Special Study
Wrong Way Driving (WWD) Crashes IMPACT Study

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Data Comparisons: CY2016-2020 WWD vs Non-WWD
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0.0 Introduction

This document presents the results of a comparison of Wrong Way Driving (WWD) crashes compared to non-WWD crashes over a recent five-year period (CY2016-2020). The determination of whether a crash was a WWD or not is given by the filter definition in Section 3.1. Three attributes were examined: Primary Contributing Circumstances, CU Contributing Circumstances and V2 Contributing Circumstances. If any one of these showed "Traveling Wrong Way/Wrong Side" or "Wrong Side of Road," the crash was considered to be WWD.

The analytical technique employed to generate most of the displays below is a component within the Critical Analysis Reporting Environment (CARE) called Information Mining Performance Analysis Control Technique (IMPACT). For a detailed description of the meaning of each element of the IMPACT outputs, please see: http://www.caps.ua.edu/software/care/

The main objective of performing IMPACT comparisons is to surface "over-representations." An *over-represented value* of an attribute is found (for this study) when that attribute has a greater share of WWD crashes than would be expected if its proportion were the same as for the non-WWD crashes. Thus, the non-WWD crashes are serving as a *control group* to which the WWD crashes are being compared.

As an example, we found that WWD crashes for the Day-of-the-Week attribute value of Sunday had almost 31% higher proportion of crashes than did the non-WWD crashes (Section 5.3; Odds Ratio = 1.308). When such differences are statistically significant (as in this case), this surfaces characteristics that should be given attention, and in some cases, further analyses performed for countermeasure development. For example, additional selective enforcement for WWD causes (e.g., excessive speed, drowsiness, DUI, etc.) might be performed on Sunday and other days at times where they have their highest over-representations. Unless otherwise stated, the output tables given above the charts are in *Max Gain* order. The *Max Gain* is the gain (in crash reduction) that could be obtained if some countermeasure could be applied to reduce the proportion of the WWD crashes to equal the proportion of non-WWD crashes within the corresponding attribute.

This report continues with two short sections that provide a high-level summary of recommendations and findings for those who just need an executive summary. The sections are called: (1) Executive Summary and Recommendations, and (2) Summary of Findings. Section 3 is also introductory in that it provides a detailed definition of the filter that was used to define WWD crashes in the analytical sections that follow. After Section 3, the comparison between WWD and non-WWD crashes will be presented under the following headings with section numbers:

- 4. Geographic Factors,
- 5. Time Factors,
- 6. Factors Affecting Severity,

- 7. Driver and Vehicle Demographics, and
- 8. Driver Behavior.

See the Table of Contents for a guide to the sections of interest.

1.0 Executive Summary and Recommendations

The recommendations of this special study are presented first for two reasons (1) for those who do not have time to go through all of the IMPACT analyses, and/or (2) as an introduction to these more detailed analyses. Recommendations are referenced to the more detailed analyses sections so that questions regarding the source of any given recommendation can be easily accessed.

Recommendations are organized into the three areas of: (1) Law enforcement concentration and direction, (2) Legal and judicial countermeasure development, and (3) PI&E information on WWD content. The ordering of these, either generally or within their respective categories, is not meant to imply priority. However, the more detailed information given is useful in the further prioritization and allocation of traffic safety resources. This process should consider all of the recommendations, which should be validated against the information presented in the IMPACT sections 4.0-7.0 (referenced sections will be given in parenthesis).

The following recommendations are made to reduce the frequency and/or severity of Wrong Way Driving (WWD) crashes in Alabama:

- **Law enforcement concentration and direction**
    - Increased recognition is essential, both on the part of law enforcement and the general public, that the relatively high deadly combination in WWD crashes is caused by their comparatively high impact speeds (6.1, 6.2) coupled with a failure of all drivers and passengers involved in WWD crashes to use restraints (6.5, 6.6). Because of the doubling of the impact speed effect in WWD crashes excessively high speeds by the causal vehicles are not essential to causing death.
    - Seek out new ways to increase law enforcement methods to address these issues, both of which stem from the acceptance of risk-taking behaviors, especially on the part of younger drivers of age less than 35.
    - Identify vehicles/drivers that give indications that they are not stable in their lanes. This is something that officers are looking for at all times, but increased attentiveness may be required in areas where several vehicles have had problems maintaining their lane discipline in the past.
    - Since a relatively large proportion of WWD crashes are caused by Impaired Driving (ID), all of the ID countermeasures (8.3, 8.4) should be increased. Hotspot analyses should be performed to determine where WWD selective enforcement will be most effective, and consideration should be given to using WWD as an additional proxy for ID. Since ID crashes tend to result in higher severity, this countermeasure will have the effect of reducing fatalities.

- More effective drug detection techniques (8.4) should be identified, especially for law enforcement officers who have nor had training in their use.
- Law enforcement training should focus on the concentration on the times of day, days of the week (5.3-5.7, generally similar to ID), and the particular over-represented vehicle types e.g., Pick-up Trucks, Bicyclists, Pedestrians and Passenger Cars (7.3).
- Training needs to focus on the specific driver over-representations: 1) males (7.2), 2) age groups (7.1), ages 24-35, 3) the locations that these over-represented groups (determined by hotspot analyses); and 4) over-represented times, generally night-time (5.4).
- Counties with a combination of medium to large metropolitan areas and fairly large rural areas (4.3, 4.6) should generally be given additional emphasis in WWD selective enforcement programs (4.1, 4.2). These should be evaluated on a county-by-county basis taking the population and traffic volume crash rates into consideration. Over-represented cities and counties should be subjected to Hotspot analyses, recognizing the high correlation between ID and WWD.
- The rural areas (4.6) of these counties, and especially the County Roads (4.5) should be given special consideration for enforcement, since that is where increased fatalities occur (4.4).
- Those cities with a high frequency of WWD crashes (4.2) should be given special guidance and perhaps additional funding to address their WWD crash problems. Many such large city areas have a considerable amount of Open Country (4.6) that would tend to multiply their WWD crash severity. It should be recognized that Residential areas of these cities also have a significant WWD over-representation (4.6), probably stemming from their larger pedestrian and bicycle travel.
- Additional hotspot analysis needs to be done to surface those County Roads (4.5), which account for their overall 31.59% of the WWD crashes and have an over-representation of over twice (2.310) their expected number. It is possible that impaired causal drivers may be using the county roads in attempts to avoid being apprehended, and their intoxication result in WWD crashes.
- Time for enforcement might be optimized by local culture, but for the average statewide picture, if workers are typically "off" the following day, the optimal times for enforcement would begin shortly after the Friday afternoon rush hour and continue through at least 3 AM (5.3-5.6). Friday here being any day before a holiday off-day.

- **Legal and judicial countermeasure development**
  - Since WWD is so correlated with ID, Drug/Alcohol Diversion Programs should continue (or new programs adopted) that concentrate on keeping the age 25 through 35 (typically *social users*) from becoming habitual to the point where they become part of the 36-60-year old over-representation of predominantly *problem users* (7.1).

- The role that unemployment plays should be considered in formulating remedial measures (7.7). Methods should be explored to communicate with appropriate individuals through their respective unemployment offices. The relationship between WWD crashes and unemployment is not surprising because of the underlying drug/alcohol root cause of many WWD crashes (8.2-8.5). The correlation between not having a job and being involved in an WWD crash should be watched carefully going forward in that it could affect the type and location for countermeasures.
- Because of the high correlation of WWD and ID crashes, breath-alcohol ignition interlock devices are recommended for reducing the WWD problem caused by problem drinkers in Alabama. Conduct an in-depth study to improve and expand the current program. While the data do not show a high level of drugs/alcohol causing WWD crashes directly, (8.2, 8.4) the fact that they are over-represented is an indication that this could be a cause even if the presence of drugs/alcohol do not reach the reporting threshold, especially in cases involving prescription drugs.

