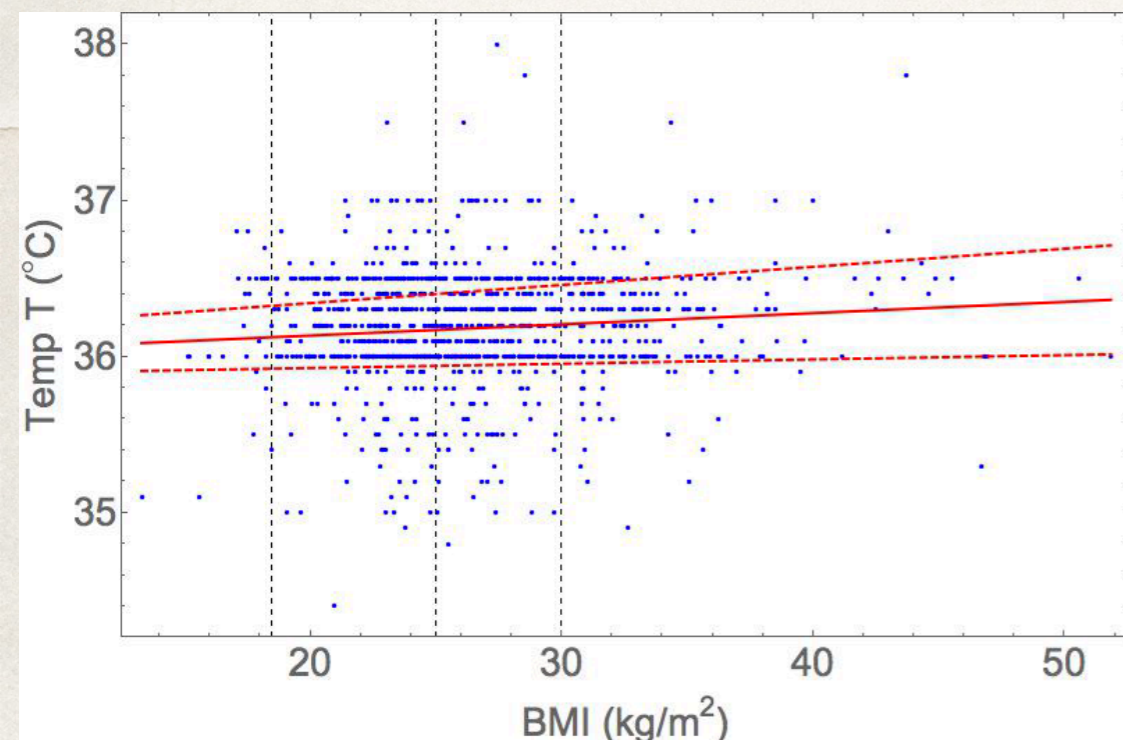
The data shows an overconsumption of 200-300 Cals/day at age 20-30. 8 Cal/day is enough (naively through the famous/infamous 3500 cal rule) to generate the observed increase in BMI.

Where do the other calories go?

Why aren't we even fatter?

	Study 1		Study 2	
	points	deciles	7-day mean	1-day mean
slope	0.0072	0.0067	0.0093	0.015
intercept	35.99	36.00	33.69	33.524
Clslope	0.0028	0.0024	-0.019	0.0019
	0.012	0.011	0.038	0.029
Clintercept	35.88	35.89	32.88	33.15
	36.11	36.12	34.51	33.90
tslope	3.18	3.56	0.68	2.25
tintercept	590.34	708.93	86.9	174.92
F	10.15	12.64	0.46	5.06
p	0.0015 (*)	0.0074 (*)	0.50	0.026 (*)
R2	0.0094	0.61	0.022	0.027

