



U.S. Department  
of Transportation  
**Pipeline and  
Hazardous Materials  
Safety Administration**

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# **Top Consequence Hazardous Materials by Commodities & Failure Modes, 2010-2014**

*Data Update*

**Office of Hazardous Materials Safety**

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## Background

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The mission of the Pipeline and Hazardous Materials Safety Administration (PHMSA) is to protect people and the environment by advancing the safe transportation of energy products and other hazardous materials that are essential to daily life. With emerging technologies and the development of new commodities and products, the scope and complexity of PHMSA's safety mission are evolving and growing.

To keep pace with our changing world, PHMSA uses data and analysis to achieve our safety goals. PHMSA has developed our strategic framework to reflect our efforts to be more innovative and *data-driven*. PHMSA strives to better leverage our collection of and access to relevant data to identify and analyze safety risks.

This data update furthers these goals by presenting the hazmat commodities, failure modes<sup>1,2</sup>, transportation modes, and transportation phases<sup>3</sup> that have been linked to the most serious consequences in terms of fatalities and major injuries<sup>4</sup> during the years, 2010-2014. This update is an outgrowth of the 2011 PHMSA report, "Top Consequence Hazardous Materials by Commodities & Failure Modes (2005-2009)," also known as the 2011 Top Consequence Report.<sup>5</sup> While we discourage analytical comparisons between this data update and the 2011 Top Consequence Report, this document employs essentially the same computational approaches as the 2011 report.

One notable difference is the use of revised Department of Transportation (DOT) guidance regarding Maximum Abbreviated Injury Scale (MAIS) coefficients.<sup>6</sup> Specifically, DOT's 2016 guidance on the economic Value of a Statistical Life (VSL) uses a coefficient of 0.266 for the injury class of MAIS 4, "Severe." This is the same injury class cited in the 2011 Top Consequence Report; PHMSA is simply revising the coefficient from 0.1875 to 0.266. This

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<sup>1</sup> In the PHMSA 5800.1 incident report form, failure mode is referred to as "failure cause." The 5800.1 form can be accessed at: <http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/IncidentForm010105.pdf> (Accessed April 12, 2017).

<sup>2</sup> PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, GUIDE FOR PREPARING HAZARDOUS MATERIALS INCIDENT REPORTS (2004) *available at* [http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/reporting\\_instructions\\_rev.pdf](http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/reporting_instructions_rev.pdf) (Accessed April 12, 2017) [hereinafter PHMSA Incident Report Guide].

<sup>3</sup> *Ibid.*

<sup>4</sup> For the purposes of this data update, a "major injury" occurs when an individual is injured as a direct result of the hazardous material release and was admitted to the hospital overnight and/or lost three days or more from work due to the injury.

<sup>5</sup> PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, "Top Consequence Hazardous Materials by Commodities & Failure Modes, 2005-2009," (2011) *available at* <http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Hazmat/Top%20Consequence%20Hazardous%20Materials%20Commodities%20Report.pdf> (Accessed April 12, 2017).

<sup>6</sup> OFFICE OF THE SECRETARY OF TRANSPORTATION, U.S. DEPARTMENT OF TRANSPORTATION, "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses – 2016 Adjustment," (August 8, 2016) *available at* <https://www.transportation.gov/sites/dot.gov/files/docs/VSL%20Guidance%202016.pdf> (Accessed April 12, 2017) [hereinafter 2016 DOT VSL Guidance].



means that the weighting value employed in this data update is different from the 2011 Top Consequence Report (by about 8%). This data update also differs from the 2011 report to the extent that the incident data presented in each report are different; this data update covers hazmat incidents from 2010 to 2014, whereas the 2011 report covered 2005 to 2009. In addition, the 2011 report used the 2007 Commodity Flow Survey (CFS), whereas this data update uses the 2012 CFS.<sup>7,8</sup>

Lastly, this data update uses a modified competition ranking technique (i.e., “1334” ranking) for equal ranked commodities. This ranking ensures that a commodity only comes second if it scores higher than all but one, third if it scores higher than all but two, and so on.

