Evans Vaughan. Trends in Fatalities in Motorcycle Accidents in Great Britain With Reference to the Studies by Hugh Cairns. Journal of Education, Health and Sport. 2020;10(3):66-75. eISSN 2391-8306. DOI http://dx.doi.org/10.12775/JEHS.2020.10.03.006
https://apcz.umk.pl/czasopisma/index.php/JEHS/article/view/JEHS.2020.10.03.006
https://zenodo.org/record/3712134

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.

Received: 20.02.2020. Revised: 25.02.2020. Accepted: 16.03.2020.

Trends in Fatalities in Motorcycle Accidents in Great Britain With Reference to the Studies by Hugh Cairns

Vaughan Evans*

*Vaughan Evans, MSc., ARCS. Nuffield Department of Population Health, Richard Doll Building, Old Road Campus, University of Oxford, OX3 7LF, UK.
Email: **vaughan.evans@ndph.ox.ac.uk**
https://orcid.org/0000-0002-2366-2301

Abstract

Introduction: Hugh Cairns, a neurosurgeon practising in Oxford, noted in a 1941 report the high number of deaths in motorcycle accidents, and advocated the use of helmets.
Objective: to review road traffic accident fatality data to assess how the risk of death in a motorcycle accident has changed, or not changed, since the publication of Cairns' findings.
Material and Methods: Analyses of road traffic accident data for Great Britain (1950–2017).
Results and Discussion: in modern times, the risk of fatality for a motorcycle rider is around fifty times greater than that for a car driver, per mile travelled. Although the wearing of a helmet became mandatory in Great Britain in 1973, motorcyclist fatalities increased in the following years, against a background of falling all-road-user fatalities. Fatalities, however, declined markedly after restrictions were placed on novice riders in the early 1980s.
Conclusions: a motorcyclist remains essentially as vulnerable as one was in the 1940s, aside from the reduced risk of head injury, and death from head injury, afforded by use of a helmet.

On most modern motorcycles, in contrast to modern motor cars, there is no restraint system, nor impact energy-absorbing vehicular structure. The implementation of restrictions on novice rider led to a greater fatality rate reduction than had the enactment of the requirement to wear a helmet a decade earlier.

Key words: motorcycle, fatality, injury, helmet, accident.

Funding
The author hereby declares that there are no potential conflicts of interest associated with this publication, and no financial support has been received for this work.

Introduction
Hugh William Bell Cairns (1896–1952) was a neurosurgeon, born in Australia, who having trained at Oxford, practised in hospitals in Oxford and London, and received specialist training in the USA; later becoming the first Nuffield Professor of Surgery at Oxford and founder of the Neurological Unit at the Radcliffe Infirmary [1]. In 1935, Cairns was one of the team of specialists who strove to save the life of Lawrence of Arabia (T.E. Lawrence) who had sustained a severe head injury in a motorcycle accident; Lawrence had not been wearing a helmet and died within days [1]. The death of Lawrence, at the relatively young age of 47, had a significant effect on Cairns, and led to his interest in the prevention of head injury amongst motorcyclists [1].
In Cairns' first report on head injuries in motorcyclists, published in the British Medical Journal in 1941, the sharp rise in rider fatalities in the first 21 months of the Second World War was noted; 2,279, compared to 1,884 during corresponding months of peacetime (1937-1939) [2]. In a sample of 149 motorcycle rider deaths that occurred in the last four months of 1940, in 102 the certified cause of death was reported as head injury, with 83 of these having no other injury mentioned [2]. Detailed studies of the non-fatal head injuries sustained in seven cases Cairns had seen, where the rider had been wearing a helmet, as well as one fatal case where the rider had not, led him to conclude that a suitable crash helmet may mitigate the effect of a head impact, and thus may save life [2]. Further findings concerning head injuries in motorcyclists, and a comparison of the relative effectiveness of different types of helmet then in use, were reported in the BMJ in 1943 by Cairns and the Oxford physicist, and motorcyclist, A.H.S. Holbourn [3]. Cairns noted, in his final report on motorcyclist fatalities (1946), that after the crash helmet had been made mandatory for Army motorcyclists in November 1941, there was a "considerable sustained fall in the total death rate" of motorcyclists (in the first 21 months of the war, two thirds of the motorcyclist fatalities had been Army personnel) [4, p.323]. The total death rate referred to, however, included civilians, and for this reason and other factors, it was considered not possible to discern the role of helmet use in the reduction in fatalities [4]. It was not until 1973 that helmet wear became a legal requirement for motorcyclists in the UK [1].

