# Technical report: Comparisons of work-related fatal injuries between Great Britain and other countries

Data up to 2026
Periodic statistics
Official statistics in development
Published 1st July 2026

# Contents

# Executive summary

This research examines how work-related fatal injuries in Great Britain compare with a range of international comparator countries. The analysis was undertaken to support the assessment of whether Great Britain maintains its position as one of the safest countries in which to work.

The study includes comparisons with countries across Europe, as well as Argentina, Australia, Japan, New Zealand, South Korea, and the United States. These countries were selected based on the availability and comparability of data.

Data from each country were modelled alongside Great Britain using generalised linear models. Poisson regression was applied where appropriate, with Negative Binomial models used in cases of over-dispersion. The models estimated rate ratios relative to Great Britain, trends over time, and differences between countries, while accounting for workforce size and industry composition. Model fit, statistical significance, and predictive performance were also assessed.

The results show that most comparator countries have higher work-related fatal injury rates than Great Britain to some degree, with many differences being statistically significant. Only the Netherlands showed a lower relative rate, while six countries were assessed as being similar to Great Britain. Work-related fatal injuries were considered to generally decline over time across countries, but differences in trends compared to Great Britain are limited. Model performance is generally moderate to good regarding predictive accuracy and the majority of models met diagnostic assumptions.

Overall, the findings provide an evidence base that in the comparisons with each country, Great Britain consistently has lower relative work-related fatal injury rates, and the trend over time was considered to be decreasing. Though differences in temporal trends between Great Britain and comparator countries are rarely statistically significant, this suggests that countries are improving at broadly similar rates.

However, the analysis is subject to several limitations. These include differences in international data collection, reporting practices and definitions, the use of simplified modelling approaches, and a limited time series for some countries. Thus, results should be interpreted as indicative, rather than definitive, measures of relative differences in work-related fatal injuries.

# 1. Introduction

## 1.1 Report Overview

This report presents an analysis of work-related fatal injury rates in Great Britain in comparison with a selected group of international counterparts. The primary focus of the report is to assess how rates in Great Britain compare with those observed in other countries, and how these differences vary over time.

The analysis is based on statistical modelling of internationally sourced data, with the aim of producing estimates of work-related fatal injury rate ratios compared to Great Britain while accounting for differences in workforce population and industry composition.

The analysis is designed to compare Great Britain against individual comparator countries, rather than to produce a ranking or comparison between all countries. Each country is analysed in relation to Great Britain separately, allowing for a more focused assessment of relative performance and trends over time.

This approach reflects both methodological considerations and the limitations of international data, recognising that differences in definitions, reporting systems, and coverage mean that direct comparisons between all countries is not appropriate.

## 1.2 Research Problem

International comparisons of work-related health and safety outcomes provide important context for assessing national performance and identifying areas for improvement. Historically, such comparisons were supported by harmonised data collections through Eurostat (the statistical body of the European Union), which enabled Great Britain to benchmark its performance against other European countries using standardised definitions and methodologies.

However, following the UK's departure from the European Union, Great Britain is no longer obligated to be included in the data collection exercise conducted by Eurostat. As a result, comparable international statistics on work-related fatal injuries are no longer readily available through a single harmonised source.

The absence of a centralised, harmonised dataset means that comparisons must instead be constructed using data sourced directly from national organisations, each of which may differ in scope, definitions, and coverage.

The core challenge addressed by this research is therefore how to develop a robust and transparent approach to comparing work-related fatal injury rates in Great Britain with those in other countries, despite substantial differences in data collection systems. This includes accounting for variation in definitions of work-related fatalities, differences in population coverage, and inconsistencies in available breakdowns such as industry and age.

Addressing this problem is needed to provide evidence to support HSE's strategic objective of maintaining Great Britain's record as one of the safest countries to work in.

## 1.3 Research Objectives

This analysis is guided by the following research questions:

- How do work-related fatal injury rates in Great Britain compare with those in other countries after accounting for differences in workforce population and industry composition when expressed as modelled rate ratios?
- How have work-related fatal injury rates changed over time within each country after accounting for differences in workforce population and industry composition?
- How do trends in work-related fatal injury rates in other countries compare with those observed in Great Britain after accounting for differences in workforce population and industry composition?

These questions are addressed using statistical models that estimate rate ratios relative to Great Britain, within-country trends over time, and differences in trends between countries.

## 1.4 Research Scope

This analysis of work-related fatal injuries is conducted across a selected group of countries, with Great Britain used as the reference for comparison. Countries included are Argentina, Australia, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland and the United States.

The study originally aimed to compare against G20 countries. However, this was not fully achievable due to data availability and comparability constraints. In particular, several countries (including Brazil, Canada, India, Saudi Arabia, South Africa, Turkey) were explored during the initial scoping phase but were excluded due to:

- Lack of publicly available fatal injury data and/or employment denominator data
- Insufficient time series length
- Differences in definitions or coverage that could not be reliably adjusted to align with Great Britain's data

Additionally, Germany was initially included but was removed due to missing employment data for 2020, preventing its inclusion in the final model due to data completeness requirements.

The period of analysis varies by country, reflecting differences in data availability:

- 2012–2023: Australia, New Zealand, United States, Japan
- 2014–2023: European countries
- 2017–2023: South Korea
- 2019–2023: Argentina

Industry-level analysis is based on a harmonised set of high-level groupings, aligned as closely as possible across different national classification systems:

- Agriculture, mining, energy and utilities
- Manufacturing
- Construction
- Transport
- Services

These groupings were constructed by mapping country-specific classification systems (e.g. UKSIC[1], NAICS[2], NACE[3], ANZSIC[4]) to a common framework to enable cross-country comparison.

Overall, countries were included where sufficient data was available and where definitions and coverage could be aligned to a reasonable degree with the Great Britain data. Further details on country-specific data sources, adjustments, and limitations are provided in Section 2 next.

[1] UK Standard Industrial Classification of Economic Activities, see https://www.ons.gov.uk/methodology/classificationsandstandards/ukstandardindustrialclassificationofeconomicactivities

[2] North American Industry Classification System, see https://www.naics.com/search/

[3] Statistical classification of economic activities in the European Community, abbreviation is derived from the French title, see https://ec.europa.eu/eurostat/web/nace

[4] Australian and New Zealand Standard Industrial Classification, see https://www.abs.gov.au/statistics/classifications/australian-and-new-zealand-standard-industrial-classification-anzsic/latest-release

# 2. Country Profiles

## 2.1 Introduction

This section presents detailed country-level profiles for each dataset included in the analysis, with the aim of identifying and documenting key differences that may affect the comparability of work-related fatal injury rates across countries. While efforts were made to harmonise data as far as possible, variations in data sources, definitions, coverage, and methodology remain important considerations when interpreting results.

For each country, information is provided on the data source used for fatal injury counts and employment denominators, along with the time period covered, industry classifications, and any adjustments required to achieve alignment with the Great Britain dataset. Particular attention is given to differences in the scope of work-related fatalities, including the inclusion of road traffic accidents, commuting incidents, and coverage of worker types (e.g. self-employed).

Additional processing was required to improve comparability and consistency of data, including:

- Aligning industry classifications to a common set of high-level groupings
- Restricting data to comparable industry coverage (typically sections A–S)
- Removing commuting accidents where included in source data
- Supplementing the Great Britain dataset where road traffic accidents were not fully captured in the way they are in other countries

Despite this, differences in reporting systems, such as through insurance or statutory reporting, there exist differences in fatal injury inclusion time limits, definitions and accident type inclusions. These must be considered as they may influence the model results.

## 2.2 Country Details

### 2.2.1 Great Britain

**Data source:**
Work-related fatal injury data was derived from:

- The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) system
- Supplemented with road traffic accident data from the Department for Transport (STATS19)
- Road traffic accident data proportioned by industry using a bespoke output from the Labour Force Survey for estimated annual incidence of self-reported non-fatal work-related road traffic injury sustained in current or most recent job, by industry.

Work-related fatal injury statistics reported by HSE usually use financial year boundaries (April to March). However, to enable comparisons against other countries, calendar years were used in this analysis and so these figures differ from those published elsewhere by HSE.

Denominator data was derived from estimates from the Annual Population Survey (APS)

Data for Great Britain covers the period 2012-2023.

**Coverage and definitions:**
Work-related fatal injury data covers all ages and industries UK SIC A–S.

**Table 1: Industry groupings for Great Britain**

| Industry grouping | UK SIC 2007 | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | A, B, D, E | Agriculture, forestry and fishing; Mining and quarrying; Electricity, gas, steam and air conditioning supply; Water supply, sewerage, waste management and remediation |
| Manufacturing | C | Manufacturing |
| Construction | F | Construction |
| Transport | H | Transportation and storage |
| Services | G, I, J, K, L, M, N, O, P, Q, R, S | Wholesale and retail trade, repair of motor vehicles and motorcycles; Accommodation and food service; Information and communication; Finance and insurance; Real estate; Professional, scientific and technical activities; Administrative and support services; Public administration and defence; Education; Human health and social work; Arts, entertainment and recreation; Other service activities |

With the exception of suicides, the death of any person must be reported under RIDDOR if it resulted from a work-related accident. If a person suffers a reportable work-related injury and dies due to that injury within one year (365 days), this must be reported as a work-related fatality.

There is no requirement to report the death of a self-employed person when it occurs in premises where they are the sole owner or occupier.

Certain types of work-related injury are not reportable under RIDDOR, including:

- Fatal accidents involving workers travelling on a public highway (a ‘road traffic accident’). Such incidents are enforced by the police and reported to the

Department for Transport (DfT). Those killed whilst commuting (travelling from home to work, and vice versa) are also excluded;
- Fatal accidents involving workers travelling by air or sea. These incidents are the responsibility of the Air Accident Investigation Branch and Marine Accident Investigation Branch of the Department for Transport and reported accordingly;
- Fatalities to members of the armed forces on duty at the time of incident;
- Fatal injuries at work due to 'natural causes', often heart attacks or strokes, unless brought on by trauma due to the accident.

It should be noted that previous comparisons with other countries compared the United Kingdom with other countries. However, the data used in this research uses only data for Great Britain (England, Scotland, and Wales).

More information on RIDDOR reportable incidents is available at www.hse.gov.uk/riddor/reportable-incidents.htm

Due to the exclusion of road traffic accidents in RIDDOR data and the inclusion of them in other country data, the work-related fatal injury data was supplemented with road traffic accident data from the Department for Transport. The data provided by DfT was from STATS19, RSSeq231: Driver or rider casualties driving as part of work and their passengers, by severity, Great Britain 2012 to 2024. The full report, including assumptions, is available at www.gov.uk/government/statistics/reported-road-casualties-great-britain-involving-driving-for-work

The road traffic accident fatal injury data was allocated across industry grouping using an estimate from the Labour Force Survey. This used the 10 year average (2014/15-2023/24) of estimated annual incidence of self-reported non-fatal work-related road traffic injury sustained in current or most recent job, by industry. This method of allocating road traffic accidents to industries has been used before by HSE in previous work-related fatal injury data submissions to Eurostat.

More information on the Labour Force Survey is available at www.hse.gov.uk/statistics/lfs/technicalnote.htm

### 2.2.2 Argentina

**Data source:**
Work-related fatal injury data was derived from the Superintendence of Occupational Risks (SRT) administrative system. This is an insurance based system and the denominator data was derived from the number of covered workers reported through the same system.

This data was accessed via the dynamic dashboard on accidents, using the filters Workplace accident (Accidente laboral) and Productive Units (Unidades Productivas), these are the fatal accidents which occur in public and private sectors

and not in households: www.srt.gob.ar/estadisticas/acc_tablero_casos_tableau.php (accessed 12/06/26)

The denominator data was accessed from the Historical series by economic sector (Serie histórica según sector económico) using the CIIU 4th revision industry sectors at: www.srt.gob.ar/estadisticas/cf_serie_historica_up.php (accessed 12/06/26)

Data for Argentina covers the period 2019-2023. This shorter time series may increase uncertainty in the model estimates and reduce the ability to detect statistically significant trends. Results should therefore be interpreted with caution.

**Coverage and definitions:**
The SRT system records several types of incidents, including workplace accidents, occupational diseases, commuting incidents (in itinere), and readmissions.

