



TECHNISCHE UNIVERSITÄT
CHEMNITZ

„The German Naturalistic Cycling Study- Comparing cycling speed of riders of different e-bikes and conventional bicycles”

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What do we know so far?

- e-bikes can be faster than conventional bicycles

(Cherry & He, 2009 Lin; He, Tan, & He, 2007, Jellinek, Hildebrandt, Pfaffenbichler & Lemmerer, 2013)

Problems:

- Term e-bike covers broad range of vehicles (Cherry & Cervero, 2007)
- Up to now only stationary or floating observation (Jellinek et al., 2013; Lin et al., 2007)
 - Covers only limited range of infrastructure types.
 - No direct collection of age, gender and even bicycle type.

Research objectives:

- Are there speed differences? (cyclists vs. riders of different e-bikes)
- What influences the speed? (gradient of the road, infrastructure type and age)

Participants

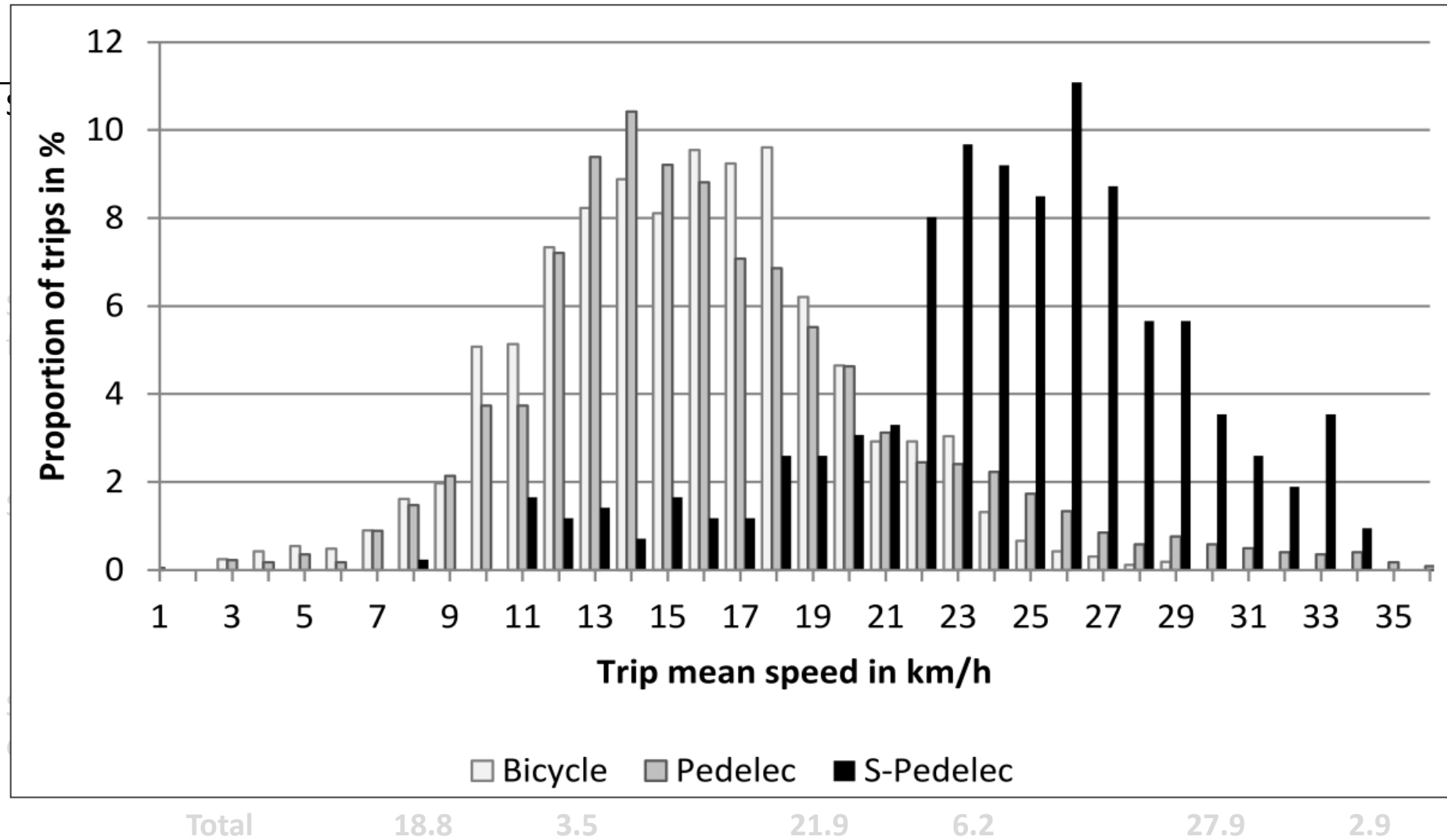
$N = 85$

Age groups	<u>Cyclist</u>			<u>Pedelec rider</u>			<u>S-pedelec rider</u>		