Relation between temperature and BMI



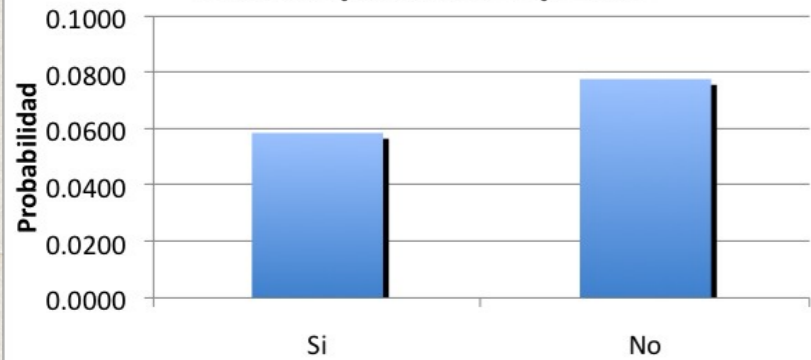
R. Fossion
DH17

Chronic disease - Risk factors

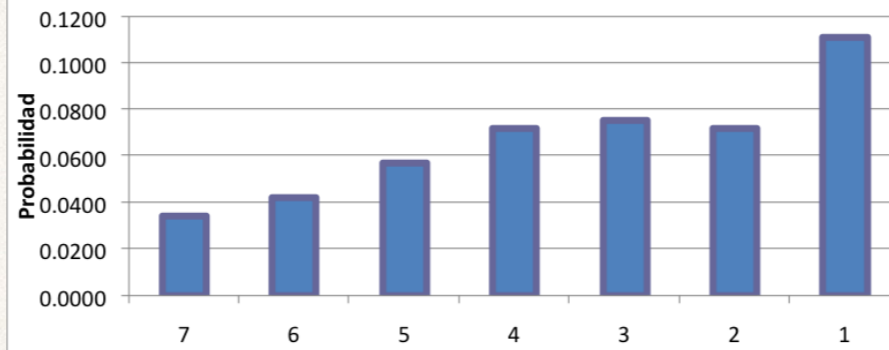
What you do Exercise



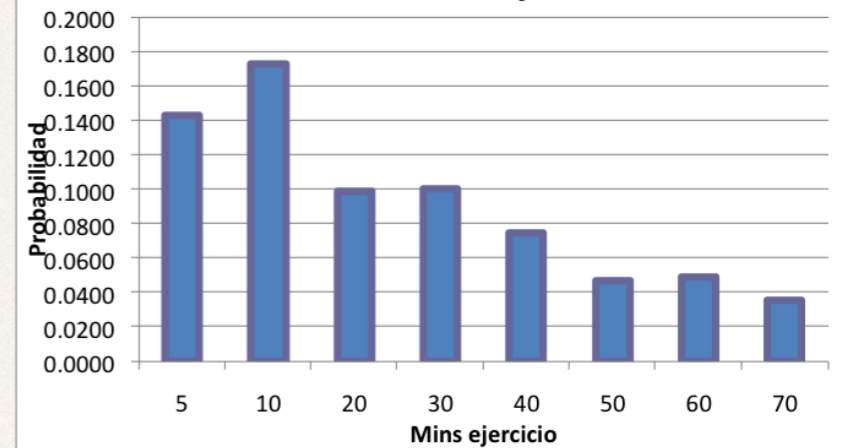
Gráfica de Probabilidad de Diabetes versus si practicas deportes



Gráfica de Probabilidad de diabetes versus Número de días de ejercicio por semana

