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# Evaluating the impact of cycle helmet use on severe traumatic brain injury and death in a national cohort of over 11000 pedal cyclists: a retrospective study from the NHS England Trauma Audit and Research Network dataset

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## ABSTRACT

**Objectives** In the last 10 years there has been a significant increase in cycle traffic in the UK, with an associated increase in the overall number of cycling injuries. Despite this, and the significant media, political and public health debate into this issue, there remains an absence of studies from the UK assessing the impact of helmet use on rates of serious injury presenting to the National Health Service (NHS) in cyclists.

**Setting** The NHS England Trauma Audit and Research Network (TARN) Database was interrogated to identify all adult (≥16 years) patients presenting to hospital with cycling-related major injuries, during a period from 14 March 2012 to 30 September 2017 (the last date for which a validated dataset was available).

**Participants** 11 192 patients met inclusion criteria. Data on the use of cycling helmets were available in 6621 patients.

**Outcome measures** TARN injury descriptors were used to compare patterns of injury, care and mortality in helmeted versus non-helmeted cohorts.

**Results** Data on cycle helmet use were available for 6621 of the 11 192 cycle-related injuries entered onto the TARN Database in the 66 months of this study (93 excluded as not pedal cyclists). There was a significantly higher crude 30-day mortality in un-helmeted cyclists 5.6% (4.8%–6.6%) versus helmeted cyclists 1.8% (1.4%–2.2%) (p<0.001). Cycle helmet use was also associated with a reduction in severe traumatic brain injury (TBI) 19.1% (780, 18.0%–20.4%) versus 47.6% (1211, 45.6%–49.5%) (p<0.001), intensive care unit requirement 19.6% (797, 18.4%–20.8%) versus 27.1% (691, 25.4%–28.9%) (p<0.001) and neurosurgical intervention 2.5% (103, 2.1%–3.1%) versus 8.5% (217, 7.5%–9.7%) (p<0.001). There was a statistically significant increase in chest, spinal, upper and lower limb injury in the helmeted group in comparison to the un-helmeted group (all p<0.001), though in a subsequent analysis of these anatomical injury patterns, those cyclists wearing helmets were still found to have lower rates of TBI. In reviewing TARN injury codes for specific TBI and facial injuries, there was a highly significant decrease in rates of impact injury between cyclists wearing helmets and those not.

**Conclusions** This study suggests that there is a significant correlation between use of cycle helmets and reduction in adjusted mortality and morbidity associated with TBI and facial injury.

## Strengths and limitations of this study

- This article contains data from 11 285 patients over a 5-year time period.
- The dataset is of an NHS England cohort of patients, inputted via the Trauma Audit and Research Network (TARN).
- TARN codes are useful in the context of this article as they specifically include anatomical injury patterns.
- This is a retrospective cohort analysis, with the inherent bias that this entails.
- It only includes those patients who have reached the threshold to be included on the TARN dataset (and thus does not capture all cyclists involved in accidents, or all cyclists undertaking journeys during this time frame).

## INTRODUCTION

Cycling as a mode of transport is environmentally friendly, benefiting the individual and the public health at large.[1 2] Over the last decade, pedal cycling has become popular both as a form of recreation and as a means of commuting within the UK; in 2017, 3.3 billion vehicles miles were cycled in the UK, though with 18 321 total casualty and 101 fatalities.[3 4]

The most common cause of death and admissions to hospital from bicycle-related trauma is traumatic brain injury (TBI).[5] Despite several studies supporting the use of helmets to TBI and facial injury[5–14] and public awareness campaigns encouraging the use of cycle helmets, the prevalence of wearing cycle helmets remains relatively low in both Britain and other countries.[7 15–18] Some authors have argued that use of cycle helmets can induce behavioural change and so alter thresholds for risk taking,[19] and so it can be debated whether the cycle populations wearing cycle helmets and those not are different, or whether individual cyclists will alter their level of risk taking behaviour dependent on whether they are wearing a helmet for a particular journey, or even whether the dynamics of behaviour between cyclist and car driver is fundamentally altered by the use of cycle helmets.[7 15 19 20]