For comparability with Great Britain, only workplace accident fatalities (Accidente laboral, AT) within productive units (excluding private households) were included in this analysis.

Included incidents:

- Fatal injuries occurring during work activity
- Road traffic accidents occurring in the course of work

Excluded incidents:

- Commuting accidents

**Table 2: Industry groupings for Argentina**

| Grouping | CIIU 4th revision | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | A, B, D, E | Agriculture, livestock, hunting, forestry and fishing; Mining and quarrying; Supply of electricity, gas, steam and air conditioning; Water supply, sewerage, waste management and material recovery and public sanitation |
| Manufacturing | C | Manufacturing |
| Construction | F | Construction |
| Transport | H | Transportation and storage |
| Services | G, I, J, K, L, M, N, O, P, Q, R, S | Wholesale and retail trade; repair of motor vehicles and motorcycles; Transportation and storage; Accommodation and food; Information and communications; Financial intermediation and |

| Grouping | CIIU 4th revision | Industry description |
|---|---|---|
| | | insurance; Real estate; Professional, scientific and technical services; Administrative activities and support services; Public administration, defence and compulsory social security; Teaching; Human health and social services; Artistic, cultural, sports and leisure services; Association services and personal services |

**Considerations:**

- The system is insurance-based and includes only workers covered by the occupational risk system, potentially excluding informal workers.
- Differences in classification (e.g. separation of commuting incidents) required additional filtering to ensure comparability.
- Data and reports are published in Spanish; therefore interpretation relies on translation, which may introduce inaccuracies or ambiguity in definitions and classifications.

More information on the Occupational Hazards System, visit www.srt.gob.ar/estadisticas/acc_definiciones.php

For more information on the denominator data, see www.srt.gob.ar/estadisticas/cf_definiciones.php

### 2.2.3 Australia

**Data source:**

Work-related fatal injury data was derived from the Safe Work Australia Traumatic Injury Fatalities (TIF) dataset. This dataset combines information from multiple sources, including notifications from work health and safety authorities, coronial records (National Coronial Information System), and workers' compensation datasets.

This was collected via the interactive dashboard: https://data.safeworkaustralia.gov.au/interactive-data/topic/work-related-fatalities (accessed 12/06/26)

Denominator data was derived from Australian Bureau of Statistics (ABS) Labour Force Survey estimates of employed persons, using annual averages.

This was collected from www.abs.gov.au/statistics/labour/employment-and-unemployment/labour-force-australia-detailed using the Original figures from Table 04. Employed persons by Industry division of main job (ANZSIC) - Trend, Seasonally adjusted, and Original (accessed 12/06/26)

Data for Australia covers the period 2012-2023.

**Coverage and definitions:**

The TIF dataset includes workers who were fatally injured due to work-related activity, regardless of employment type. This includes employees, self-employed workers and volunteers. Bystanders are recorded where the actions of a worker directly contributed to the fatality, however these were not included in the dashboard the data was sourced from.

Examples of included incidents:

- Fatal injuries arising from work-related activity or exposures
- Road traffic accidents occurring while travelling as part of work (e.g. between job sites)

Examples of excluded incidents:

- Commuting accidents (travel to and from work)
- Deaths due to natural causes (unless directly triggered by a workplace injury)
- Suicides

There is no strict time limit for inclusion, although fatalities typically occur shortly after the incident.

Coverage includes all ages.

**Table 3: Industry groupings for Australia**

| Industry grouping | ANZSIC06 | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | A, B, D | Agriculture, forestry and fishing; Mining; Electricity, gas, water and waste |
| Manufacturing | C | Manufacturing |
| Construction | E | Construction |
| Transport | I | Transport, postal and warehousing |
| Services | F, G, H, J, K, L, M, N, O, P, Q, R, S | Wholesale trade; Retail trade; Accommodation and food services; Information media and telecommunications; Financial and insurance services; Rental, hiring and real estate; Professional, scientific and technical services; Administrative and support services; Public administration and safety; Education |

| Industry grouping | ANZSIC06 | Industry description |
|---|---|---|
| | | and training; Health care and social assistance; Arts and recreation services; Other services |

**Considerations:**

The inclusion of self-employed workers results in greater comparability with Great Britain, though the inclusion of volunteers broadens Australian coverage where in Great Britain volunteers would be considered Members of the Public and thus excluded from work-related fatal injuries to workers.

Road traffic accidents are included where work-related, though some may be missed due to limitations in identifying work activity within police and coronial records.

For more information on TIF, see https://data.safeworkaustralia.gov.au/our-datasets/work-related-fatalities-data

For more information on employment estimates, see www.abs.gov.au/statistics/detailed-methodology-information/concepts-sources-methods/

### 2.2.4 European Countries

**Data source:**
Work-related fatal injury data were obtained from Eurostat's European Statistics on Accidents at Work (ESAW) dataset (hsw_ph3_02). This dataset provides harmonised information on workplace accidents across European countries.

Eurostat receives ESAW data from the relevant national authority or insurance system (administrative data sources). The original national data sources are employers' declarations of accidents at work, either to relevant insurance companies, national social security systems, or labour inspectorates or similar national authorities.

This work-related fatal injury data is available at https://ec.europa.eu/eurostat/databrowser/view/hsw_ph3_02__custom_18133461/default/table (accessed 12/06/26)

The number of employed persons for the reference population is provided either by the countries (at NACE 2-digits level) or are taken from the European Union Labour Force Survey (when countries are not able to provide their own reference populations).

Denominator data for this analysis was derived from the Employed persons by economic activity (NACE Rev. 2) (lfsq_egan2), using employed persons aged 15

years and over. Annual estimates were calculated using averages of quarterly employment data.

The employment data is available at https://ec.europa.eu/eurostat/databrowser/view/lfsq_egan2__custom_18101465/default/table (accessed 12/06/26)

Data for all European countries covers the period 2014-2023.

**Coverage and definitions:**
The ESAW dataset captures fatal occupational accidents resulting from work-related activities, using a harmonised framework across participating countries. The ESAW defines an accident at work as ‘a discrete occurrence in the course of work which leads to physical or mental harm'. This includes all accidents in the course of work, whether they happen inside or outside the premises of the employer, on the premises of another employer, in public places or during transport (including road traffic accidents or accidents in any other mean of transportation) and at home (such as during teleworking). It also includes cases of acute poisoning and wilful acts of other persons.

It excludes:

- Commuting accidents: accidents that occur during the normal journey to or from home and place of work;
- Deliberate self-inflicted injuries;
- Accidents from strictly natural causes;
- Accidents, purely private;
- Accidents to members of the public, even if such an accident is due to a work activity within a company.

It should be noted that France applies an “assumption of work-relatedness”. This means that any accident causing physical or mental injury that occurs at work or during work, regardless of its cause, is recognised as a work accident and it is the employers’ responsibility to prove the *lack* of a link to the work for the accident. Failing to establish a link between the accident and the work is not sufficient to consider that the accident is not work-related. This assumption means that fatal heart attacks and other sudden deaths that cannot be definitively proven to be unrelated to work are included and these accidents accounted for over half of all fatal workplace accidents in 2019. These inclusions can increase coverage of borderline cases or cases which would not have been deemed work-related in Great Britain, potentially causing higher reported fatality counts.

A fatal accident at work is defined as an accident that leads to the death of a victim within one year of the accident. In practice the notification of an accident as fatal ranges from national registration procedures where the accident is registered as fatal.

## Table 5: Fatal injury time limits for ESAW countries

| Country | Fatal injury time limit |
|---|---|
| Austria | No time limit |
| Belgium | No time limit |
| Bulgaria | Within 1 year |
| Croatia | Within 1 year |
| Cyprus | Within 1 year |
| Czechia | Within 1 year |
| Denmark | Within 1 year |
| Estonia | Within 1 year |
| Finland | Within 1 year |
| France | No time limit (except for deaths occurring after the recognition of a permanent disability) |
| Germany | Within 30 days |
| Greece | No time limit |
| Hungary | Within 1 year |
| Iceland | Within 1 year |
| Ireland | Within 1 year |
| Italy | No time limit |
| Latvia | Within 1 year |
| Lithuania | Within 1 year |
| Luxembourg | No time limit |
| Malta | Within 1 year |
| Netherlands | Same day |
| Norway | No time limit |
| Poland | Within 6 months |
| Portugal | Within 1 year |
| Romania | Within 1 year |
| Slovakia | Within 1 year |
| Slovenia | Within 1 year |
| Spain | Within 1.5 years |
| Sweden | No time limit |
| Switzerland | Within 1 year |

In terms of employment types covered by ESAW, countries are required to report on 'employees'. The other employment types (i.e. self-employed, family workers, etc.) are voluntary.

Additionally, some sectors are subject to confidentiality rules, thus the following NACE Rev. 2 divisions of sector O are provided on a voluntary basis only:

- 84.22 Defence activities;
- 84.23 Justice and judicial activities;
- 84.24 Public order and safety activities;
- 84.25 Fire services activities.

Data were restricted to NACE Rev. 2 industries A–S for this analysis, ensuring comparability and alignment with Great Britain and other national datasets.

**Table 6: Industry groupings for ESAW countries**

| Grouping | NACE | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | A, B, D, E | Agriculture, forestry and fishing; Mining and quarrying; Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities |
| Manufacturing | C | Manufacturing |
| Construction | F | Construction |
| Transport | H | Transportation and storage |
| Services | G, I, J, K, L, M, N, O, P, Q, R, S | Wholesale and retail trade, repair of motor vehicles and motorcycles; Accommodation and food service; Information and communication; Financial and insurance activities; Real estate; Professional, scientific and technical activities; Administrative and support services; Public administration and defence, compulsory social security; Education; Human health and social work; Arts, entertainment and recreation; Other service activities |

**Considerations:**

- ESAW provides a harmonised framework, improving comparability across European countries, particularly regarding definitions of work-related fatal accidents.
- Despite harmonisation, data quality varies between countries, reflecting differences in national reporting systems and administrative practices.
- Several countries exhibit breaks in time series, most notably around 2021, which may affect longitudinal analysis.

- Missing or low reliability estimates in employment data occurs in certain industries (e.g. mining), with some annual values based on fewer than four quarterly observations.
- Differences in fatality time limits and reporting completeness across countries may still influence comparability, despite the ESAW harmonisation framework.
- Though commuting accidents are excluded from ESAW, many countries still collect this data and so separating commuting accidents from work-related road traffic accidents may be incomplete, despite the ESAW harmonisation.
- Some worker types and industry groupings are voluntary to be submitted for ESAW. Thus this can inflate or deflate country rates depending on whether these voluntary categories are included in fatal injury data or employment data.
- Germany was excluded from the final analysis due to missing employment (denominator) data for 2020, which prevented a consistent time series and therefore its inclusion in the final model.

For more information on ESAW and the coverage of all ESAW variables, employment types, and worker types, see https://ec.europa.eu/eurostat/cache/metadata/en/hsw_acc_work_esms.htm. This page also includes links to the metadata for each country included in ESAW.

For more information on the employment data, see https://ec.europa.eu/eurostat/cache/metadata/en/lfsq_esms.htm

### 2.2.5 Japan

**Data source:**
Work-related fatal injury data was derived from occupational accident statistics published by the Ministry of Health, Labour and Welfare (MHLW).

This data was collected from https://anzeninfo.mhlw.go.jp/user/anzen/tok/anst00_r05.html using table 4 Industry/Age (④業種・年齢) from the Final statistics on Fatal Accidents (死亡災害統計確定値) download, for years 2012 (Heisei 24) to 2023 (Reiwa 5) (accessed 12/06/26).

Denominator data was derived from the Labour Force Survey (労働力調査) using table 2-2-1 Number of Workers by Industry and Age Group (2007~) (年齢階級，産業別就業者数) (accessed 12/06/26). This can be found at https://www.e-stat.go.jp/stat-search/database/

Data for Japan covers the period 2012-2023.

**Coverage and definitions:**
The dataset includes work-related fatalities occurring during the course of employment.

Fatal injuries sustained while performing work duties, including road traffic accidents where they occur during work activity are included in the dataset. Coverage includes all ages and excludes unknown industries. Commuting accidents are excluded.

The work-related fatal injury industry groupings used in the acquired data does not match neatly to standard industry classifications.

