

Pedalling for Health & Planet?

The Co-Benefits Model

Dr James Woodcock,
University of Cambridge
Moving Active Transportation to Higher
Ground April 2015

Pedalling for Health & Planet?

The Co-Benefits Model

Provisional Results!

Dr James Woodcock,

University of Cambridge

Moving Active Transportation to Higher

Ground April 2015

Our Issue

- Health consistently large
 - except if young with high injury risk
- Carbon mixed
 - Visions England & Wales
 - London hire bikes
- So more systematic approach



Structure of Talk

- Methods
 - Data sources
 - Marginal METs
 - Relation to ITHIM
 - Physical activity dose response curve
 - Probabilistic approach to switching to cycling
 - Distance Decay for Cycling
 - Trip Distance Reduction
- Results
- Future work

Methods

Data

Data Source	Use of Data
National Travel Survey for England (NTS)	Trips & person level data
	Probability of Cycling 1 mile
	Relative probability of cycling longer trips
Health Survey for England (HSE)	Non-travel Physical Activity
Netherlands National Travel Survey	Relative probability of cycling longer trips for ebikes
Global Burden of Disease	Deaths, Years of Life Lost

Marginal METs - MMETs

- Metabolically Equivalent Tasks (METs)
- Marginal METs (MMETs): METs above resting
- Ebikes 3.5, Walking 3.6, Cycling 5.4



I know this is a session on ITHIM but...

- Sorry not really using ITHIM
- Neither spreadsheet model nor Analytica model
- Analysis done in R

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	English and Welsh urban areas (outside London)																	Scenario		3	(enter 4 if you want to enter new values)													

		Person travel time, speeds and distance																																			
		Eng/Wales Baseline(0)	Vison 1	Vison 2	Vison 3	Data entry (4)	Scenario																														
Time (minutes per day)	walk	11.5	12.8	14.1	14.8	16.8	2.8%	21.0	3.5%	70.0	4.5%	21.0	3.5%																								
	cycle	0.9	1%	6.4	11%	9.5	16%	18.1	30%	40.0	20%	18.1	30%																								
	bus	4.6	8%	6.9	11%	15.8	17%	9.6	16%	4.6	3%	9.6	16%																								
	minibus	0.5	1%	1.9	5%	6.3	11%	1.3	2%	0.5	0%	1.3	2%																								
	train	1.8	3%	4.0	7%	6.6	10%	5.1	8%	1.8	0%	5.1	8%																								
	car < 8km	19.7	14%	7.2	11%	1.1	1%	1.3	1%	11.0	7%	1.3	1%																								
	car > 8km	17.9	35%	16.1	28%	1.3	4%	1.4	4%	26.0	17%	1.4	4%																								
Mean speed (kmph)	mbike	0.1	0%	0.1	0%	0.1	0%	0.3	0%	0.3	0%	0.3	0%																								
	elec bike	0.1	0%	0.3	1%	0.8	1%	1.5	1%	0.1	0%	1.5	1%																								
	total	50.1	100%	58.1	100%	59.5	100%	61.1	100%	194.2	100%	61.1	100%																								
	walk	4.3		4.6		4.9		5.2		4.3		5.2																									
	cycle	11.8		13.0		14.0		16.0		11.8		16.0																									
	bus	13.0		16.0		13.0		13.0		13.0		13.0																									
	minibus	13.0		13.0		13.0		13.0		13.0		13.0																									
Distance (km per day)	train	65.1		45.0		50.0		45.0		66.1		45.0																									
	car < 8km	19.7		15.0		15.0		15.0		20.5		15.0																									
	car > 8km	50.7		51.0		50.0		35.0		50.7		35.0																									
	mbike	41.0		38.0		35.0		30.0		42.0		30.0																									
	elec bike	11.8		11.0		13.0		14.0		11.8		14.0																									
	walk	0.9		1.1		1.4		1.4		1.9		1.9																									
	cycle	0.2		1.4		0.8		2.2		1.8		4.8																									
bus	1.8		3.0		1.8		6.1		3.7		1.8																										
minibus	0.1		0.6		3%		1.4		7%		0.1																										
train	1.8		3.0		3.5		2.9		3.5		1.8																										
car < 8km	4.7		1.2		0.3		0.3		0.3		3.8																										
car > 8km	18.5		6.6%		12.7		5.5%		1.9		10%																										
mbike	0.2		0.1		0%		0.1		1%		0.1																										
elec bike	0.0		0%		0%		0.1		1%		0.3																										
total	18.1		100%		15.1		100%		19.0		100%																										
Coefficient of var	1.12		1.05		0.98		0.84		0.08		0.08																										
CO2	100%		82%		46%		39%		10%		39%																										

London Cycle Hire Health Impact Model

Created by James Woodcock CEDAR, University of Cambridge
 jw745@cam.medschl.ac.uk with Anna Goodman LSHTM

Acknowledgements in development of model
 Anna Goodman
 Zaid Chalabi
 Phil Edwards
 Neil Maizlish
 Marko Tainio

Health outcome **Calc**

Risk per billion hours **Calc**

Burden summary for all cause death **Calc**

DALYs summed **Calc**

gains per million hours by age & gender all cause? **Calc**

gains per million hours by age & gender by disease? **Calc**

Physical activity data entry

Speed_by_age_gende (km/day) **Edit Table**

Population size

Cycle time variability

Mode shift (% shift) **Edit Table**

LBSS Cycle Time Variability

Proportion pop cycl (fraction) **Edit Table**

Overreporting non-travel physical activity (Fraction) **Triangular**

The model

Male age structure **Normal**

Age structure women **Normal(30**

% male

% trips newly generated by LBSS **Triangular**

Injury underreporting scaling **Edit Table**

LBSS specific risk on =1, Version C=2

Air pollution data entry

Ventilation rates (Ratios) **Edit Table**

PM2.5 concentrations in the Underground (PM 2.5) **Triangular**

Harms from PM2.5 exposure in the Underground (Ratio) **Uniform**

Air pollution off =1

Performance Profiler

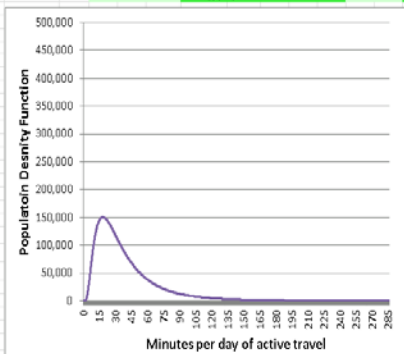
Compared with ITHIM & HEAT

- Uses Comparative Risk Assessment
- No air pollution or injuries!
- Only mortality- but includes YLLs from GBD
- Like ITHIM age & gender specific
- Like ITHIM 2 ½ individual level travel survey data