In spite of lively media, political and societal interest in these arguments, since 1994, only two studies have been published in the UK literature relating to the impact of cycle helmet use on morbidity. The first of these pre-dates the inception of the UK trauma network.[9] The second of these, published in September 2017, accounts for 97 patients.[21] This retrospective cohort study assesses the impact of cycling helmet use on injury patterns and TBI in cyclists presenting to the national trauma registry the Trauma Audit and Research Network (TARN) to provide a national comparison to previous international literature.

## METHODS

The national TARN Database was used to identify all adult (≥16 years) patients presenting with cycling-related injuries during a period from 14 March 2012 to 30 September 2017 (latest date available with validated data at inception of project). Within the context of NHS England, TARN includes patients of all ages reaching hospital alive after injury and who subsequently die or require critical care, interhospital transfer and, or acute inpatient care for >72 hours. Patients aged >64 years with isolated low energy hip or pubic rami fractures are excluded from the TARN Database, as are those sustaining isolated closed limb injuries (www.tarn.ac.uk).

Data requested from the national TARN Database included the patient's age, sex, date, time, place and nature of the incident. Further details recorded were helmet use, injuries sustained, including the presence of a brain injury, and information on their subsequent follow-up; including length of intensive care and hospital stay, and need for neurosurgical intervention.

In this study, injury pattern based on TARN Abbreviated Injury Scale codings were used to identify the prevalence of certain injuries between hospitalised helmeted and un-helmeted injured cyclists. Local ethical and research guidelines were followed throughout, with a Data Transfer Agreement between North Bristol NHS Trust and TARN.

Statistical results were generated using Wizard 1.9.13 for Mac OS X (Copyright 2014–2016, John McNamara). In the specific calculation of mortality rates, W scores[22] were also used (observed - expected from modelling, adjusted for dataset weighting).

### Patient and public involvement

TARN has patient and public involvement on the TARN Board which has oversight of the research portfolio.

### Ethics approval

TARN has Health Research Authority approval (Patient Information Advisory Group (PIAG) Section 251) for research on the anonymised data it holds from NHS Trusts. Local approval by the NHS Trust was granted by The Quality Assurance and Clinical Audit Department (reference CE90100).

## RESULTS

### Demographics

During the 66 month study period, a total of 11 285 patients with cycle-related injuries were submitted to TARN. The injury mechanism free text was reviewed on each patient. Ninety three patients were excluded due to non-cycle-related injuries. Of the 11 192 cycle-related injuries, data on the use of cycling helmets were available in 6621 patients.

The median age (IQR) was 48.6 (36.3–58) and 84.7% were male subjects. Three hundred and twenty-one (2.8%) patients died as a result of their injuries. Secondary transfer from trauma units to the Major Trauma Centre occurred in 25.9% of cases.

Of the 6621 included in subsequent analyses, 4075 cyclists (61.5%) were wearing helmets at the time of injury, 2546 (38.5%) were not. The two groups showed (table 1) significant differences in their age (Mann-Whitney, p<0.001) and sex distribution, p=0.041. There was an increased crude 30-day mortality in the group not wearing a cycle helmet 5.6% (4.8%–6.6%) versus helmeted cyclists 1.8% (1.4%–2.2%) (p<0.001); corresponding risk adjusted excess survival rates (W scores)[22] were 1.1 (−0.1 to 2.2) and 2.4 (1.3–3.6), respectively. There was an association between alcohol intoxication and the failure to wear a cycle helmet (p<0.001). However, there was no correlation between crude mortality and alcohol consumption (3.5% vs 3.2% NS); this was true for those wearing a helmet (2.4% vs 1.8%) at the point of injury and those not (6% vs 3.8%). Data on the use of cycle helmet use were not available in 4571 patients. Age, gender and crude mortality rate for this group are shown in table 1. As a comparator, also included in table 1 is an analysis assuming all of those with no documentation of helmet use were not actually wearing a helmet.

