Risk perception and differences in self-reported cycling behavior between electric- and conventional-bike riders in Denmark

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1 INTRODUCTION

Electric bikes can contribute to the decrease of emissions and present a carbon-positive alternative to gas-powered forms of motorized transport [1][2]. Hence, the fact that both conventional and e-bike use have increased considerably during the Covid-19 pandemic can be considered as a positive development [3]. At the same time, studies find that e-bike riders are traveling with higher speeds [4], and report new types of safety incidents, that they did not experience during conventional cycling [5]. Risk related behavior of e-bike and c-bike riders has frequently been linked to crash-risk and injury severity [6][7]. But little research has been conducted on the comparison of self-reported risk related behavior between e-bike and conventional bike (c-bike) riders. Hence, in this study, the self-reported risk-related behavior of c-bike and e-bike riders was investigated.

2 METHOD

2.1 Sample

A total of 557 cyclists were recruited as a convenience sample through social media and a newsletter from the Danish cyclist federation for an online study on their behavior during everyday cycling. 316 participants were female (57%), and 241 male (43%). Mean age of participants was m= 47 (SD=14). With 87% (n=483), most respondents used a c-bike as their main form of transportation, while 13% (n=74) used an e-bike.

2.2 Instruments

In this study, the Cycling Behavior Questionnaire (CBQ) was used to assess safety related behavior of e-bike and c-bike users [8]. It consists of 29 items which assess the frequency of cycling behavior on a five-point scale (0=never; 1=hardly ever; 2=sometimes; 3=frequently; 4=almost always). The CBQ items map to three factors, *violations* (e.g. “Going against the direction of traffic (wrong way)”), *errors* (e.g. “Fail to notice the presence of pedestrians crossing when turning”), and *positive behavior* (e.g. “I usually keep a safe distance from other cyclists or vehicles.”). In addition, sociodemographic items, as well as questions on general cycle use (type of bike mainly used (c-bike/e-bike), frequency, usual trip length, purpose) were added. Single items on risk-perception and traffic law regulation were presented [9].

2.3 Analysis

First, sample characteristics (e.g., age, gender, trip length) for c-bike and e-bike riders are compared using χ2-tests and *Aspin-Welch-Satterthwaite t-test*. To investigate possible latent cycling behavior, relating to either e-bike or c-bike use, a factor analysis is performed on the three scales of the CBQ. Analyses were performed with Varimax rotation and confirmed the three different scales of the CBQ: *Violations, Errors*, and *Positive behavior*. Cronbach’s alpha was 0.70. All items have factor loadings above 0.43 and explained 42% of the variance. Finally, a structural equation model (SEM) is employed to identify latent cycling behavior and their relation to riders' demographic features, trip length, purpose and self-assessed risk perception and regulation knowledge to e-bike use.

3 RESULTS

Personal and trip characteristics for all respondents are presented in Table 1. It can be observed that e-bike users are more likely to be female and live in a smaller city, with less than 50,000 inhabitants. We also find e-bike users to be more likely to have retired but find no significant difference between age groups for e-bike and c-bike users (age of riders: e-bike, *m*=49, *SD*=14.0; c-bike, *m*=47, *SD*=14.5). No significant differences were found for number of hours biking during a normal week or duration of the most frequent trip. However, results show c-bike users to more often (45%, *n*=217) use their bike for exercise than e-bike users (31%, *n*=23).

Table 1: A comparison of person and trip characteristics between e-bike and c-bike users

		e-bike		c-bike			X^2-test, p-value
Variable	**category**	**Number**	**%**	**Number**	**%**	**total**	
Gender	Male	22	9	220	91	242	
	Female	52	16	264	84	316	**<0.01**
Number of inhabitants in city	less than 50,000	27	21	102	79	129	
	between 50,000 and 200,000	20	11	163	89	183	
	Above 200,000	27	11	218	89	245	**0.01**
Occupation	Working (self-employed and others)	53	13	356	87	409	
	Retired	13	23	43	77	56	
	Unemployed, student and other	8	11	84	91	92	**0.04**
Bike use in a (normal) week	Less than 3 hours	16	14	96	86	112	
	between 3 and 5 hours	28	14	178	86	206	
	between 6 and 9 hours	20	14	127	86	148	
	10 hours or more	10	11	81	89	91	0.91
Time for most frequent trip	Less than 20 minutes	11	8	119	92	130	
	20-30 minutes	30	13	200	87	230	
	31-59 minutes	25	20	102	80	127	
	more than 60 minutes	8	11	62	89	70	0.06