Objective

To assess how the risks of motorcycling have changed (or not changed) over the decades following the 1941–1946 reports by Cairns, and to determine the current relative risk of fatality.

Materials and Methods

National traffic and fatality data for Great Britain are principally utilised in the analyses. The effects of legislative changes on accident data are assessed by comparing average fatality data in the five years before implementation, with the five years after. Data from elsewhere in the world are also reviewed, where considered appropriate.

Results and Discussion

Cairns (1941) noted the sharp rise in motorcycle deaths in the first 21 months of war, compared to an equivalent period shortly before the outbreak of war [2]. With hindsight, it is known that this period had the highest level of road traffic fatalities recorded (all road users) from 1926 to modern times [5]. On account of the exigencies of war, a blackout had been imposed (1939), which can, in part, account for the high level of road fatalities [6].

In modern times, total road deaths in Great Britain are a fraction of the peak during the early years of the second world war; having fallen from around nine, to less than two thousand per annum [5, 7]. The fall in total road deaths has occurred against a background of a marked rise in road usage in the decades following the end of the war; average annual all (road) traffic vehicle miles increased from an annual average of 53.8 billion in years 1951–1955, to an average 314.8 billion in years 2012–2016 [7], a six-fold increase in six decades. Taking into account the increased total mileage, the risk of death in an accident (all road users) has dropped considerably since the early 1950s, from an average per year of around 95 fatalities per billion miles, to around 6 in recent times (Table 1).

Table 1 – The decline in road deaths in Great Britain over six decades

Annual fatalities, and fatality rates per billion miles

1951–1955	*Fatalities*[a]	*Fatality rate*[b]
All road users [7]	5116	95.3
Motorcyclists [8]	1213	299
2012–2016		
All road users [7]	1753	5.57
Motorcyclists [7, 9]	336	121

[a]Mean of five years data

[b]Mean of the fatality rate for each year

Many factors have contributed to the fall in total road deaths since the 1950s, including [10, 11]:

- Technological and engineering improvements to vehicles and highways,
- Improved education and training, and
- Improvements in emergency response and trauma care.

Whilst having benefitted from these general improvements, the reduction in risk amongst motorcyclists has been modest; 40 per cent of the level of risk of fatality, to which a rider was exposed in the early 1950s, remains in modern times (Table 1).

The fall in total road deaths has occurred against a background of a twenty-fold increase in car use in Great Britain since the end of 1940s, whilst motorcycle use has increased by a modest factor of approximately 1.5 (Table 2).

Table 2 – Car and motorcycle use in Great Britain

Years 1949 and 2017 compared; billion vehicle miles [9]

	Car	*Motorcycle*
1949	12.6	1.9
2017	254.4	2.8

Motorcycle use was still fairly significant, compared to car use, in 1949 – the first year road traffic estimates were recorded in Britain [12]; by 2017, however, the distance covered by car had increased to approximately *ninety* times that covered by motorcycle (Table 2).

The great increase in car use has been accompanied by considerable improvements in car safety technology. In the 1960s cars started to be built with safety features such as head restraints, energy-absorbing steering wheels, shatter-resistant windshields, and seatbelts [13]. The rigid passenger cell coupled with a deformable zone, ubiquitous in modern car design,

was first patented by Mercedes engineer Béla Barényi in 1951; in an accident the vehicle's front and rear structures are designed to deform and progressively absorb the impact energy, reducing the risk that the occupant space (safety cell) is impinged [14]. In general, motorcycle riders have no restraint system, or rigid enclosure or crumple zone, except for the BMW C1, sold from 2000 to 2004, which had *all three* [15, 16].