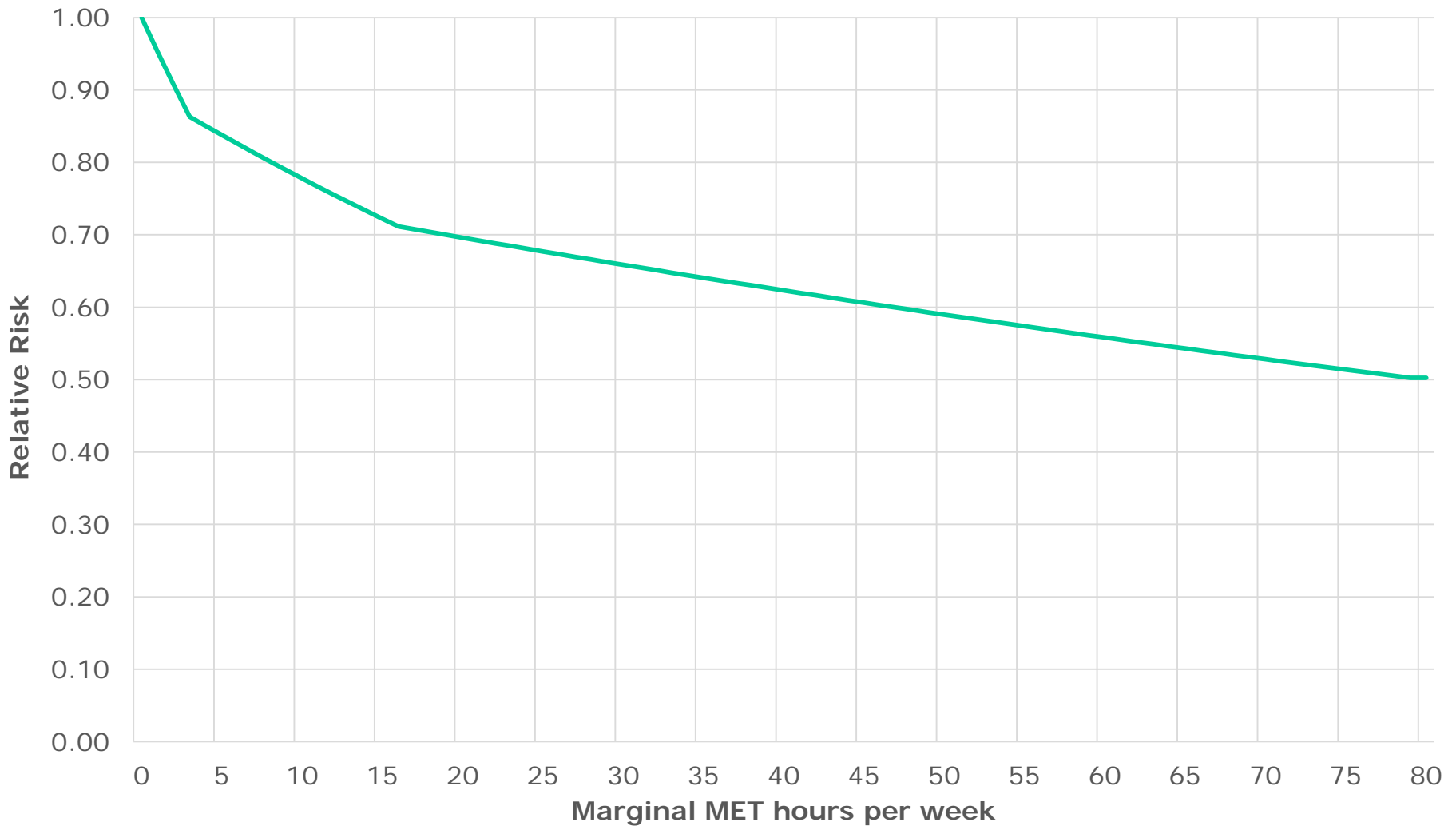


English and Welsh urban areas (outside London)										Scenario		3		(enter 4 if you want to enter new values)																			
Person travel time, speeds and distance										Results										These a													
		Eng/Wales Road/mile		Visum 1		Visum 2		Visum 3		Data entry (4)		Scenario		Breast Cancer		Colon Cancer		Ischemic Heart Disease		Depression		Dementia		Diabetes		Stroke		Road Traffic Injuries		All-cause mortality Woodcock			
		m		f		m		f		m		f		m		f		m		f		m		f		m		f					
Time (minutes per day)	walk	12.5	12%	14.1	14%	16.8	18%	21.6	25%	78.0	45%	11.6	35%																				
	cycle	0.9	1%	0.4	1%	0.5	1%	1.1	2%	18.1	50%	18.1	50%																				
	bus	4.6	8%	6.9	13%	15.5	27%	9.6	16%	4.6	3%	9.6	16%																				
	minibus	0.5	1%	1.0	3%	0.3	1%	1.3	2%	0.5	0%	1.3	2%																				
	train	1.8	3%	4.0	7%	8.8	18%	5.0	8%	1.8	0%	5.0	8%																				
Mean speed (kmph)	car <8km	13.7	14%	7.1	13%	1.1	2%	1.3	2%	11.0	7%	1.3	2%																				
	car >8km	21.9	29%	16.1	18%	2.3	4%	2.4	4%	28.0	17%	1.4	4%																				
	mbike	0.1	0%	0.1	0%	0.1	0%	0.3	0%	0.2	0%	0.3	0%																				
	elec bike	0.1	0%	0.3	1%	0.8	1%	1.5	1%	0.1	0%	1.5	1%																				
	total	56.1	100%	56.1	100%	59.5	100%	81.2	100%	191.2	100%	81.2	100%																				
Distance (km per day)	walk	11.5	12%	14.1	14%	16.8	18%	21.6	25%	78.0	45%	11.6	35%																				
	cycle	0.9	1%	0.4	1%	0.5	1%	1.1	2%	18.1	50%	18.1	50%																				
	bus	4.6	8%	6.9	13%	15.5	27%	9.6	16%	4.6	3%	9.6	16%																				
	minibus	0.5	1%	1.0	3%	0.3	1%	1.3	2%	0.5	0%	1.3	2%																				
	train	1.8	3%	4.0	7%	8.8	18%	5.0	8%	1.8	0%	5.0	8%																				
Coefficient of var	car <8km	60.1	10%	45.0	10%	50.0	10%	45.0	10%	60.1	10%	45.0	10%																				
	car >8km	50.7	9%	51.0	9%	50.0	9%	50.7	9%	50.7	9%	51.0	9%																				
	mbike	41.0	7%	35.0	7%	35.0	7%	30.0	7%	42.0	7%	30.0	7%																				
	elec bike	11.8	2%	12.0	2%	12.0	2%	12.0	2%	11.8	2%	12.0	2%																				
	total	18.1	100%	15.1	100%	19.0	100%	16.7	100%	42.5	100%	16.7	100%																				
CO2		100%	82%	46%	39%	105%	39%																										
Physical Activity Risk Function (power 0.25=0, power 0.5=1, power 0.375=2, log=3, linear=4)										1																							
Air Pollution: Mean PM urban areas England and Wales																																	
population		10.3	10.1	9.6	9.1	10.1	9.4																										