- **PI&E information content on WWD crashes**
  - Combinations of recreational or medical drugs and alcohol can be particularly lethal, and medical practitioners should warn against such problems and discourage all alcohol use for their patients who are taking prescription drugs. Additional programs to publicize these dangers are recommended.
  - Legalized recreational drugs are not a good alternative to alcohol use and should not be advertised as such. PI&E programs should take the opposite approach to warn drivers that legalization in no way relaxes their responsibilities.
  - Promote the use of those routes that avoid county roads, which have over twice their expected proportion of WWD crashes. The largest cause of County Road fatalities is Driving Too Fast for Conditions and other speed-related behaviors. These are driver errors that can be easily avoided. The promotion of Interstates should contain warnings against speeding.
  - One of the most critical needs is for all drivers and their passengers to buckle up (6.6). There is little hope of surviving a crash for a large proportion of them if they fail to realize this, especially a head-on crash.
  - While clearly the problems found in this study are those of WWD, other driver behaviors (8.1) that are correlated with WWD might provide alternatives for countermeasure development. These behaviors are:
    - DUI 221
    - Crossed Centerline 93
    - Made Improper Turn 59
    - Improper Lane Change/Use 41
    - Fatigued/Asleep 41
    - Improper Passing 37
    - Aggressive Operation 35
    - Swerved to Avoid Vehicle 30

These were the Primary Contributing Circumstances that had high frequencies exclusive of WWD even though the standard WWD filter was in effect (indicating a high correlation with WWD).

2.0 Summary of Findings

Note: subsections 2.1, 2.2 and 2.3 have been omitted in order to keep the numbering system in this Section consistent with that of the IMPACT displays that follow. The following findings are mainly from the IMPACT analysis below that compared WWD vs Non-WWD crashes for all five years (CY2016-2020):

- **2.4 Geographical Factors (4.0)**
    - County (4.1) - Generally, the over-represented counties are those with combined fairly large population centers bordering on rural areas, as opposed to the highly urbanized counties or the extremely rural counties. One reason that the highly urbanized counties are under-represented is the large number of low severity crashes that occur there that are separate and apart from WWD crashes. See the rural-urban comparison in Section 4.3. Placed in Max Gain order, the ones with the highest potential for reduction were: Cullman, DeKalb, Marshall, Talladega, Blount and Chilton.
    - City Comparisons (4.2) of WWD to Non-WWD crashes, include rural areas of counties (virtual cities). There is little surprise in this output, which tracks the rural areas by county population. Traffic safety professionals should look for any locations that fall counter to this trend. City (and rural area) comparisons are presented for all areas that had a Max Gain in excess of 100 WWD crashes over the five-year period of the study. The county rural areas (virtual cities) with Max Gains in excess of 160 WWD crashes over their expected numbers are: Rural Jefferson, Rural Mobile, Rural Cullman, Rural DeKalb and Rural Madison.
    - Overall Area Comparisons Conclusions (4.1-4.2) – Generally those rural areas that are adjacent to (or contain) significant urbanized areas are over-represented, since their large urban areas generate more traffic in the rural areas. Possible factors for *relatively fewer severe WWD crashes* within urban areas include:
        - Less need for motor vehicle travel and shorter distances;
        - Larger police presence in the metropolitan areas; and
        - Lower speeds in urban areas.

      Note: These city, county, and area comparisons are, of necessity, a selection of the total outputs that could be generated. They are given to illustrate CARE capabilities as much as to present the numerical results. Anyone wishing additional cities, counties, or other areas, please contact CAPS – brown@cs.ua.edu.

- Rural/Urban WWD Crash Proportion (4.3) – WWD crashes appear in a proportion that is quite different from their non-WWD counterparts. WWD crashes occurred in 41.81% rural and 58.19% urban areas, while the non-WWD proportions were 22.77% rural and 77.07% urban. Thus we conclude that the number of WWD crashes is mainly determined by traffic volumes as opposed to the rural/urban environments per se.
- Severity of Crash by Rural-Urban (4.4) – See Section 3.3 which shows that WWD crashes have about 8 times the fatal crashes as do non-WWD crashes. While only 41.81 of WWD crashes occurred in rural areas, 68.97% of the fatal crashes occurred there. Similar results are found for the highest severity non-fatal crashes. This is obviously the result of higher impact speeds in the rural areas. Note that additional causes of increased severity are given in the Factors Affecting Severity, Section 6, below.
- Highway Classifications (4.5) – County roads had a proportion of WWD crashes that was well over twice that of non-WWD crashes.
- All other roadway classifications were under-represented. County road characteristics no doubt contribute to the crash frequency (see 4.4). County roads are also known to be less "crashworthy" (i.e., they result in more severe crashes at comparable impact speeds).
- Locale (4.6) – Residential and Open Country roadways show a high level of over-representation (1.427 and 1.558 Odds Ratios, respectively) as compared with the more urbanized area types, especially Shopping or Business, which only has a little over half of its expected proportion.
- Most Harmful Event (4.7). All positive Max Gains are shown. Collision with Vehicle in Traffic is, by far, the most catastrophic of WWD crashes. The following items were obstacles that have over 20 occurrences in five years (at least 4 per year):

Collision with Vehicle in Traffic	3682
Crossed Centerline	54
Collision with Vehicle in (or from) Other Roadway	132
Collision with Non-Motorist: Pedestrian	42
Collision with Non-Motorist: Pedalcycle	23

- Roadway curvature and Grade (4.8). WWD crashes are dramatically over-represented on all curve types, and especially right curves. Right curves tend to throw the vehicles into the oncoming traffic lane on two-lane roads (almost all County Roads – see Section 4.5). For example, someone dozing would have a much larger problem on a right curve than on a left curve. The numbers do not show a great variation in this regard since for every vehicle on a right curve that has a WWD crash, there is a corresponding (causal or victim) vehicle on a left curve. Thus the frequency of right and left curves is nearly equal.

- **2.5 Time Factors (5.0)**
    - Year (5.1) – The years 2017, 2018 and 2020 were over-represented. Years 2016, 2017 and 2018 had a significantly larger proportion than the non-WWD. The other two, 2019 and 2020, had a smaller proportion than expected. So the general trend would seem to be a reducing number of WWD crashes in 2019 and 2020.
    - Month (5.2) – No significant over- or under-representations by month were found, and it is reasonable that WWD crash frequencies are not dependent on the time of the year.
    - Day of the Week (5.3-5.4) – This analysis is not only useful for the typical work week, but it also reflects the typical "holiday weekend" patterns. Traffic safety professional will notice that the distribution throughout the week is quite similar to that of impaired driving. Since many WWD crashes are caused by ID, that would create this distribution for WWD as well. However, this pattern is further reinforced by drivers who are not familiar with the new roads that they might be traveling, especially if they are in any way deficient in design. Assuming that a significant number of WWD crashes are caused by ID, the days can be classified as follows:
        - Typical work weekday (Monday through Thursday) – these days are under-represented in WWD crashes due to the need for many users to go to work the following day.
        - Friday – this pattern is also reflected in the day before a weekend (or holiday), i.e., before a day off. The high WWD frequency on this day is due to those who are getting an early substance abuse start to the weekend, recognizing that they have no work responsibilities the following day. However, the large numbers of non-WWD crashes on Fridays causes Friday to be statistically under-represented in WWD crash proportion compared to non-WWD crashes. This is the typical Friday general increase due to the normal rush hours coupled with individuals leaving for vacations and weekend activities.
        - Saturday – the "Saturday" pattern is the worse for WWD crashes in that it has both an early morning component (like Sunday) and a late night component (like Friday). So, it could be viewed as a combination of the typical Friday and Sunday.
        - Sunday – since this is the last day of a holiday sequence or weekend, its over-representation comes mainly from those who start on Saturday night and do not complete their use of alcohol/drugs until after midnight. Sunday is the most over-represented day with over twice its expected number of WWD crashes; however, the low number of non-WWD crashes on Sunday also contributes to this proportional over-representation.

- Time of Day (5.4-5.5) – The extent to which night-time hours are over-represented is quite striking. Optimal times for WWD enforcement would start immediately following any rush hour details on Friday (or its equivalent pre-holiday), and would continue through at least 1:00 to 1:59 AM (odds ratio 1.720). The 2-4 AM hours are also significantly over-represented, but with lower odds ratios, and then it increases again at 4:00 to 4:59 AM. Some of the late-night WWD crashes will also be due to drowsiness and/or the diminished ability to see road edge lines.
- Time of Day by Day of the Week (5.6) – This quantifies the extent of the crash concentrations on Friday nights, Saturday mornings and Saturday nights and early Sunday mornings. This is a very useful summary for deploying selective enforcement details, especially during the weekend hours.