### Injury severity and clinical course

The median Injury Severity Score (ISS) (IQR) for all patients was 13 (9–21). Median ISS was higher (Mann-Whitney, p<0.001) in those not wearing helmets (median ISS (IQR): 16 (9–25)) versus those that did (median ISS (IQR): 12 (9–20)) (table 2).

TBI (as described by an Abbreviated Injury Scale (AIS) score of ≥3) occurred in 47.6% of patients not wearing helmets by comparison to only 19.1% of patients wearing

**Table 1** Comparison of demographic and mortality data for cyclists with either known, not known or no documented use of cycle helmet (last column: C+D)

| | Wearing helmet | Not wearing helmet | Information unknown | Assuming all unknown=not wearing a helmet (Column E = Columns C+D) |
|---|---|---|---|---|
| Number | 4075 | 2546 | 4571 | 7117 |
| Age (IQR) | 49.7 (39.7–58.5) | 45.3 (30.4–57.1) | 47.6 (36.3–58.8) | 47.6 (34–58.2) |
| % Male (n, 95% CI) | 84.7% (3451, 83.5% to 85.8%) | 82.8% (2108, 81.3% to 84.2%) | 82.3% (3764, 81.2% to 83.4%) | 82.5% (5872, 81.6% to 83.4%) |
| Crude 30-day Mortality (n, 95% CI) | 1.8% (72, 1.4% to 2.2%) | 5.6% (143, 4.8% to 6.6%) | 2.2% (102, 1.8% to 2.7%) | 3.4% (245, 3% to 3.9%) |
| Mortality rate, adjusted W score | 2.4 (1.3–3.6) | 1.1 (−0.1 to 2.2) | | |
| Alcohol intake (n, 95% CI) | 2.1% (85, 1.7% to 2.6%) | 15.6% (397, 14.3% to 17.1%) | 7.5% (4571, 6.8% to 8.3%) | 10.4% (739, 9.7% to 11.1%) |

IQR, inter-quartile range.

helmets (p<0.001). There was no such association for those cyclists with an AIS code for facial injury ≥3. Statistically significant differences occurred in the rates of chest ≥3, spinal ≥3, upper and lower limb injuries between the two groups; in each case, rates of injury were significantly higher in the helmeted group (all, p<0.001). A more detailed analysis of these injury pattern variations is shown in table 3.

This shows rates of TBI (head AIS >3) by helmet use as well as anatomical injury pattern. For each anatomical injury pattern (chest ≥3, spinal ≥3, upper and lower limb injuries) a greater proportion of cyclists have no head injury in the group wearing cycle helmets, whereas in the group not wearing cycle helmets, no such correlation is seen, that is, of patients with similar body injury severity, helmet wearers had significantly lower rates of TBI.

Those patients not wearing helmets were more likely (table 4) to have a Glasgow Come Score (GCS) under 15 (p<0.001), were more likely to require neurosurgical intervention (8.5% vs 2.5%) and intensive care unit (ICU) admission (27.1% vs 19.6%, p<0.001.)

### CT head findings

In comparing the CT head scans, there were some notable differences between the two groups (table 5). Those cyclists not wearing helmets were significantly more likely to receive TBIs and suffered a different pattern of injury to those wearing helmets. There were highly significant differences (p values <0.005) in the rates of skull vault fractures, base of skull fractures, pneumocephalus, cerebral contusions, cerebral contusions, subdural haematomas, extra-dural haematomas, sub-arachnoid haemorrhages, diffuse axonal injury, brain stem and cerebellar injuries between cyclists wearing helmets and those not.

### CT head findings: maxillo-facial injury

Injuries on initial trauma CT also differed between the two groups for facial injuries (table 6). In comparing helmeted versus non helmeted cyclists, rates of scalp contusion, laceration, mandibular fracture, maxilla fractures, nose fractures, orbital fractures and zygoma fractures significantly differed (all z-scores) between the two groups.

