

1 **Health Consequences of Bicycle Crashes**

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3 **ABSTRACT**

4 The aim of this study was to health consequences related to involvement in a bicycle crash. This
5 was done by investigating the crash's impact health-related quality of life (HRQoL). The HRQoL
6 was investigated using data collected between March 9th and April 27th, 2020 using a self-report
7 online survey. The survey contained a version of the Late Effect of Accidental Injury
8 Questionnaire and participants were selected based on indicating involvement in a bicycle crash
9 in the most recent 2 years. The final sample consisted of 358 cyclists having suffered a bicycle
10 crash in the within the past two years. The results showed that 27.3% percent of the participants
11 reported at least one negatively impacted health aspect, with physical (13.5%) and psychological
12 (12.3%) health aspects being the most frequently reported ones. The use of the LEAIQ,
13 compared to generic health surveys, allows us to reveal specifically which health changes,
14 compared to before the injury, are considered to be specifically related to the injury. This
15 allowed for more specific insight into the health consequences of bicycle crashes and revealed
16 that of the participants reporting negative impacts on their HRQoL 78% considered it to be
17 related to their crash.

18 **Keywords:** bicycle crash consequences, health impact, HRQoL, survey analysis, road traffic
19 safety

20 1 INTRODUCTION

21 In order to create more awareness and knowledge on the long-term consequences related to
22 injuries sustained in road traffic crashes, the recent decades have witnessed an increase of
23 research regarding burden of health consequences of road traffic injuries.

24 Many such studies have tried to sum up this burden in terms of single measures and compare
25 these across injury types etc. (Haagsma et al., 2012; Polinder et al., 2015; Tainio et al., 2014;
26 Weijermars et al., 2016). Disability adjusted Life Years (DALYs) have become an especially
27 popular tool in this regard. DALYs provide a framework for combining the burden related to
28 mortality (year of life lost) as well as morbidity (year lived with disease) following a road traffic
29 injury. Where the burden of a given injury is dependent on a set of generic disability weights
30 derived across diseases (Murray & Acharya, 1997). However, because the DALYs are disease
31 specific combining them is not as such possible.

32 The HRQoL however, being the health-related subset of the individual's quality of life,
33 incorporates the individual's own perception of the injury and represents a
34 multidimensional perspective of health that takes into account physical, psychological and social
35 functioning and well-being (Bowling, 2001). Understanding the effects of a crash on different
36 health aspects could prove important to fully understand the health consequences of accidental
37 injuries. For example Haagsma et al. (2011) show that psychological consequences greatly
38 affects recovery following road traffic injuries. While studies by Ohlin et al. (2017), as well as
39 Tournier et al. (2014) find that the psychological impact of bicycle crashes only trail the physical
40 impact as most frequently reported in studies evaluating the HRQoL.

41 Given the increased endorsement of active mobility in recent years, especially bicycling
42 (Infrastructures, 2015), and their assumed vulnerability and future increase of crashes reported,
43 many of the studies have been interested in how the long-term health consequences following

44 accidents differ between transport modes (Craig et al., 2016; Tainio et al., 2014; Weijermars et
45 al., 2016).

46 Most, if not all, of these studies, rely on hospital data or national register data either for direct
47 use or to short-list individuals to survey. This is a problem since hospital and register data suffer
48 from under-reporting stemming from reporting bias of especially minor injuries, when it comes
49 to bicycle crashes. For example a study by De Geus et al. (2012 shows that only 17% of recorded
50 bicycle crashes in a proposed cohort study in Belgium reported bicycle crashes to the emergency
51 department, and even fewer reported their crashes to the police. Thereby studies might not be
52 presenting the full picture when limiting data to that registered by hospital. Furthermore, many
53 of the studies considering the HRQoL following road traffic crashes use generic health surveys,
54 such as the EuroQoL-5D (EQ-5D) (Rabin & de Charro, 2001). While this specific survey has been
55 previously used with road traffic injuries (Gabbe et al., 2015). There is the short coming that
56 these do not directly associate the described health consequences or the health domain, to the
57 crash itself, i.e. a person could have suffered from something different that need not relate to
58 the original injury.