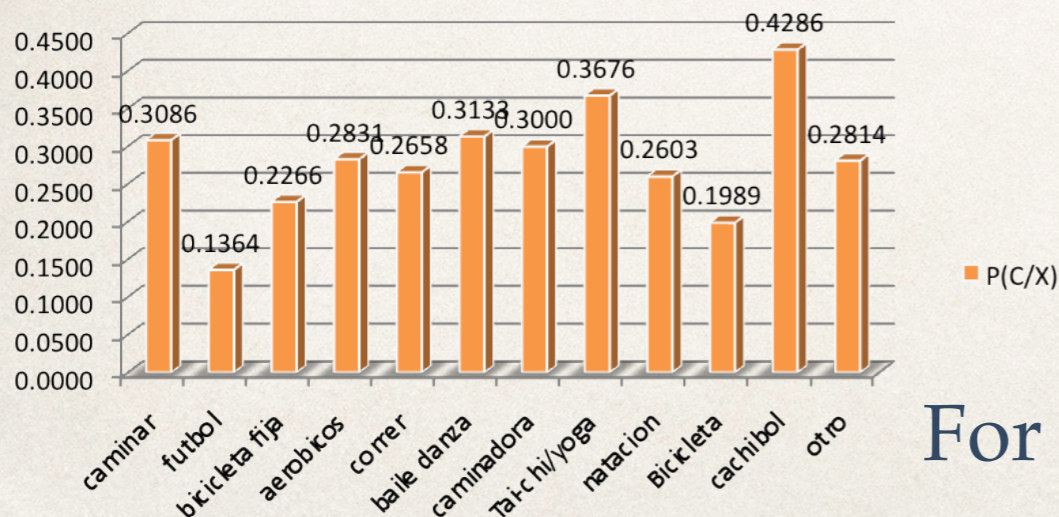


Gráfica de Probabilidad de diabetes versus mins de ejercicio

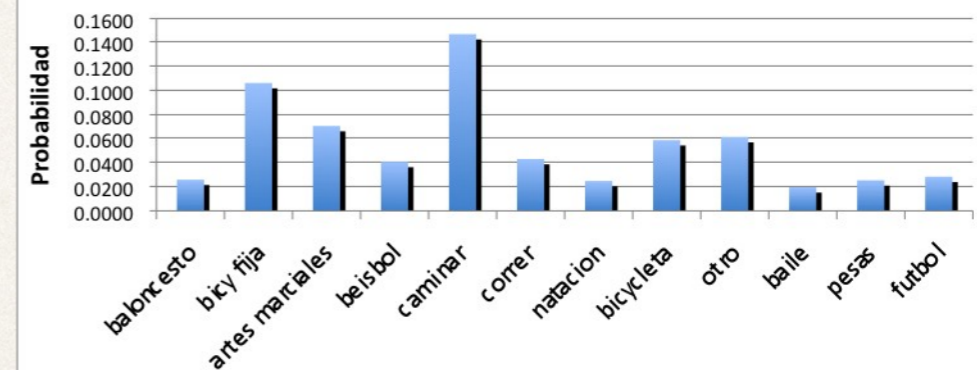


For men 20-59 de PREVENIMSS 2006

Tipo de ejercicio practicado vs probabilidad de tener diabetes P(C/X)



Gráfica de Probabilidad de Diabetes versus tipo de ejercicio



For seniors > 59

Is it riskier to walk than do nothing?