Regarding cycling behavior assesses with the CBQ, we only found significant differences between e-bike and c-bike riders in the mean for the factor *Positive behaviors* (*p*=0.02) where a higher mean was found for e-bike users. For the factors *Traffic violations* (*p*=0.07) and *Errors* (*p*=0.92) we found no significant difference. For risk perception e-bike users reported a higher awareness of risks related to headphone or general mobile phone use while cycling (*p*<0.01) and for consequences of being involved in a traffic crash (*p*=0.04). Regarding traffic regulation e-bike users reported higher knowledge of traffic rules for other vehicles (*p*=0.01), knowledge of cycling safety regulations (*p*=0.04), and higher recognition of areas prohibited to traffic or bicycle parking (*p*=0.02).

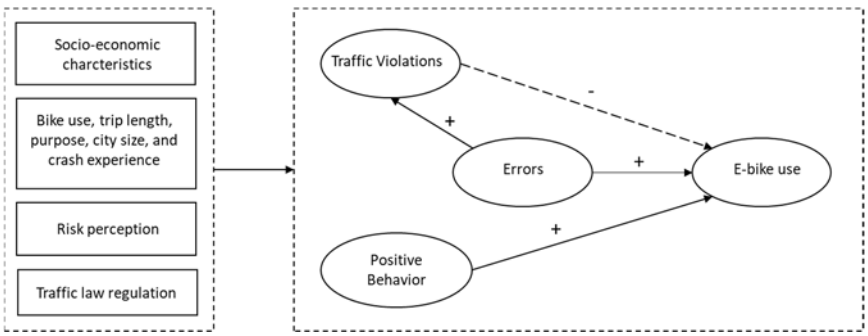

Figure 1: Structural Equation Model for study variables related to e-bike use.

The results of the structural equation model revealed e-bike use to be directly and positively related to *Errors* and *Positive Behavior* and negatively related to *Traffic Violations,* which are positively related to *Errors*. The most relevant factor for mainly cycling on an e-bike is *Positive Behavior* (Figure 1). We further find that the use of an e-bike is positively related to a higher reported awareness of increased crash risk in cities and when using headphones or mobile phone while cycling. A positive relation with e-bike use is also found for females, smaller cities (number of inhabitants below 50,000) and occupation.

4 DISCUSSION AND CONCLUSION

The results of this study revealed that female, retired people, and cyclist living outside the large cities were more likely to use an e-bike as main transport mode compared to a c-bike. Likewise, we found that using an e-bike as main transport mode is positively related to a higher crash risk awareness which may make e-bike riders more careful in traffic. This could be due to an increased focus in social media and news about the high crash risk when cycling on an e-bike, which is also supported by research on e-bike safety [5][6].

Regarding the cycling behavior assessed with the CBQ, we found that *Traffic Violations* were negatively related to the use of e-bikes which indicates that e-bike users are more careful in traffic than c-bike users**.** At the same time, the data suggests that a higher frequency of self-reported *Errors* is positively related to *Traffic Violations* for e-bike riders. This can indicate that cyclists' susceptibility to make errors (unconsciously), can contribute to traffic rule violations. *Positive Behavior* when cycling and a higher reporting of *Errors* were found to be positively related to the use of e-bikes. This could be interpreted as e-bike riders making more errors in traffic but could also indicate that they are just more aware of the errors they make than c-bike users (no causal inference can be derived from our study design). In general, our data suggests that e-bike riders have a safety-positive behavior when cycling and higher knowledge of the traffic rules compared to c-bike users.

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