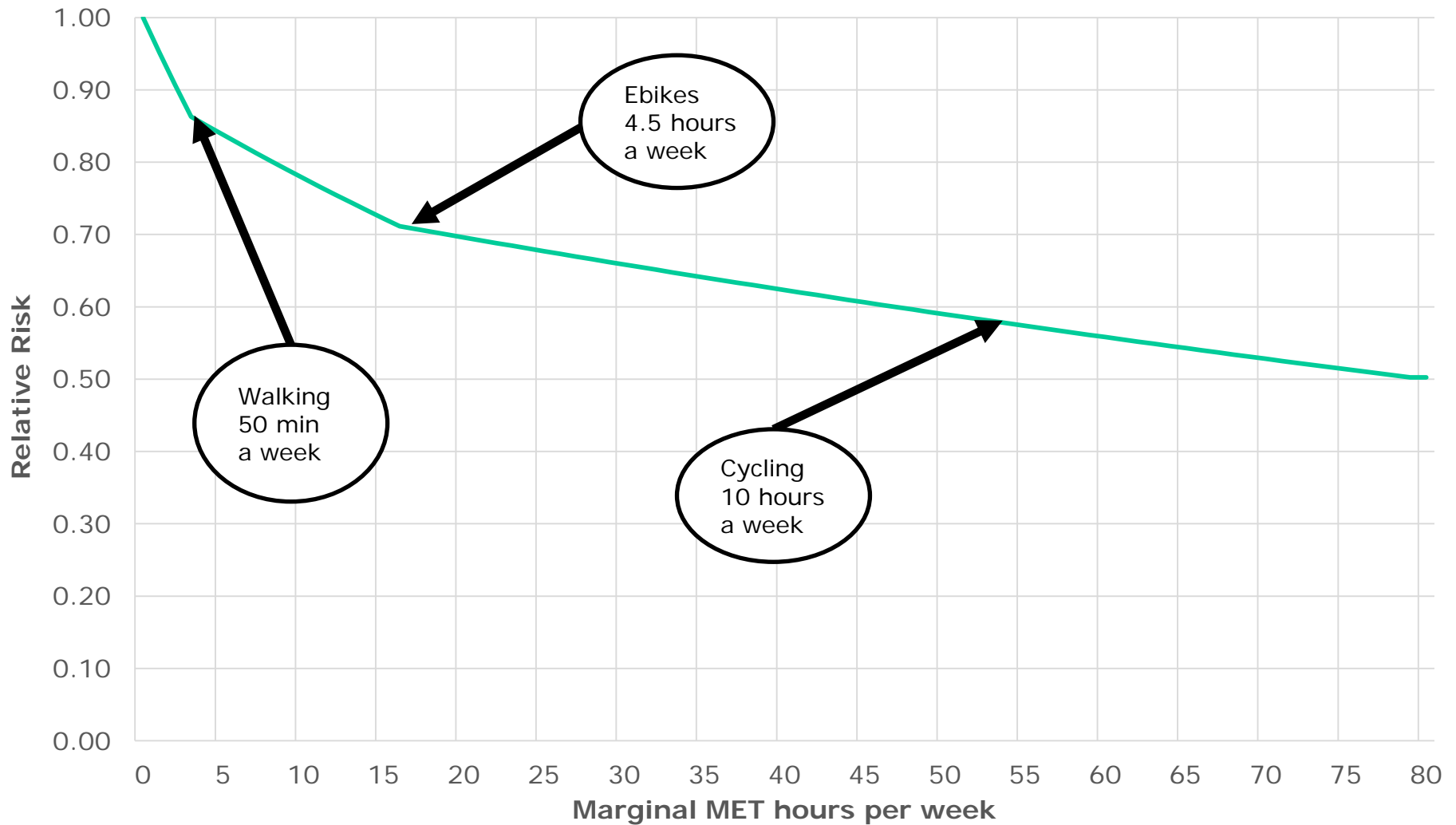
Total DALYs -245,056 -2.8% CO2 -61.5%



Relative Risks All-Cause Mortality from Leisure Activity



Relative Risks for All-Cause Mortality from Leisure Activity

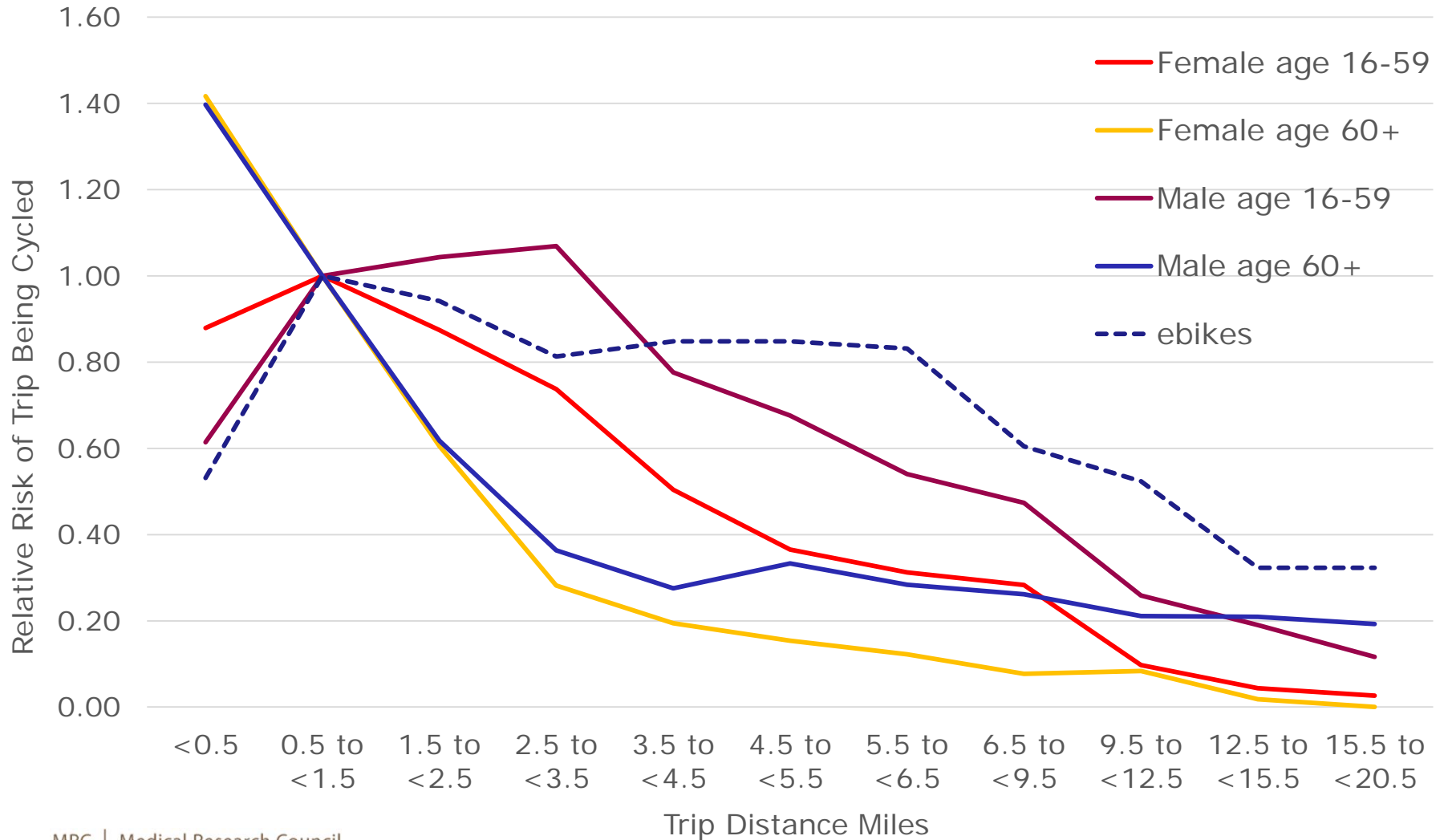


Probability of Cycling a Trip

- Probabilistic rules better than fixed distance cut-off
- Probabilistic rules better than excluding groups e.g. age/gender/ ethnicity
- Models should offer scenarios about change



Relative Risk of Trip Being Cycled

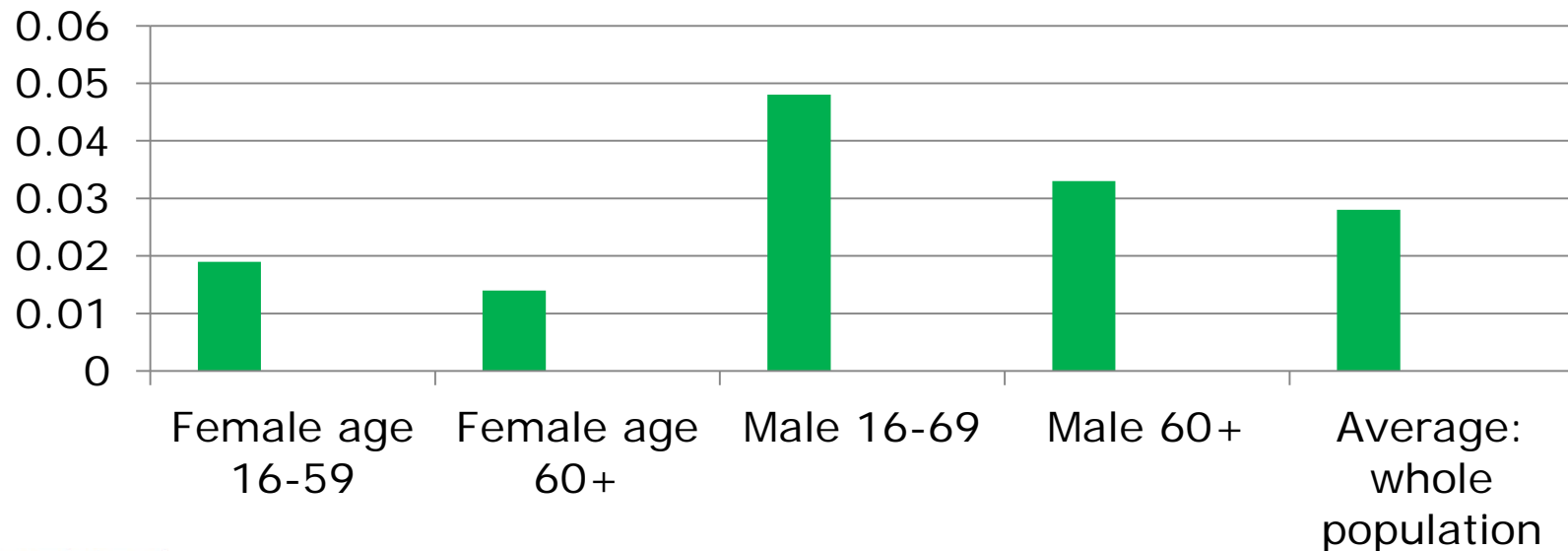


Relative Risks of Cycling Trips By Distance

Distance (miles)	Female age 16-59	Female age 60+	Male age 16-59	Male age 60+	Ebikes
<0.5	0.88	1.42	0.61	1.40	0.53
0.5 to <1.5	1.00	1.00	1.00	1.00	1.00
1.5 to <2.5	0.87	0.60	1.04	0.62	0.94
2.5 to <3.5	0.74	0.28	1.07	0.36	0.81
3.5 to <4.5	0.50	0.19	0.78	0.28	0.85
4.5 to <5.5	0.37	0.15	0.68	0.33	0.85
5.5 to <6.5	0.31	0.12	0.54	0.28	0.83
6.5 to <9.5	0.28	0.08	0.47	0.26	0.60
9.5 to <12.5	0.10	0.08	0.26	0.21	0.52
12.5 to <15.5	0.04	0.02	0.19	0.21	0.32
15.5 to <20.5	0.03	0.00	0.12	0.19	0.32