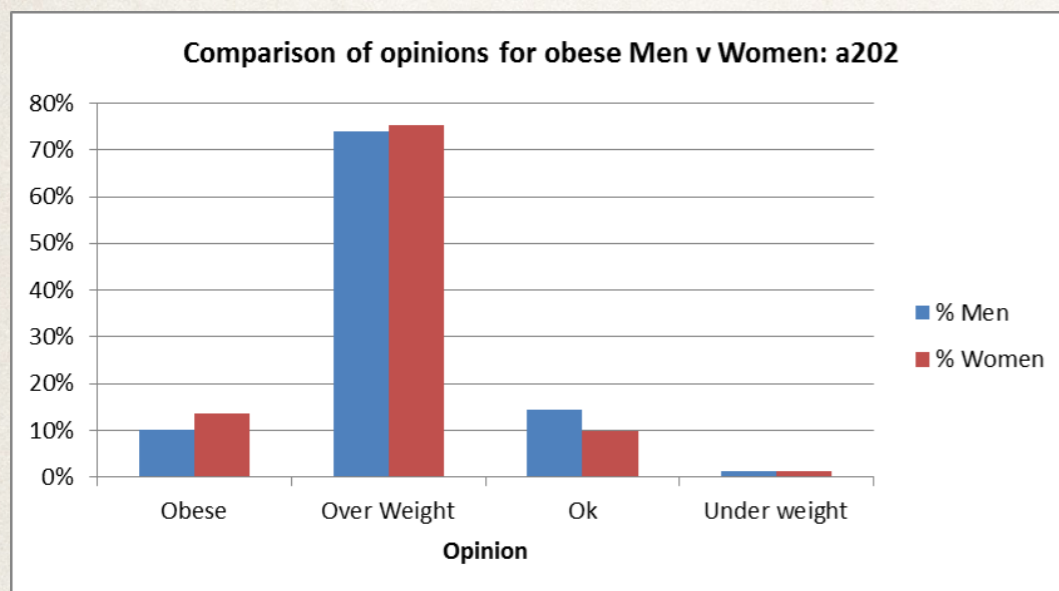
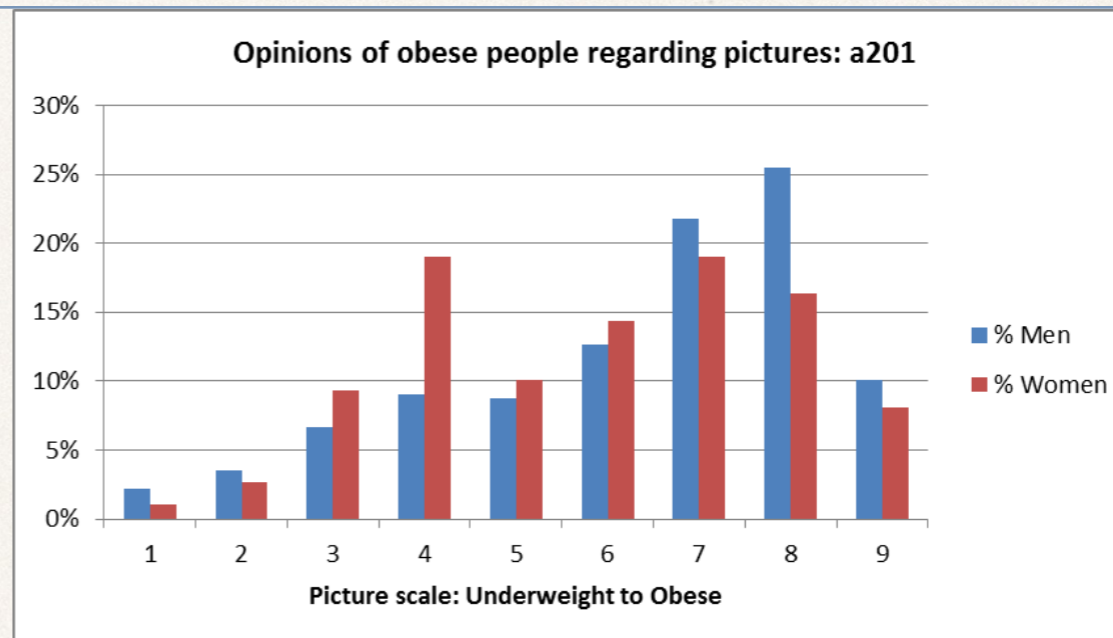
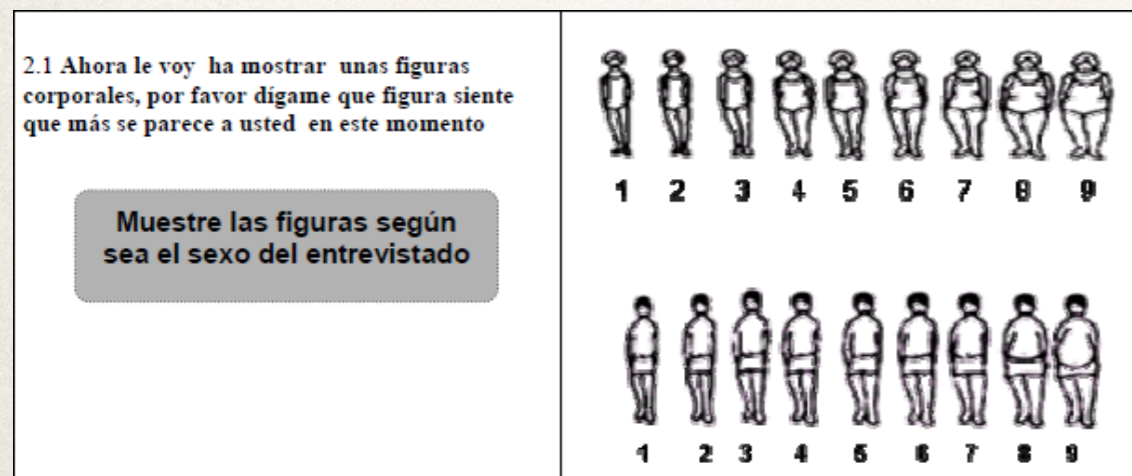


Obesity- risk factors

What you think/feel

Obesity is unrecognised by the sufferer in spite of the symptoms

Epidemiological data from ENSANUT 2006



People think they're less overweight/ obese than they are. Symptom severity is underestimated.

Fundamental question: Why do we "lie" to ourselves?