## DISCUSSION

Using a national dataset, the primary finding of this study is that unadjusted mortality is lower in hospitalised cyclists injured wearing a helmet. This 30-day survival benefit is significant (p<0.001). Corresponding adjusted excess survival rates (W scores) are 1.1 (−0.1 to 2.2) for un-helmeted and 2.4 (1.3–3.6) for helmeted cyclists. We have employed a primary strategy of ignoring cases where there is missing data on helmet use. However, we have included a sensitivity analysis where we have assumed that a group with intermediate mortality results (unknown helmet usage where some are likely to have been wearing helmets) are not wearing helmets. The observation of significantly lower overall mortality in known helmet use, still occurs in this

Table 2 Anatomical injury pattern variation by cycle helmet use

| | Wearing helmet (n=4075) | Not wearing helmet (n=2546) | P value |
|---|---|---|---|
| Median ISS (IQR) | 12 (9–20) | 16 (9–25) | <0.001 |
| Head AIS ≥3 (%, n, 95% CI) | 19.1% (780, 18.0% to 20.4%) | 47.6% (1211, 45.6% to 49.5%) | <0.001 |
| Face ≥3 (%, n, 95% CI) | 0.52% (21, 0.3% to 0.8%) | 0.63% (16, 0.4% to 1.0%) | 0.760 |
| Chest AIS ≥3 (%, n, 95% CI) | 34.9% (1422, 33.4% to 36.4%) | 26.9% (686, 25.3% to 28.7%) | <0.001 |
| Abdo AIS ≥3 (%, n, 95% CI) | 4.2% (173, 3.7% to 4.9%) | 4.3% (109, 3.6% to 5.1%) | 0.944 |
| Pelvis AIS ≥3 (%, n, 95% CI) | 3.7% (150, 3.1% to 4.3%) | 3.0% (76, 2.4% to 3.7%) | 0.129 |
| Spine AIS ≥3 (%, n, 95% CI) | 10.7% (437, 9.8% to 11.7%) | 5.4% (137, 4.6% to 6.3%) | <0.001 |
| Upper limb (%, n, 95% CI) | 61.5% (2507, 60.0% to 63.0%) | 47.5% (1210, 45.6% to 49.5%) | <0.001 |
| Lower limb (%, n, 95% CI) | 62.7% (2556, 61.2% to 64.2%) | 49.4% (1257, 47.4% to 51.3%) | <0.001 |

AIS, Abbreviated Injury Scale; IQR, inter-quartile range; ISS, Injury Severity Score.

sensitivity analysis, and therefore, the primary find of this paper can be considered robust to selection bias.

There are significantly differing rates of severe TBI between a cyclist who wears a helmet and those who do not. We have also demonstrated significant differences in the pattern of TBI identified; this study has found that injuries such as skull fractures, meningeal and parenchymal bleeds are at least three times more likely in the non-helmet wearing cycling group in comparison to their counterparts; all these results were highly statistically significant. We have demonstrated statistically significant reductions in the incidence of facial injuries, impaired consciousness, need for neurosurgical intervention and ICU admission between cyclists injured wearing a helmet and those who do not.

It is notable that chest, spinal, and upper and lower limb injuries were more likely in cyclists wearing helmets than those not. Although previous studies have suggested variations in car driver behaviour towards helmeted and unhelmeted cyclists that may influence the biomechanics of any subsequent collision[19 20] it seems unlikely that cycle helmet wearing fundamentally alters the mechanics and injury burden of distant body regions. A plausible explanation for this significant difference between the helmet and non helmet wearing groups lies in the threshold to inclusion in the TARN Database. Not all cycle accidents are included in the TARN Database—only those of patients who satisfy a defined injury severity, injury type or duration of hospital admission. Hence an intervention