59 The aim of this study is to investigate the health related quality of life and the health
60 consequences regarding physical, psychological, social, economic health, following implication
61 in a bicycle crash, through the use of a questionnaire specifically created to evaluate the health-
62 effects of road traffic injuries, thereby allowing to identify specific contribution of the accident.
63 Meanwhile, it is believed that distributing the questionnaire on an on-line survey platform will
64 allow us to overcome the reporting bias issue, allowing for the most truthful description of the
65 health consequences of bicycle crashes.

66 **2 METHODOLOGY**

67 **2.1 Study design**

68 In this study we analysed cross-sectional data collected through an on-line survey, distributed
69 through social and university networks as well as being distributed by the SoMe department of
70 The Council for Traffic safety and a link in the Danish Cyclist Federation newsletter. The data
71 collection period lasted from March 9th until April 27th. The total number of participants that
72 reported crashes was 358 (50% male, 50% female). The participants were distributed evenly
73 between the ages 15-75.

74 **2.2 Content of survey and measurements**

75 Individuals were asked to supply information regarding their most recent crash : month
76 and year, duration suffered from ailments, type of crash, and describe what injuries were
77 sustained. To be able to investigate the health consequences, participants were asked to fill out
78 a slightly modified form of the Late Effect of Accidental Injury Questionnaire (LEAIQ) (Malt,
79 1988). This questionnaire investigates effects of accidental injuries on different health aspects
80 such as physical, psychological, social, leisure and economic, and should therefore be well suited
81 to describe the HRQoL of an individual following a bicycle crash.

82 The questionnaire addresses the consequences regarding these health aspects by asking the
83 questions in Table 1.

84 Table 1: Overview of questions addressing the different health aspects

Physical

Has the participant has suffered permanent physical changes following the crash? (PPC)

Has the participant suffered reduced mobility following the crash, and does he still? (RPF)

How is the participant's overall bodily health compared to before the crash? (BH)

Psychological

How are the participant's overall psychological health/nerves compared to before the crash? (PsH)

Has the participant been bothered by any of 24 specified stress/anxiety markers in the past 6 months, and which? (SSC)

Social and leisure time

How has the participant's contact with the family compared to before the crash?(CoF)

How has the participant's contact with others been, compared to before the crash? (CO)

How has the participant's pleasure of leisure time activity been, compared to before the crash? (PL)

Economic

How has the participant's economic situation been, compared to before the crash? (Econ)

How much has the participant been able to work following accident (i.e. change in work capacity), in relation to the previous standard? (CaW)

Has the participant's work occupation changed? (ChW)

85

86 The questions regarding overall change compared to before the incident were all marked by the
87 participant's as either "improved", "unchanged" or "worse". The questions on physical change
88 and functioning, PPC and RPF, were marked with "yes" or "no". The question on change in work
89 capacity, CaW could be answered with: "full time", "most of the time", "little or not at all" or "I
90 cannot work or care for myself". On the change of work, ChW, question, people could choose
91 the from responses: "same as before", "different than before", "sickness benefit/
92 rehabilitation", "disability pension" or "old age pension".

93 Lastly participants were asked if their amount of cycling compared to before the crash had
94 decreased, stayed the same, or increased.

95 All questions regarding a change in a status compared to that before the crashes were equipped
96 with a follow-up question forcing the participant to indicate whether or not the accident was
97 causal of or related to the current state. This is an important consideration, as health of any
98 individual could also develop in any direction regardless of any incident.

99 A negative impact of any of the aspects of overall health were associated to a negative impact
100 on the HRQoL.

101 **3 RESULTS**

102 **3.1 Crash and injury characteristics**

103 **3.1.1 Age and Gender**

104 The study ended up consisting of 358 (50% female, 50% male) participants that had suffered at
105 least one bicycle crash in the past two years. Specifically, 259 reported to have been suffered
106 one crash, while 100 responded to have suffered several. Based on the age groups most of the
107 reported crashes were experienced by participants in the age group 25-34 years of age (26.8%),
108 followed by those 55-64 (19.2%) and 65-74 (16.5%) years of age.

109 **3.1.2 Accident types**

110 The majority of the reported crashes for both genders were single-bicycle crashes, making out
111 approximately 60% of the bicycle crashes for male bicyclists and 50% for female (see Table 2).
112 Other than that, 13% of male cyclist's had a collision with a car and the same amount suffered
113 collisions with pedestrians. For females this number is approximately 18% for both types. The of
114 the crashes were classified as either collision with other cyclists or "other" crash types.