Perception of weight and Cognitive Biases - What you think/feel

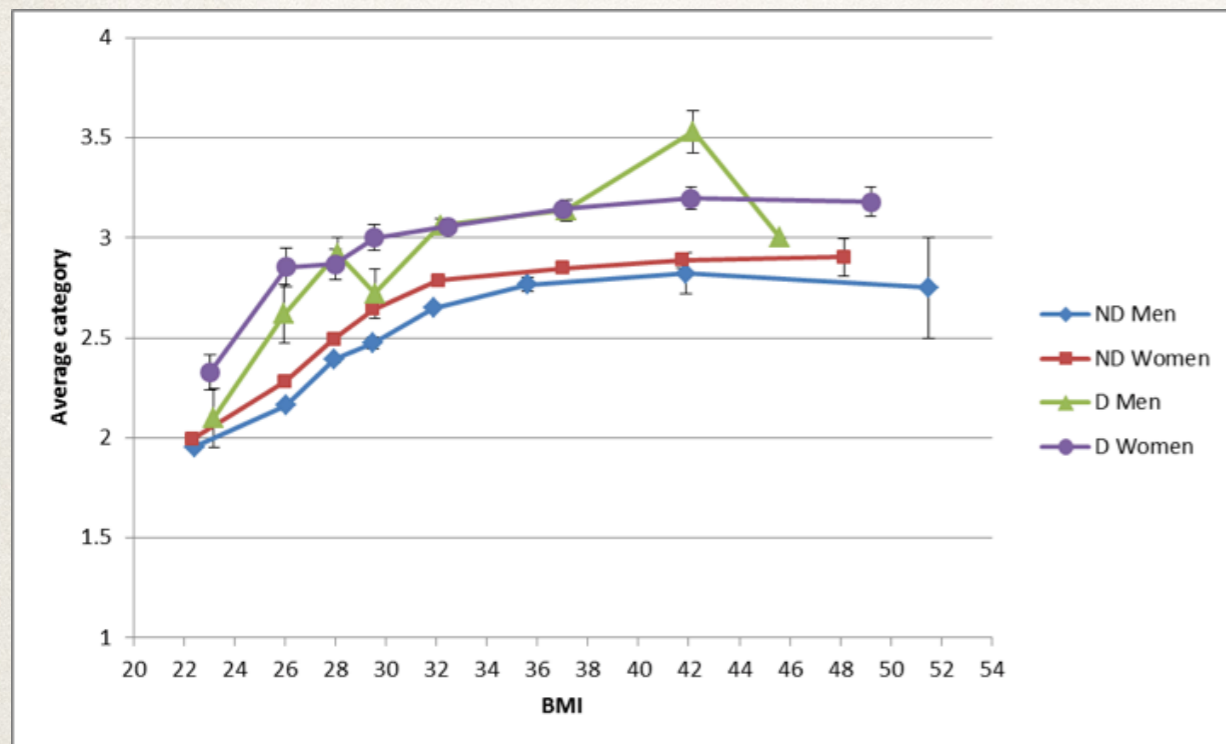


Figure 2. Comparison of non-diagnosed (ND) versus diagnosed (D) obese mean responses for the category self-perception question by gender.

Slopes in the linear range are 35-50% less than one would expect if people could gauge their weight accurately! The lobster in the pot syndrome