	N	M age	SD age	N	M age	SD age	N	M age	SD age
≤ 40 years	8	30.8	7.1	15	33.3	6.6	3	25.0	9.5
41 - 64 years	9	52.4	8.5	14	54.1	7.2	6	43.2	1.7
≥ 65 years	11	69.5	3.2	19	70.4	3.2	-	-	-
Total	28	51.5	17.2	48	53.5	16.8	9	37.1	10.3

Video annotation

- Infrastructure type
- Road gradient
- Free flow conditions

Mean operating speed



Total

18.8

3.5

21.9

6.2

27.9

2.9

Mean operating speed

		<u>Bicycle</u>		<u>Pedelec</u>		<u>S-pedelec</u>	
	Age group	M	SD	M	SD	M	SD
Speed	≤ 40	16.6	3.4	20.5	5.2	23.4	0.9
	41-64	15.8	2.3	17.5	4.0	25.1	3.7
	≥ 65	13.9	2.6	14.8	1.9	-	-
	Total	15.3	2.3	17.4	4.4	24.5	3.1
Speed free flow	≤ 40	18.0	2.9	23.6	5.9	22.1	3.5
	41-64	17.6	3.4	18.6	4.5	26.3	4.1
	≥ 65	13.6	2.8	15.6	2.5	-	-
	Total	16.1	3.6	19.0	5.5	24.9	4.2
Speed uphill	≤ 40	14.5	3.1	20.4	5.1	20.7	1.9
	41-64	13.9	4.0	16.1	3.2	22.2	4.4
	≥ 65	10.9	2.1	13.5	2.2	-	-
	Total	12.9	3.4	16.4	4.6	21.7	3.7
Speed down-hill	≤ 40	19.6	3.2	26.9	7.0	27.0	2.6
	41-64	20.6	2.3	21.2	5.6	28.3	3.1
	≥ 65	16.7	3.6	18.5	2.4	-	-
	Total	18.8	3.5	21.9	6.2	27.9	2.9