**Table 7a: Industry groupings for Japan – Fatal injury data**

| Industry grouping | MHLW industry | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | 02; 06; 07; 1502; 1503; 1505 | Mining; Agriculture and forestry; Livestock and fisheries; Industrial waste; Other waste; Slaughtering |
| Manufacturing | 01 | Manufacturing |
| Construction | 03 | Construction |
| Transport | 04; 05 | Transportation; Cargo handling |
| Services | 08; 09; 10; 11; 12; 13; 14; 1501; 1504; 1509; 16; 17 | Commerce; Financial advertising; Film and theatre; Communications; Education and research; Health and hygiene; Hospitality and entertainment; Building maintenance; Cremation; Other cleaning and slaughtering; Government and public offices; Other businesses |

The industry code 15 Cleaning and slaughtering had 6 subsectors which broadly fit into UK SIC A – Agriculture, E – Water supply, N – Administrative services and S – Other services. Thus, these have been separated across the broad industry groupings.

The industry classifications in the employment estimates data uses the Japanese Standard Industrial Classification (JSIC) and thus aligns with international industry classifications.

**Table 7b: Industry groupings for Japan – Worker data**

| Industry grouping | JSIC | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | 01; 08; 35 | Agriculture, forestry; Mining, quarrying, and gravel extraction; Electricity, gas, heat supply, water supply |
| Manufacturing | 10 | Manufacturing |
| Construction | 09 | Construction |

| Industry grouping | JSIC | Industry description |
|---|---|---|
| Transport | 42 | Transportation, postal industry |
| Services | 36; 51; 58; 59; 62; 67; 71; 75; 78; 82; 85; 95 | Information and communication; Wholesale and retail; Finance and insurance; Real estate, goods leasing; Academic research, professional and technical services; Accommodation, food and beverage; Lifestyle and entertainment; Education; Medical care and welfare; Combined services; Other services; Official duties |

**Considerations:**

- Limited publicly available methodological detail means some differences in coverage (e.g. worker types included) cannot be fully assessed.
- Data and reports are published in Japanese; therefore interpretation relies on translation, which may introduce inaccuracies or ambiguity in definitions and classifications.

For more information on the data source, see www.mhlw.go.jp/bunya/roudoukijun/anzeneisei11/rousai-hassei/

### 2.2.6 New Zealand

**Data source:**
Work-related fatal injury data was derived from administrative records provided by WorkSafe New Zealand, using the WorkSafe New Zealand Fatalities Register, which includes information based on confirmed fatal work-related incidents reported to WorkSafe, and Accident Compensation Corporation (ACC) claims, based on accepted ACC claims for work-related fatalities. ACC claims can include work-related fatalities that come under the Maritime New Zealand, Civil Aviation Authority, and New Zealand Police jurisdictions.

This data was accessed from the WorkSafe fatalities dashboard and excludes members of the public. This can be accessed through https://data.worksafe.govt.nz/graph/detail/fatalities (accessed 12/06/26).

Denominator data was derived from Linked Employer–Employee Data (LEED), using the annual average total filled jobs from https://explore.data.stats.govt.nz/ (accessed 12/06/26).

Data for New Zealand covers the period 2012-2023.

**Coverage and definitions:**
The dataset includes work-related fatalities across all industries.

Included incidents:

- Fatal injuries occurring during work activity
- Road traffic accidents occurring in the course of work

Excluded incidents:

- Commuting accidents
- Self-harm
- Natural causes

Coverage includes all ages and excludes unknown industries.

**Table 8: Industry groupings for New Zealand**

| Industry grouping | ANZSIC06 | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | A, B, D | Agriculture, forestry and fishing; Mining; Electricity, gas, water and waste |
| Manufacturing | C | Manufacturing |
| Construction | E | Construction |
| Transport | I | Transport, postal and warehousing |
| Services | F, G, H, J, K, L, M, N, O, P, Q, R, S | Wholesale trade; Retail trade; Accommodation and food services; Information media and telecommunications; Financial and insurance services; Rental, hiring and real estate; Professional, scientific and technical services; Administrative and support services; Public administration and safety; Education and training; Health care and social assistance; Arts and recreation services; Other services |

**Considerations:**

- The use of “filled jobs” rather than employed persons as the denominator may result in differences compared to labour force-based estimates.

### 2.2.7 South Korea

**Data source:**
Work-related fatal injury data was derived from industrial accident statistics produced by the Korea Occupational Safety and Health Agency (KOSHA).

This data was accessed from https://portal.kosha.or.kr/archive/indus-acc-statis/ with the disaster classification of fatal accident (사고사망자), and the row of major industry (대업종) (accessed 25/06/26).

Denominator data was based on workers covered by industrial accident insurance systems, published alongside the fatal injury data in the Industrial Accident Status Analysis Yearbook, page 22 in the table Comparison of Occupational Accident Fatalities Compared to Previous Years. These can be accessed via https://portal.kosha.or.kr/archive/indus-acc-statis/ and www.moel.go.kr/policy/policydata/

Data for South Korea covers the period 2017-2023. This shorter time series may increase uncertainty in the model estimates and reduce the ability to detect statistically significant trends. Results should therefore be interpreted with caution.

**Coverage and definitions:**
The dataset includes work-related fatalities across all industries and worker groups covered by the national system.

Included incidents:

- Some road traffic accidents, including those occurring outside the workplace but related to work (particularly in transport-related industries)

Excluded incidents:

- Commuting accidents
- Sporting events
- Acts of violence
- Fatalities occurring more than one year after the date of the accident

Coverage includes all ages and excludes unknown industries.

**Table 9: Industry groupings for South Korea**

| Industry grouping | Industry description (KSIC) |
|---|---|
| Agriculture, mining, energy and utilities | Mining; Electricity, gas, steam and water supply; Forestry; Fishing; Agriculture |
| Manufacturing | Manufacturing |
| Construction | Construction |
| Transport | Transportation, warehousing and communications |
| Services | Finance and insurance; Other businesses |

**Considerations:**

- The use of an insurance-based denominator means coverage is limited to insured workers, potentially excluding informal employment.
- Partial inclusion of road traffic accidents may make comparisons difficult without knowing the full extent of the exclusions.

- Some non-standard worker groups (e.g. overseas personnel) cannot be fully excluded but represent a small proportion of cases.
- Data and reports are published in Korean; therefore interpretation relies on translation, which may introduce inaccuracies or ambiguity in definitions and classifications.
- Transportation industry group includes communications which has a broader scope than the UKSIC Transportation and storage industry group used in the Great Britain data.

For more information and for annual reports, see www.moel.go.kr/policy/policydata/

### 2.2.8 United States

**Data source:**
Work-related fatal injury data was derived from the Census of Fatal Occupational Injuries (CFOI), produced by the Bureau of Labor Statistics. This dataset uses multiple data sources, including death certificates, workers' compensation reports, and other administrative records.

This data was accessed from the Industry by event or exposure tables and All worker profile, 2003-2018 table at www.bls.gov/iif/fatal-injuries-tables.htm (accessed 12/06/26)

Denominator data was derived from the Current Population Survey (CPS), using monthly surveys of households. The employment information is using estimated annual average of employed persons aged 16 and over.

This data was accessed from table 18b. Employed persons by detailed industry and age via www.bls.gov/cps/tables.htm (accessed 12/06/26)

Data for the United States covers the period 2012-2023.

**Coverage and definitions:**
CFOI includes all fatal occupational injuries resulting from traumatic events.

Included incidents:

- Fatal injuries resulting from acute exposure to energy or environmental factors
- Road traffic accidents and transport-related incidents where work-related
- Fatalities involving employees, self-employed persons, government workers, and some volunteers
- Homicide if it meets the work relationship criteria
- Suicide if:
  - the suicide occurred on the work premises
  - the suicide occurred off the work premises but can be definitively linked back to work (e.g. a suicide note that mentions that work was a factor in the suicide. Suicides are usually considered to be multicausal, so for

this reason, suicides that occur off the work premises need to be conclusively linked to work to be included)

- Suicides after a homicide – if the assailant had an existing or prior work relationship with the establishment or with those they killed, if they then commit suicide at the scene or shortly after, the assailant may also be included. If the assailant had no prior work connection to those they killed or to the worksite, a subsequent suicide by this person would not be included
- Drug overdose after an injury at work – deaths at work that result from drug overdoses are included regardless of when the drugs were taken, whether the drugs were medicinal/illicit, or the reason for taking the drugs. In other cases, an injury at work will require the use of medication to alleviate the pain and workers occasionally die after a reaction to or overdose from these. Inclusion generally stems from two factors:
  - First factor – the closer to the initial injury, the more likely it will be included. An overdose of drugs 5 years after the injury will be less likely to be included than one that occurs 5 days after the injury. Drug intake 5 days after an injury is expected, while drug intake 5 years after the injury is more difficult to link back to the underlying injury
  - Second factor – the drug must be one that is generally used to treat an injury (i.e. not cocaine or alcohol)
- Complications – if the complication (e.g. embolisms, allergic reactions, surgical complications, pneumonia) can be definitively linked back to the original work-related injury, the case would be included
- Commuting accidents that falls outside of the normal commute for work

Excluded incidents:

- Overexertion – generally not included as it is not considered a traumatic injury and cannot be linked back to an acute exposure
- Commuting accidents during normal commute
- Fatal occupational illnesses (unless triggered by an acute injury event)

The dataset uses a strict case verification process, requiring multiple independent data sources to confirm each fatality.

**Table 10: Industry groupings for United States**

| Industry grouping | NAICS | Industry description |
|---|---|---|
| Agriculture, mining, energy and utilities | 11; 21; 22 | Agriculture, forestry, fishing and hunting; Mining, quarrying, and oil and gas extraction; Utilities |
| Manufacturing | 31-33 | Manufacturing |
| Construction | 23 | Construction |
| Transport | 48-49 | Transportation and warehousing |

| Industry grouping | NAICS | Industry description |
|---|---|---|
| Services | 42; 44-45; 51; 52-53; 54-56; 61-62; 71-72; 81; 92 | Wholesale trade; Retail trade; Information; Financial activities; Professional and business services; Educational and health services; Leisure and hospitality; Other services, except public administration; Public administration |

**Considerations:**

- Inclusion of volunteers, good Samaritans using specialist skills, undocumented workers, off-duty police, professional athletes, inmates and institutionalised persons working outside of where they are incarcerated/institutionalised increases coverage, whereas many of these are excluded from Great Britain data or would be considered Members of the Public
- Inclusion of certain commuting and travel accidents where Great Britain data may exclude could inflate rates for USA

More information on the CFOI is available at www.bls.gov/iif/overview/cfoi.htm

For more information on the CPS, visit www.bls.gov/cps/cps_over.htm

# 3. Methodology

## 3.1 Summary

Data for work-related fatalities were collected for Great Britain and each comparator country. These datasets were then prepared prior to modelling by removing any records with missing values, standardising industries classification inclusions across all countries and creating high-level industry groupings for consistency and comparability. Road traffic accident data was then incorporated into the dataset for Great Britain, as a step to harmonise the data. Where alignment was not possible without introducing significant uncertainty, datasets or years were excluded from the analysis. Year values were standardised for each data pairing.

A Poisson regression modelling approach was taken, with the data for each comparator country modelled with the data for Great Britain. Poisson regression models were fit to the data initially, then the acceptable value for dispersion was calculated to give a threshold for over-dispersion. Any models showing over-dispersion were changed to a Negative Binomial regression model if the level of dispersion was greater than the calculated acceptable value (1.6). No models showed sufficient under-dispersion, so no alternative model was required to address under-dispersion.

The models estimated fatality rates while accounting for country, year, industry, and a log offset for the denominator values. An interaction between country and year was included to estimate annual trends for the comparator countries. The DHARMa package was used to measure the model performance, and an analysis of the predicted confidence intervals compared to actual fatality rates was used to assess predictive accuracy. Outputs were extracted for each model, including model details and fit statistics, coefficients and statistical significance, plus model predictions, with confidence intervals, for both the industry breakdowns and the totals per country per year. The model fitting and collection of results were performed using R Studio.

## 3.2 Introduction

This section describes the methodologies used to create the “Comparisons of work-related fatal injuries between Great Britain and other countries” report. It outlines each stage of the analytical process, including data preparation, modelling approaches, and quality assurance steps. The reasoning behind key methodological decisions is also presented.