115

116 Table 2: Gender based distribution of crash types experienced.

	Single- bicycle	Collision with car	Collision with cyclist	Collision with pedestrian	other
Male (N=179)	64.2%	12.9%	5.6%	12.9%	4.7%

	Single-bicycle	Collision with car	Collision with cyclist	Collision with pedestrian	other
Female (N=179)	55.3%	18.4%	6.7%	16.8%	2.8%
Total (N=358)	59.8%	15.6%	6.2%	14.8%	3.6%

117

118 3.1.3 Injuries sustained

119 The injuries sustained were grouped into the categories shown in Table 3. It is evident that
 120 almost all of the of the crashes resulted in a type of superficial injuries. Furthermore, eye and
 121 facial injuries are also rather common. Lower extremity injuries and/ or fractures are observed
 122 for approximately 20% of the crashes, approximately half of them being fractures.

123 Table 3: Distribution of injuries sustained in crashes

Superficial inj., Open Wounds	Head inj., spine or neck inj.	Eye or Facial inj.	Internal or torso inj.	Upper extremity frac or inj.	Lower extremity frac or inj.
76%	12.6%	30.7%	7.5%	12.9%	14.8%

124

125 When disclosing the approximate time that the participants had suffered ailments following the
 126 crashes shown in Table 4, most people (approx. 50%) reported ailments lasted one week or less.
 127 This indicates that many participants in the survey only suffered minor injuries from their
 128 crashes. Meanwhile, the proportion of participants reporting longer durations of ailments,
 129 declined as a function of increased ailment duration.

130 When asked if the crash was severe, 25% of the respondents felt that their crash had been
 131 severe. In Table 4 we see the self-reported time that people suffered ailments following the
 132 accident.

133 Table 4: Distribution of ailment time following accident

Ailment time	< 1 week	~ 1 week	~ 2 weeks	~ 3 weeks	~ 4 weeks	1-3 months	3-6 months	6-12 months	>= 12 months	not yet recovered
	60	89	36	26	22	57	9	15	12	29

134

135 Regarding the number of “not recovered” respondents, this need not directly indicate long and
 136 severe suffering but can also be an indication of a very recent incident.

137 **3.2 Health Consequences of Accidental Injuries**

138 In this section we summarise the outcomes regarding the effects on the different health aspects
 139 (physical, psychological, social and economic) that participants experienced following their most
 140 recent bicycle crash.

141 Firstly, we evaluate the overall responses regarding the different health domains, and how the
 142 participants have experienced change regarding their health compared to before the crash. Also,
 143 the negatively impacted health aspects, where participants considered the impact was related
 144 to the accident, were combined with the type of injury that the participants suffered.

145 Following this we further evaluate the health aspects and implications following the crashes.

146 **3.2.1 Impact on health aspects following accidental injury.**

147 The frequency of the changes/ impact of the different health aspects experienced by the
 148 participants are shown in Table 5.

149
150
151

Table 3: The distribution of the frequency of the outcomes according to the Late Effect of Accidental Injury Questionnaire (LEAIQ) and amount of cycling compared to before the bicycle crash

	Change in health aspects after crash		
	Improved	Unchanged	Worsened
Overall HRQoL			
HrQoL	17.3%	55.4%	27.3%
HRQoL related to the crash	5.6%	73.1%	21.3%
Physical			
PPC	-*	82.5%	17.5%
RPF	-	72%	28%
RPF still	=	86%	14%
BH	5.6%	80.8%	13.5%
BH related to the crash	1.1%	-	11.7%
Psychological			
PSH	1.4%	86.4%	12.3%
PSH related to the crash	0.3%	-	10.6%
Social			
LP	5.3%	86.6%	8.1%
LP related to the crash	3.6%	-	7.5%
CoF	2.0%	95.8%	2.2%
CoF, related to the crash	1.7%	-	2.0%
CO	0.8%	93.3%	5.6%
CO, related to the crash	0%	-	4.8%
Economic situation			
Econ	7.0%	88.8%	4.5%
Econ, related to the crash	0.3%	-	1.7%
Cycling habits			
Cyc	11.6%	73.4%	14.0%
Cyc, related to the crash (N=102)	3.7%	13.1%	11.7%
*: Indicating that no possible choice of that type was available to participants			