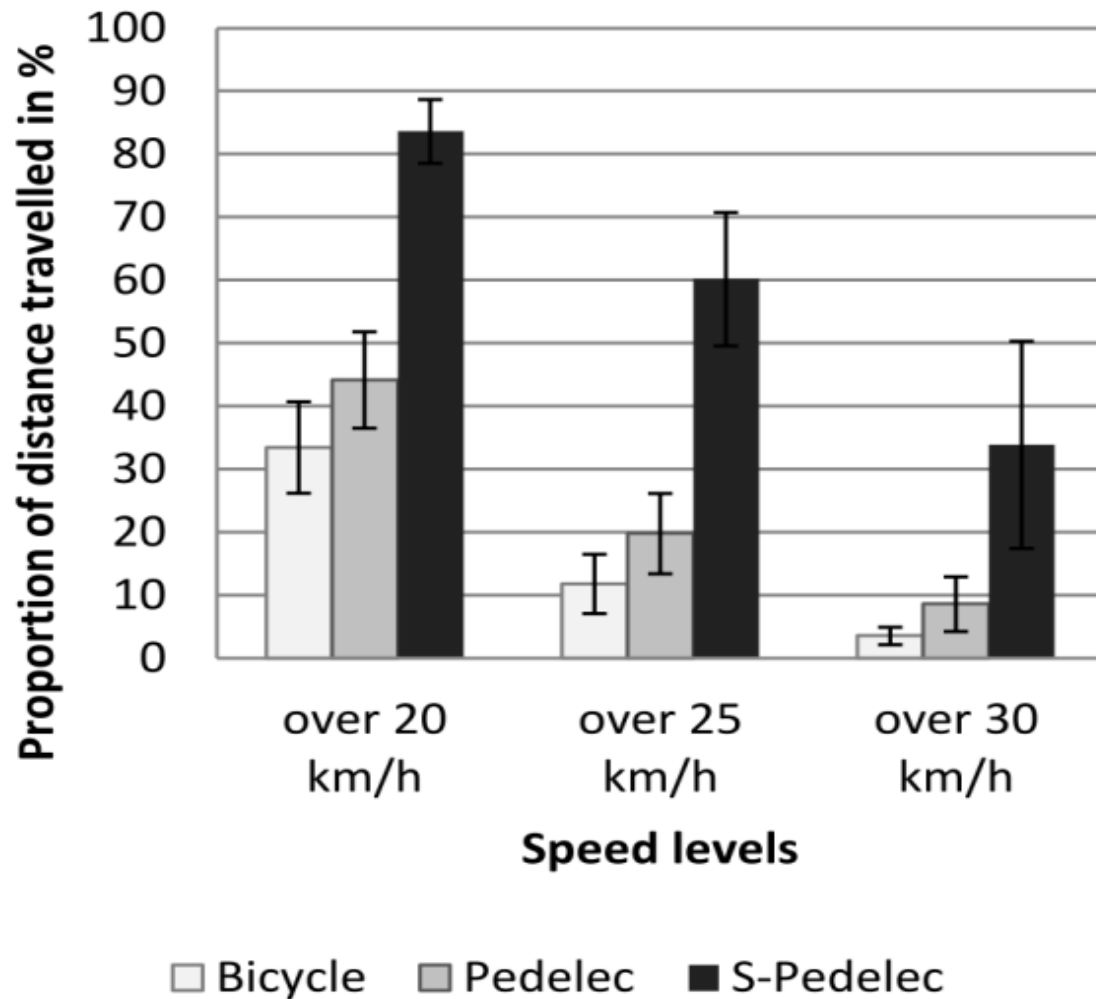
Mean speed free flow condition

		<u>Bicycle</u>		<u>Pedelec</u>		<u>S-pedelec</u>	
	Age group	M	SD	M	SD	M	SD
Speed	≤ 40	16.6	3.4	20.5	5.2	23.4	0.9
	41-64	15.8	2.3	17.5	4.0	25.1	3.7
	≥ 65	13.9	2.6	14.8	1.9	-	-
	Total	15.3	2.3	17.4	4.4	24.5	3.1
Speed free flow	≤ 40	18.0	2.9	23.6	5.9	22.1	3.5
	41-64	17.6	3.4	18.6	4.5	26.3	4.1
	≥ 65	13.6	2.8	15.6	2.5	-	-
	Total	16.1	3.6	19.0	5.5	24.9	4.2
Speed uphill	≤ 40	14.5	3.1	20.4	5.1	20.7	1.9
	41-64	13.9	4.0	16.1	3.2	22.2	4.4
	≥ 65	10.9	2.1	13.5	2.2	-	-
	Total	12.9	3.4	16.4	4.6	21.7	3.7
Speed down-hill	≤ 40	19.6	3.2	26.9	7.0	27.0	2.6
	41-64	20.6	2.3	21.2	5.6	28.3	3.1
	≥ 65	16.7	3.6	18.5	2.4	-	-
	Total	18.8	3.5	21.9	6.2	27.9	2.9