This work is considered Official Statistics in Development, as this is a new, exploratory approach to comparisons with other countries. Previous work-related fatal injury comparisons were only against European countries using standardised incidence rates compiled by Eurostat. However, following the UK’s departure from the European Union and thus from Eurostat data, there is a gap in more recent research into how Great Britain compares with other countries.

The core challenge addressed by this research is therefore how to develop a robust and transparent approach to comparing work-related fatal injury rates in Great Britain with those in other countries, despite substantial differences in data collection systems. This includes accounting for variation in definitions of work-related fatalities, differences in population coverage, and inconsistencies in available breakdowns such as industry and age.

This research applies statistical modelling techniques to compare Great Britain with selected comparator countries. As this approach is under development, they are undergoing further development and evaluation to improve their quality, the methodology, and the presentation. The current modelling approach will be kept under review and user feedback is welcomed to inform future releases. Findings should be interpreted with appropriate caution because of this. Limitations of the analysis are discussed in section 5 of this report.

Directly comparing rates of work-related fatalities may appear more straightforward, however this assumes that the datasets are directly comparable. It does not account for the differences in data collection methods, fatality definitions, workforce characteristics or other differences. Statistical modelling allows for a more robust comparison, as it allows for uncertainty to be quantified and, where possible, adjust for variations in the data, such as changes over time.

The core analytical approach of this project was the use of generalised linear modelling, specifically Poisson and Negative Binomial regression. These models are commonly used for analysing count data, where outcomes represent the number of events occurring within a defined exposure period or population. Poisson regression assumes that the mean and variance of the outcome are equal, while Negative Binomial regression allows for over-dispersion when the variance exceeds the mean[5]. Both approaches allow the relationship between predictor variables and the outcome to be modelled through a log link function, with an offset used to account for differing exposure levels between observations. The analysis was conducted using R within RStudio, supporting reproducibility and the implementation of appropriate statistical methods for count data. Details of the software environment are provided in Table 11.

**Table 11: Software details and versions**

| Name | Type | Version |
|---|---|---|
| R | Programming language | 4.5.2 |
| R Studio | Integrated Development Environment (IDE) | 2025.9.1.401 |
| dplyr | R package – data manipulation and transformation | 1.1.4 |

[5] Schober, Patrick MD, PhD, MMedStat*; Vetter, Thomas R. MD, MPH†. Count Data in Medical Research: Poisson Regression and Negative Binomial Regression. Anesthesia & Analgesia 132(5). Available at: https://journals.lww.com/anesthesia-analgesia/fulltext/2021/05000/Count_Data_in_Medical_Research__Poisson_Regression.26.aspx

| Name | Type | Version |
|---|---|---|
| readxl | R package – Excel file import | 1.4.5 |
| writexl | R package – Excel file export | 1.5.4 |
| purrr | R package – Functional programming and iteration | 1.0.4 |
| MASS | R package – Statistical modelling (Negative Binomial) | 7.3-65 |
| DHARMa | R package – Model diagnostics | 0.4.7 |

The following sections will describe the analytical process in more detail, beginning with details of the stages for data preparation.

## 3.3 Data Preparation

### 3.3.1 Data Harmonisation

**Scope harmonisation**
Each country has its own scope for what is included in the official statistics of work-related fatal injuries. As all countries do not include the same variables, the first step of harmonisation was to research the collection methods for the comparator countries, compare the definitions, coverage and data collection methods and assess how these compared against Great Britain's data sources and how Great Britain's data could be altered so that the scope for each were as similar as possible.

Where differences were identified, adjustments were made to the Great Britain dataset where feasible, to align its scope more closely with comparator countries. However, there were several areas where full harmonisation was not possible. For example:

- Suicides and certain violent incidents are included in some datasets (e.g. United States) where a work-related link can be established, but are excluded in Great Britain. These cases could not be reliably added or removed due to limited detail in publicly available data, making it difficult to identify and reclassify them consistently across countries. Attempts were made to create estimates for these using data available from police reports; however this could not reliably be included.
- Fatal occupational illnesses or deaths from natural causes are treated differently across countries. In most datasets these are excluded unless directly linked to an acute event, but some countries (e.g. France in ESAW) may include cases where work-relatedness is assumed. These differences could not be adjusted due to a lack of knowing how many fatalities that occur in Great Britain would be considered work-related in France. Exploration into using figures from fatalities reported under RIDDOR but deemed non-reportable due to lack of establishing work-relatedness was undertaken, however many of these cases would go unreported in RIDDOR due to them being explicitly considered non-reportable.

- Worker coverage (e.g. inclusion of self-employed workers, volunteers, or public sector workers) varies between countries and could not be standardised, as these groups cannot be consistently separated within the available data.

One category that could be accounted for in the data was road traffic accidents. All countries, apart from Great Britain, include road traffic accidents in their data. To ensure that the results were not unfairly biased towards Great Britain given the lack of counts included for road traffic accidents, these were included in the Great Britain data. To achieve this, counts were obtained from the Department for Transport's STATS19 dataset of driver or rider casualties driving as part of work and their passengers. These fatalities were then distributed across industry groupings using proportions derived from the Labour Force Survey. The Labour Force Survey provided estimates of the annual incidence of non-fatal work-related road traffic injuries by industry, which were averaged over a ten-year period (2014/15–2023/24) to produce stable industry-level weights. These weights were then applied to the total number of road traffic accident fatalities provided by DfT to allocate them proportionally across industries. This approach assumes that the distribution of fatal road traffic accidents by industry is broadly similar to the distribution of non-fatal road traffic accidents, which is a reasonable approximation in the absence of detailed fatality-level industry breakdowns. This method has also been used in previous HSE analyses submitted to Eurostat, providing additional methodological justification.

While this approach improves comparability, it should be noted that it introduces some uncertainty, as it relies on self-reported non-fatal data as a proxy, and differences in inclusions and definitions of work-related road traffic accidents may still exist between Great Britain and each comparator country.

**Year harmonisation**

The years that each country could supply data for differed across each country. For each comparison between Great Britain and a comparator country, only the years that had full data available for both countries were used. For example, though Great Britain data was available for 2012-2023, South Korea data was only available for 2017-2023, thus Great Britain's time series was limited to 2017-2023 for this country comparison. Where a country had missing years for either the fatal injury or denominator population dataset, the country would be removed from the analysis due to a lack of consistent time period.

**Industry harmonisation**

Industry-level analysis required the alignment of multiple national classification systems, including UK SIC, NAICS, NACE, ANZSIC, KSIC, and other bespoke industry classifications. To enable comparison, these were mapped to a common set of high-level industry groupings, designed to reflect broadly comparable economic sectors across countries.

The final groupings used were:

- Agriculture, mining, energy and utilities
- Manufacturing

- Construction
- Transport
- Services

Country-specific industry codes were aggregated into these categories by mapping individual sectors from each classification system to their closest equivalent grouping. In cases where a single country-level industry code spanned multiple groupings, where possible industry subgroups were used to allocate against the most suitable industry group. However, if this was not possible, a best-fit allocation approach was applied based on the primary activity described.

For each country:

- Fatality counts were summed across relevant industry codes to produce totals for each grouping
- Employment data were aggregated using the same mappings to ensure consistency between numerators and denominators

In some cases, additional adjustments were required:

- Where industries were not directly comparable or partially missing (e.g. voluntary reporting of public administration subgroups in ESAW), they were included in broader categories
- Where industries were combined differently (e.g. transport and communications), these were retained within the closest matching grouping

This approach prioritised balancing comparability and practicality, allowing meaningful cross-country comparisons while recognising that perfect alignment between classification systems would not be possible.

### 3.3.2 Data Cleaning

The data for each country was collated into a single spreadsheet, which includes the country code, year, industry, count of fatalities, and denominator value for each combination of country, industry and year. Any rows with missing values were removed directly from this spreadsheet. If there were missing fatal injury or denominator values for a given year, the country was removed due to not having a consistent time series. The data was read in to R and checked to ensure all missing values were removed.

### 3.3.3 Model Preparation

There were a few steps required to ensure that the data was in the appropriate format to be used in the models. The first step was to manually set the data type for each variable. The variables ‘country’ and ‘industry’ both contained text descriptions, so were specified as ‘factor’ types. The ‘year’ and ‘fatalities’ variables should contain only integer values, so these were set as ‘int’ type. The ‘denominator’ variable contained some floating-point values, so this was set as ‘numeric’ type.

As comparisons were between Great Britain and each individual comparator country, the data was split so that Great Britain was paired with each different country. The

paired data contained only the shared years as detailed in section 3.2.1. Years were standardised, with the mean of all years subtracted from each year, so that all years were centred.

The data was relevelled to make Great Britain the reference country, so that all models were presented in comparison to Great Britain. The 'Services' industry was used as the reference industry category. This was selected as it represents a large grouping across all countries, covering a broad range of economic activities and the largest share of employment. In addition, work-related fatal injury counts in this category are generally lower relative to higher-risk industries (e.g. construction, agriculture, transport), which provides a stable baseline for comparison. Using this category as the reference supports more interpretable rate ratios, as comparisons are made relative to a broadly representative and lower-risk sector rather than a high-risk outlier.

## 3.4 Modelling

### 3.4.1 Model Selection

Given that the outcome variable consists of count data (fatalities), and that the number of observations available for each country is relatively limited, a Poisson regression model was selected as the initial modelling framework. Poisson regression is appropriate for modelling count outcomes, under the assumption that the mean is equal to the variance. The Poisson model specification can be seen in Equation 1, where $Y_i$ represents the number of fatalities for observation $i$, and $\lambda_i$ represents the expected number of fatalities. The intercept term $\beta_0$ denotes the baseline log rate of fatalities. $\text{Country}_{ic}$ are indicator variables for each country, with associated coefficients $\beta_c$, capturing differences relative to a reference country. $\text{Year}_i$ is included as a continuous variable, with coefficient $\beta_1$ representing the overall time trend. The interaction terms $\text{Country}_{ic}$ x $\text{Year}_i$ , with coefficients $\gamma_c$, allow this time trend to vary across countries. $\text{Industry}_{ij}$ are indicator variables for industry categories, with coefficients $\delta_j$ capturing differences relative to a reference industry. Finally, $\log(\text{denom}_i)$ is included as an offset term to account for differing levels of exposure, so that the model estimates rates rather than raw counts.

**Equation 1 - Poisson regression model**

$$Y_i \sim \text{Poisson}(\lambda_i)$$

$$\log(\lambda_i) = \beta_0 + \sum_c \beta_c \,\text{Country}_{ic} + \beta_1 \text{Year}_i + \sum_c \gamma_c \,(\text{Country}_{ic} \times \text{Year}_i) + \sum_j \delta_j \,\text{Industry}_{ij} + \log(\text{denom}_i)$$

The interaction term between country and year was included so that the difference in temporal changes could be effectively assessed, as building this model without the interaction would impose a shared time trend across the countries.

After running the Poisson model on the data, the levels of dispersion were examined to see whether there was evidence of over-dispersion or under-dispersion. The lowest dispersion value was approximately 0.89, which was not considered significant enough to suggest under-dispersion. Two countries had models with this value for dispersion, both retained the Poisson model.

Values for dispersion that suggested over-dispersion of the Poisson model were more difficult to interpret. To decide on an appropriate threshold, each model with a dispersion value greater than 1 was tested using a score test. The score test provides a statistical check of whether the observed variability in the data exceeds that expected under a Poisson distribution. It does this by comparing the fitted Poisson model against an alternative, which contains an additional dispersion parameter. The null hypothesis of this test is that the Poisson model is not over-dispersed, while the alternative hypothesis is that there is overdispersion. The results were examined to assess the point at which the test determined that the value for dispersion suggested over-dispersion [6]. The threshold appeared to be at a value of approximately 1.6, so any countries with a dispersion value above this used a Negative Binomial model, rather than the Poisson model. The Negative Binomial model specification can be seen in Equation 2. The Negative Binomial model extends the Poisson specification by introducing an additional dispersion parameter, $\theta$, allowing the variance to exceed the mean. The model parameters are unchanged from the Poisson model.