Table 3 Breakdown of head injury severity by helmet use and anatomical injury pattern

| | Impact protection | | | | | |
|---|---|---|---|---|---|---|
| | Helmet use (n=4075) | | | No helmet use (n=2546) | | |
| | No head AIS ≥3 | Head AIS ≥3 | Total | No head AIS ≥3 | Head AIS ≥3 | Total |
| Chest AIS ≥3 | 1160<br>81.6%<br>(79.5% to 83.5%) | 262<br>18.4%<br>(16.5% to 20.5%) | 1422 | 387<br>56.4%<br>(52.7% to 60.1%) | 299<br>43.6%<br>(39.9% to 47.3%) | 686 |
| Spine AIS ≥3 | 367<br>84%<br>(80.2% to 87.1%) | 70<br>16%<br>(12.9% to 19.8%) | 437 | 105<br>76.6%<br>(68.9% to 82.9%) | 32<br>23.4%<br>(17.1% to 31.1%) | 137 |
| Upper limb | 2133<br>85.1%<br>(83.6% to 86.4%) | 374<br>14.9%<br>(13.6% to 16.4%) | 2507 | 769<br>63.6%<br>(60.8% to 66.2%) | 441<br>36.4%<br>(33.8% to 39.2%) | 1210 |
| Lower limb | 2175<br>85.1%<br>(83.7% to 86.4%) | 381<br>14.9%<br>(13.6% to 16.3%) | 2556 | 841<br>66.9%<br>(64.3% to 69.5%) | 416<br>33.1%<br>(30.5% to 35.7%) | 1257 |

AIS, Abbreviated Injury Scale.

| Table 4 Characteristics of patient injury and subsequent hospital stay | | | |
|---|---|---|---|
| | **Wearing helmet (n=4075)** | **Not wearing helmet (n=2546)** | **P value** |
| Initial GCS 15 (%, n, 95% CI) | 83.5% (3301, 82.4% to 84.7%) | 64.8% (1606, 62.9% to 66.6%) | <0.001 |
| Neurosurgical intervention (%, n, 95% CI) | 2.5% (103, 2.1% to 3.1%) | 8.5% (217, 7.5% to 9.7%) | <0.001 |
| Any operative intervention (%, n, 95% CI) | 47.5% (1936, 46.0% to 49.0%) | 42.4% (1080, 40.5% to 44.3%) | <0.001 |
| ICU admission (%, n, 95% CI) | 19.6% (797, 18.4% to 20.8%) | 27.1% (691, 25.4% to 28.9%) | <0.001 |

GCS, Glasgow Come Scale/Score; ICU, intensive care unit.

that reduces a specific injury type (for instance in this study a helmet that may reduce the incidence of TBI) will ensure that those who might have sustained severe isolated injuries to that body region do not meet inclusion criteria for the TARN Database. Consequently, an intervention's success in eliminating one isolated body region injury from the database will result in a relative overrepresentation of all other injury types in that intervention group when compared a control group. This is exactly what the data in this study suggest—the bio-mechanically plausible reduction in head and maxillofacial injuries conferred by wearing a cycle helmet prevents inclusion on the TARN Database for isolated injuries to these regions and therefore results in a relative overrepresentation in almost all other injury types—chest, spinal, upper and lower limb injuries. In a more detailed analysis of rates of TBI by both cycle helmet use and anatomical injury pattern (table 3), rates of TBI were reduced in each anatomical injury pattern sub group (chest ≥3, spinal ≥3, upper and lower limb injuries) when wearing a helmet in comparison to those not wearing a helmet.