Probability of Cycling Trip of 1 mile

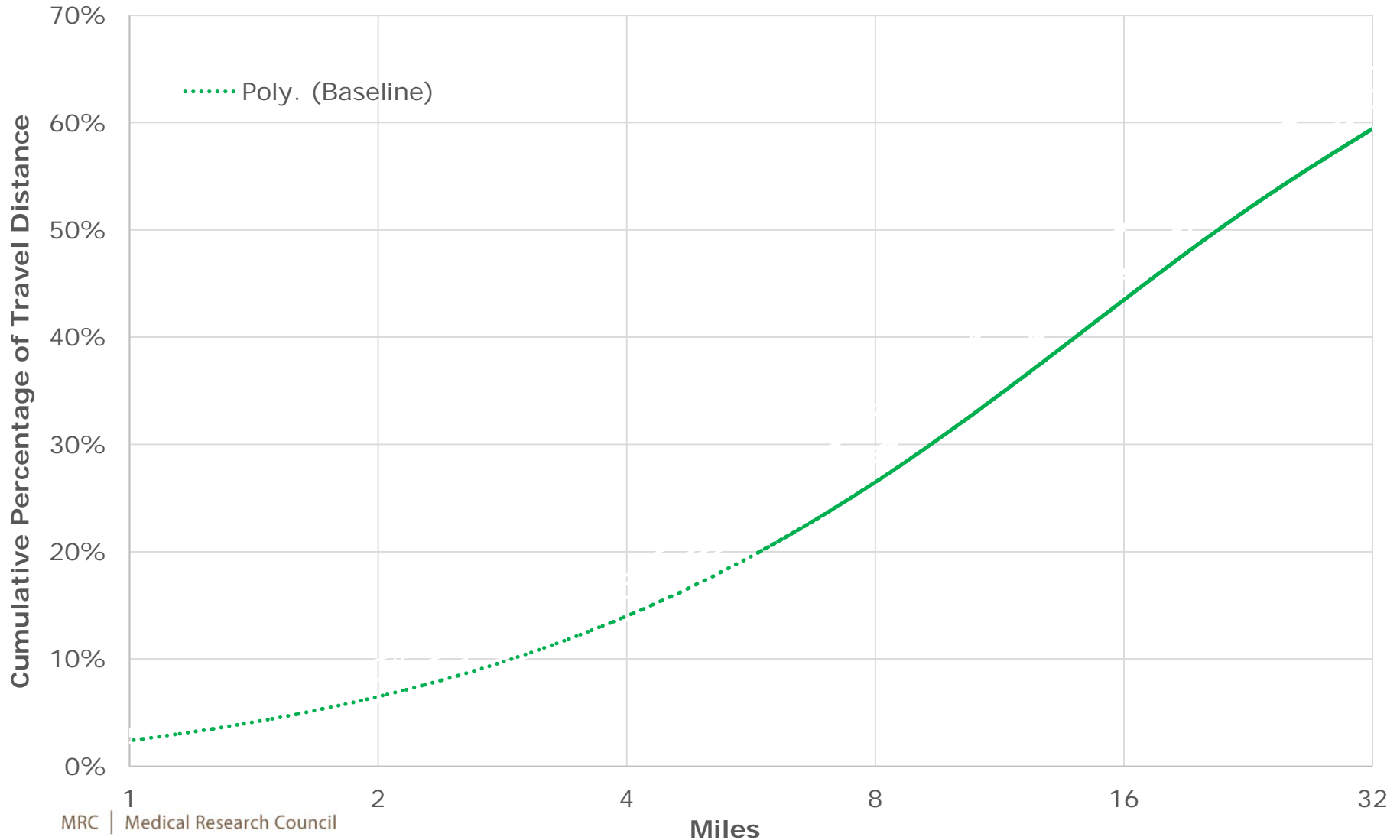
	Female age 16-59	Female age 60+	Male age 16-59	Male age 60+	whole population
BASELINE RISK (for trip 0.5 to <1.5 miles)	0.019	0.014	0.048	0.033	0.028