152 In Table 5 it is seen that health aspects most frequently subject to negative impacts following
 153 crashes are the physical and psychological. This concerns both the overall changes since the
 154 crash and amongst the ones that feel changes are related to the crash. Combined 27.4%
 155 complained of worsening in any “aspect” of health (i.e. the HRQoL) compared to prior to the
 156 incident, 40% of whom experienced worsening in several domains. However, only 78% of these
 157 claims are considered by the participant to be related to the crash involvement. Meanwhile,
 158 some also report improved health aspects and sometimes even consider this to be related to
 159 the crashes.

160 Looking into the relation of impacted health aspects to the different types of injuries suffered in
 161 Table 6, it is seen that upper and lower extremity fractures and injuries and head and neck injuries
 162 are most often related to negative impacts on the HRQoL. Meanwhile, it is evident that the
 163 injuries also are related to different impacts on the different health aspects. For example,
 164 internal and torso injuries are related to the seconds highest frequency of negative impact
 165 reported, meanwhile is associated to the fewest reports of impacted psychological health.

166 Table 6: Frequency of negatively impacted health aspects (worsened change) given
 167 participant’s reported injury

	BH	PsH	Econ	LP	CoF	CO	HRQoL
Superficial inj., Open Wounds (N=272)	8.2%	8.9%	1.1%	6.0%	1.5%	3.7%	17.5%
Head inj. spine or neck inj. (N=45)	24.4	20%	2.2%	8.9%	4.4%	6.7%	35.6%
Eye or Facial inj. (N=111)	21.6	14.1	3.6%	12.6%	3.6%	9.0%	31.5%
Internal or torso inj. (N=27)	25.9%	7.4%	3,7%	3.7%	7.4%	7.4%	29.6%
Upper extremity frac or inj. (N=46)	32.6%	15.2%	4.3%	17.3%	6.5%	13.0%	39.1%

	BH	PsH	Econ	LP	CoF	CO	HRQoL
Lower extremity frac or inj. (N=64)	23.4%	17.1%	3.1%	15.6%	4.7%	6.3%	35.9%

168

169 **3.2.2 Physical and Psychological health aspects**

170 In Table 5 we see that BH (13.5%) and PsH (12.3%) were the health aspects where participants
171 most frequently experienced a negative impact. 86.6% and 88.6% respectively considered their
172 worsened BH and PsH to be related to the crash. 17.5% of the participants replied to have PPC
173 following the accident and 28% reported that the injury led to an RPF, 50% of whom reported
174 to still suffer from RPF, today. The most common reasons being joint issues and related mobility
175 issues in the wrist, ankle, shoulder, elbows and knees, but also spinal and neck issues resulting
176 in headaches. The latter also matches well that 17.8% complained to been bothered by bodily
177 aches and pains in the past six months, in the stress/anxiety checklist, and considered this to be
178 related to the crash. In total, 62% of the participants marked to have been bothered by at least
179 one stress symptom in the past 6 months, with 1 stress marker being the fewest, 23 the most
180 markers checked off by a single individual and an average of 4.3 stress markers per participant.
181 Almost 50% of these participants, felt that the experienced stress/anxiety symptoms are related
182 to the crash and 33.5 % report the crash to have caused pre-existing stress/anxiety symptoms
183 to worsen.

184 **3.2.3 Economic health aspect**

185 On the change in their economic situation (Econ) compared to before the accident, few (1.7%)
186 consider any negative impact to be related to the crash. Meanwhile, 12.5% considered a
187 decrease of working capacity (not work full time, compared to before the accident), to be related
188 to the crash.