This study is a retrospective cohort study, and there are numerous limitations inherent in this study design. First, the study is limited by the use of retrospective data, especially in relation to the crucial question of whether the patient was wearing a cycle helmet (61.5% of total) or not (38.5% of total); in spite of this, use of cycle helmet was documented in 59.2% of cases. There are numerous confounders which affect the certainty of our findings. Mechanisms of injury has not been reviewed in

| Table 5 TARN injury descriptors of traumatic brain injury | | | |
|---|---|---|---|
| | **Wearing helmet (n=4075)** | **Not wearing helmet (n=2546)** | **P value** |
| Skull vault fracture (%, n, 95% CI) | 5.8% (238, 5.2% to 6.6%) | 27.2% (695, 25.6% to 29.1%) | <0.001 |
| Base of skull # (%, n, 95% CI) | 7.6% (308, 6.8% to 8.4%) | 25.8% (658, 24.2% to 27.6%) | <0.001 |
| Pneumocephalus (%, n, 95% CI) | 2.3% (95, 1.9% to 2.8%) | 13.5% (345, 12.3% to 15.0%) | <0.001 |
| Cerebral contusion (%, n, 95% CI) | 7.8% (317, 7.0% to 8.6%) | 21.7% (553, 20.2% to 23.4%) | <0.001 |
| Subdural haematoma (%, n, 95% CI) | 5.9% (240, 5.2% to 6.7%) | 22.0% (561, 20.5% to 23.7%) | <0.001 |
| Extradural haematoma (%, n, 95% CI) | 1.9% (77, 1.5% to 2.4%) | 12.3% (313, 11.1% to 13.6%) | <0.001 |
| SAH (%, n, 95% CI) | 8.8% (358, 8.0% to 9.7%) | 24.1% (614, 22.5% to 25.8%) | <0.001 |
| DAI (%, n, 95% CI) | 2.5% (100, 2.0% to 3.0%) | 3.7% (93, 3.0% to 4.5%) | 0.005 |
| Brainstem compression (%, n, 95% CI) | 0.8% (34, 0.6% to 1.2%) | 3.1% (80, 2.5% to 3.9%) | <0.001 |
| Brainstem injury involving haemorrhage (%, n, 95% CI) | 0.3% (12, 0.2% to 0.5%) | 1.3% (32, 0.9% to 1.8%) | <0.001 |
| Cerebellar haematoma (%, n, 95% CI) | 0.2% (8, 0.1% to 0.4%) | 1.4% (34, 1.0% to 1.9%) | <0.001 |

DAI, diffuse axonal injury; SAH, sub-arachnoid haemorrhages; TARN, Trauma Audit and Research Network.

Table 6 TARN injury descriptors of facial injury

| | Wearing helmet (n=4075) | Not wearing helmet (n=2546) | P value |
|---|---|---|---|
| Scalp contusion (%, n, 95% CI) | 3.8% (156, 3.3% to 4.5%) | 7.2% (183, 6.5% to 8.3%) | <0.001 |
| Scalp laceration (%, n, 95% CI) | 2.1% (85, 1.7% to 2.6%) | 7.8% (198, 6.8% to 8.9%) | <0.001 |
| Mandibular fracture (%, n, 95% CI) | 2.4% (99, 2.0% to 2.9%) | 3.5% (89, 2.8% to 4.3%) | 0.011 |
| Maxilla fracture (%, n, 95% CI) | 7.2% (295, 6.5% to 8.1%) | 10.7% (273, 9.6% to 12.0%) | <0.001 |
| Nose fracture (%, n, 95% CI) | 3.4% (140, 2.9% to 4.0%) | 5.9% (151, 5.1% to 6.9%) | <0.001 |
| Orbit fracture (%, n, 95% CI) | 6.0% (246, 5.3% to 6.8%) | 12.1% (307, 10.9% to 13.4%) | <0.001 |
| Zygoma fracture (%, n, 95% CI) | 4.1% (170, 3.6% to 4.8%) | 9.1% (232, 8.1% to 10.3%) | <0.001 |

TARN, Trauma Audit and Research Network.

this dataset and no indication is given as to what type of cycling activity was being undertaken (mountain biking versus urban commuting, for example). TARN data lack granularity as to the type of cycle helmet, and therefore the degree of protection offered by it. Patterns of cycle use may have changed over the 5 years of the study, as have road conditions. It is also assumed that populations of helmeted and unhelmeted cyclists are similar, when other studies have demonstrated (although for a paediatric population) that this is not the case.[23]

Further, no long term outcomes are included in our study (Glasgow Outcome Scale - Extended at 1 year might, for instance be useful as a longer term marker of outcome in this population). A Patient Reported Outcome Measures (PROMS) programme has recently been commenced by TARN, but only 6 months of data have been collected thus far, and this dataset is not comprehensive in TBI patients. Longer term mortality is available using NHS number, but no current permission has been granted to use this in research.