Mean speed road gradient

		<u>Bicycle</u>		<u>Pedelec</u>		<u>S-pedelec</u>	
	Age group	M	SD	M	SD	M	SD
Speed	≤ 40	16.6	3.4	20.5	5.2	23.4	0.9
	41-64	15.8	2.3	17.5	4.0	25.1	3.7
	≥ 65	13.9	2.6	14.8	1.9	-	-
	Total	15.3	2.3	17.4	4.4	24.5	3.1
Speed free flow	≤ 40	18.0	2.9	23.6	5.9	22.1	3.5
	41-64	17.6	3.4	18.6	4.5	26.3	4.1
	≥ 65	13.6	2.8	15.6	2.5	-	-
	Total	16.1	3.6	19.0	5.5	24.9	4.2
Speed uphill	≤ 40	14.5	3.1	20.4	5.1	20.7	1.9
	41-64	13.9	4.0	16.1	3.2	22.2	4.4
	≥ 65	10.9	2.1	13.5	2.2	-	-
	Total	12.9	3.4	16.4	4.6	21.7	3.7
Speed down-hill	≤ 40	19.6	3.2	26.9	7.0	27.0	2.6
	41-64	20.6	2.3	21.2	5.6	28.3	3.1
	≥ 65	16.7	3.6	18.5	2.4	-	-
	Total	18.8	3.5	21.9	6.2	27.9	2.9

Mean distance travelled at higher speed



Both groups of e-bike riders spend more kilometers at high speed areas than conventional cyclists.