## Limitations

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This document refrains from offering the same level of interpretation as the 2011 Top Consequence Report because there are important analytical and statistical considerations that may limit the usefulness of ranking hazmat commodities. These considerations include:

- The formula used to weight “high-impact casualties” assumes that major injuries are 26.6% of the severity of a fatality, based on the Maximum Abbreviated Injury Scale (MAIS) coefficient for “severe” injuries, per DOT policy in 2016.<sup>9</sup> Different weighting systems could produce different results.
- Ranking hazmat commodities may give a false impression that the commodity itself is a causal factor for a fatality or major injury in a given incident.
- Incident data are self-reported, and in some cases, may be misreported. In particular, self-reported failure modes may not represent the root cause of an incident and this reporting does not indicate that a root cause analysis was conducted.
- The rankings in this data update and the 2011 report do not incorporate factors that readily indicate risks to the environment; these rankings focus on safety risks as expressed by the prevalence of fatalities and major injuries.
- A five-year period of analysis is short and may be susceptible to overrepresentation of low-probability, high-consequence events, including events which have very little precedent in the overall incident record.
- The Commodity Flow Survey (CFS) data<sup>10</sup> used to normalize the hazmat incident data do not cover all of the commodities that are implicated in hazmat incidents.

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<sup>7</sup> BUREAU OF TRANSPORTATION STATISTICS, U.S. DEPARTMENT OF TRANSPORTATION AND U.S. CENSUS BUREAU, U.S. DEPARTMENT OF COMMERCE, 2007 COMMODITY FLOW SURVEY – HAZARDOUS MATERIALS (2010) available at <http://www.census.gov/econ/cfs/2007/Hazmat%20FINAL.pdf> (Accessed April 12, 2017).

<sup>8</sup> BUREAU OF TRANSPORTATION STATISTICS, U.S. DEPARTMENT OF TRANSPORTATION AND U.S. CENSUS BUREAU, U.S. DEPARTMENT OF COMMERCE, 2012 COMMODITY FLOW SURVEY – HAZARDOUS MATERIALS (2015) available at <http://www.census.gov/econ/cfs/2012/ec12tcf-us-hm.pdf> (Accessed April 12, 2017) [hereinafter 2012 Hazmat CFS].

<sup>9</sup> See 2016 DOT VSL Guidance. The MAIS values applicable to hospitalized injuries could range from “moderate” (4.7%) to “critical” (59.3%). Consistent with the 2011 report, PHMSA uses the coefficient associated with “severe” as an intermediate value given injury data uncertainty and variation.

<sup>10</sup> See 2012 Hazmat CFS.



- Some data collected in support of the CFS do not meet Bureau of Transportation Statistics standards for publication and are withheld. This also limits the number of commodities that can be included in the rankings.
- UN Numbers with small transport volumes are withheld because CFS data for UN Numbers do not consider sampling variability.

Because of these considerations, PHMSA urges stakeholders to exercise care in interpreting the aggregated results of this data update. In particular, PHMSA cautions against equating a commodity's ranking with safety risk; a commodity's ranking in this data update may not be indicative of the extent of the risks associated with the transport of that commodity. Further, the commodity is one of many factors to be considered in the occurrence or severity of an incident. PHMSA also cautions against using the rankings contained in this data update as the primary driver for policy or business decisions.

## Path Forward

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In light of these limitations, PHMSA is developing more effective and innovative ways to engage our stakeholders and foster a better understanding of PHMSA incident data. Instead of producing periodic static reports, PHMSA plans to develop dynamic, browser-based data reporting and visualization tools so stakeholders can interact directly with PHMSA hazmat incident data. This will allow information from this data update and other static reports to be automated online with the latest data. Additional information will be provided on PHMSA's website as innovation occurs.<sup>11</sup>

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<sup>11</sup> PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, "Program Development" (2017) available at <http://www.phmsa.dot.gov/hazmat/program-development> (Accessed April 12, 2017).

**Table 1.1: Commodities Ranked by Weighted High-Impact Casualties\* from 2010 – 2014**

Rank	Abbreviated Commodity Name	High-Impact Casualties (Weighted)*	Fatalities	Major Injuries	Incident Count
1	Gasoline**	38.192	35	12	1305
2	Liquefied Petroleum Gas	13.512	5	32	487
3	Diesel Fuel	5.798	5	3	1930
4	Ammonia, Anhydrous	5.128	3	8	226
5	Sulfuric Acid	2.596	1	6	867
7	Petroleum Crude Oil	2.266	2	1	976
7	Petroleum Distillates, N.O.S.	2.266	2	1	794
12	Alcohols, N.O.S.	2	2	0	1463
12	Coating Solution	2	2	0	252
12	Organic Peroxide Type D, Liquid	2	2	0	265
12	Organic Peroxide Type F, Solid	2	2	0	13
12	Perfumery Products with Flammable Solvents	2	2	0	267