Our study may also suffer from reporting bias of CT scans against more subtle traumatic brain pathology, which might still influence long term morbidity. Also, only initial CT reports have been used to define injury burden in this study—interval CT scans (more likely to demonstrate an increase in brain parenchymal involvement) have not been reviewed. It is also notable that there was a correlation between lack of helmet protection and alcohol use. Again, this is a confounder for the biomechanics of impact, assessment of risk at the scene by attending pre hospital teams, and in the assessment and documentation of consciousness level on arrival in e mergency department (ED) and subsequent early management decisions. Alcohol use/intoxicationas registered in the TARN dataset, is a clinical diagnosis (is not based on assays from the ED) and thus suffers under-representation or recording bias. Precise TBI patterns are elucidated from CT scan results, so are unlikely to be affected by whether the patient was alcohol intoxicated or not.

Few papers have looked at specific TBIs and compare CT head findings between cycle populations. A paper from the Royal London Hospital from 2017,[21] using a cohort of 97 patients was able to demonstrate a protective effect of cycle helmets against intracranial injury in general, and more specifically against skull fractures. This team concluded that cycle helmets were able to protect against direct impact injury to the head, though further research was required to clarify their role against shear type injuries. Using the national dataset, we have been able to demonstrate the protective effect of cycle helmet use in diffuse axonal injury.

Looking at the specific burden of TBI among cyclists, a review from 2015 in the Canadian Journal Neurological Sciences[17] found a significant difference in CT head radiology reports between cyclists wearing (59%) and not wearing (77%) cycle helmets (p=0.004), using the Marshall classification to compare injury severity between the two groups. As with our study, cyclists not wearing helmets at the time of injury were also more likely to require neurosurgical intervention and require a greater length of stay in ICU. Not included in this study is a detailed analysis of the parenchymal insult sustained as part of the over-all injury pattern.

The only other study to look more generally at the incidence of morbidity and mortality in cyclists wearing cycle helmets in the UK predates the advent of UK Major Trauma Network[9] and is now over 20 years old. This retrospective study included 1040 cyclists, 114 of whom had worn cycle helmets at the time of the accident. The authors found no significant difference in the two groups in terms of the distribution of injuries other than those affecting the head, with 4% of cycle helmet wearers sustaining head injury, in comparison to 11% of those that did not (p=0.023).

Likewise, and more generally, within the international literature, several reviews have found helmet wearing to be associated with significant reduction in TBI and facial injury. These papers include a meta-analysis[5] a Cochrane review[10] and a more recent systematic review of 40 studies from 2016.[24]

Such studies typically demonstrate that the cycle population is young (median age in our study 45 years), with injuries that represent a significant socioeconomic burden, particularly given the longer term rehabilitation requirement following TBI.[25] In spite of its many confounders, and the use of retrospective data, this study provides a strong association between the wearing of a cycle helmet and a significant reduction in brain injury, and should act as a compelling argument for cycle helmet use.

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# Correction: *Evaluating the impact of cycle helmet use on severe traumatic brain injury and death in a national cohort of over 11000 pedal cyclists: a retrospective study from the NHS England Trauma Audit and Research Network dataset*

Dodds N, Johnson R, Walton B, *et al*. Evaluating the impact of cycle helmet use on severe traumatic brain injury and death in a national cohort of over 11000 pedal cyclists: a retrospective study from the NHS England Trauma Audit and Research Network dataset. *BMJ Open* 2019;9:e027845. doi: 10.1136/bmjopen-2018-027845.

This article was previously published with an error.

The patients mentioned under Participants section in Abstract should be 11 192 instead of 11.



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