For motorcyclists, helmet designs of modern construction were first introduced in the 1950s, Roth and Lombard (1953) [17] presented a design of helmet that is now commonplace [18]. The use of a helmet by a motorcyclist reduces the risk of death, or head injury, in the event of an accident; data collected in the USA indicates that helmets are about 37 per cent effective in preventing motorcycle deaths, and 67 per cent effective in preventing brain injuries [19]. There were broadly similar findings reported in the results of a Cochrane Collaboration systematic review, based on data from more than one country, helmets reduce the risk of death in crashes by 42 per cent, and head injury by 60 per cent [20].

The wearing of a helmet (meeting a regulatory standard) has been mandatory for motorcyclists in Britain since 1973 [1], though a proportion of riders wore helmets in earlier years. Some of the injured motorcyclists seen by Cairns had been wearing helmets, and the proportion of helmeted riders rose during the course of the war [2, 4]. In the following decades, the prevalence of helmet wear was reported as increasing from 40 per cent of motorcyclists in 1956, to 70 per cent by 1962, and 88 per cent by the time it was made mandatory in 1973 [21]. The high level of voluntary helmet wear, prior to it being made a legal requirement, could account for there not being a great reduction in the mileage-adjusted fatality rate in the years following the year of enactment of the legislation.

Comparing the average annual motorcyclist fatality rate during the five years (1974–1978) after the year of enactment of the legislation, with the five years before (1968–1972), the reduction in the rate was 10 per cent, compared to a background reduction of approximately 25 per cent in the average annual fatality rate for all road users (Table 3).

Table 3 – Motorcycle fatalities before and after the requirement[a] to wear a helmet

Annual fatalities, and fatality rates per billion miles; data for Great Britain

1968–1972	*Fatalities*[b]	*Fatality rate*[c]
All road users [7]	7427	57.7
Motorcyclists [8]	792	319
1974–1978		
All road users [7]	6652	43.5
Motorcyclists [8]	994	286

[a]Enacted 1973
[b]Mean of five years data
[c]Mean of the fatality rate for each year

The reduction of the all-road-user fatality rate is broadly consistent with the decline over the post-war decades (Table 1).

Not adjusting for mileage, average annual motorcyclist fatalities were 26 per cent higher in the latter period (1974–1978), against a background fall of 10 per cent in average all-road-user fatalities (Table 5). Of the year 1978 total of 1163 motorcyclist fatalities, an annual figure that has not been exceeded in any subsequent year [7]; notably, two-thirds (772) of the total were aged between 15 and 24, and male [8].

This rise in motorcyclist fatalities in the late 1970s was reversed (Table 4) in the years following implementation (1982–1983) of the 1981 Transport Act – the next significant legislative change to affect motorcyclists following the Helmet Law of 1973. A provision of 1981 Act, implemented February 1 1983, reduced the maximum engine displacement of a motorcycle that could be ridden by a learner from 250cc to 125cc [22]. In addition to the restriction on engine *displacement*, restrictions were placed on the *power* (and *power-to-weight ratio)* of machines that a learner could ride, though this restriction only applied to machines that had been registered for use on the road in 1982, or later [22]. Other provisions of the Act came into force in 1982, including the necessity to pass a two-part test before a full motorcycle licence could be gained, and a new *time-limited* provisional licence [22].

Table 4 – Motorcycle fatalities before and after restrictions[a] on novice riders

Annual fatalities, and fatality rates per billion miles; data for Great Britain

1977–1981	*Fatalities*[b]	*Fatality rate*[c]
All road users [7]	6319	38.2
Motorcyclists [8]	1160	269
1984–1988		
All road user [7]	5265	25.2
Motorcyclists [7, 9]	784	178

[a]Provisions of the 1981 Transport Act, implemented 1982–1983 [22].
[b]Mean of five years data
[c]Mean of the fatality rate for each year.