\* **Weighted High-Impact Casualties** = Fatalities + (0.266) x Major Injuries

\*\* Also includes fatality and major injury outcomes associated with the proper shipping name, “Gasohol Gasoline Mixed with Ethyl Alcohol, With Not More Than 10% Alcohol”

**Table 1.2: Commodities Ranked by Unweighted High-Impact Casualties\* from 2010 – 2014**

Rank	Abbreviated Commodity Name	High-Impact Casualties (Unweighted)*	Fatalities	Major Injuries	Incident Count
1	Gasoline**	47	35	12	1305
2	Liquefied Petroleum Gas	37	5	32	487
3	Ammonia, Anhydrous	11	3	8	226
4	Diesel Fuel	8	5	3	1930
5	Sulfuric Acid	7	1	6	867
6	Hydrochloric Acid	4	0	4	1596
13	Petroleum Crude Oil	3	2	1	976
13	Petroleum Distillates, N.O.S.	3	2	1	794
13	Cresylic Acid	3	0	3	5
13	Hydrogen Peroxide	3	0	3	834
13	Hypochlorite Solutions	3	0	3	591
13	Nitric Acid	3	0	3	403
13	Sulfur, Molten	3	0	3	118

\* **Unweighted High-Impact Casualties** = Fatalities + Major Injuries

\*\* Also includes fatality and major injury outcomes associated with the proper shipping name, “Gasohol Gasoline Mixed with Ethyl Alcohol, With Not More Than 10% Alcohol”

**Table 1.3(a): Top 10\* Commodities Normalized\*\* by Exposure (Weighted High-Impact Casualties\*\*\* per Million Ton-Miles)**

Rank*	Abbreviated Commodity Name	Normalization Factor**	High-Impact Casualties (Weighted)***	Fatalities	Major Injuries	Million Ton-Miles (CFS 2012)
1	Liquefied Petroleum Gas	2.93	13.51	5	32	4617
2	Ammonia, Anhydrous	0.89	5.13	3	8	5792
3	Hypochlorite Solutions	0.71	0.80	0	3	1122
4	Gasoline****	0.66	38.19	35	12	57769
5	Propane	0.65	1.53	1	2	2371
6	Hydrochloric Acid	0.52	1.06	0	4	2035
7	Petroleum Distillates, N.O.S.	0.45	2.27	2	1	5066
8	Sulfuric Acid	0.38	2.60	1	6	6821
10	Chlorine	0.20	0.27	0	1	1322
10	Sulfur, Molten	0.20	0.80	0	3	4002

\* Ranked by Normalization Factor. UN Numbers with small volumes are withheld because Commodity Flow Survey data for UN Numbers do not consider sampling variability. These include UN3110, UN3105, UN1033, UN1139, UN1266, UN1719, UN1903, UN2924, UN1073, UN2014, UN2672, UN2922, and UN1866. Commodities UN1202 (Diesel) and UN1267 (Crude oil) are not considered in this ranking because the 2012 Commodity Flow Survey estimate for UN1202 and UN1267 ton-miles did not meet BTS publication standards.

\*\* **Normalization Factor** = 1,000 x (Weighted High-Impact Casualties / Million Ton-Miles)

\*\*\* **Weighted High-Impact Casualties** = Fatalities + (0.266) x Major Injuries

\*\*\*\* Also includes fatality and major injury outcomes associated with the proper shipping name, "Gasohol Gasoline Mixed with Ethyl Alcohol, With Not More Than 10% Alcohol"



**Table 1.3(b): Top 10\* Commodities Normalized\*\* by Exposure (Weighted High-Impact Casualties\*\*\* per Thousand Tons Transported)**

Rank*	Abbreviated Commodity Name	Normalization Factor**	High-Impact Casualties (Weighted)***	Fatalities	Major Injuries	Thousand Tons (CFS 2012)
1	Liquefied Petroleum Gas	0.35	13.51	5	32	38344
2	Ammonia, Anhydrous	0.28	5.13	3	8	18296
3	Petroleum Distillates, N.O.S.	0.18	2.27	2	1	12536
4	Propane	0.15	1.53	1	2	10111
5	Sulfur, Molten	0.12	0.80	0	3	6656
7	Sulfuric Acid	0.09	2.60	1	6	28327
7	Alcohols, N.O.S.	0.09	2.00	2	0	23504
9	Hypochlorite Solutions	0.07	0.80	0	3	11524
9	Phosphoric Acid	0.07	0.53	0	2	8052
10	Gasoline****	0.04	38.19	35	12	1087396