- **2.6 Factors Affecting Severity (6.0)**
  - WWD Crash Severity (6.1) -- The rate of injuries and fatalities are consistently higher in WWD crashes than that of non-WWD crashes. Fatality crashes are nearly 7.883 (Odds Ratio) times their expected proportion, while the two highest non-fatal injury classifications also have high proportions when compared with non-WWD crashes.
  - Speed at Impact (6.2) – All impact speeds from 21-55 MPH are highly over-represented with Odds Ratios above 1.30. See the next attribute for the effect this has on fatalities. Speeds above 55 MPH are generally under-represented, probably reflecting the lower speed requirements of County roads. Of course, in a head-on collision, the speed of either one of the vehicles is not as important as the combined speeds of both vehicles. This is the reason for the extremely high severity of these types or crashes, as shown in Section 6.1. Past analyses have found the general rule of thumb that for every 10 MPH increase in impact speeds, the probability of the crash being fatal doubles. This was validated in the discussion below of the cross-tabulation of impact speeds by severity (6.4).
  - Severity by Impact Speed (6.3-6.4) –Past analyses have found the general rule of thumb that for every 10 MPH increase in speeds, the probability of the crash being fatal doubles. This was further validated in the discussion of this cross-tabulation. In the 31-35 MPH impact speed the probability is only a little over one in every 70 crashes. As impact speeds climb to the 46-55 MPH, this probability more than doubles to one in about 22 crashes. At 76-85 MPH it increases again (exponentially) to one in about every 2 crashes. For above 100 MPH, effectively all crashes proved fatal. While not 100%, in most cases the driver at the higher of the two vehicle speeds is the causal driver. Assuming this to be the case, approximately 38% of the fatalities were in the victim vehicle as opposed to the causal vehicle.

- Restraint Use by WWD Crash Causal Drivers (6.5) – The WWD causal drivers are over 3 times more likely to be unrestrained than non-WWD causal drivers. Clearly WWD drivers lose a good part of their concept of risk when they do not realize that they are in a lane with oncoming traffic. This rate is about the same as run-off-the-road crashes. In both cases alcohol/drug abuse is a major factor (see Sections 8.2 and 8.3.
- Fatality Crashes by Restraint Use for WWD crashes (6.6) – A comparison of the probability of a fatal crash indicates that a fatality is almost seven (6.90) times more likely if the WWD causal driver is not using proper restraints. Generally, one in 34.5 WWD crashes are fatal; but without restraints, the fatal crash ratio is 1 in about 5, an increase in probability of close to seven times. So the combined effect of lower restraint use and higher speeds is a devastating combination that accounts for much of the high lethality of WWD crashes.
- Number of Vehicles Involved (6.7) – the number of single vehicle WWD crashes is only about a third (0.365) of crashes in general. Close to 9 out of 10 (86.98%) of the crashes were two-vehicle. This is expected since most of the crashes involved one vehicle running off their lane and crashing into a second vehicle, usually coming in the opposite direction.
- Police Arrival Delay (6.8) – WWD crashes generally did not have good police response times. Arrival delay times of ten minutes or less occurred only 40% of the time. All arrival delays over 12 minutes or above were significantly over-represented. There can be little doubt that this has to do with so many of them being in rural areas (41.81%, see Section 4.3). The next analysis below shows how this impacts EMS arrival time, which is a comparison of those crashes that only include injuries, and thus would generally call for an EMS response.
- EMS Arrival Delay (6.9) – For much the same reasons as the police arrival delays, EMS delays were under-represented for Wrong Way Driving (WWD) crashes in the 0-5 and 6-10 minute categories. All longer delay times were over-represented. There were relatively few in these very long categories, which were probably caused by the crash not be discovered late night.

- **2.7 Driver and Vehicle Demographics (7.0)**
  - Driver Age (7.1) – Younger (16-20 year old) drivers have proportions of WWD crashes that are lower than their non-WWD crashes. Ages 31 and above are generally over-represented, perhaps due to problem impairments (alcohol/drugs). Several ages tend to be over-represented above the age of 55, with very little consistency.
  - WWD Crash Driver Gender (7.2) – the breakdown in WWD causal drivers is 60.91% male and 39.09% female. For non-RC, the percentage is 56.15 male and 43.85 female, which also gives a good estimate for male/female drivers in

general. These differences in proportions certainly indicate that males are a greater cause of the WWD problems, and if there are countermeasures that can be directed toward them, doing so would be much more cost-effective than those directed toward all drivers, all other things being equal.

- Causal Vehicle Type (7.3) – Pickup Trucks have the highest for potential crash reduction according to the Max Gain, but Passenger Cars have about the same Odds Ratio with a much higher frequency. So both need to be given top consideration. Pedestrian and Bicyclists have relatively much higher proportions than most other vehicles, which is counter to both legal requirements and common warnings for these transportation modes. Several of the other classifications have significant over-representations, indicating from their proportions that they need to be given additional consideration. Some vehicles, notably Tractor/Semi-Trailers, Mini-vans, Pick-Ups and Sport Utility Vehicles (SUVs) are *under*-represented indicating their tendency to avoid WWD crashes.
- Number of Pedestrians (7.4). Pedestrians are quite over-represented in WWD crashes (actually, Wrong Way Walking), indicating that many pedestrian crashes occur when pedestrians walk with the traffic as opposed to against it. This is useful information for pedestrian crash reduction. Pedestrians need to be educated as to the advantages of being able to see oncoming traffic, and the need at night to have a flashlight, or at least reflective clothing, is essential to being seen.
- Number of Pedalcycles involved (7.5). The number of pedalcycle crashes is very close to that of pedestrians. Unlike pedestrian WWD, Pedalcycle WWD would be riding against traffic. Traffic laws require that bicycles and other similar vehicles travel with the traffic as opposed to against it. These data indicate that these laws are consistent with crash prevention.
- Driver License Status (7.6) – WWD crashes are significantly over-represented in being caused by drivers without legitimate licenses. About 15% of the WWD causal drivers did not have a legitimate driver's license. The following gives the highest over-represented categories along with the number of crashes (in parenthesis) that were attributed to the DL Status: Suspended (1,815), Revoked (893), Expired (814), and Cancelled (33).
- Driver Employment Status (7.7) – WWD driver unemployment rate at 27.32%, and its proportion is about 50% higher than expected. This factor should be watched carefully going forward, especially to determine if there is not some countermeasure that could be implemented in conjunction with their unemployment payments.

- **2.8 Driver Behavior (8.0)**
  - Primary Contributing Circumstances (8.1). This was introduced at the end of Section 1.0. While clearly the problems found in this study are those of WWD,

other driver behaviors (8.2) that are correlated with WWD might provide alternatives for countermeasure development. Those behaviors that had over twice their expected PCC proportion when compared to non-WWD crashes are:

- Driving too Fast for Conditions
- Impaired Driving (DUI)
- Swerved to Avoid Vehicle
- Fatigued/Asleep,
- Aggressive Operation,
- Over Correcting/Over Steering
- Swerved to Avoid Animal [most often deer]
- Over Speed Limit
- Swerved to Avoid Object.

These were the Primary Contributing Circumstances that were at least doubly over-represented even though the standard WWD filter was in effect (indicating that WWD was identified by attributes other than that of PCC).

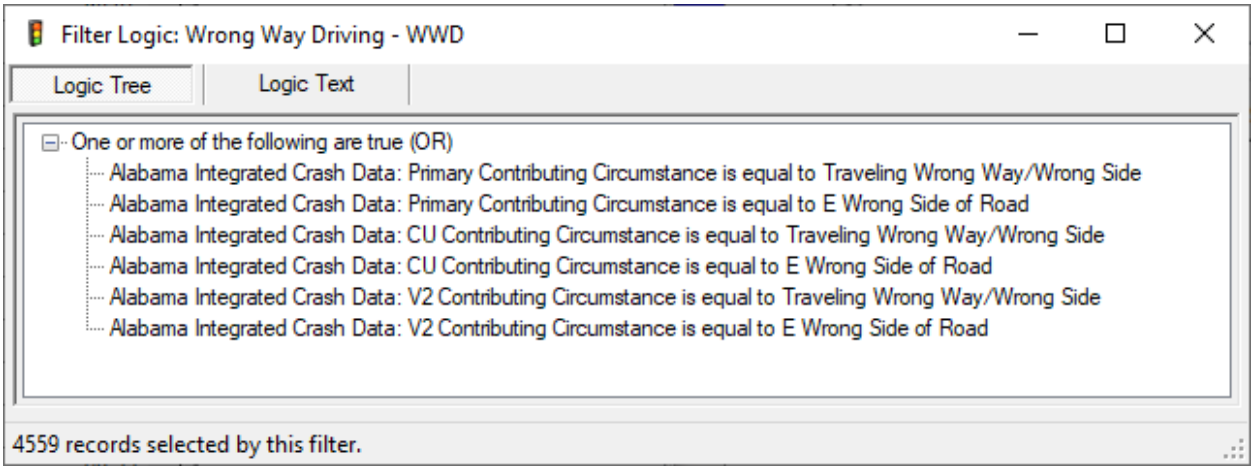
- CU Officer's Opinion Impaired Driving – Alcohol (8.3). We saw ample evidence for WWD crashes being caused by Impaired Driving (ID) in the time of day and day of the week. The two ID attributes (C122 and C123) indicate the degree that ID was involved in WWD crashes as opposed to non-WWD crashes. For alcohol, the proportion of ID crashes was 3.619 times as many for WWD crashes as for non-WWD crashes. For drugs this multiplier was even greater at 3.894. This was sufficient to verify that the WWD time over-representations reported above, were correlated very closely to ID.
- CU Officer's Opinion Impaired Driving – Non-alcohol Drugs (8.4). The reported non-alcohol drug cases for WWD crashes is less than half of that for alcohol. The 1,464 cases are only about 4.00% of all WWD crashes. However, the Odds Ratio indicates that it has an over-representation comparable to alcohol. In both cases (WWD and non-WWD), drug use is difficult to detect compared to alcohol, which has well-established tests for the blood-alcohol level that are relatively easy to administer. Our conclusion is that both alcohol and non-alcohol drug use are major contributors to increasing the frequency of WWD crashes, and their use and severity is further compounded by trying to avoid detection by using county roads.