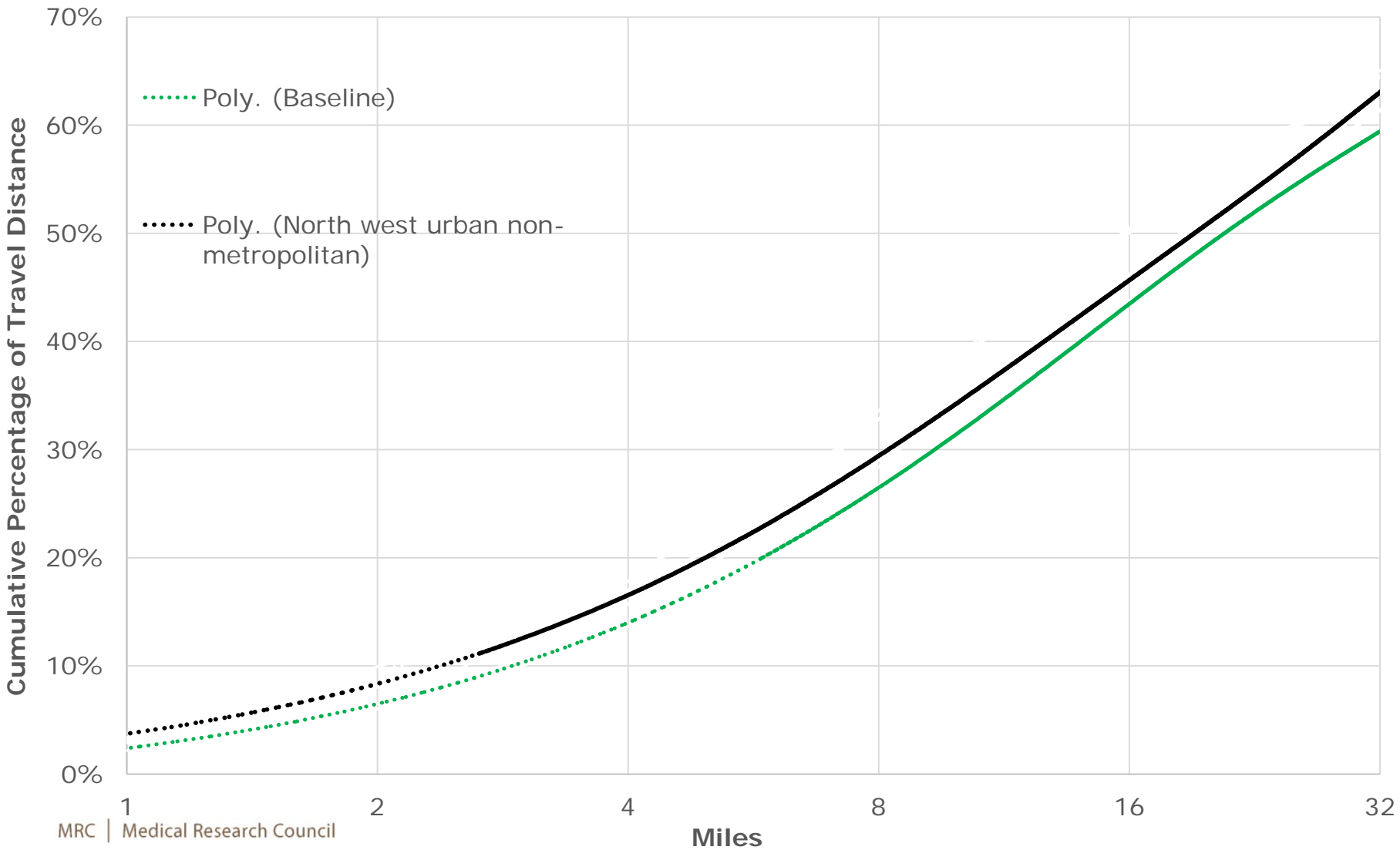
Sprawl versus Density & Trip Distances



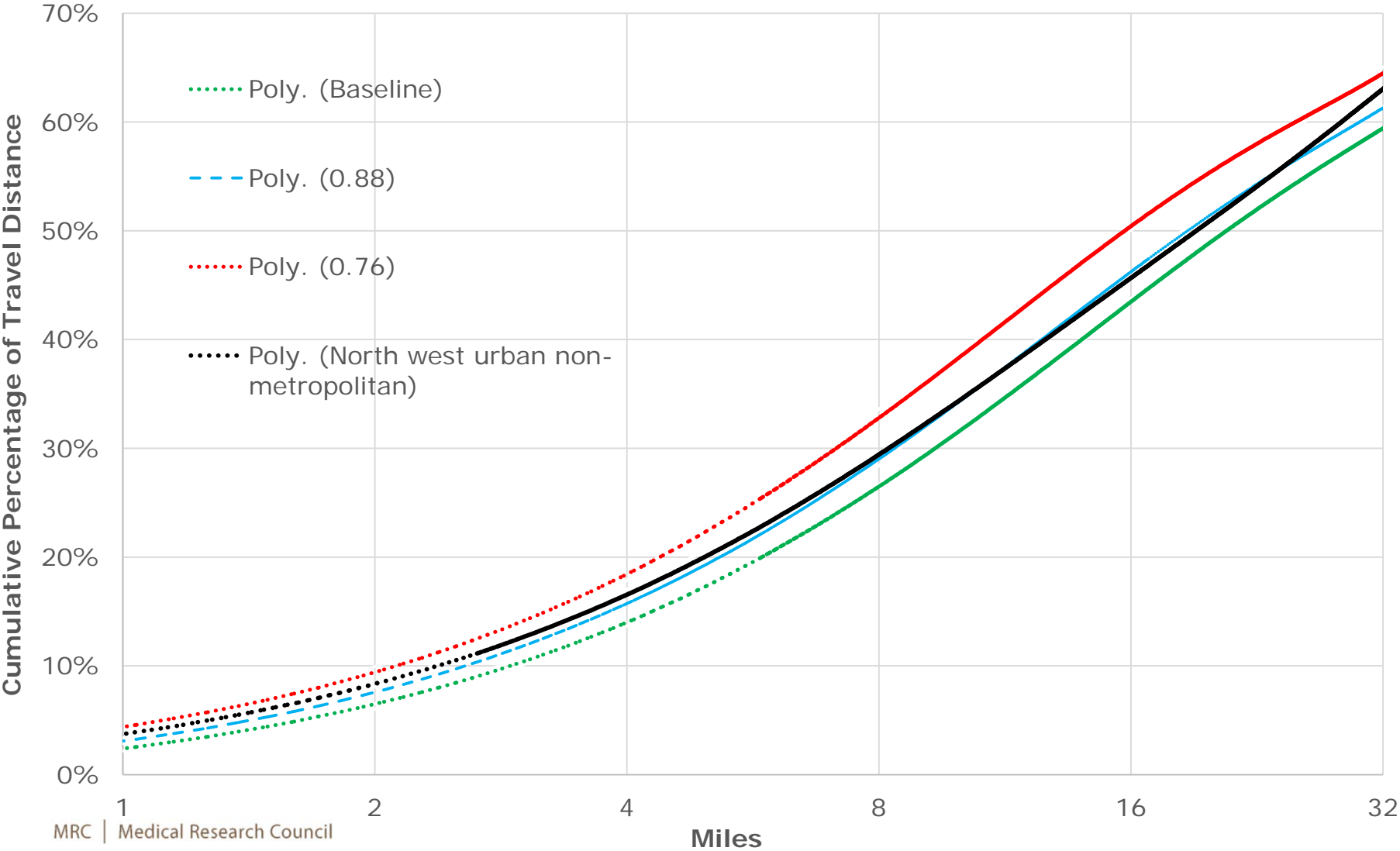
Cumulative % of Travel Distance: England



England Urban North West non-metropolitan



Trip Distance Reduction



Logic of model

- Generate multiple scenarios by
 - Reducing trip distances
 - Increasing probability of cycling each trip

Logic of model: For All Trips

1. Calculate MMETs based on walking or cycling time
2. Apply Trip Distance Reduction
 - Range 0% to 24%
3. Apply Increase in Odds of Cycling* Baseline Odds of Cycling
 - Non-cycled trips <20.5 miles
 - Range 1 to 64
4. Probabilistically decide if trip is now cycled
5. If trip is now cycled then calculate MMETs from cycling
6. If trip previously had walking element lose walking MMETs
7. Sum MMETs for each person
8. Compare scenario vs baseline
9. Calculate outcomes

Scenario Trip Distance Reduction 0.88 Mode Shift * 8 No Equity, No Ebikes

Trip Distance (miles)	Mode	Old MMET Hours	New Trip Distance	Probability of Cycling	New mode	New MMET Hours
2	Walk	1.7	1.76	<u>12%</u>	Cycle	0.95
4	Bus	1	3.53	8.3%	Bus	1
10	Car	0	8.8	4.5%	Cycle	4.8
		Total: 2.7				Total: 6.7

Female 40 year

Baseline risk 0.019

For the Walking Trip:

Trip Distance 1.76 so relative risk 0.87

Mode Shift *8

So Odds of Cycling= $(0.019 * 0.87) / (1 - (0.019 * 0.87)) * 8 = 0.13$

Probability of Cycling= 0.12

Changing the Assumptions: Equity and Ebikes

Scenario Type	Risk of Cycling 1 Mile	Relative Odds of Cycling Longer Trip
Basic	Age & gender odds of cycling 1 miles	Age & gender relative odds of cycling a longer trip
Equity	Population average odds of cycling 1 mile	Age & gender relative odds of cycling a longer trip
Ebikes	Age & gender odds of cycling 1 mile	Ebike specific relative odds of cycling a longer trip
Ebikes plus equity	Population average odds of cycling 1 mile	Ebike specific relative odds of cycling a longer trip

Caveats

- Only applied to people aged 18 to 79 years
- Not included injuries
 - Likely higher for electric bikes
- Run on sample of data- 30,000 trips
- Only reporting car miles not carbon emissions

Provisional Results

Provisional Results:

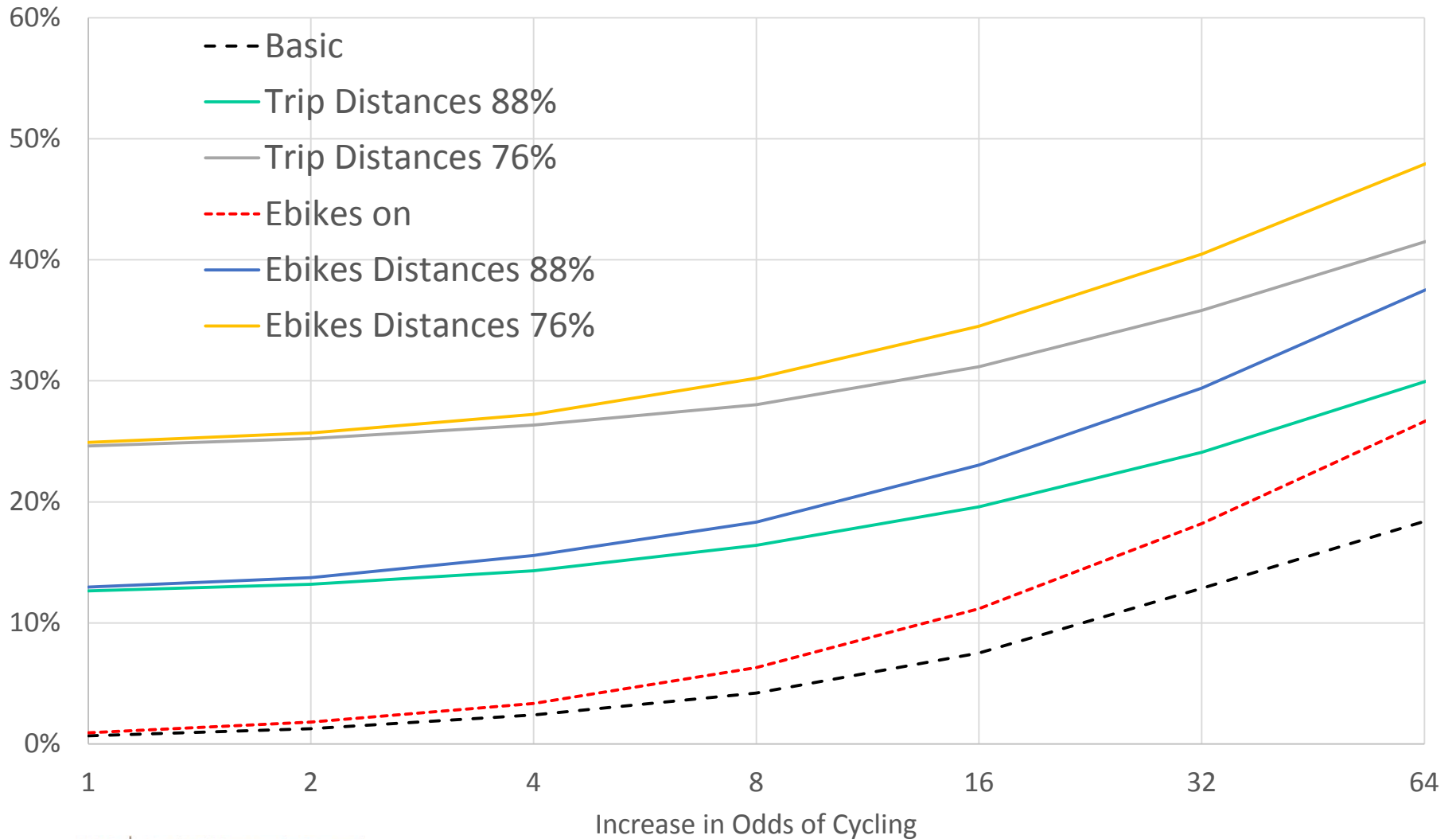


Putting Results in Context

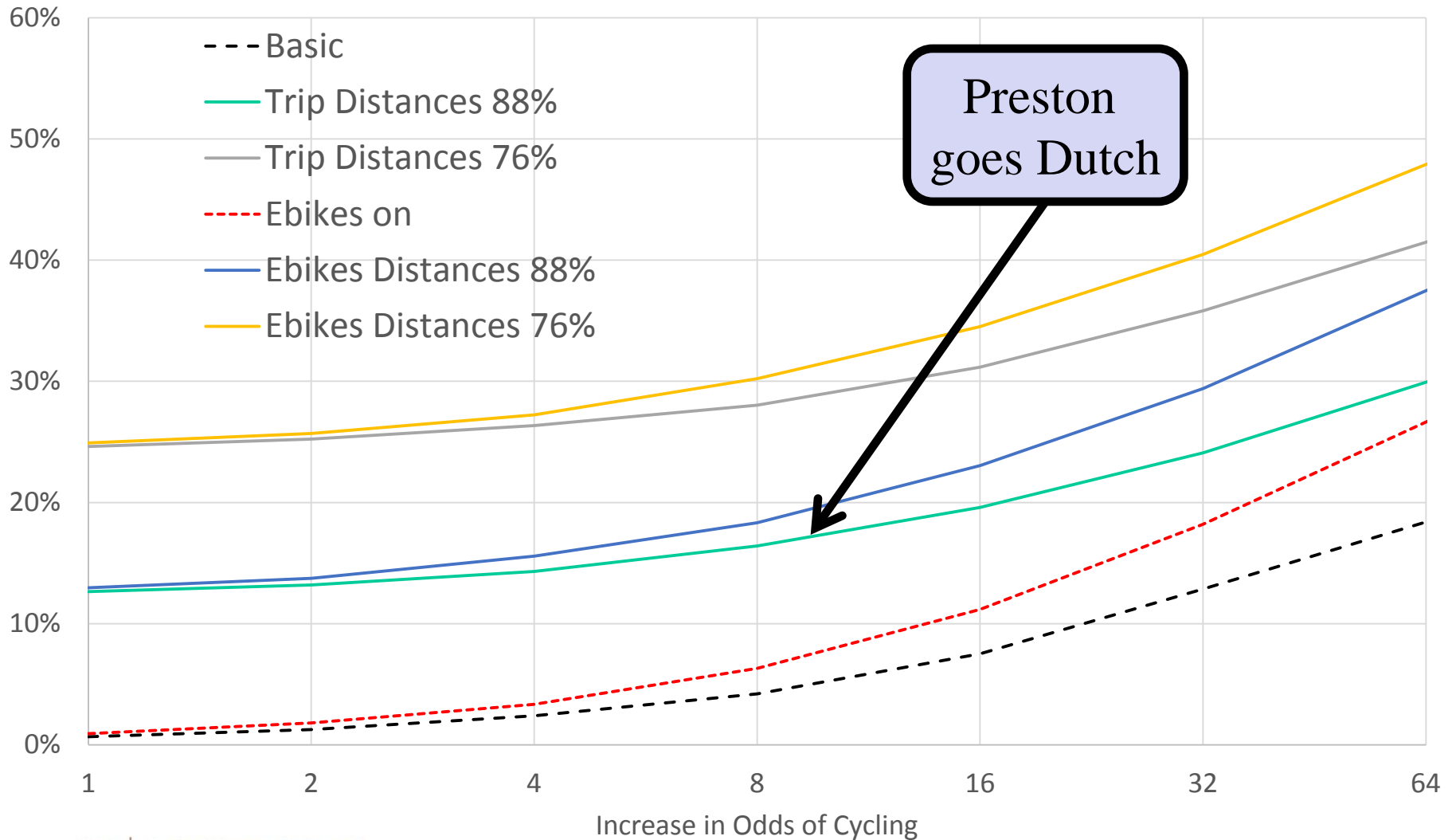
- Dutch mode share 27% vs England 1.9%
 - Hilliness of England reduce Dutch value to c.19%
 - So c.10* greater cycling propensity in the Netherlands
- Trip distance reduction 12% \approx urban area with shorter trips