\* Ranked by Normalization Factor. UN Numbers with small volumes are withheld because Commodity Flow Survey data for UN Numbers do not consider sampling variability. This includes UN3110, UN3105, UN1265, UN1033, UN1139, UN1832, UN1221, UN1266, UN1719, UN1903, UN2924, UN1073, UN1133, UN2014, UN2922, UN3266, UN1866, UN2672, and UN1789.

\*\* **Normalization Factor** = 1,000 x (Weighted High-Impact Casualties / Thousand Tons)

\*\*\* **Weighted High-Impact Casualties** = Fatalities + (0.266) x Major Injuries

\*\*\*\* Also includes fatality and major injury outcomes associated with the proper shipping name, "Gasohol Gasoline Mixed with Ethyl Alcohol, With Not More Than 10% Alcohol"





**Table 2.1: Top 10\* Failure Modes<sup>12</sup> Across All Transportation Phases<sup>13</sup> Ranked by Weighted High-Impact Casualties\*\***

Rank*	Failure Mode	High-Impact Casualties (Weighted) **	High-Impact Casualties (Unweighted) ***	Fatalities	Major Injuries	Incidents with Death or Major Injury	Transportation Phase	Weighted by Phase
1	Vehicular Crash or Accident Damage	30.52	43	26	17	32	IN TRANSIT	28.46
							UNLOADING	2.06
2	Rollover Accident	13.06	16	12	4	16	IN TRANSIT	13.06
3	Human Error	12.99	35	5	30	32	IN TRANSIT	1.27
							IN TRANSIT STORAGE	0.27
							LOADING	4.13
							UNLOADING	7.32
4	Fire, Temperature, Or Heat	7.93	16	5	11	8	IN TRANSIT	5.00
							IN TRANSIT STORAGE	2.13
							LOADING	0.53
							UNLOADING	0.27
5	Component or Device+	5.52	18	1	17	13	IN TRANSIT	3.39
							LOADING	0.53
							UNLOADING	1.60
6	Over-Pressurized	3.06	6	2	4	5	LOADING	1.53
							UNLOADING	1.53
7	Multiple Causes++	2.80	5	2	3	4	IN TRANSIT	2.00
							UNLOADING	0.80
8	Overfilled	1.53	3	1	2	3	UNLOADING	1.53
9	Cause Not Reported	1.34	5	0	5	5	IN TRANSIT	0.27
							IN TRANSIT STORAGE	0.27
							UNLOADING	0.80
10	Deterioration or Aging	1.27	2	1	1	1	UNLOADING	1.27

<sup>12</sup> See PHMSA Incident Report Guide.

<sup>13</sup> Ibid.



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**Table 2.1 Continued: Table Notes**

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\* Ranked by Weighted High-Impact Casualties