3.0 Wrong Way Driving (WWD) crashes CY2016-2020

As part of the ongoing Alabama Office of Traffic Safety (AOTS) problem identification efforts, UA-CAPS and ATI compared FY2016-2020 (WWD) crashes against non-WWD crashes over this same 5-year time period. The goal was to determine all significant differences between these two subsets of data, and to pinpoint common factors to assess strategies that could be used to combat any major inconsistencies between these two subsets of the crash data. The findings are presented to be taken into consideration when planning the large variety of countermeasures that exist to reduce the frequency and/or severity of these crashes.

3.1 WWD Filter Definition

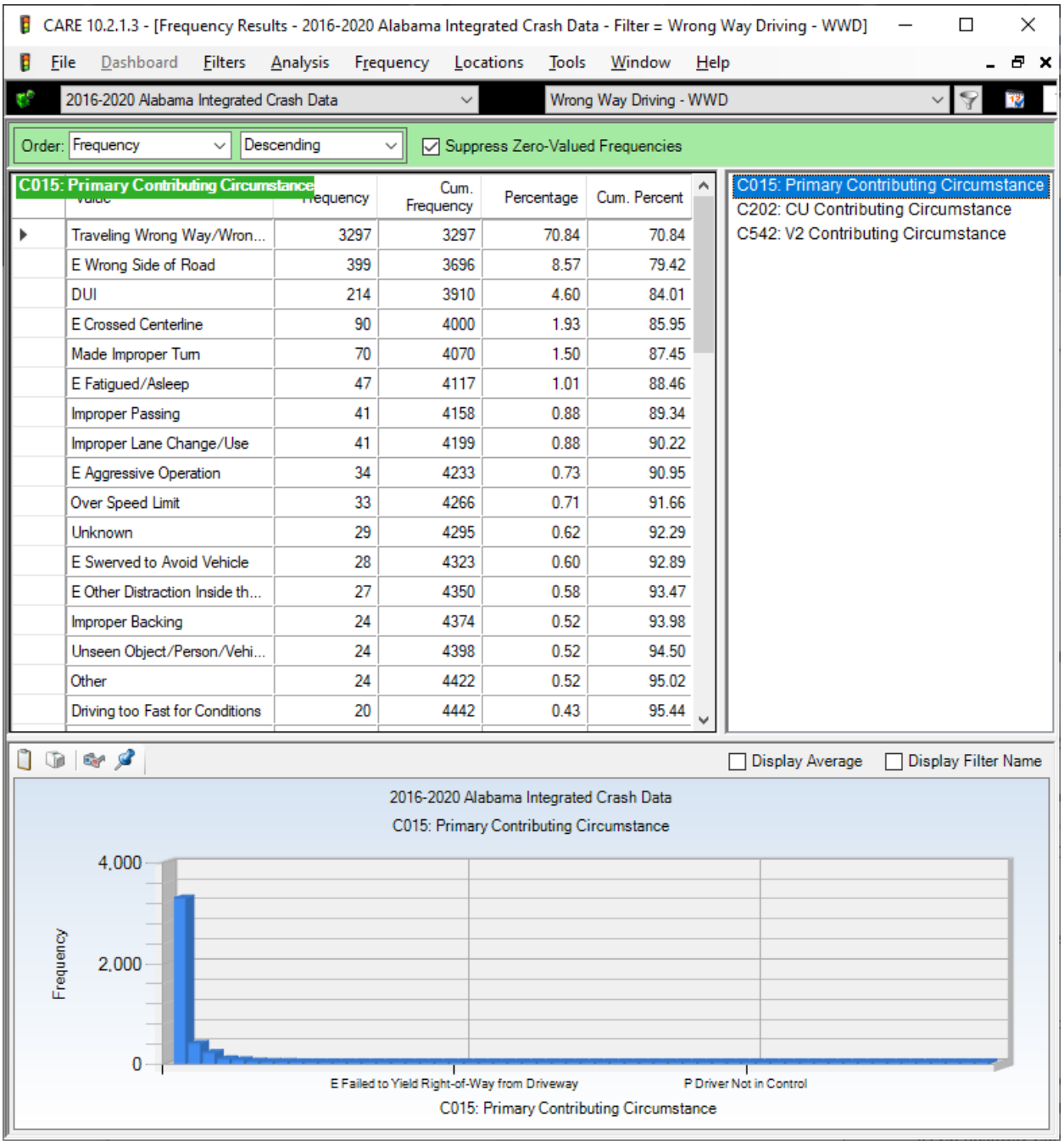
The following is the formal filter definition for Wrong Way Driving (WWD) crashes:



This formalizes the definition of the crashes in the WWD subset of crash reports being considered here. As mentioned above, these crashes are those reported to have either: (1) a Primary Contributing Circumstance, (2) a Causal Unit Contributing Circumstance, or (3) a V2 (second vehicle often called the Victim Vehicle) Contribution Circumstance of either: (a) Wrong Way/Wrong Side, or (b) Wrong Side of the Road.