189 **3.2.4 Social health and leisure time aspects**

190 As seen in table 5, leisure time pleasure is the health aspect that is the most negatively impacted
191 following bicycle crashes. 7.5% of participants consider their worsened leisure time pleasure to
192 be related to the crash. Regarding contact to others and family respectively 4.8% and 2.0%
193 report a negative impact and consider it related to the crash. Especially the people who suffered
194 internal and/or torso injuries as well as upper extremity injuries seem to experience worsened
195 contact, as seen in Table 6

196 **3.2.5 Cycling habits**

197 Regarding the cycling habits since the crash in Table 5 we see that 73.4% stated that their habits
198 were unchanged, while 11.6% reported increased bicycle use and 14.0% reported a decrease.
199 Overall 28.5% consider their current cycling habits to be related to suffering a crash, of whom
200 41.2% reported to cycle less, 46% had unchanged cycling habits and 12.8% cycled more than
201 prior to the crash.

202 **4 DISCUSSION**

203 Based on a survey among people recently involved in bicycle crashes, this study explores the
204 impacts on the health-related quality of life associated to accidental injuries following the
205 crashes. The results show that 27.3% suffer negative impacts on their health-related quality of
206 life compared to before their crash, 78% of whom consider this to be related to the injury. The
207 results show that several health aspects suffer negative impacts following the bicycle crashes
208 with the most frequently reported aspects being the physical and psychological health, and that
209 extremity and head injuries/fractures are the most related to these outcomes. This is in line with
210 previous studies, where psychological and physical impacts also tend to dominate the HRQoL
211 related impacts of road traffic accident related injuries (Ohlin et al., 2017; Tournier et al., 2014).
212 Meanwhile, the results also show that one health aspect being impacted does not necessarily

213 indicate all health impacts being impacted. This is seen as 27% of the participants reported
214 impacted HRQoL, while the most impacted health aspect was the physical one, being impacted
215 among 11.5% of the participants. The addition of the question regarding amount of cycling that
216 the participants do compared to before the incident, while not directly related to the HRQoL,
217 still has a major impact on future personal and societal health. The fact that almost 25% relate
218 a non-increase or decrease of the cycling they do to their crash involvement is detrimental, given
219 the positive aspects of related to the physical activity it yields (Mueller et al., 2015).

220 An additional contribution of this study is achieved through the use of the Late Effect of
221 Accidental Injury Questionnaire. By including the participant's opinion on the relation between
222 crash involvement and the experienced changes in health, this questionnaire enables the
223 separation of accident and non-accident related change. This is an important contribution when
224 comparing to generic health surveys, such as the EQ-5D, where no such separation is attempted
225 and thus allows for potential "noise" in the reported results. However, it has to be noted that in
226 our sample around 80% or more of the participants reporting negative impacts on health aspects
227 related this impact to being in a bicycle crash.

228 One difference of this study in comparison to studies such as (Hours et al., 2010; Khati et al.,
229 2014; Mayou & Bryant, 2003) was the use of an online survey not based on national/regional or
230 hospital registries. This means that we could not, with medical certainty, score the injury
231 severities using AIS system. However, the participants did report the duration in which they felt
232 ailed by the injury directly.

233 52% percent of the participants indicated that ailments lasted less than a month following the
234 crashes, 65% of whom stated to have suffered ailments 1 week or less. This could indicate that
235 our sample contains rather many minor injuries, which is supported by the fact that only 47% of

236 the participants even sought medical attention. When comparing to a study such as such as
237 Polinder et al. (2015), head injuries in this study were rather rare.

238 However, even among these participants some report impacted HRQoL aspects, which supports
239 the need to not neglect the focus of minor injuries (McClure & Douglas, 1996). An investigation
240 of the specific frequency of impacted health aspects in contrast to “injury severity” would have
241 to be conducted for additional insight on this.

242 Lastly an interesting aspect of the Questionnaire that was employed reveals that some
243 participants consider some of the positive impacts compared to before the crash to be related
244 to the actual crash. This is a rather interesting and surprising result, but in the meantime also
245 not entirely unimaginable. It could be stipulated that such a relation is due to new habits being
246 obtained following rehabilitation work or similar.

247 **5 CONCLUSION**

- 248 • 27.3 % percent report at least one negatively impacted health aspect, 78% of whom
249 consider this to be related to the crash.
- 250 • The use of the LEAIQ allows us to distinguish between negatively impacted health
251 aspects related to, and not related to the accidental injuries.
- 252 • Physical and Psychological health consequences are the health aspects most often
253 related to a negative health impact following bicycle crashes.
- 254 • Head and extremity injuries and fractures are the injury types most often related to
255 negative health impacts.

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