\*\* **Weighted High-Impact Casualties** = Fatalities + (0.266) x Major Injuries

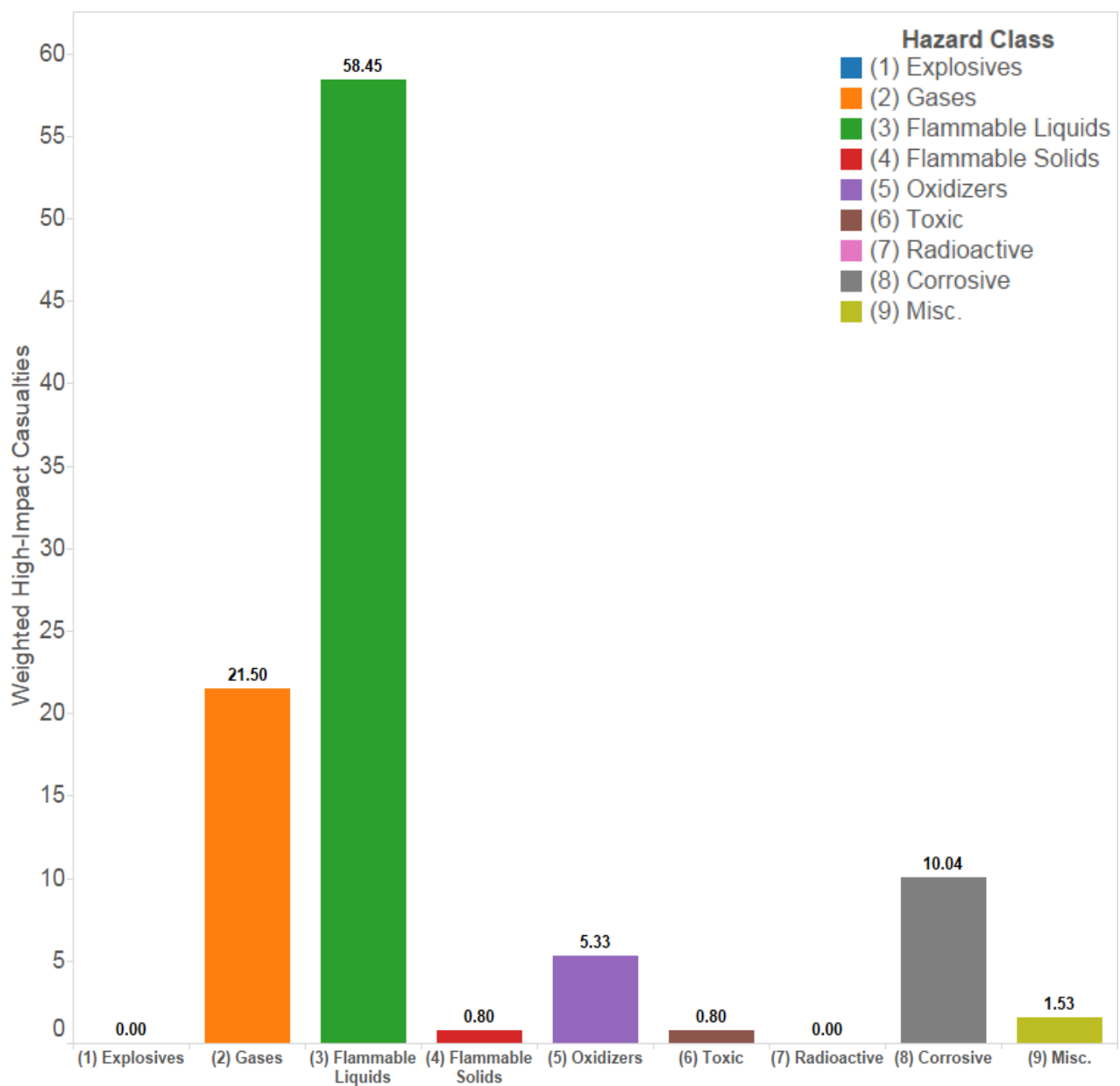
\*\*\* **Unweighted High-Impact Casualties** = Fatalities + Major Injuries

+ “Component or Device” is an aggregate of five failure modes: (1) Broken Component or Device; (2) Loose Closure, Component or Device; (3) Defective Component or Devices; (4) Missing Component or Device; (5) Misaligned Material, Component or Device. The values provided have been adjusted to ensure that there is no double counting as a result of this aggregation.

++ “Multiple Causes” contains incidents for which there were two or more failure modes reported.