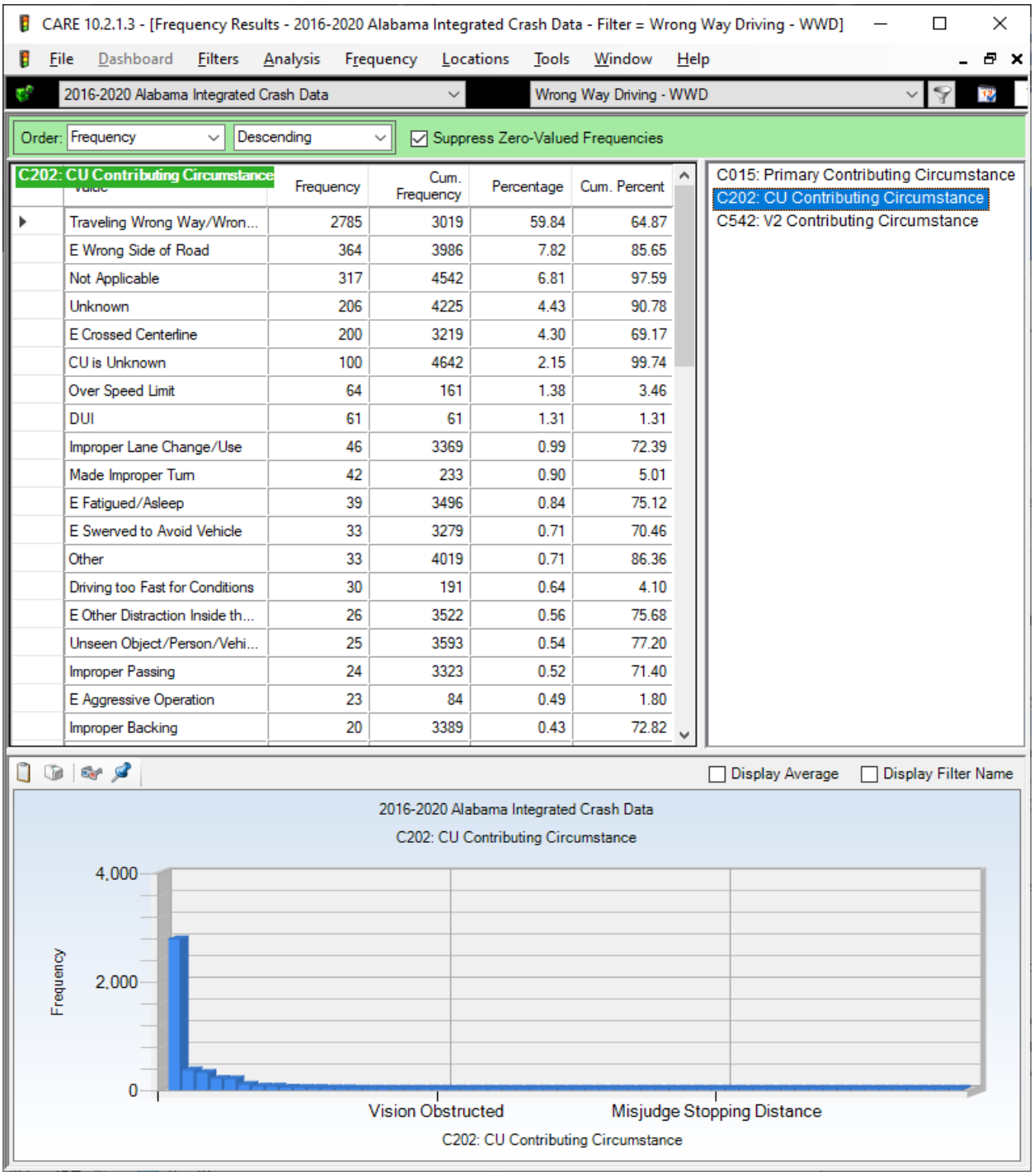
With this filter in effect, we will now present the frequency distributions for each of the attributes that appear in the filter. These attributes are ORed together, so if any one of them showed WWD, the record will be included in the WWD subset. These three Frequency displays essentially show in a nutshell those non-WWD attributes that are highly correlated with WWD crashes. They are arranged with those of the highest at the top. The reason that non-WWD crashes are included in some displays is that the WWD requirement was met by one or two of the other Contributing Circumstance variables.

3.1.1 C015 Primary Contributing Circumstances with WWD Filter in Effect



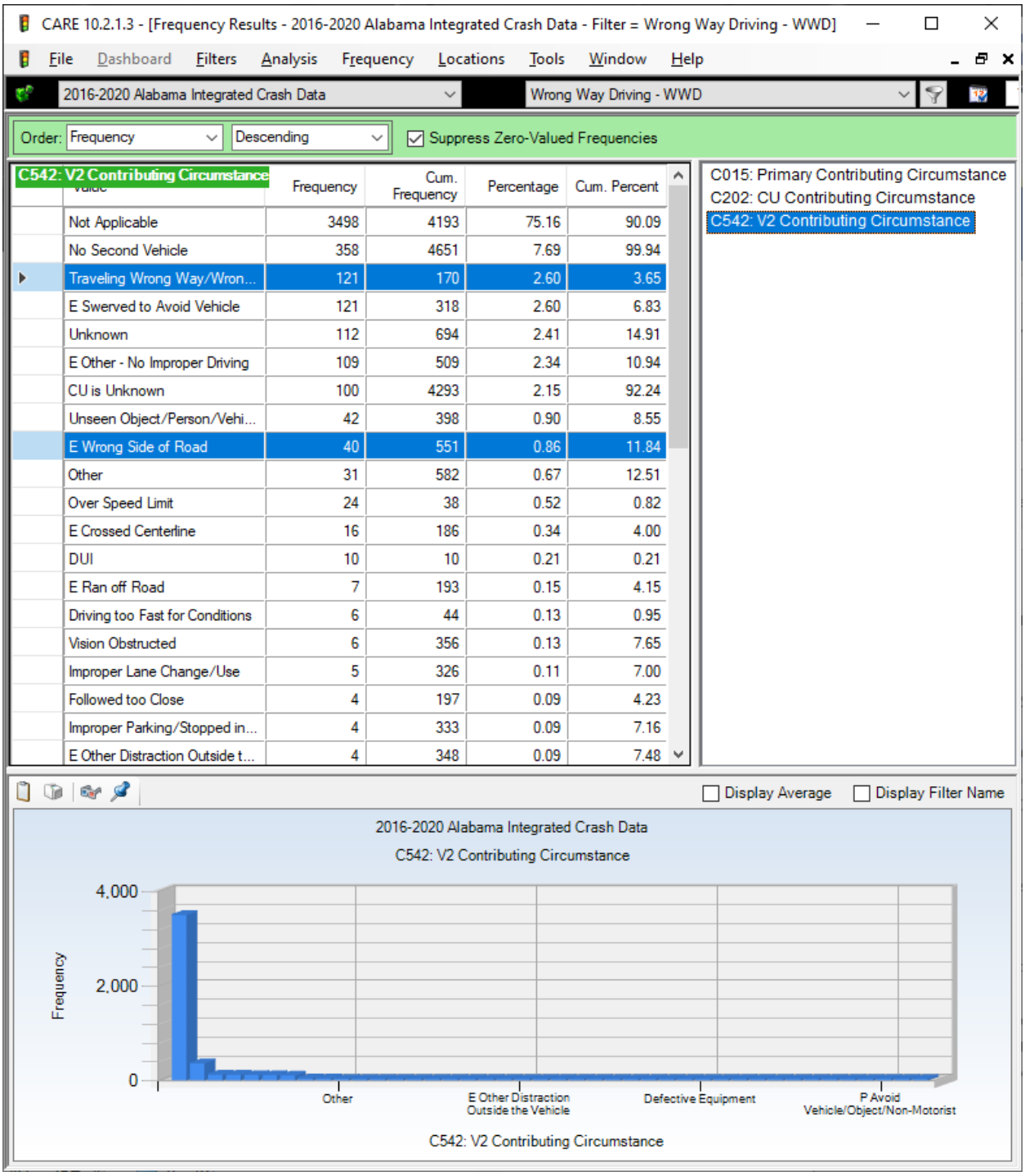
Items with less than 20 occurrences over the five years have been omitted from the above. See Section 8.1 for more details on the use of this attribute within this context of WWD.

3.1.2 C202 Causal Unit (CU) Contributing Circumstances with WWD Filter in Effect



Items with less than 20 occurrences have been omitted from the above.

3.1.3 C542 V2 Contributing Circumstances with WWD Filter in Effect

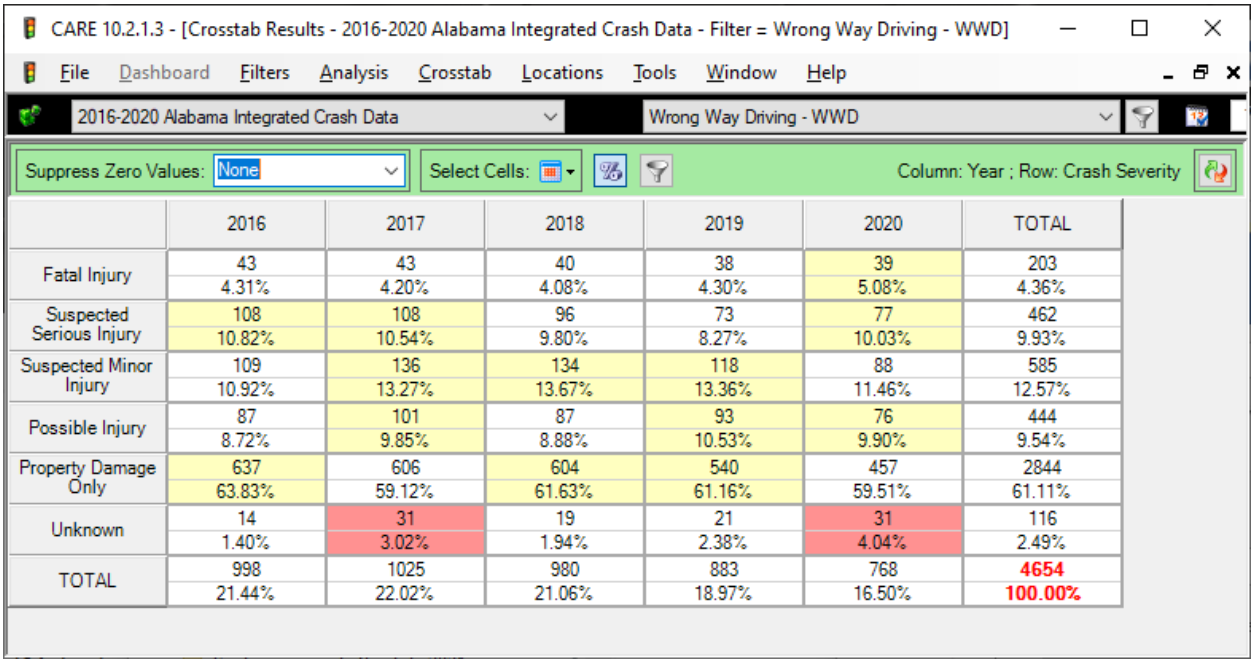


Items with less than 4 occurrences have been omitted from the above.