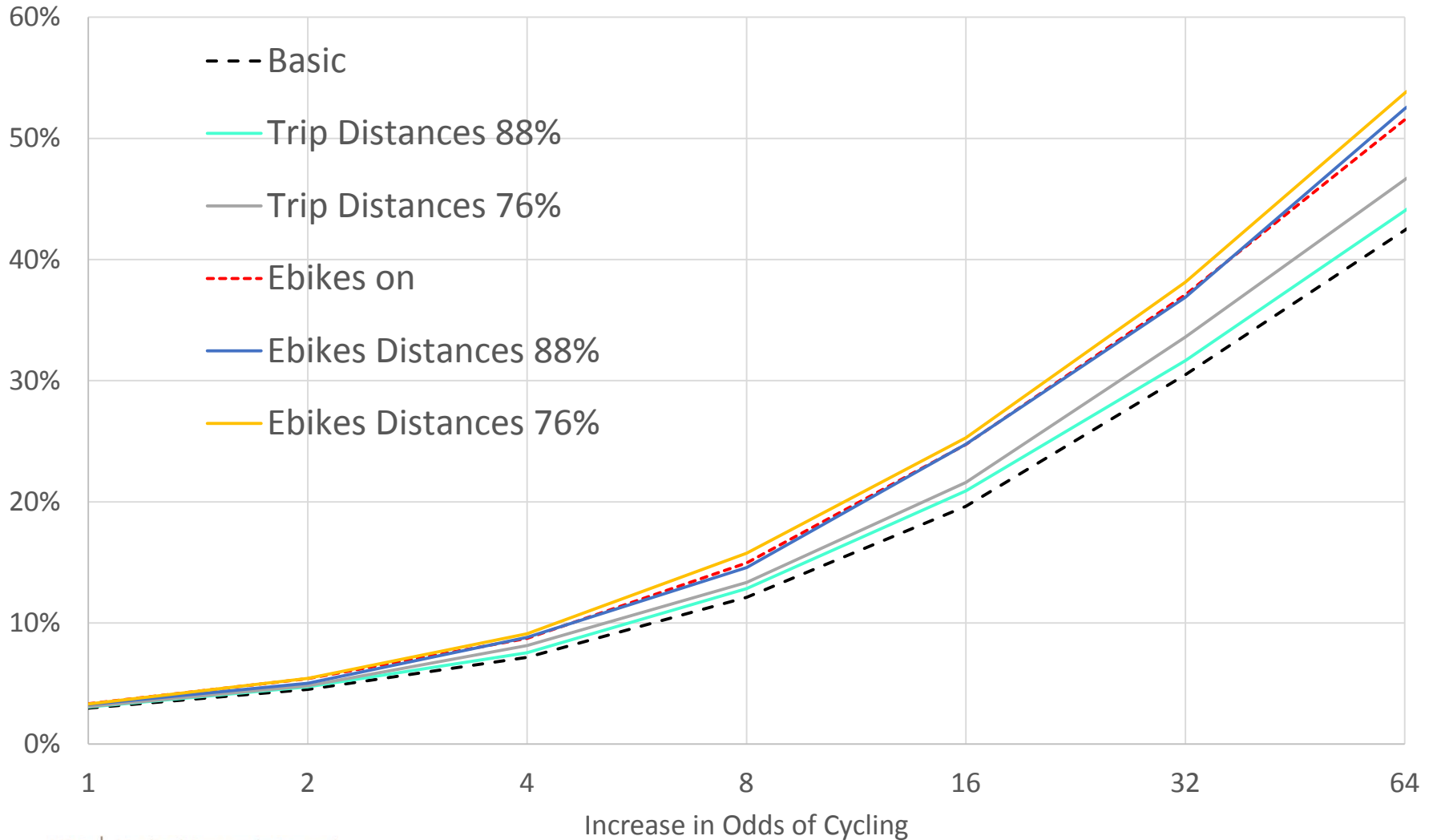
Reduction in Car Miles: Equity Off



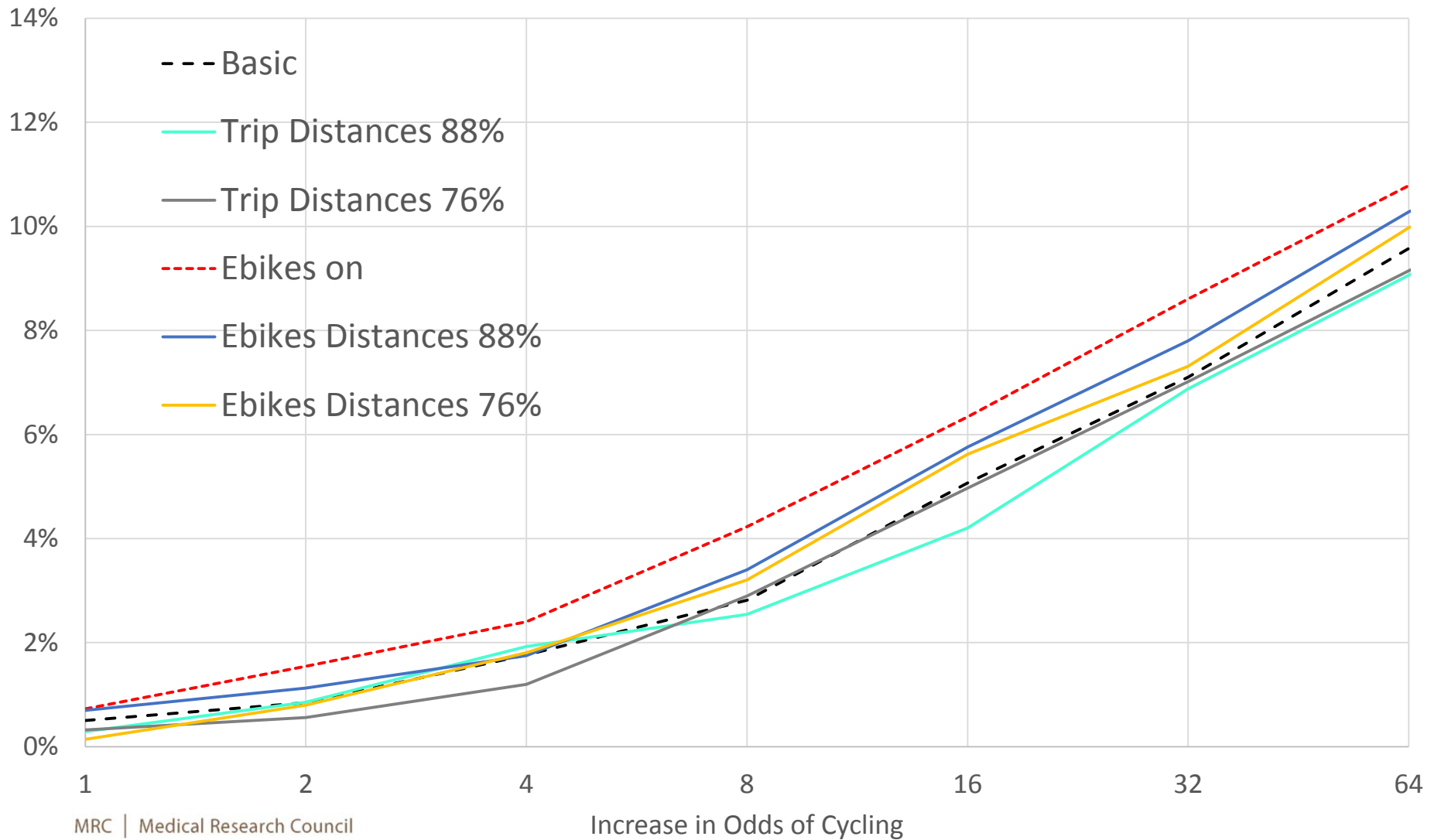
Reduction in Car Miles: Equity Off



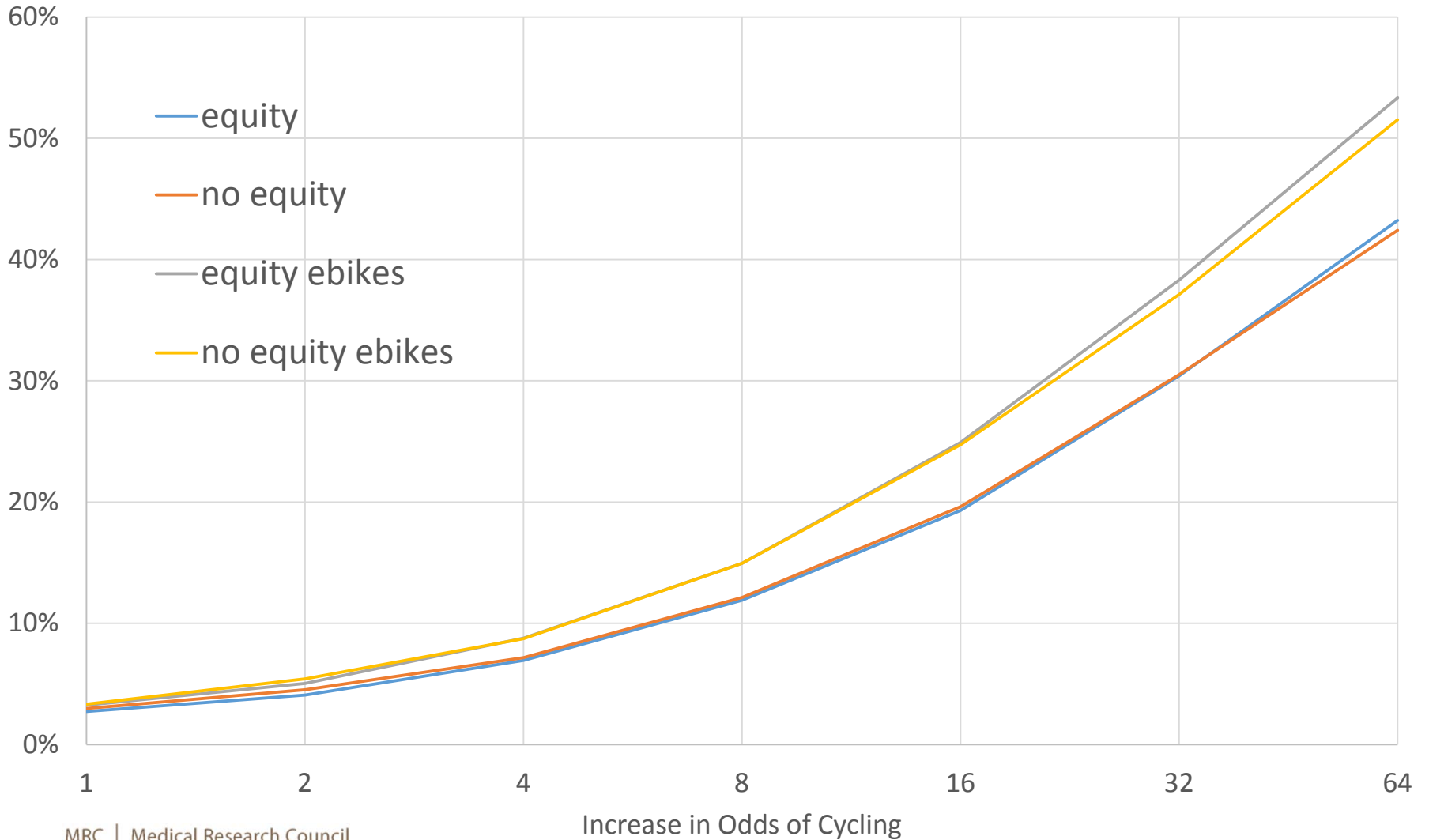
Mode Share no equity



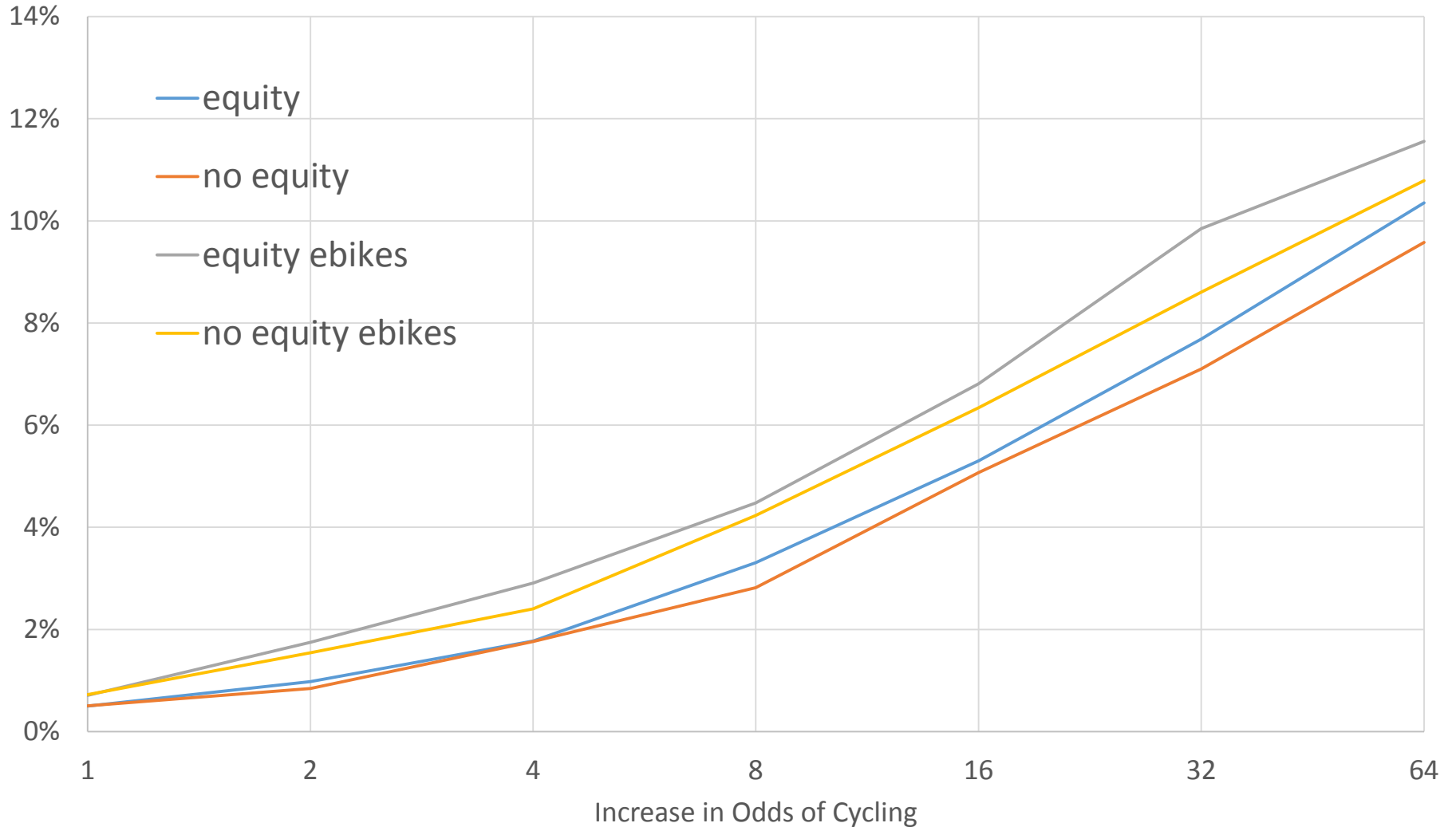
% Reduction Years of Life Lost



Mode share: equity vs no equity



Health Gain: equity vs no equity



What is happening with results?

- Provisional – could change substantially
- Walking & Health
 - As distances fall walking trips become shorter so fewer MET hours
 - Not assuming shift between other modes

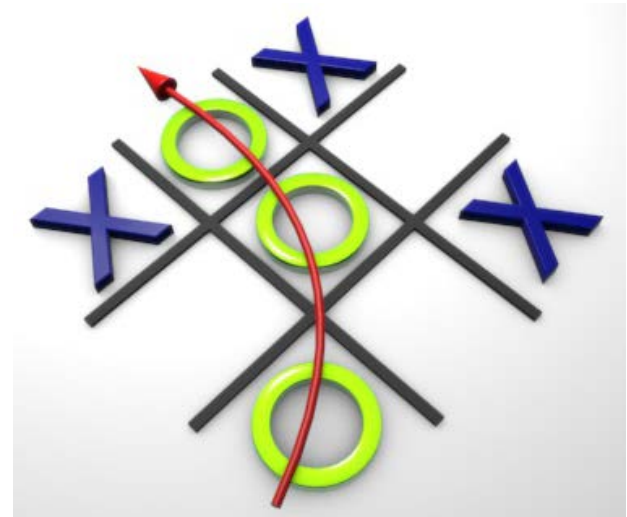


Future Steps

- **Redoing & checking the analysis!**
- **Simulation**
 - Uncertainty & variability
 - Optimising speed
- **Health outcomes**
 - Morbidity
 - Injuries: higher risks for ebikes
 - Air pollution (less important)
- **Adding other outcomes**
 - By age, gender, socio-economic status
 - Time savings/costs
 - Who stops needing to own a car?

Future Steps: Modifying the rules

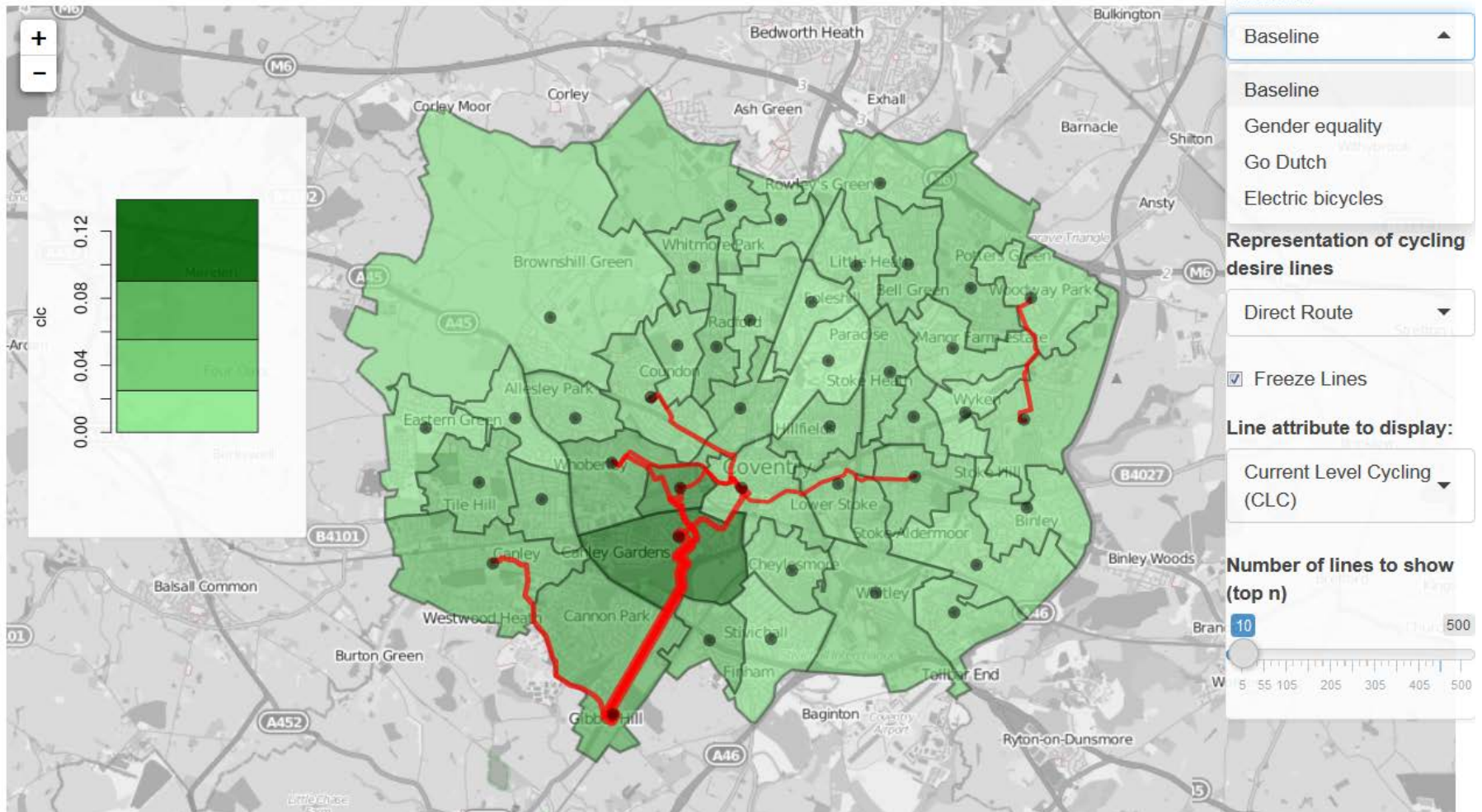
- Walking mode shift assumptions
- Trips longer than 20 miles
- Oldest ages & behaviour change?
- Limits on individual cycling
- Varying Trip Distance Reduction by trip purpose
- Ebike assumptions



Future Steps: Propensity to Cycle Tool

Infrastructure planning tool

Interactive map



Thanks for listening!

Co-authors

**Alvaro Ullrich¹, Robin Lovelace², Marko Tainio¹, Rachel
Aldred³, Thiago Hérick de Sá⁴, Ali Abbas¹, Anna
Goodman⁴**

**¹ CEDAR MRC Epidemiology Unit, ² University of Leeds, ³
University of Westminster, ⁴ University of Sao Paulo, ⁵ LSHTM**

ACKNOWLEDGEMENT

Thanks for listening!

This work was undertaken by the Centre for Diet and Activity Research (CEDAR), a UKCRC Public Health Research Centre of Excellence.

Funding from Cancer Research UK, the British Heart Foundation, the Economic and Social Research Council, the Medical Research Council, the National Institute for Health Research, and the Wellcome Trust, under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged.

Funding for this project for the NPCT from the Department for Transport is gratefully acknowledged.