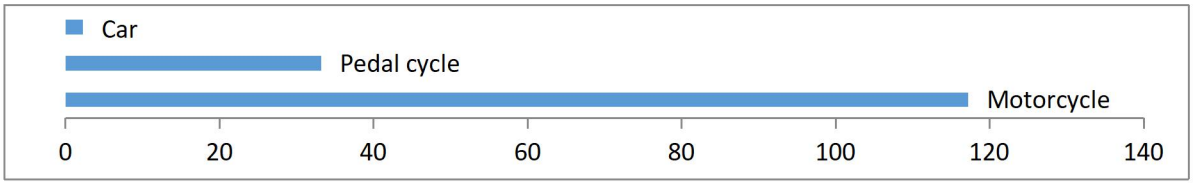
Average annual motorcyclist fatalities, and the fatality rate, both reduced by approximately a third in the five years following the implementation of the 1981 Act, compared to the five years prior; average annual fatalities showing a 32 per cent reduction, compared to a background reduction of 17 per cent for all road users (Table 4).

In modern times, the risk of death for a motorcyclist is a statistical outlier, compared to other common forms of road transport, notwithstanding the protection provided by the wearing of a helmet. In Great Britain, motorcycle riders, on average over the five years 2012–2016, had 52 times the death rate in road traffic accidents, compared to car drivers (per billion miles; Table 5).

Table 5 – Relative risks of personal transport by road in Great Britain
Annual driver/rider fatality rate per billion miles by vehicle type [23], averaged over five years 2012–2016.

Fatality rate:	
Car	2.26
Pedal cycle	33.2
Motorcycle	117.2

Presenting the averages as a bar chart:



Worldwide, nearly a quarter of the 1.25 million road traffic deaths in 2013 were among motorcyclists, with injuries to the head and neck are the main cause of death, severe injury, and disability [24].

Conclusions

Cairns' attention had been drawn to the high death rate in motorcycle accidents in the first 21 months of the Second World War, and his analyses, including those conducted in collaboration with Holbourn, led him to conclude that the wearing of a helmet reduces the risk of head injury, and death from head injury, in accidents. Helmets were made mandatory in Britain in 1973, however, with an increase in the popularity of motorcycling in the late 1970s, fatalities increased, though declined markedly in the years following the implementation (1982–1983) of restrictions on learner riders.

In modern times, motorcycling carries the highest risk of death in an accident in comparison with any other common form of road transport. A modern helmet, meeting a regulatory standard, and correctly fitted, reduces the risk of death and risk of head injury; notwithstanding the mandatory use of a helmet, a motorcyclist in Britain is around fifty times as likely to be killed in an accident than a car driver over the same distance, based on data from recent years.

A radical re-design of the motorcycle to incorporate the inherent safety features of modern cars (seatbelts, rigid passenger compartment and crumple zones) has the potential to bring the risks of motorcycle use more into line with car use; a design of motorcycle incorporating these features was produced commercially, by a major manufacturer, for some years.