3.2 Overall WWD Crashes by Year 2016-2020 Data

Before analyzing the WWD subset, it is good to get a feel for the overall difference in the crash frequencies over the past years. The following table gives a comparison of total crashes over CY2016-2020 by severity.

WWD Crashes by Severity for Calendar Years 2016-2020

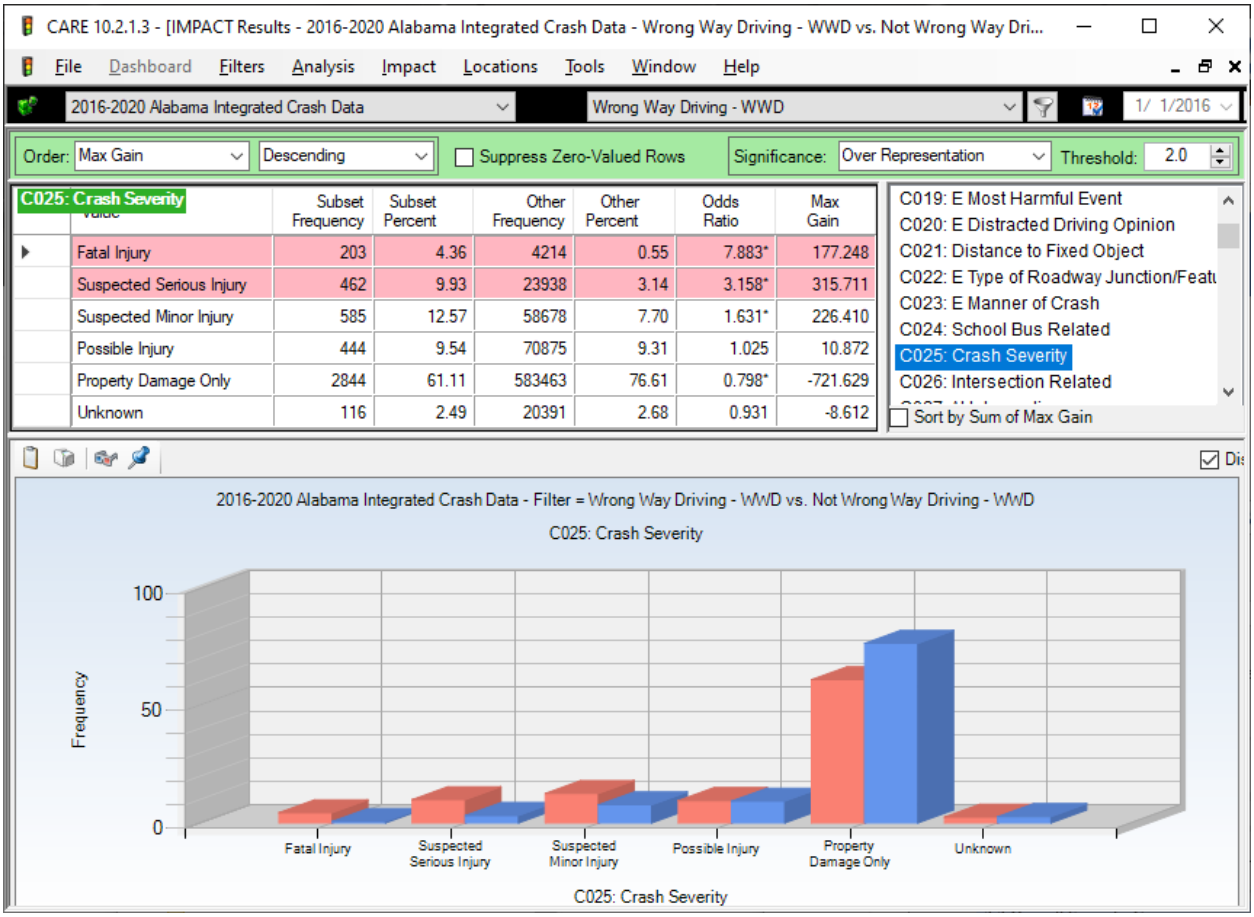


	2016	2017	2018	2019	2020	TOTAL
Fatal Injury	43 4.31%	43 4.20%	40 4.08%	38 4.30%	39 5.08%	203 4.36%
Suspected Serious Injury	108 10.82%	108 10.54%	96 9.80%	73 8.27%	77 10.03%	462 9.93%
Suspected Minor Injury	109 10.92%	136 13.27%	134 13.67%	118 13.36%	88 11.46%	585 12.57%
Possible Injury	87 8.72%	101 9.85%	87 8.88%	93 10.53%	76 9.90%	444 9.54%
Property Damage Only	637 63.83%	606 59.12%	604 61.63%	540 61.16%	457 59.51%	2844 61.11%
Unknown	14 1.40%	31 3.02%	19 1.94%	21 2.38%	31 4.04%	116 2.49%
TOTAL	998 21.44%	1025 22.02%	980 21.06%	883 18.97%	768 16.50%	4654 100.00%

We conclude from considering the percentage numbers at the bottom of the table that 2016-1018 were significantly higher in total WWD crashes than 2019 and 2020. However, there was a general reduction in crashes in 2020 due to the COVid-19 restrictions. Fatal crashes were fairly stable over these years, while Suspected Serious Injury followed the pattern of total WWD crashes.

3.3 Overall Severity Comparisons: WWD vs nonWWD

The following presents a comparison of the severities of WWD crashes over the five-year period (2016-2020) against non-WWD crashes. The *Subset Frequency* and *Subset Percent* are for WWD crashes, while the *Other Frequency* and *Other Percent* are for non-WWD crashes. Comparisons must be against the percentage columns because the large disparity in the sample sizes between the WWD and non-WWD crashes makes their frequencies not comparable.