**Equation 2 - Negative Binomial regression model**

$$Y_i \sim \text{NegBin}(\lambda_i, \theta)$$

$$\log(\lambda_i) = \beta_0 + \sum_c \beta_c \,\text{Country}_{ic} + \beta_1 \text{Year}_i + \sum_c \gamma_c \,(\text{Country}_{ic} \times \text{Year}_i) + \sum_j \delta_j \,\text{Industry}_{ij} + \log(\text{denom}_i)$$

### 3.4.2 Parameters

The parameters used for the model build can be seen in Table 12. Industry was included to allow the models to account for differences in fatality rates across industries.

[6] Testing Overdispersion, STAT 197 ST: Count Data Analysis, 1st Semester, A.Y. 2023 – 2024 – Available at https://rpubs.com/DonArres/TestingOverdispersion

**Table 12 – Model parameters**

| Parameter | Description |
|---|---|
| Fatalities | The count of fatalities. The dependent variable in the model |
| Country | The country (Great Britain and a comparator country for each model) |
| Year | The year for the data (centred for the models) |
| Industry | The industry for the data |
| Denominator (offset) | The offset term used to convert counts into rates |

### 3.4.3 Outputs

There were four sets of outputs collected for each model:

- Model details and fit statistics
- Model coefficient estimates and statistical significance
- Model predictions, with confidence intervals, for all country / year / industry combinations
- Model predictions, with confidence intervals, as totals for all country / year combinations

Model outputs were derived from Poisson and Negative Binomial regression models fitted in R using the MASS package. Standard model summary functions were used to extract fit statistics, coefficient estimates and p-values. The comparator-year effect was calculated as the sum of the estimated year coefficient and the country-year interaction term. Standard errors were derived using the model variance-covariance matrix to account for covariance between coefficients. Z-values were then computed and corresponding p-values were derived using the standard normal distribution.

Model predictions by industry breakdown were extracted using the 'predict()' function, generating predictions on the linear predictor (link) scale for each country/year/industry combination. Confidence intervals were generated assuming approximate normality on the link scale, using ±1.96 standard errors.

Model predictions by industry totals were obtained using a parametric simulation approach based on the estimated coefficient distribution. Model coefficients were repeatedly sampled from a multivariate normal distribution defined by the estimated coefficients and their variance–covariance matrix. For each draw, predictions were generated and aggregated across industries to produce country–year totals. Empirical 2.5% and 97.5% quantiles of the simulated distribution were used to form 95% confidence intervals.

## 3.5 Quality Assessment

The DHARMa package was used to assess the performance of the models through simulation-based residual diagnostics. Four key tests were applied:

- Uniformity – assesses whether the residuals follow a uniform distribution, as expected under a well specified model. Significant results indicate potential issues with model fit indicating the model may not adequately fit the observed data.
- Dispersion – tests whether the observed variance matches the model assumption (Poisson or Negative Binomial). Significant results indicate overdispersion or underdispersion, suggesting the chosen model may not capture variability in the data.
- Zero inflation – evaluates whether the number of observed zero outcomes exceeds what would be expected under the fitted model. Significant results suggest that the model may not adequately account for excess zeros in the data and a zero-inflated model may be more appropriate.
- Outliers – identifies whether there are any outliers in the data which are not well explained by the model. Significant values suggest that there are observations that are extreme or influential values.

Where a model failed a test, the results were examined to understand why the test had failed and if the model used for given country should be changed, whilst also considering the impact on interpretation. In these instances, potential actions included:

- Switching from a Poisson model to Negative Binomial in cases of overdispersion
- Assessing and retaining outliers where they reflected real data
- Assessing whether zero inflation reflected differences in data rather than poor model fit
- Retaining the best-fit model where deviations had been investigated and considered minor and did not affect interpretation

To further assess the accuracy of the models, the actual fatality counts for each country were compared against the 95% confidence intervals for the model predictions, creating a percentage score calculated to assess how many of the actual scores were within the model 95% confidence intervals.

High percentage indicate that the model provides a reasonable representation of observed data variability, whereas low percentages may suggest poor fit or overly narrow confidence intervals.

In addition to pointwise comparisons, temporal patterns were assessed to ensure that model predictions captured the overall trends in fatality counts over time.

Model outputs were also considered in the context of existing published statistics, such as the broad patterns in the European work-related fatal injury comparisons

compiled by Eurostat. This step provided an additional face validity check, helping to ensure that model results were plausible and consistent with wider evidence. Substantial deviations from expected patterns were investigated to determine whether they reflected genuine differences in country data specifications or poor model fit.

# 4. Results

## 4.1 Interpreting model outputs

The results presented are based on statistical models comparing each country individually with Great Britain. The below guidance is designed to help anyone who wishes to use data from this report to ensure it is interpreted and reported correctly.

You can:

- Compare work-related fatal injury rates of a given country against Great Britain using the rate ratios
- Assess the within-country trends
- Compare trends in a given country against the trend of Great Britain
- Use confidence intervals and statistical significance to understand the uncertainty in estimates

You cannot:

- Conclude that one comparison country has a higher work-related fatal injury rate than another comparison country by comparing their rate ratios with Great Britain; the models compare each country with Great Britain individually and do not compare one another
- Interpret non-significant results as evidence that no differences exist. This indicates that there is insufficient evidence to conclude that a difference exists

## 4.2 Model details and fit statistics

Overall, Negative Binomial models were selected for the majority of countries, indicating that over-dispersion was commonly present in the data. This is supported by dispersion values exceeding 1.6 in many cases; thus a Poisson model would not adequately capture the variability in work-related fatal injury counts.

Poisson models were retained for some countries (e.g. Denmark, Estonia, Finland), where dispersion values were close to 1, indicating that the Poisson assumptions were reasonable.

Dispersion levels varied substantially across countries. For example, France (8.27), Romania (10.05), and Poland (5.56) show particularly high dispersion, reflecting considerable variability in work-related fatal injury counts. Countries with lower dispersion values (e.g. Denmark and Estonia) appear to have more stable data and better adherence to Poisson assumptions.

Overall, the model selection process reflects differences in variability, with model choice driven primarily by the presence of over-dispersion.

Table 13 shows the model selected for each country comparison, along with a range of statistics used to assess the model fit and performance. It contains:

- Country – The comparator country included in the model comparison with Great Britain
- Model – The regression model selected (Poisson or Negative Binomial)
- Akaike Information Criterion (AIC) – The value used to compare statistical models, where lower values indicate a better fit.
- Deviance – The residual deviance, which measures how closely the model's predictions match the observed data. Lower values indicate a better fit.
- Residual Degrees of Freedom (RDF) - The number of dimensions remaining after model fitting, used alongside deviance to assess goodness of fit.
- Log Likelihood – A measure of how likely the observed data are under the fitted model.
- Dispersion – A measure of whether the variability in the data matches the assumptions of a Poisson model. Values greater than 1.6 indicate over-dispersion in a Poisson model, as outlined in section 3.3.1.

**Table 13 – Model details and fit statistics**

| Country | Model | AIC value | Deviance | RDF | Log Likelihood | Dispersion |
|---|---|---|---|---|---|---|
| Argentina | Negative Binomial | 391.181 | 52.549 | 42 | -186.590 | 2.645 |
| Australia | Negative Binomial | 895.100 | 120.263 | 112 | -438.550 | 2.531 |
| Austria | Negative Binomial | 710.592 | 103.594 | 92 | -346.296 | 2.350 |
| Belgium | Poisson | 636.100 | 139.864 | 92 | -310.050 | 1.423 |
| Bulgaria | Negative Binomial | 742.679 | 104.800 | 92 | -362.340 | 3.133 |
| Croatia | Negative Binomial | 689.461 | 118.725 | 92 | -335.730 | 2.687 |
| Cyprus | Poisson | 499.104 | 117.225 | 92 | -241.552 | 1.321 |
| Czechia | Poisson | 655.317 | 124.685 | 92 | -319.659 | 1.397 |
| Denmark | Poisson | 571.275 | 95.992 | 92 | -277.637 | 1.097 |
| Estonia | Poisson | 523.808 | 96.444 | 92 | -253.904 | 1.041 |
| Finland | Poisson | 567.341 | 104.599 | 92 | -275.671 | 1.143 |
| France | Negative Binomial | 922.716 | 102.371 | 92 | -452.358 | 8.266 |
| Greece | Negative Binomial | 722.145 | 115.740 | 92 | -352.072 | 4.073 |
| Hungary | Negative Binomial | 683.162 | 104.946 | 92 | -332.581 | 1.969 |
| Iceland | Poisson | 413.664 | 80.088 | 92 | -198.832 | 0.898 |
| Ireland | Negative Binomial | 631.086 | 141.045 | 92 | -306.543 | 1.623 |
| Italy | Negative Binomial | 832.016 | 93.796 | 92 | -407.008 | 5.102 |
| Japan | Negative Binomial | 1054.162 | 123.945 | 112 | -518.081 | 3.864 |
| Latvia | Negative Binomial | 632.038 | 153.621 | 92 | -307.019 | 1.764 |
| Lithuania | Poisson | 614.723 | 127.748 | 92 | -299.362 | 1.349 |
| Luxembourg | Poisson | 493.859 | 83.878 | 92 | -238.929 | 0.888 |
| Malta | Negative Binomial | 500.874 | 141.864 | 92 | -241.437 | 1.694 |
| Netherlands | Negative Binomial | 634.111 | 163.373 | 92 | -308.055 | 1.647 |
| New Zealand | Negative Binomial | 801.573 | 147.375 | 112 | -391.786 | 1.990 |
| Norway | Poisson | 624.628 | 143.276 | 92 | -304.314 | 1.589 |
| Poland | Negative Binomial | 823.592 | 99.030 | 92 | -402.796 | 5.558 |
| Portugal | Negative Binomial | 744.098 | 98.197 | 92 | -363.049 | 3.025 |
| Romania | Negative Binomial | 854.505 | 97.282 | 92 | -418.253 | 10.050 |
| Slovakia | Poisson | 586.813 | 103.721 | 92 | -285.407 | 1.151 |

| Country | Model | AIC value | Deviance | RDF | Log Likelihood | Dispersion |
|---|---|---|---|---|---|---|
| Slovenia | Poisson | 581.741 | 141.292 | 92 | -282.870 | 1.529 |
| South Korea | Negative Binomial | 604.779 | 71.904 | 62 | -293.389 | 3.717 |
| Spain | Negative Binomial | 798.297 | 100.942 | 92 | -390.149 | 3.026 |
| Sweden | Poisson | 584.906 | 100.140 | 92 | -284.453 | 1.079 |
| Switzerland | Negative Binomial | 658.388 | 128.216 | 92 | -320.194 | 1.739 |
| United States | Negative Binomial | 1159.824 | 170.746 | 112 | -570.912 | 3.335 |

## 4.3 Model coefficient estimates and statistical significance

Each model output had a set of regression coefficients to describe how fatality rates vary by country, year, and industry, relative to Great Britain. These coefficients are presented in a log scale and are interpreted as rate ratios when exponentiated.

The coefficients are grouped into the following categories:

- Intercept – Represents the baseline log fatality rate for Great Britain, in the reference industry at the reference year
- Country effect – Represents the difference in baseline fatality rates between each comparator country and Great Britain
- Year effect (Great Britain trend) – Represents the annual change in fatality rates in Great Britain
- Country x Year interaction – Represents how the annual trend in each comparator country differs from Great Britain
- Comparator-year effect – Represents the combined annual trend for each comparator country (Great Britain trend + interaction effect)
- Industry effects – Represents the differences in fatality rates between industries, relative to the reference industry

For each coefficient group, four standard statistical outputs are available:

- Estimate – The estimated effect size on the log scale
- Std Error – The estimated uncertainty around the coefficient
- Z value – The test statistic used to assess whether the coefficient is significantly different from zero
- P value – The probability of observing the estimated effect if the true effect were zero

Country effect, Year effect, Country x Year interaction and Comparator-year effect also have the following available:

- Rate Ratio – The exponentiated coefficient estimate
- Lower confidence interval (CI) – The lower bound of the 95% confidence interval for the rate ratio
- Upper confidence interval (CI) – The upper bound of the 95% confidence interval for the rate ratio

### 4.3.1 Intercept

The intercept estimate represents the expected log fatality rate for the reference country (Great Britain), in the reference industry (Services), at the reference year (centred year). It is the baseline level of the outcome from which all country, industry and year effects are measured.

Across all models, intercept estimates are very similar (approximately -12.7), indicating a consistent baseline level. These values primarily serve as a reference point.