REFERENCES

1. Maartens, NF, Wills AD, Adams, CBT. Lawrence of Arabia, Sir Hugh Cairns, and the Origin of Motorcycle Helmets. *Neurosurgery.* 2002; 50: 176–180. doi:10.1097/00006123-200201000-00026.
2. Cairns H. Head Injuries in Motor-cyclists. The Importance of the Crash Helmet. *British Medical Journal.* 1941; 2: 465–471. doi:10.1136/bmj.2.4213.465.
3. Cairns H, Holbourn AHS. Head Injuries in Motorcyclists, with Special Reference to Crash Helmets. *British Medical Journal.* 1943; 1(4297); 591–598. doi:10.1136/bmj.1.4297.591.
4. Cairns H. Crash helmets. *British Medical Journal.* 1946; 2: 322–344. doi:10.1136/bmj.2.4470.322.
5. Keep M, Rutherford T. *Reported Road Accident Statistics. Research Briefing SN/SG/2198*. London: House of Commons Library; 2013. http://researchbriefings.files.parliament.uk/documents/SN02198/SN02198.pdf
6. Office of National Statistics (ONS), *Causes of death over 100 years.* London: GOV.UK; 2017). https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/causesofdeathover100years/2017-09-18
7. Department for Transport (DfT) statistics, Road Accident Statistics. RAS40007. *Reported road accidents and casualties, Great Britain, 1950-2017*. London: DfT; 2018.
8. Department of Transport data, in Woodward A. Time trends in motorcycle accidents in Britain. *Journal of Epidemiology and Community Health.* 1983; 37: 66–69. [Note: rates per 10 million (motorcycle) kilometres converted to per billion miles using factor 160.9].
9. DfT, Road Traffic Statistics. TRA0101. *Road traffic (vehicle miles) by vehicle type in Great Britain, annual from 1949*. London: DfT; 2018.
10. DfT, Road Accident Statistics. *Facts on Road Fatalities.* London: DfT; 2015. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/448037/road-fatalities-2013-data.pdf
11. DfT, *Factors affecting reported road casualties. Reported road casualties Great Britain: 2015 annual report*. London: DfT; 2016. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/556406/rrcgb2015-02.pdf
12. DfT, *Road Accident Statistics. Facts on Motorcyclist Casualties*. London: Department for Transport; 2015. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/447673/motorcyclist-casualties-2013-data.pdf
13. Centers for Disease Control and Prevention (CDC), "Achievements in Public Health, 1900-1999. Motor-Vehicle Safety: A 20th Century Public Health Achievement." In *Morbidity and Mortality Weekly Report (MMWR).* 1999; 48: 369–374. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm4818a1.htm
14. Sawyer C, *The Building Blocks of Safety. Automotive Design & Production*. Cincinnati: Gardner Business Media, Inc; 2013. https://www.adandp.media/articles/the-building-blocks-of-safety

15. BMW Motorrad, *Pressemappe BMW C1*. München: BMW AG; 2000. [Electronic copy of original press release, supplied to the author by BMW Motorrad AG., München].
16. DeAmicis M, "The BMW C1 – BMW's First Scooter." *BMWBLOG* [online]. Chicago: BMWBLOG.COM; 2013. https://www.bmwblog.com/2015/12/22/the-bmw-c1/
17. Roth, H, Lombard C, "*Crash helmet*." US patent 2,625,683. Washington, DC: U.S. Patent and Trademark Office; 1953.
18. Fernandes FAO, Alves de Sousa RJ. Motorcycle Helmets—A State of the Art Review. *Accident Analysis and Prevention.* 2013; 56: 1–21. doi: 10.1016/j.aap.2013.03.011
19. National Highway Traffic Safety Administration (NHTSA). *Traffic safety facts, laws: motorcycle helmet use laws*. Report number DOT HS-810-887W. Washington, DC: NHTSA; 2008. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/810887.pdf
20. Liu BC, Ivers R, Norton R, Boufous S, Blows S, Lo SK. Helmets for preventing injury in motorcycle riders. Cochrane Database of Systematic Reviews 2008, Issue 1. Art. No.: CD004333. doi: 10.1002/14651858.CD004333.pub3.
21. Hansard. *Motor cyclists (helmets).* HC Deb 05 April 1973. 854: 745–775. London: UK Parliament; 1973. https://api.parliament.uk/historic-hansard/commons/1973/apr/05/motor-cyclists-helmets
22. Broughton J, *The effect of the 1981 Transport Act*. Transport and Road Research Laboratory (TRRL). Research Report 106. Crowthorne: TRRL; 1987. https://trl.co.uk/reports/RR106
23. DfT, Road Accident Statistics. RAS30013. *Reported casualty by road user type and severity, Great Britain, 2006-2016***.** 28 September 2017. London: DfT; 2017.
24. World Health Organization (WHO), *Global status report on road safety*; Geneva: WHO; 2015.