Self-serving bias
Anchoring bias

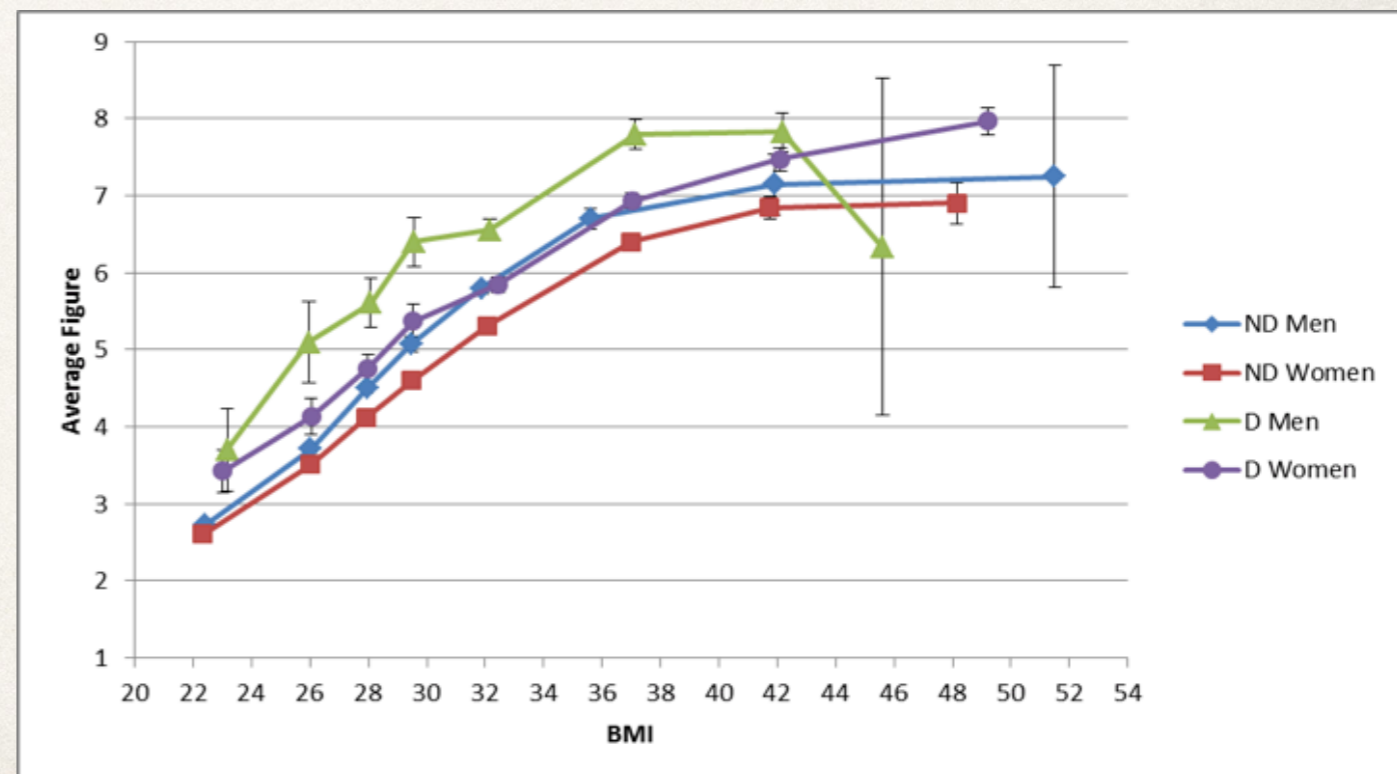


Figure 3. Comparison of non-diagnosed (ND) versus diagnosed (D) obese mean responses for the Stunkard figure rating scale question by gender.

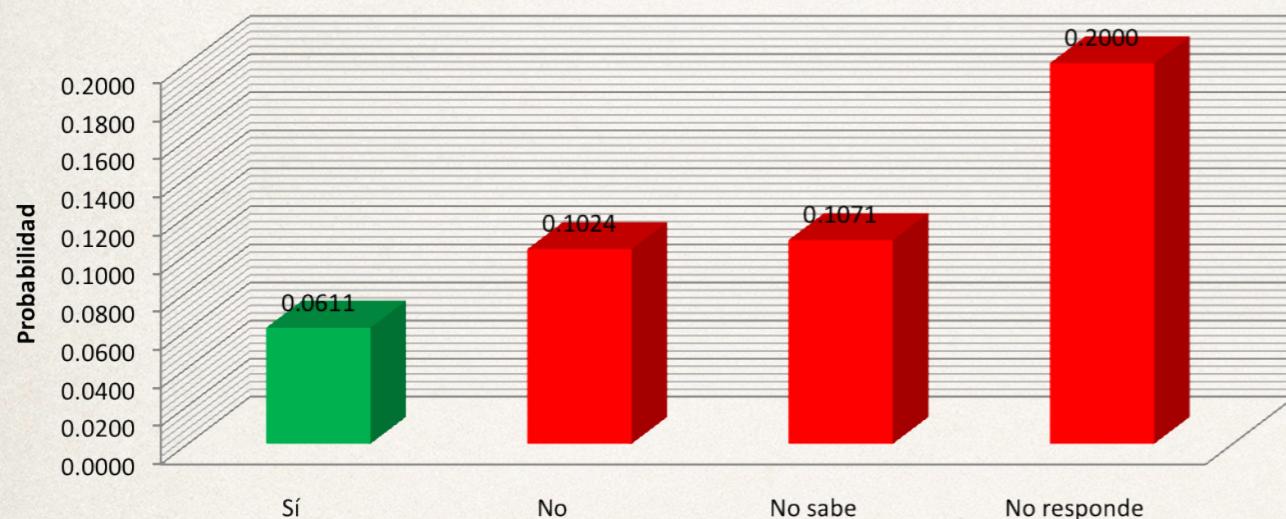


Chronic disease - risk factors

What you think (know): Ignorance can kill

Epidemiological data from ENCOPREVENIMSS 2006

¿Sabe leer o escribir un recado?