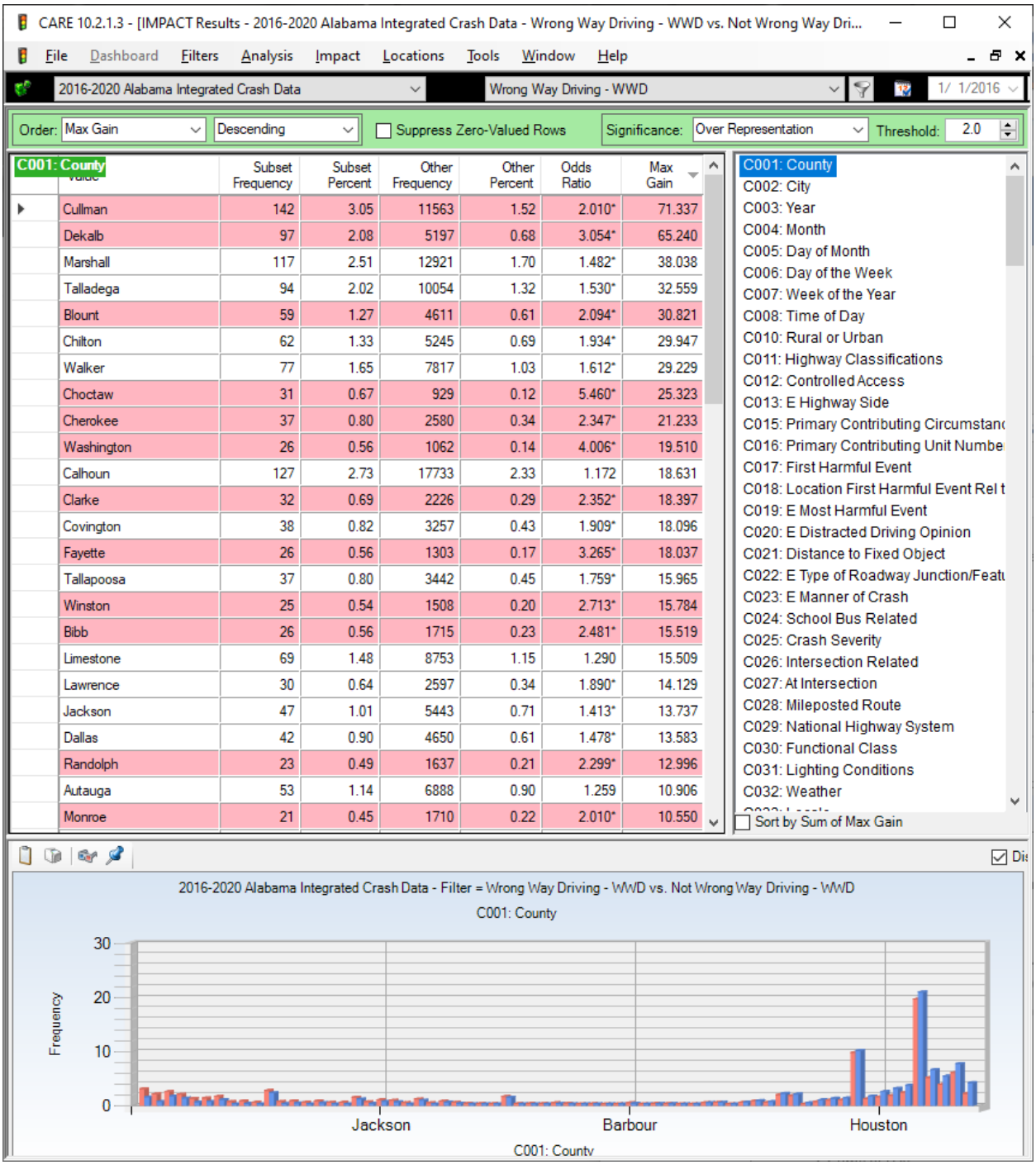
It is clear (and certainly no surprise) that WWD crashes are generally more severe than their non-WWD counterparts. The top three injury values are significantly over-represented, and the two top most severe have at least twice the proportion of the non-WWD crashes. For fatal crashes the Odds Ratio multiplier is almost eight times (7.883) the non-WWD crashes. In the other injury severities, there is a very significant increase in the Suspected Serious Injury category with an Odds Ratio indicating over 3 times the proportion of the non-WWD crashes. The Suspected Serious Injury difference tends to confirm the increase in the fatal crashes, since quite often the characteristics of Serious Injury crashes are not at that different from those crashes that are fatal.

The following sections (4.0-8.0) provide the IMPACT displays for the various attributes that could have an influence on countermeasure development. The outputs are ordered by highest Max Gain first unless otherwise indicated in the IMPACT "Order" box (located upper left just under the data description). *Max Gain* is a term that CARE users have assigned to indicate *the number of crashes that would be reduced if the respective proportion value was not at all over-represented* (i.e., it had an Odds Ratio of 1.000). An over-represented value of an attribute is the situation where that attribute has a greater share (proportion) of WWD crashes than its non-WWD counterpart. Thus, the non-WWD attribute proportion are serving as the control to which the WWD crash attributes are being compared. In this way anything different about WWD crashes surfaces, and they can be subjected to further analyses. The analytical technique employed to generate most of the displays below is called Information Mining Performance Analysis Control Technique (IMPACT). For a detailed description of the meaning of each element of the IMPACT outputs, see:

http://www.caps.ua.edu/software/care/

4.0 Geographic and Harmful Event Factors

4.1 County



The above has omitted all items with a Max Gain of less than 10. It is arranged in highest Max Gain order to indicate the counties that have the highest potential for gain if they were to eliminate their over-representations. Cullman, DeKalb, Marshall, Talladega, Blount and Chilton have the highest potentials for WWD reductions, with Max Gains over 30 crashes each. The display above contains all of the counties with Odds Ratios greater than 2.000 (red backgrounds).

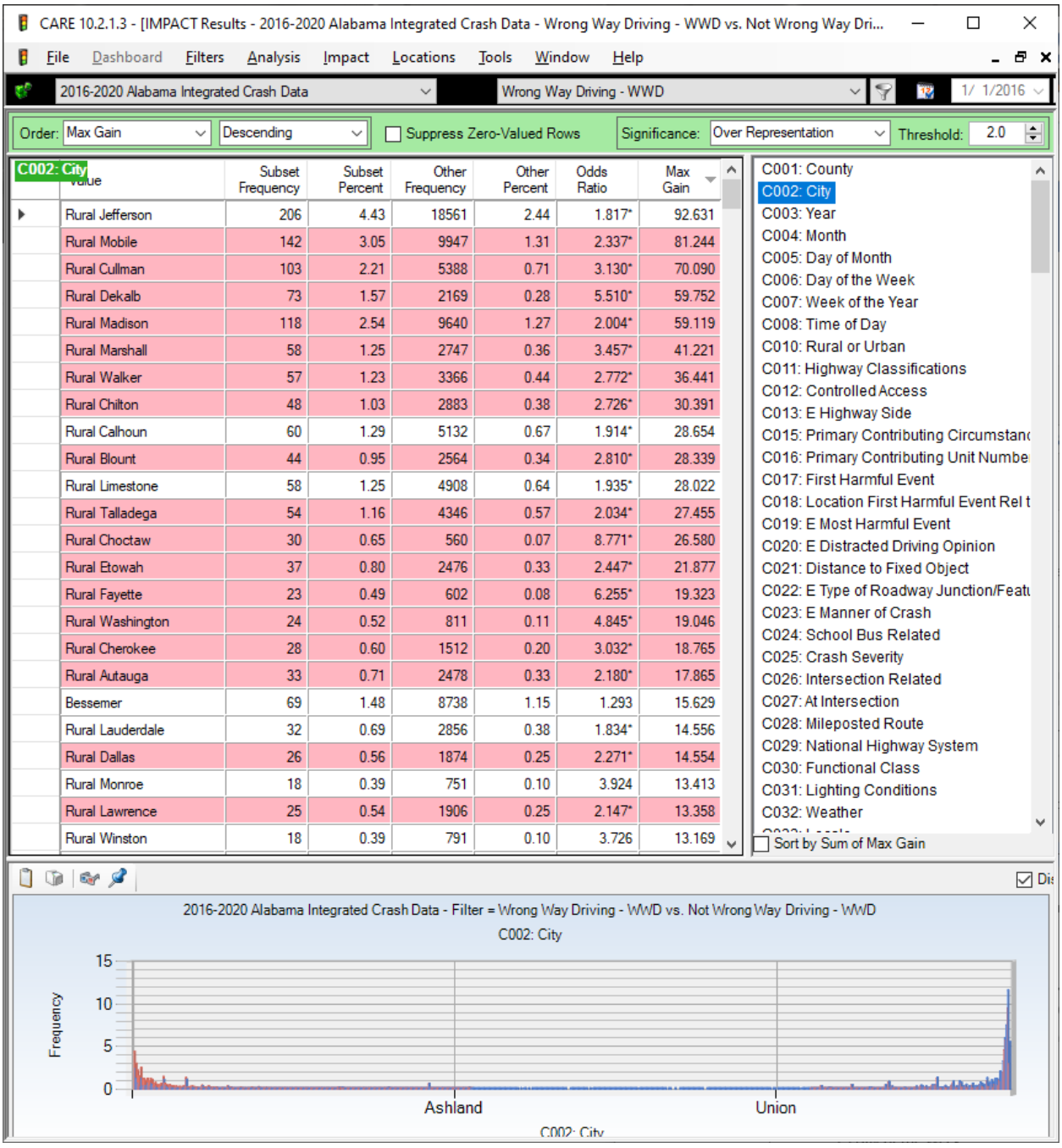
At the other end of the spectrum, the counties with large cities (e.g., Shelby, Madison, Tuscaloosa, Montgomery, Jefferson, and Baldwin) were the most under-represented counties. Although some of their numbers of WWD crashes are quite large, the number of non-WWD crashes are even larger

4.2 Cities Over-represented by Highest Max Gains (Including Rural Areas)

For comparison purposes, the rural areas of counties are considered to be "virtual cities" in that crashes that occur there are listed as "Rural County Crashes" so that these crashes can be effectively accounted for and compared. Generally, these rural areas are adjacent to (or contain) significant urban areas. Contrasted with this finding, there was significant under-representation for Wrong Way Driving (WWD) crashes in the largest cities themselves (e.g., Huntsville, Birmingham, Mobile, Tuscaloosa, Hoover, etc.).