**Table 14 – Intercept model outputs**

| Country | Estimate | Std. Error | Zvalue | P value |
|---|---|---|---|---|
| Argentina | -12.668 | 0.064 | -196.880 | 0.000 |
| Australia | -12.731 | 0.051 | -251.803 | 0.000 |
| Austria | -12.762 | 0.060 | -211.967 | 0.000 |
| Belgium | -12.678 | 0.034 | -375.787 | 0.000 |
| Bulgaria | -12.590 | 0.075 | -167.406 | 0.000 |
| Croatia | -12.589 | 0.081 | -154.533 | 0.000 |
| Cyprus | -12.698 | 0.036 | -352.172 | 0.000 |
| Czechia | -12.660 | 0.033 | -381.505 | 0.000 |
| Denmark | -12.720 | 0.035 | -360.197 | 0.000 |
| Estonia | -12.694 | 0.036 | -353.931 | 0.000 |
| Finland | -12.675 | 0.035 | -363.213 | 0.000 |
| France | -12.342 | 0.079 | -156.953 | 0.000 |
| Greece | -12.717 | 0.113 | -112.534 | 0.000 |
| Hungary | -12.662 | 0.056 | -227.612 | 0.000 |
| Iceland | -12.694 | 0.036 | -350.031 | 0.000 |
| Ireland | -12.785 | 0.047 | -273.145 | 0.000 |
| Italy | -12.604 | 0.055 | -230.950 | 0.000 |
| Japan | -12.685 | 0.046 | -275.197 | 0.000 |
| Latvia | -12.700 | 0.039 | -321.924 | 0.000 |
| Lithuania | -12.699 | 0.035 | -360.945 | 0.000 |
| Luxembourg | -12.705 | 0.036 | -354.121 | 0.000 |
| Malta | -12.713 | 0.036 | -349.126 | 0.000 |
| Netherlands | -12.640 | 0.037 | -339.639 | 0.000 |
| New Zealand | -12.772 | 0.052 | -247.400 | 0.000 |
| Norway | -12.751 | 0.036 | -356.955 | 0.000 |
| Poland | -12.524 | 0.076 | -165.662 | 0.000 |
| Portugal | -12.675 | 0.064 | -197.572 | 0.000 |
| Romania | -12.382 | 0.094 | -131.570 | 0.000 |
| Slovakia | -12.693 | 0.035 | -360.916 | 0.000 |
| Slovenia | -12.691 | 0.036 | -355.414 | 0.000 |
| South Korea | -12.815 | 0.062 | -206.920 | 0.000 |
| Spain | -12.730 | 0.053 | -242.260 | 0.000 |
| Sweden | -12.732 | 0.035 | -362.039 | 0.000 |
| Switzerland | -12.667 | 0.048 | -265.230 | 0.000 |

| Country | Estimate | Std. Error | Zvalue | P value |
|---|---|---|---|---|
| United States | -12.461 | 0.027 | -469.635 | 0.000 |

### 4.3.2 Country effect

The country estimate represents the difference in the expected log fatality rate between the comparator country and Great Britain, adjusting for year and industry. The country estimate has been exponentiated to get the rate ratio between the comparator country and Great Britain.

Overall, many comparator countries have higher fatality rates than Great Britain to varying degrees, with many differences statistically significant. Several countries show particularly higher rates relative to Great Britain (e.g. Argentina, Luxembourg, South Korea, and United States). Countries showing similar rates relative to Great Britain include Belgium, Denmark, Finland, Poland, Slovakia, Switzerland. The Netherlands shows a lower rate relative to Great Britain.

Overall, these findings suggest that Great Britain generally has comparatively lower fatality rates, though the magnitude of differences varies across countries.

**Table 15 - Country model outputs**

| Country | Estimate | Std. Error | Zvalue | P value | Rate Ratio | Lower C.I. | Upper C.I. |
|---|---|---|---|---|---|---|---|
| Argentina | 1.513 | 0.059 | 25.853 | 0.000 | 4.538 | 4.047 | 5.090 |
| Australia | 0.576 | 0.045 | 12.837 | 0.000 | 1.779 | 1.629 | 1.942 |
| Austria | 0.998 | 0.055 | 18.147 | 0.000 | 2.712 | 2.435 | 3.021 |
| Belgium | 0.485 | 0.048 | 10.180 | 0.000 | 1.624 | 1.479 | 1.783 |
| Bulgaria | 1.083 | 0.067 | 16.258 | 0.000 | 2.955 | 2.593 | 3.367 |
| Croatia | 0.855 | 0.080 | 10.755 | 0.000 | 2.351 | 2.012 | 2.748 |
| Cyprus | 0.856 | 0.122 | 7.031 | 0.000 | 2.354 | 1.854 | 2.988 |
| Czechia | 0.666 | 0.040 | 16.503 | 0.000 | 1.946 | 1.798 | 2.107 |
| Denmark | 0.448 | 0.060 | 7.513 | 0.000 | 1.566 | 1.393 | 1.760 |
| Estonia | 0.815 | 0.088 | 9.280 | 0.000 | 2.259 | 1.902 | 2.684 |
| Finland | 0.256 | 0.064 | 3.971 | 0.000 | 1.292 | 1.138 | 1.466 |
| France | 1.001 | 0.067 | 15.011 | 0.000 | 2.722 | 2.389 | 3.102 |
| Greece | -0.044 | 0.103 | -0.427 | 0.669 | 0.957 | 0.782 | 1.171 |
| Hungary | 0.598 | 0.054 | 11.027 | 0.000 | 1.819 | 1.636 | 2.023 |
| Iceland | 0.266 | 0.218 | 1.219 | 0.223 | 1.305 | 0.851 | 2.001 |
| Ireland | 0.685 | 0.060 | 11.370 | 0.000 | 1.984 | 1.763 | 2.233 |
| Italy | 0.954 | 0.047 | 20.229 | 0.000 | 2.596 | 2.367 | 2.848 |
| Japan | 0.496 | 0.039 | 12.592 | 0.000 | 1.642 | 1.520 | 1.773 |
| Latvia | 1.138 | 0.064 | 17.891 | 0.000 | 3.119 | 2.754 | 3.534 |
| Lithuania | 1.027 | 0.056 | 18.482 | 0.000 | 2.793 | 2.504 | 3.114 |
| Luxembourg | 2.132 | 0.094 | 22.664 | 0.000 | 8.431 | 7.012 | 10.138 |
| Malta | 1.239 | 0.138 | 8.976 | 0.000 | 3.453 | 2.635 | 4.527 |
| Netherlands | -0.521 | 0.060 | -8.677 | 0.000 | 0.594 | 0.528 | 0.668 |
| New Zealand | 1.148 | 0.053 | 21.462 | 0.000 | 3.151 | 2.837 | 3.499 |
| Norway | 0.516 | 0.056 | 9.220 | 0.000 | 1.675 | 1.501 | 1.869 |

| Country | Estimate | Std. Error | Zvalue | P value | Rate Ratio | Lower C.I. | Upper C.I. |
|---|---|---|---|---|---|---|---|
| Poland | 0.250 | 0.064 | 3.879 | 0.000 | 1.284 | 1.132 | 1.456 |
| Portugal | 1.196 | 0.057 | 20.973 | 0.000 | 3.308 | 2.958 | 3.699 |
| Romania | 0.795 | 0.079 | 10.016 | 0.000 | 2.214 | 1.895 | 2.586 |
| Slovakia | 0.427 | 0.057 | 7.512 | 0.000 | 1.532 | 1.371 | 1.712 |
| Slovenia | 0.654 | 0.079 | 8.235 | 0.000 | 1.922 | 1.646 | 2.246 |
| South Korea | 1.541 | 0.053 | 29.179 | 0.000 | 4.669 | 4.210 | 5.178 |
| Spain | 0.817 | 0.045 | 17.964 | 0.000 | 2.263 | 2.070 | 2.474 |
| Sweden | 0.099 | 0.055 | 1.818 | 0.069 | 1.104 | 0.992 | 1.229 |
| Switzerland | 0.449 | 0.055 | 8.141 | 0.000 | 1.567 | 1.406 | 1.745 |
| United States | 1.486 | 0.025 | 59.861 | 0.000 | 4.420 | 4.210 | 4.641 |

### 4.3.3 Year effect

The year estimate represents the change in the expected log fatality rate associated with a one-unit increase in year, adjusting for country and industry. It captures the temporal trend in fatality rates for Great Britain. The estimate value is exponentiated to give the annual rate ratio for Great Britain.

Across most models, the estimated rate ratios are approximately 0.98–0.99, indicating a small annual decrease in fatality rates over time. Not all of these estimates are statistically significant, suggesting that the downward trend is gradual and not consistently strong across models.

**Table 16 – Year model outputs**

| Country | Estimate | Std. Error | Zvalue | P value | Rate Ratio | Lower C.I. | Upper C.I. |
|---|---|---|---|---|---|---|---|
| Argentina | 0.022 | 0.031 | 0.703 | 0.482 | 1.022 | 0.962 | 1.085 |
| Australia | -0.017 | 0.009 | -1.830 | 0.067 | 0.984 | 0.966 | 1.001 |
| Austria | -0.018 | 0.012 | -1.494 | 0.135 | 0.982 | 0.958 | 1.006 |
| Belgium | -0.019 | 0.007 | -2.586 | 0.010 | 0.981 | 0.967 | 0.995 |
| Bulgaria | -0.019 | 0.015 | -1.255 | 0.209 | 0.981 | 0.952 | 1.011 |
| Croatia | -0.020 | 0.016 | -1.307 | 0.191 | 0.980 | 0.950 | 1.010 |
| Cyprus | -0.019 | 0.007 | -2.552 | 0.011 | 0.981 | 0.967 | 0.996 |
| Czechia | -0.019 | 0.007 | -2.624 | 0.009 | 0.981 | 0.967 | 0.995 |
| Denmark | -0.019 | 0.007 | -2.539 | 0.011 | 0.981 | 0.967 | 0.996 |
| Estonia | -0.019 | 0.007 | -2.563 | 0.010 | 0.981 | 0.967 | 0.996 |
| Finland | -0.019 | 0.007 | -2.584 | 0.010 | 0.981 | 0.967 | 0.995 |
| France | -0.019 | 0.017 | -1.102 | 0.270 | 0.981 | 0.949 | 1.015 |
| Greece | -0.021 | 0.022 | -0.990 | 0.322 | 0.979 | 0.938 | 1.021 |
| Hungary | -0.020 | 0.011 | -1.735 | 0.083 | 0.981 | 0.959 | 1.003 |
| Iceland | -0.019 | 0.007 | -2.555 | 0.011 | 0.981 | 0.967 | 0.996 |
| Ireland | -0.018 | 0.009 | -2.018 | 0.044 | 0.982 | 0.964 | 0.999 |
| Italy | -0.019 | 0.012 | -1.581 | 0.114 | 0.981 | 0.957 | 1.005 |
| Japan | -0.018 | 0.009 | -2.062 | 0.039 | 0.982 | 0.965 | 0.999 |
| Latvia | -0.019 | 0.008 | -2.361 | 0.018 | 0.981 | 0.966 | 0.997 |
| Lithuania | -0.019 | 0.007 | -2.575 | 0.010 | 0.981 | 0.967 | 0.995 |

| Country | Estimate | Std. Error | Zvalue | P value | Rate Ratio | Lower C.I. | Upper C.I. |
|---|---|---|---|---|---|---|---|
| Luxembourg | -0.019 | 0.007 | -2.554 | 0.011 | 0.981 | 0.967 | 0.996 |
| Malta | -0.019 | 0.007 | -2.540 | 0.011 | 0.981 | 0.967 | 0.996 |
| Netherlands | -0.019 | 0.008 | -2.388 | 0.017 | 0.981 | 0.966 | 0.997 |
| New Zealand | -0.017 | 0.008 | -2.022 | 0.043 | 0.983 | 0.967 | 0.999 |
| Norway | -0.019 | 0.007 | -2.531 | 0.011 | 0.981 | 0.967 | 0.996 |
| Poland | -0.019 | 0.016 | -1.211 | 0.226 | 0.981 | 0.951 | 1.012 |
| Portugal | -0.020 | 0.013 | -1.494 | 0.135 | 0.980 | 0.955 | 1.006 |
| Romania | -0.019 | 0.019 | -0.998 | 0.319 | 0.981 | 0.944 | 1.019 |
| Slovakia | -0.019 | 0.007 | -2.565 | 0.010 | 0.981 | 0.967 | 0.996 |
| Slovenia | -0.019 | 0.007 | -2.571 | 0.010 | 0.981 | 0.967 | 0.995 |
| South Korea | -0.024 | 0.020 | -1.170 | 0.242 | 0.977 | 0.939 | 1.016 |
| Spain | -0.019 | 0.012 | -1.633 | 0.102 | 0.981 | 0.959 | 1.004 |
| Sweden | -0.019 | 0.007 | -2.536 | 0.011 | 0.981 | 0.967 | 0.996 |
| Switzerland | -0.019 | 0.010 | -1.946 | 0.052 | 0.981 | 0.963 | 1.000 |
| United States | -0.019 | 0.006 | -2.998 | 0.003 | 0.981 | 0.969 | 0.993 |

### 4.3.4 Country x Year interaction

The country × year interaction estimate represents whether the annual trend in fatality rates for each comparator country differs from the corresponding trend in Great Britain, after adjusting for industry. It captures whether the rate of change over time is faster or slower in each country relative to Great Britain. When exponentiated, the estimate gives the ratio of rate ratios, indicating the relative difference in the annual rate of change between the comparator country and Great Britain.