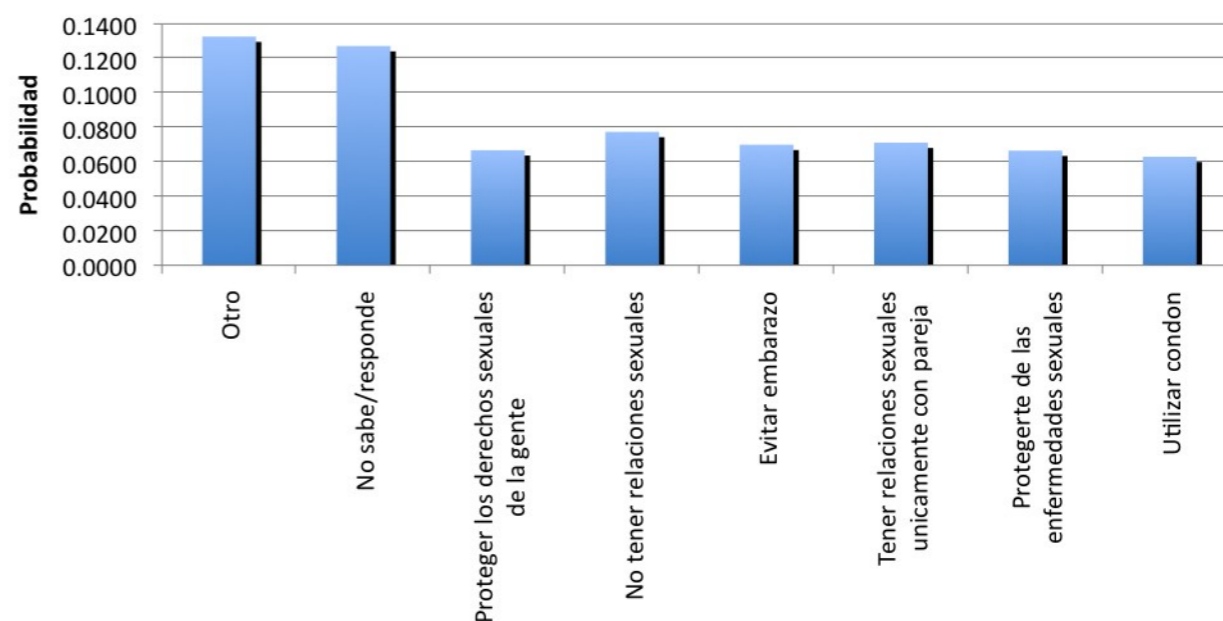


For men 20-59 from
PREVENIMSS 2006

- Sí
- No
- No sabe
- No responde

Ignorance and especially about health issues is as important a risk factor as obesity

Gráfica de probabilidad de diabetes versus qué piensas que significa el sexo protegido