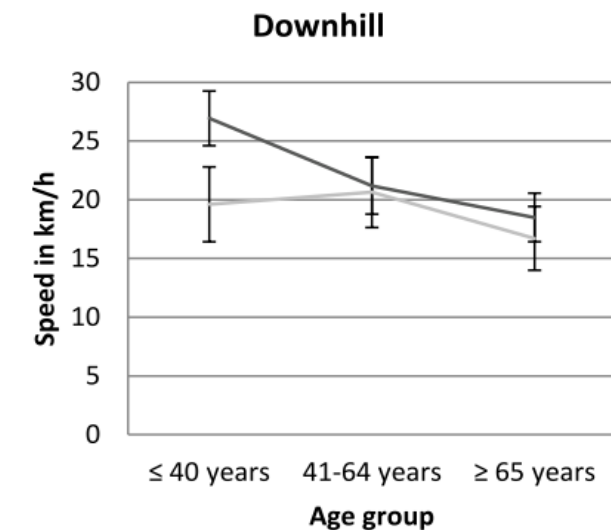
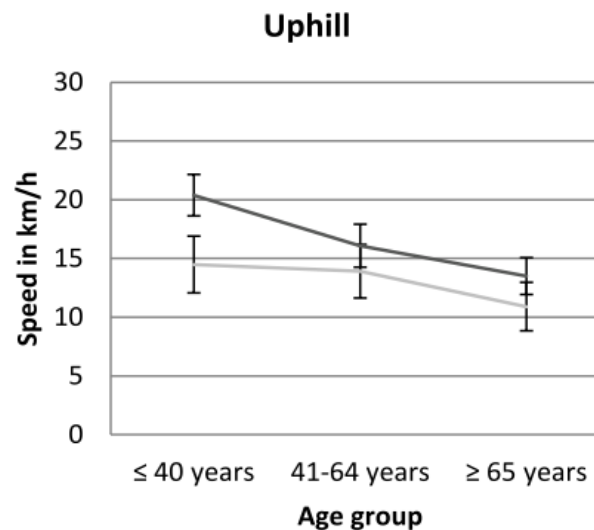
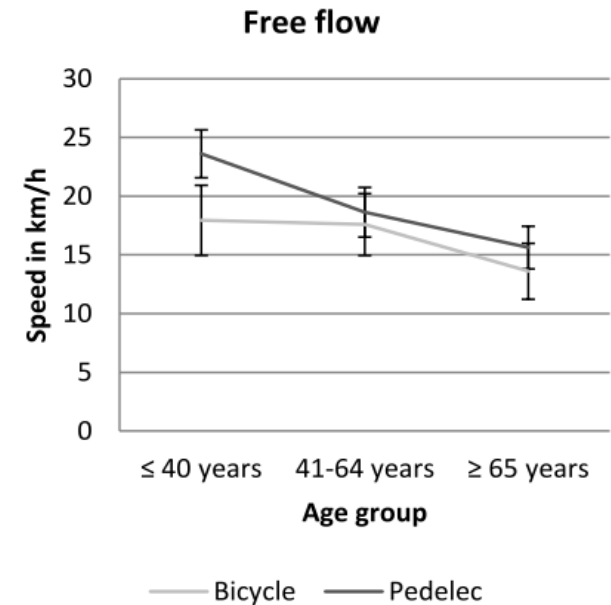
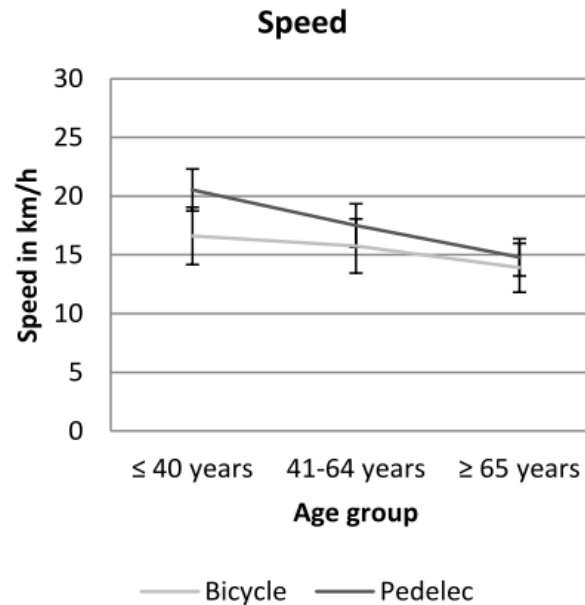
Speed on different types of infrastructure

Infrastructure type	<u>Bicycle</u>			<u>Pedelec</u>			<u>S-pedelec</u>		
	N	M	SD	N	M	SD	N	M	SD
Road	28	16.4	2.7	48	18.8	4.4	9	25.6	2.8
Bicycle infrastructure	27	16.7	4.0	42	18.4	4.7	6	23.6	2.3
Pavement	28	13.3	3.0	48	13.9	4.8	7	17.6	3.2
Pedestrian area	17	12.7	4.0	15	11.1	2.8	2*	19.8	2.9
Unpaved	15	13.7	4.7	31	14.5	5.0	5	16.4	3.1
Miscellaneous	27	9.9	2.2	48	9.4	3.3	9	14.2	1.6