For most countries, interaction effects are not statistically significant, suggesting that time trends are broadly similar to Great Britain. However, some statistically significant differences include:

- Decreasing more rapidly than Great Britain in Czechia, Ireland, Netherlands, Norway, Poland, and Romania
- Decreasing slower in the United States
- Increasing whilst Great Britain is decreasing in Croatia, Cyprus, and Malta

Despite these differences, the magnitude of effect is generally small, indicating that Great Britain-country differences in trend estimates are limited.

**Table 17 – Country x Year interaction model outputs**

| Country | Estimate | Std. Error | Zvalue | P value | Rate Ratio | Lower C.I. | Upper C.I. |
|---|---|---|---|---|---|---|---|
| Argentina | -0.006 | 0.041 | -0.156 | 0.876 | 0.994 | 0.917 | 1.077 |
| Australia | -0.008 | 0.013 | -0.653 | 0.514 | 0.992 | 0.967 | 1.017 |
| Austria | 0.008 | 0.019 | 0.445 | 0.656 | 1.009 | 0.971 | 1.047 |
| Belgium | -0.020 | 0.017 | -1.185 | 0.236 | 0.981 | 0.949 | 1.013 |
| Bulgaria | -0.008 | 0.023 | -0.326 | 0.744 | 0.992 | 0.948 | 1.039 |
| Croatia | 0.074 | 0.027 | 2.681 | 0.007 | 1.076 | 1.020 | 1.136 |
| Cyprus | 0.114 | 0.041 | 2.754 | 0.006 | 1.121 | 1.033 | 1.216 |

| Country | Estimate | Std. Error | Zvalue | P value | Rate Ratio | Lower C.I. | Upper C.I. |
|---|---|---|---|---|---|---|---|
| Czechia | -0.030 | 0.014 | -2.192 | 0.028 | 0.970 | 0.945 | 0.997 |
| Denmark | 0.025 | 0.021 | 1.186 | 0.236 | 1.025 | 0.984 | 1.067 |
| Estonia | -0.033 | 0.030 | -1.084 | 0.278 | 0.968 | 0.912 | 1.027 |
| Finland | -0.031 | 0.022 | -1.369 | 0.171 | 0.970 | 0.928 | 1.013 |
| France | 0.043 | 0.023 | 1.851 | 0.064 | 1.044 | 0.997 | 1.093 |
| Greece | 0.012 | 0.036 | 0.337 | 0.736 | 1.012 | 0.944 | 1.085 |
| Hungary | -0.026 | 0.019 | -1.367 | 0.172 | 0.975 | 0.939 | 1.011 |
| Iceland | -0.070 | 0.075 | -0.931 | 0.352 | 0.932 | 0.804 | 1.081 |
| Ireland | -0.049 | 0.021 | -2.366 | 0.018 | 0.952 | 0.914 | 0.992 |
| Italy | 0.022 | 0.016 | 1.355 | 0.175 | 1.022 | 0.990 | 1.056 |
| Japan | -0.017 | 0.011 | -1.519 | 0.129 | 0.983 | 0.961 | 1.005 |
| Latvia | 0.011 | 0.022 | 0.502 | 0.616 | 1.011 | 0.969 | 1.055 |
| Lithuania | -0.010 | 0.019 | -0.537 | 0.592 | 0.990 | 0.954 | 1.027 |
| Luxembourg | -0.049 | 0.032 | -1.522 | 0.128 | 0.952 | 0.893 | 1.014 |
| Malta | 0.095 | 0.047 | 2.022 | 0.043 | 1.100 | 1.003 | 1.206 |
| Netherlands | -0.054 | 0.021 | -2.624 | 0.009 | 0.947 | 0.910 | 0.986 |
| New Zealand | -0.010 | 0.015 | -0.619 | 0.536 | 0.990 | 0.961 | 1.021 |
| Norway | -0.047 | 0.019 | -2.450 | 0.014 | 0.954 | 0.919 | 0.991 |
| Poland | -0.051 | 0.022 | -2.260 | 0.024 | 0.951 | 0.910 | 0.993 |
| Portugal | 0.002 | 0.020 | 0.088 | 0.930 | 1.002 | 0.964 | 1.042 |
| Romania | -0.077 | 0.028 | -2.789 | 0.005 | 0.926 | 0.877 | 0.977 |
| Slovakia | -0.012 | 0.020 | -0.630 | 0.529 | 0.988 | 0.951 | 1.026 |
| Slovenia | 0.003 | 0.027 | 0.095 | 0.925 | 1.003 | 0.951 | 1.057 |
| South Korea | 0.006 | 0.026 | 0.218 | 0.827 | 1.006 | 0.955 | 1.059 |
| Spain | 0.027 | 0.016 | 1.692 | 0.091 | 1.027 | 0.996 | 1.059 |
| Sweden | 0.029 | 0.019 | 1.510 | 0.131 | 1.029 | 0.991 | 1.068 |
| Switzerland | -0.013 | 0.019 | -0.691 | 0.490 | 0.987 | 0.950 | 1.025 |
| United States | 0.018 | 0.007 | 2.449 | 0.014 | 1.018 | 1.004 | 1.032 |

### 4.3.5 Comparator-year effect

The comparator-year estimate represents the annual trend in fatality rates for the comparator country, obtained by combining the Great Britain year effect with the country-specific year interaction term. It reflects the overall temporal trend in the comparator country after accounting for differences relative to Great Britain. When exponentiated, the estimate gives the annual rate ratio for the comparator country, representing the multiplicative change in fatality rates for each additional year.

Most countries exhibit slight declines in fatality rates over time, consistent with the Great Britain trend.

The strongest declines were observed in Romania, Netherlands and Poland. Whereas Croatia and Cyprus showed an increasing trend.

Overall, the results suggest that fatality rates are generally decreasing over time across countries, although the rate of change varies.

**Table 18 – Comparator-year effects model outputs**

| Country | Estimate | Std. Error | Zvalue | P value | Rate Ratio | Lower C.I. | Upper C.I. |
|---|---|---|---|---|---|---|---|
| Argentina | 0.015 | 0.027 | 0.552 | 0.581 | 1.015 | 0.962 | 1.071 |
| Australia | -0.025 | 0.009 | -2.678 | 0.007 | 0.975 | 0.958 | 0.993 |
| Austria | -0.010 | 0.015 | -0.675 | 0.500 | 0.990 | 0.962 | 1.019 |
| Belgium | -0.039 | 0.015 | -2.622 | 0.009 | 0.962 | 0.934 | 0.990 |
| Bulgaria | -0.027 | 0.018 | -1.519 | 0.129 | 0.974 | 0.941 | 1.008 |
| Croatia | 0.053 | 0.023 | 2.355 | 0.019 | 1.055 | 1.009 | 1.103 |
| Cyprus | 0.095 | 0.041 | 2.335 | 0.020 | 1.100 | 1.015 | 1.191 |
| Czechia | -0.050 | 0.012 | -4.292 | 0.000 | 0.952 | 0.930 | 0.973 |
| Denmark | 0.006 | 0.019 | 0.294 | 0.769 | 1.006 | 0.968 | 1.044 |
| Estonia | -0.052 | 0.030 | -1.762 | 0.078 | 0.949 | 0.896 | 1.006 |
| Finland | -0.050 | 0.021 | -2.365 | 0.018 | 0.952 | 0.913 | 0.992 |
| France | 0.024 | 0.016 | 1.533 | 0.125 | 1.025 | 0.993 | 1.057 |
| Greece | -0.009 | 0.028 | -0.330 | 0.741 | 0.991 | 0.937 | 1.047 |
| Hungary | -0.045 | 0.015 | -3.000 | 0.003 | 0.956 | 0.928 | 0.984 |
| Iceland | -0.089 | 0.075 | -1.188 | 0.235 | 0.915 | 0.789 | 1.060 |
| Ireland | -0.068 | 0.019 | -3.627 | 0.000 | 0.935 | 0.901 | 0.969 |
| Italy | 0.003 | 0.011 | 0.251 | 0.801 | 1.003 | 0.982 | 1.024 |
| Japan | -0.036 | 0.007 | -4.930 | 0.000 | 0.965 | 0.952 | 0.979 |
| Latvia | -0.008 | 0.020 | -0.394 | 0.694 | 0.992 | 0.953 | 1.032 |
| Lithuania | -0.029 | 0.017 | -1.684 | 0.092 | 0.971 | 0.939 | 1.005 |
| Luxembourg | -0.068 | 0.032 | -2.164 | 0.030 | 0.934 | 0.878 | 0.994 |
| Malta | 0.076 | 0.046 | 1.641 | 0.101 | 1.079 | 0.985 | 1.182 |
| Netherlands | -0.073 | 0.019 | -3.834 | 0.000 | 0.929 | 0.895 | 0.965 |
| New Zealand | -0.027 | 0.013 | -2.056 | 0.040 | 0.974 | 0.949 | 0.999 |
| Norway | -0.066 | 0.018 | -3.727 | 0.000 | 0.937 | 0.905 | 0.969 |
| Poland | -0.070 | 0.016 | -4.438 | 0.000 | 0.932 | 0.904 | 0.962 |
| Portugal | -0.018 | 0.015 | -1.249 | 0.212 | 0.982 | 0.954 | 1.010 |
| Romania | -0.097 | 0.020 | -4.930 | 0.000 | 0.908 | 0.874 | 0.944 |
| Slovakia | -0.031 | 0.018 | -1.732 | 0.083 | 0.969 | 0.935 | 1.004 |
| Slovenia | -0.017 | 0.026 | -0.634 | 0.526 | 0.984 | 0.935 | 1.035 |
| South Korea | -0.018 | 0.017 | -1.048 | 0.295 | 0.982 | 0.950 | 1.016 |
| Spain | 0.008 | 0.011 | 0.720 | 0.472 | 1.008 | 0.987 | 1.029 |
| Sweden | 0.010 | 0.018 | 0.567 | 0.571 | 1.010 | 0.976 | 1.045 |
| Switzerland | -0.032 | 0.017 | -1.949 | 0.051 | 0.968 | 0.937 | 1.000 |
| United States | -0.002 | 0.003 | -0.542 | 0.588 | 0.998 | 0.992 | 1.004 |

## 4.4 Predicted values analysis

To evaluate model performance, the proportion of actual values that fit within the predicted confidence intervals was calculated (as described in Section 3.4). This measure indicates how often the model's predicted range successfully captures the true observed value.

Table 19 shows these proportions for both each comparator country and Great Britain, across all models used to predict fatalities.

Across the results, most proportions fall between approximately 70% and 80%, indicating that the models generally provide reasonable coverage. However, there is variation in performance between countries. Models for Argentina and Iceland achieved full coverage (100%), which may suggest that the prediction intervals are relatively wide. In contrast, other countries, including Czechia, Italy, and the Netherlands, have lower proportions (around 40%), indicating that their intervals may be too narrow and fail to capture the true values more frequently.