Obesity -risk factors

Who you are

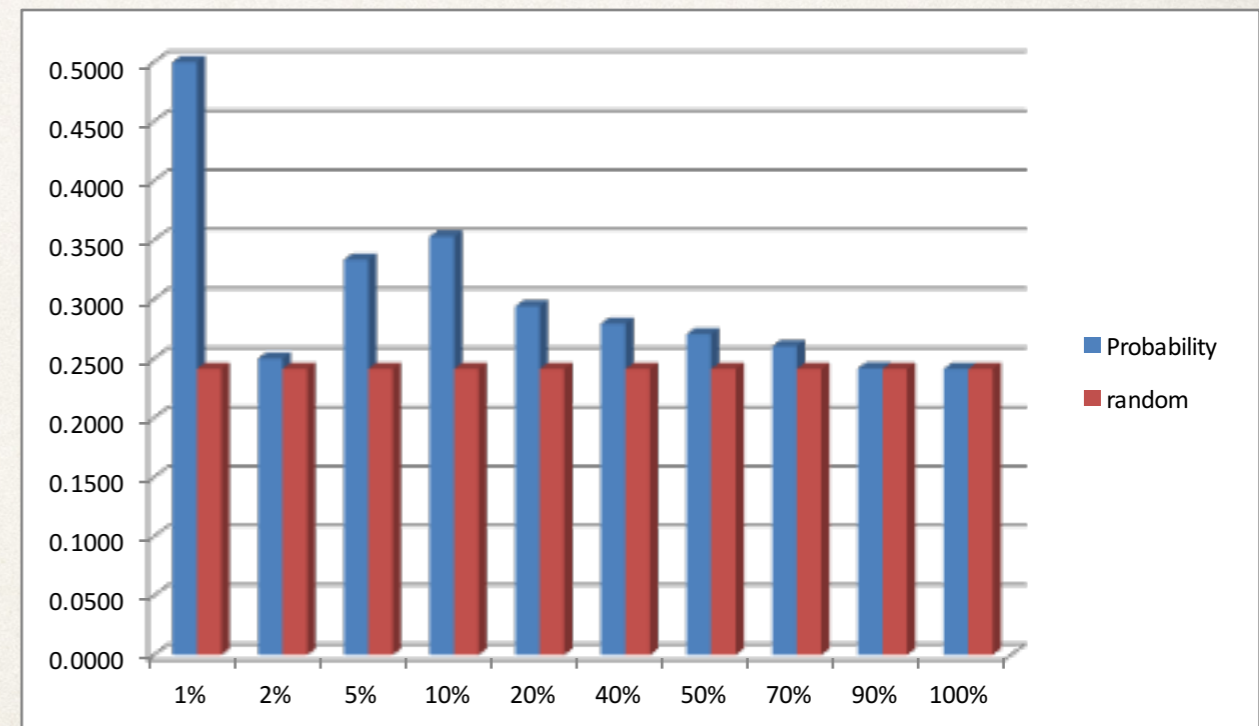


772 SNPs considered
Subsets with obesity,
DM2, lipids, hepatic

Driver	Value	Epsilon	P(C/X)	P(C)	N(X/C)	N(X)	N(C)	NTotal
rs2943641_A	2	2.9391	0.6000	0.2169	6	10	123	567
rs2972146_C	2	2.9391	0.6000	0.2169	6	10	123	567
rs2943650_G	2	2.9391	0.6000	0.2169	6	10	123	567
rs12629908_A	2	2.6981	0.3116	0.2169	43	138	123	567
rs870347_C	2	2.2200	0.2914	0.2169	44	151	123	567
rs1407434_G	0	2.1617	0.2841	0.2169	50	176	123	567
rs972283_A	2	2.1543	0.3085	0.2169	29	94	123	567
rs10496971_C	2	1.9688	0.3011	0.2169	28	93	123	567
rs2241766_C	1	1.9472	0.2741	0.2169	54	197	123	567
rs10885122_A	2	1.9426	0.5000	0.2169	4	8	123	567
rs2986742_G	2	1.9121	0.4545	0.2169	5	11	123	567
rs1799884_A	2	-2.0385	0.0000	0.2169	0	15	123	567
rs3943253_A	2	-2.0502	0.1364	0.2169	15	110	123	567
rs4607517_A	2	-2.1053	0.0000	0.2169	0	16	123	567
rs4880436_A	2	-2.1388	0.0870	0.2169	4	46	123	567
rs174537_C	2	-2.1927	0.0851	0.2169	4	47	123	567
rs174546_G	2	-2.1927	0.0851	0.2169	4	47	123	567
rs174550_A	2	-2.1927	0.0851	0.2169	4	47	123	567
rs972283_A	0	-2.3181	0.1521	0.2169	33	217	123	567
rs2073821_A	2	-2.3502	0.1170	0.2169	11	94	123	567
rs1513181_G	2	-2.3605	0.1250	0.2169	14	112	123	567
rs2237895_A	2	-2.3836	0.1308	0.2169	17	130	123	567
rs7803075_G	2	-2.4635	0.0847	0.2169	5	59	123	567
rs896854_A	0	-2.5528	0.1398	0.2169	26	186	123	567
rs7809589_C	2	-2.5964	0.1231	0.2169	16	130	123	567
rs1111875_A	0	-3.2065	0.1211	0.2169	23	190	123	567

obesity (score = 0.904, predictive but scarce)

obesity (score = 0.105, not so predictive but common)



Doesn't give a good model on its own

The Challenges of Modelling Lifestyle Diseases



Lifestyle diseases, in particular, can only be understood within the paradigm of CAS. We can't model such systems very well.

1. They are extraordinarily multifactorial, requiring big data across multiple scales: genetics, epigenetics, physiology, psychology, neuroscience, epidemiology, sociology, ...
We don't have the data to tackle this.
 1. Standard approach of type "clinical trial" won't work C vs X1, C vs X2 etc.
 2. To present scientific results in such a setting is an enormous challenge.
2. They require the construction of causal chains across long periods of time where adaptation plays a crucial role. We can't do that.
3. They require large, interdisciplinary teams to analyse and model all the relevant data.
We don't have them.

Only by making progress with 1-3) will we be able to come up with suitable interventions.