Influence of age on speed

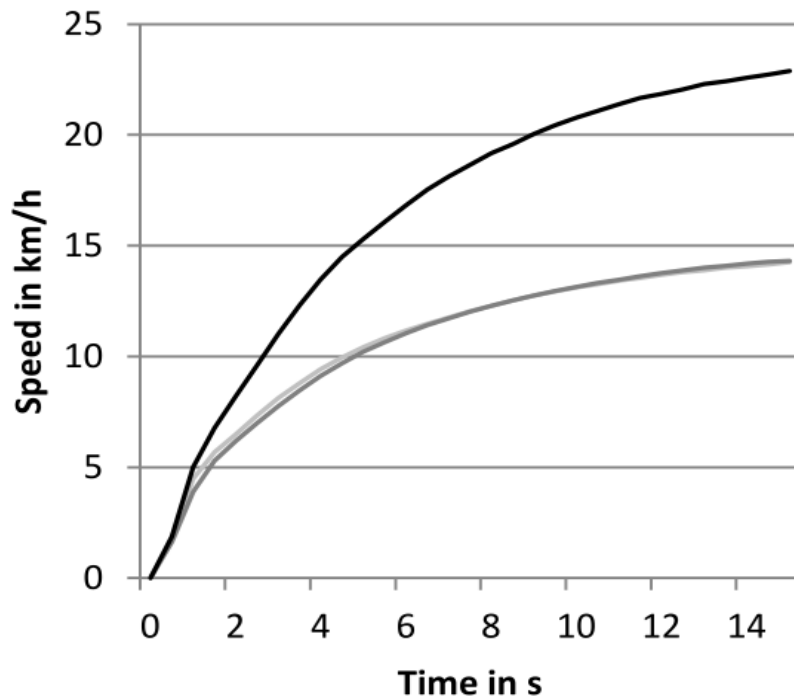
(only pedelec riders and cyclists $n = 76$)

Age has a significant effect on speed



Acceleration

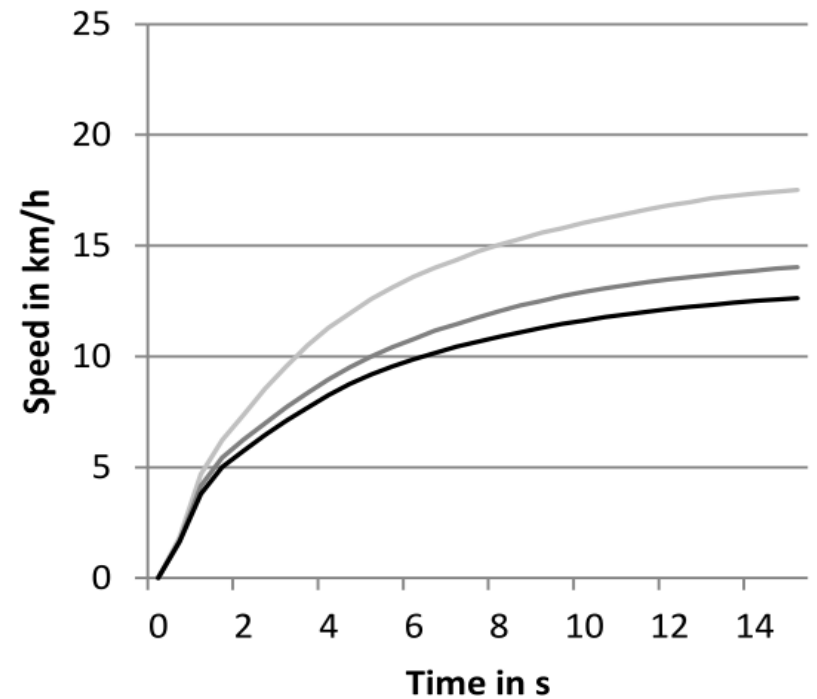
Bicycle type



— Bicycle — Pedelec — S-pedelec

$N = 85$

Age groups



— ≤ 40 years — 41-64 years — ≥ 65 years

only pedelec rider and cyclists $n = 76$

What do we know now?

- S-pedelec riders:
 - higher mean speed overall and under various conditions
 - cover larger distances at a higher speed
 - accelerate stronger than conventional bicycles and pedelecs
- Pedelec-riders cycle faster than conventional cyclists

Infrastructure

- S-pedelecs are fastest on each type of infrastructure
- substantial amount of illegal infrastructure use

Age

- Significant age effects on speed: 65 and older slowest overall, 40 and younger had highest speeds

Thank you for your attention

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Literature

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