When applied to Great Britain, coverage values typically sit around 70-80% suggesting that models based on other countries provide moderately reliable predictions for Great Britain.

Overall, the models provide reasonable coverage with variable predictive performance, showing that some prediction intervals are either too wide or too narrow.

**Table 19 – Proportion of actual fatality counts within predicted confidence intervals**

| Comparator country | Own country | Great Britain |
|---|---|---|
| Argentina | 1.00 | 1.00 |
| Australia | 0.83 | 0.83 |
| Austria | 0.50 | 0.90 |
| Belgium | 0.80 | 0.70 |
| Bulgaria | 0.70 | 0.80 |
| Croatia | 0.70 | 0.80 |
| Cyprus | 0.60 | 0.70 |
| Czechia | 0.40 | 0.70 |
| Denmark | 0.70 | 0.70 |
| Estonia | 0.60 | 0.70 |
| Finland | 0.70 | 0.70 |
| France | 0.80 | 0.70 |
| Greece | 0.80 | 0.90 |
| Hungary | 0.80 | 0.80 |
| Iceland | 1.00 | 0.70 |
| Ireland | 0.70 | 0.80 |
| Italy | 0.40 | 0.80 |
| Japan | 0.92 | 0.83 |
| Latvia | 0.40 | 0.70 |
| Lithuania | 0.80 | 0.70 |
| Luxembourg | 0.50 | 0.70 |
| Malta | 0.60 | 0.70 |
| Netherlands | 0.40 | 0.70 |
| New Zealand | 0.67 | 0.75 |
| Norway | 0.70 | 0.70 |

| Comparator country | Own country | Great Britain |
|---|---|---|
| Poland | 0.50 | 0.80 |
| Portugal | 0.60 | 0.80 |
| Romania | 0.40 | 0.80 |
| Slovakia | 0.50 | 0.70 |
| Slovenia | 0.70 | 0.70 |
| South Korea | 0.86 | 0.86 |
| Spain | 0.60 | 0.80 |
| Sweden | 0.50 | 0.70 |
| Switzerland | 0.40 | 0.70 |
| United States | 0.67 | 0.58 |

## 4.5 DHARMa tests

DHARMa diagnostic tests were used to assess model assumptions, with significance evaluated at the 5% level.

Overall, most models pass all diagnostic tests, indicating that model assumptions are broadly satisfied. However, some exceptions were identified:

- Dispersion: Bulgaria, Italy
- Zero-inflation: Malta, Netherlands
- Outliers: Norway, Malta

These findings suggest that while the majority of models are well specified, a small number may have limitations in capturing key features of the data.

**Table 20 – DHARMa test p-values and outcomes**

| Country | Uniformity | Dispersion | Zero Inflation | Outlier | Outcome |
|---|---|---|---|---|---|
| Argentina | 0.944 | 0.964 | 1.000 | 1.000 | Passed all tests |
| Australia | 0.768 | 0.666 | 1.000 | 1.000 | Passed all tests |
| Austria | 0.885 | 0.840 | 1.000 | 1.000 | Passed all tests |
| Belgium | 0.745 | 0.994 | 1.000 | 1.000 | Passed all tests |
| Bulgaria | 0.634 | 0.048 | 1.000 | 1.000 | Failed: Dispersion |
| Croatia | 0.582 | 0.112 | 1.000 | 1.000 | Passed all tests |
| Cyprus | 0.997 | 0.112 | 0.640 | 1.000 | Passed all tests |
| Czechia | 0.833 | 0.454 | 1.000 | 0.520 | Passed all tests |
| Denmark | 0.875 | 0.156 | 1.000 | 0.420 | Passed all tests |
| Estonia | 0.929 | 0.098 | 1.000 | 1.000 | Passed all tests |
| Finland | 0.958 | 0.202 | 0.958 | 0.360 | Passed all tests |
| France | 0.856 | 0.890 | 1.000 | 1.000 | Passed all tests |
| Greece | 0.530 | 0.076 | 0.784 | 1.000 | Passed all tests |
| Hungary | 0.844 | 0.310 | 1.000 | 1.000 | Passed all tests |
| Iceland | 0.770 | 0.066 | 0.666 | 1.000 | Passed all tests |
| Ireland | 0.472 | 0.676 | 0.128 | 1.000 | Passed all tests |
| Italy | 0.312 | 0.006 | 1.000 | 0.680 | Failed: Dispersion |

| Country | Uniformity | Dispersion | Zero Inflation | Outlier | Outcome |
|---|---|---|---|---|---|
| Japan | 0.728 | 0.674 | 1.000 | 1.000 | Passed all tests |
| Latvia | 0.865 | 0.770 | 1.000 | 0.240 | Passed all tests |
| Lithuania | 0.428 | 0.896 | 1.000 | 1.000 | Passed all tests |
| Luxembourg | 0.927 | 0.082 | 0.614 | 1.000 | Passed all tests |
| Malta | 0.301 | 0.226 | 0.032 | 0.000 | Failed: Zero inflation, Outlier |
| Netherlands | 0.275 | 0.888 | 0.014 | 0.400 | Failed: Zero inflation |
| New Zealand | 0.711 | 0.398 | 1.000 | 1.000 | Passed all tests |
| Norway | 0.765 | 0.992 | 1.000 | 0.040 | Failed: Outlier |
| Poland | 0.508 | 0.482 | 1.000 | 1.000 | Passed all tests |
| Portugal | 0.844 | 0.716 | 1.000 | 1.000 | Passed all tests |
| Romania | 0.246 | 0.068 | 1.000 | 0.460 | Passed all tests |
| Slovakia | 0.918 | 0.280 | 1.000 | 1.000 | Passed all tests |
| Slovenia | 0.399 | 0.520 | 1.000 | 1.000 | Passed all tests |
| South Korea | 0.396 | 0.824 | 1.000 | 1.000 | Passed all tests |
| Spain | 0.996 | 0.828 | 1.000 | 1.000 | Passed all tests |
| Sweden | 0.745 | 0.292 | 1.000 | 0.340 | Passed all tests |
| Switzerland | 0.996 | 0.320 | 1.000 | 0.260 | Passed all tests |
| United States | 0.408 | 0.418 | 1.000 | 0.600 | Passed all tests |

# 5. Limitations

## 5.1 Introduction

The methodology for this analysis has included steps to ensure the quality and accuracy of the results, however there are still limitations to the analysis. This section will highlight any limitations that exist within the analysis.

## 5.2 Data Limitations

There are a number of limitations for this analysis relating to the data used. The selection of countries was restricted to those for which both work-related fatality data and appropriate employment denominator data were publicly available and sufficiently detailed for analysis. Although the initial scope aimed to include all G20 countries, several were excluded due to data unavailability, incomplete time series, or lack of sufficiently comparable definitions. As a result, the final set of countries is not representative of all major economies across all continents.

Each country reports work-related fatal injury data using different data collection systems, definitions, and coverage inclusions/exclusions as outlined in Section 2. While efforts were made to harmonise these differences (Section 3.2), including aligning industry groupings and adjusting for key factors such as road traffic accidents, not all inconsistencies could be accounted for. In particular, differences in the treatment of certain incident types (e.g. suicides), fatality time limits, and variations in reporting practices mean that the data are not fully comparable. Thus, the results should be interpreted as estimates of relative differences rather than precise measures, and they may not fully capture the true relationship between Great Britain and each comparator country.

The data is also limited by the length and completeness of available time series, which vary by country. The limited number of years in some cases may limit the ability to observe trends over time. In addition, for all countries included the study period overlaps with the COVID-19 pandemic. During the years of 2020 and 2021 in particular, workplace activities, exposures, and reporting may have been affected, which could influence both fatal injury counts and the underlying employment levels. This brings in an issue of comparability across years.

Additionally, differences in reporting systems mean that some systems are more prone to under-reporting or excluding variables which would be covered elsewhere. This introduces additional uncertainty and so results must be interpreted with these limitations in mind.

## 5.3 Model Limitations

The models used in this analysis are generalised linear models. These models assume that there is a linear relationship between year and the log fatality rate. This

means that the annual trend is assumed to be constant throughout the years. Thus, the models may not fully capture non-linear trends, leading to inaccuracies for countries where fatality patterns are more irregular. This is particularly an issue in smaller countries with a smaller workforce.

The models include a limited number of variables, meaning that the models will not be able to account for all of the variation within the data. This, combined with the limited number of years for each country, means that the models may be too simplistic to accurately describe the differences between Great Britain and the comparator countries.

Confidence intervals for the comparator country year rate ratio were generated using simulations from the estimated variance-covariance matrix. This approach assumes that the estimated regression coefficients follow an approximately multivariate normal distribution. While this is a generally appropriate assumption for generalised linear models, it can be less accurate for small sample sizes or for coefficient estimates with high levels of uncertainty.

Alternative modelling approaches were explored during the span of this research, including fixed effects, mixed effects, and random effects models. However, these approaches were not suitable for the structure of the data. Poisson models were also considered but were often inappropriate due to over-dispersion, which led to the adoption of Negative Binomial models in many cases. Although the modelling approach represents the most appropriate method identified for this dataset, the results remain within the context of the limitations outlined above and should be interpreted with appropriate caution.

# 6. Conclusions and Recommendations

## 6.1 Conclusions

This analysis provides an evidence base that in the comparisons with individual countries, Great Britain consistently has lower relative work-related fatal injury rates. Out of the 32 countries used in this analysis with significant rate ratio results, 6 were considered to have rate ratios similar to Great Britain with only one country (the Netherlands) found to have a lower rate ratio relative to Great Britain.

Over time, fatality rates tend to decrease across most countries, including Great Britain. However, differences in time trends between Great Britain and comparator countries are rarely statistically significant, suggesting that while countries are improving, they are doing so at broadly similar rates.

Model performance indicators support these findings, with predicted value analysis suggesting moderate to good accuracy, particularly for Great Britain. The average predicted value coverage was 65% for comparator countries and 76% for Great Britain. Model diagnostics indicate that most models meet key statistical assumptions. The DHARMa tests evaluated key assumptions of the fitted models, of which most passed all tests, indication that the model fit was appropriate for the data. Of the 144 tests performed across the 36 models, six tests failed, though three would pass if confidence level was assessed at 90%, rather than 95%.

Considering this, these findings support the conclusion that Great Britain maintains its position as one of the safest countries when regarding work-related fatal injuries. Many countries included in this analysis also show decreasing trends suggesting improvements in workplace safety.

## 6.2 Recommendations

While the results provide comparative evidence, they should still be interpreted with caution. Limitations in this research include:

- Differences in data collection methods and reporting practices between countries, which may affect comparability
- The use of simplified models that do not account for all factors influencing fatality rates, such as age
- Limited time series data, which may restrict the ability to detect more complex trends, and does include years that may have been affected by impacts of the coronavirus pandemic

As a result, these findings should be interpreted as indicating relative differences in reported fatality rates, rather than being a complete measure of workplace safety.

Future research could strengthen this analysis by:

- Further developing industry-level modelling, which was found to have low reliability in this analysis and thus was excluded
- Incorporating additional explanatory variables (e.g. age or regulatory differences)
- Extending the time period and including more countries from different parts of the world
- Exploring more modelling approaches to better capture non-linear trends
- Collaborating with countries to acquire comparable data, rather than using only publicly available data with differences in scope and methodology

While acknowledging these limitations, the evidence presented here is consistent with the conclusion that Great Britain performs well in international comparisons of relative work-related fatal injury rates, supporting its position as one of the safest countries to work in.

# Further information

This technical report accompanies the full research report, available at www.hse.gov.uk/statistics/assets/docs/international-comparisons.pdf

The underlying model input data used in this research is available at www.hse.gov.uk/statistics/assets/docs/international-model-data.xlsx

For information regarding the quality guidelines used for statistics within HSE see www.hse.gov.uk/statistics/about/quality-guidelines.htm

A revisions policy and log can be seen at www.hse.gov.uk/statistics/about/revisions/

Lead Statisticians: Lauren Vango and Kerry Grindle

Users are encouraged to provide comments and feedback on how these statistics are used and how they meet their needs. Feedback on the content, relevance, accessibility and timeliness of these statistics and any non-media enquiries should be directed to: statsfeedback@hse.gov.uk

Journalists/media enquiries only: www.hse.gov.uk/contact/contact.htm