Chart 3.1: Weighted High-Impact Casualties by Hazard Class, 2010-2014

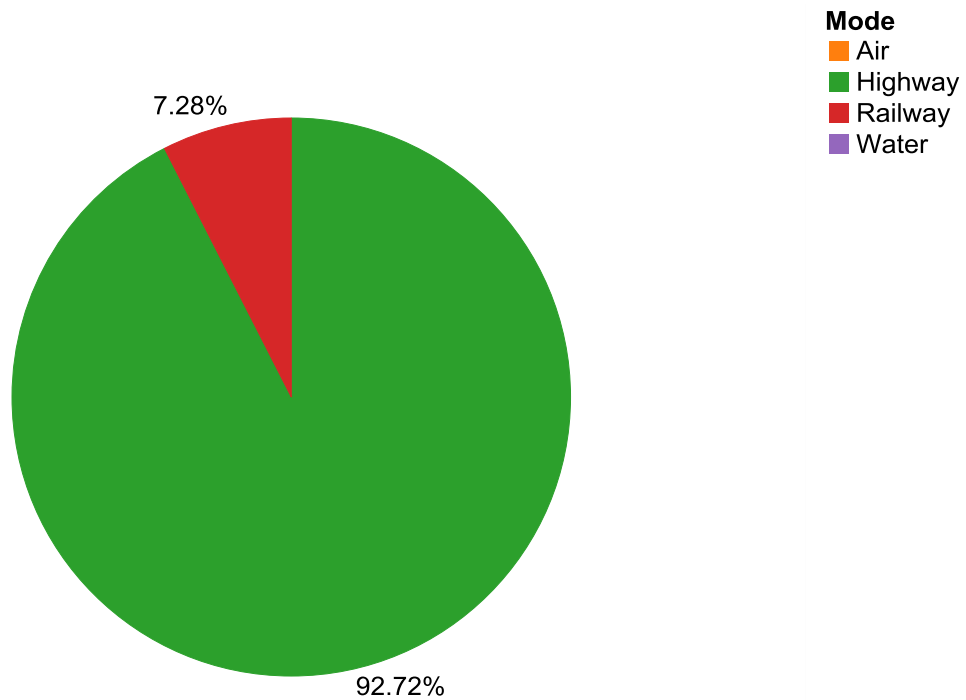




**Table 3.1:** Incident Consequences by Transportation Mode, 2010-2014

Mode of Transportation	Total Number of Fatalities	Total Number of Major Injuries	Incident Count	Incidents with Fatalities or Major Injuries
AIR	0	0	6924	0
HIGHWAY	55	96	67911	124
RAILWAY	1	20	3537	15
WATER	0	0	356	0
<b>Grand Total</b>	<b>56</b>	<b>116</b>	<b>78728</b>	<b>139</b>

**Table 3.2:** Weighted High-Impact Casualties by Transportation Mode, as Percent of Total, 2010-2014





## Appendix: Proper Shipping Name, UN ID, and Abbreviated Commodity Name Cross-Walk

Proper Shipping Name	UN ID	Abbreviated Commodity Name
Alcohols, n.o.s.	UN1987	Alcohols, N.O.S.
Ammonia, anhydrous	UN1005	Ammonia, Anhydrous
Chlorine	UN1017	Chlorine
Coating solution <i>(includes surface treatments or coatings used for industrial or other purposes such as vehicle undercoating, drum or barrel lining)</i>	UN1139	Coating Solution
Cresylic acid	UN2022	Cresylic Acid
Diesel fuel (or) Fuel oil (No. 1, 2, 4, 5, Or 6) (or) Combustible liquid, n.o.s.	UN1202 / NA1993	Diesel Fuel
Gasoline <i>includes gasoline mixed with ethyl alcohol, with not more than 10% alcohol</i>	UN1203	Gasoline
Hydrochloric acid	UN1789	Hydrochloric Acid
Hydrogen peroxide, aqueous solutions <i>with more than 40 percent but not more than 60 percent hydrogen peroxide (stabilized as necessary)</i> (or) Hydrogen peroxide, aqueous solutions <i>with not less than 20 percent but not more than 40 percent hydrogen peroxide (stabilized as necessary)</i>	UN2014	Hydrogen Peroxide
Hypochlorite Solutions	UN1791	Hypochlorite Solutions
Nitric acid <i>other than red fuming, with more than 70 percent nitric acid</i> (or) Nitric acid <i>other than red fuming, with at least 65 percent, but not more than 70 percent nitric acid</i>	UN2031	Nitric Acid
Organic peroxide type D, liquid	UN3105	Organic Peroxide, Type D, Liquid
Organic peroxide type F, solid	UN3110	Organic Peroxide, Type F, Solid
Perfumery products <i>with flammable solvents</i>	UN1266	Perfumery Products with Flammable Solvents
Petroleum crude oil	UN1267	Petroleum Crude Oil
Petroleum distillates, n.o.s. or Petroleum products, n.o.s.	UN1268	Petroleum Distillates, N.O.S.
Petroleum gases, liquefied or Liquefied petroleum gas	UN1075	Liquefied Petroleum Gas
Phosphoric acid solution	UN1805	Phosphoric Acid
Propane, <i>see also</i> Petroleum gases, liquefied	UN1978	Propane
Sulfur, molten	UN2448	Sulfur, Molten
Sulfuric acid <i>with more than 51 percent acid</i>	UN1830	Sulfuric Acid