The output display below is a list of what are considered to be the most critical cities and county rural areas (virtual cities) because of their high Max Gains, which indicate the potential for crash reduction. The criterion for this list was a Max Gain of 13 or more crashes. The red background indicates those (virtual) city areas that had over twice their expected proportion of WWD crashes (Odds Ratio).

[Terminology: The *Expected proportions* here and below are obtained from the proportion for non-WWD crashes. The non-WWD proportions are those that are *expected* of the WWD crashes. Thus, any significant positive deviation from this expected value would show that the attribute is over-represented.]



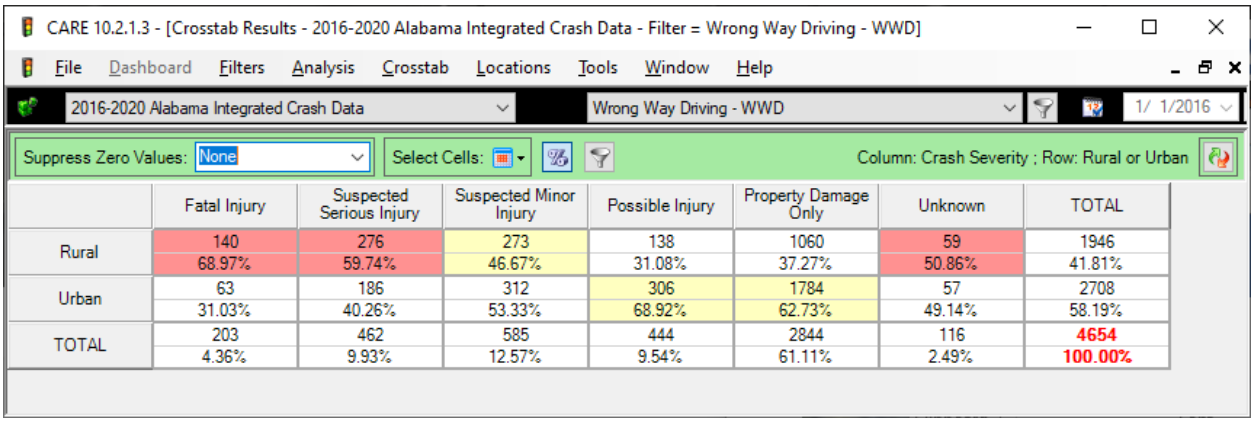
This display is in Max Gain ordering to put those cities that have the highest potential for WWD crash reduction at the top.

4.3 Rural or Urban

The rural areas of the counties (considered as virtual cities above) demonstrated how WWD is more of a rural than an urban problem. The difference (between WWD and non-WWD) in the Urban proportions is 0.753, and for the Rural proportion difference, it is 1.836 (see their Odds Ratios). So, it is clear that the rural/urban mix is different in the WWD and non-WWD crashes. It will be interesting to study other similar attributes, such as Locale. The severity comparison immediately below indicates that the Rural area crashes were *much more lethal* in their severity than were the Urban area crashes.

4.4 Severity of Crash by Rural-Urban

In the above output the proportion of WWD to non-WWD crashes tends to be nearly twice as much in the rural as in the urban areas. It is interesting to perform a cross-tabulation over the rural and urban areas to determine the extent to which rural crashes might be causing more fatalities (and more severe injuries) than would be expected from just a comparison of their crash frequency proportions. The following, *which is strictly for WWD crashes*, answers this question.

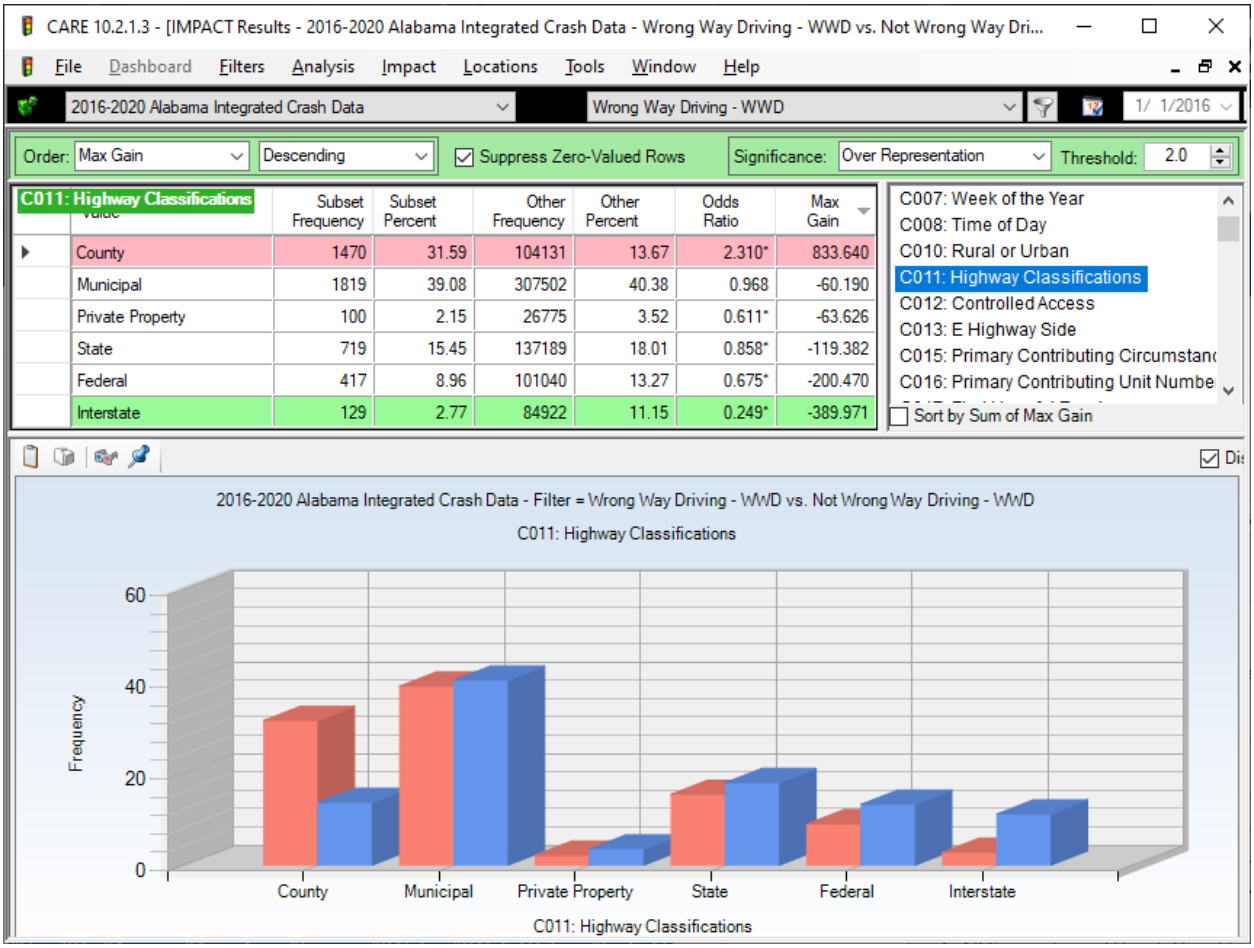


	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Property Damage Only	Unknown	TOTAL
Rural	140 68.97%	276 59.74%	273 46.67%	138 31.08%	1060 37.27%	59 50.86%	1946 41.81%
Urban	63 31.03%	186 40.26%	312 53.33%	306 68.92%	1784 62.73%	57 49.14%	2708 58.19%
TOTAL	203 4.36%	462 9.93%	585 12.57%	444 9.54%	2844 61.11%	116 2.49%	4654 100.00%

The red cells in the cross-tabulation above indicate over-representation by more than 10%. For example, while 41.81% of all the crashes were in the Rural areas, 68.97% of the fatal crashes occurred there. It is imperative to take into consideration crash severity when making geographical decisions regarding countermeasure implementation. Any of the geographic analyses shown in this report could be restricted to fatal crashes or some combination of fatal and severe injury crashes for this purpose.

Clearly fatalities and the highest severity of injuries are over-represented in the rural areas, since all three of the most severe crashes are significantly over-represented there. The reason for this is the higher speeds in the rural areas that result in higher impact speeds (see Section 6.2).

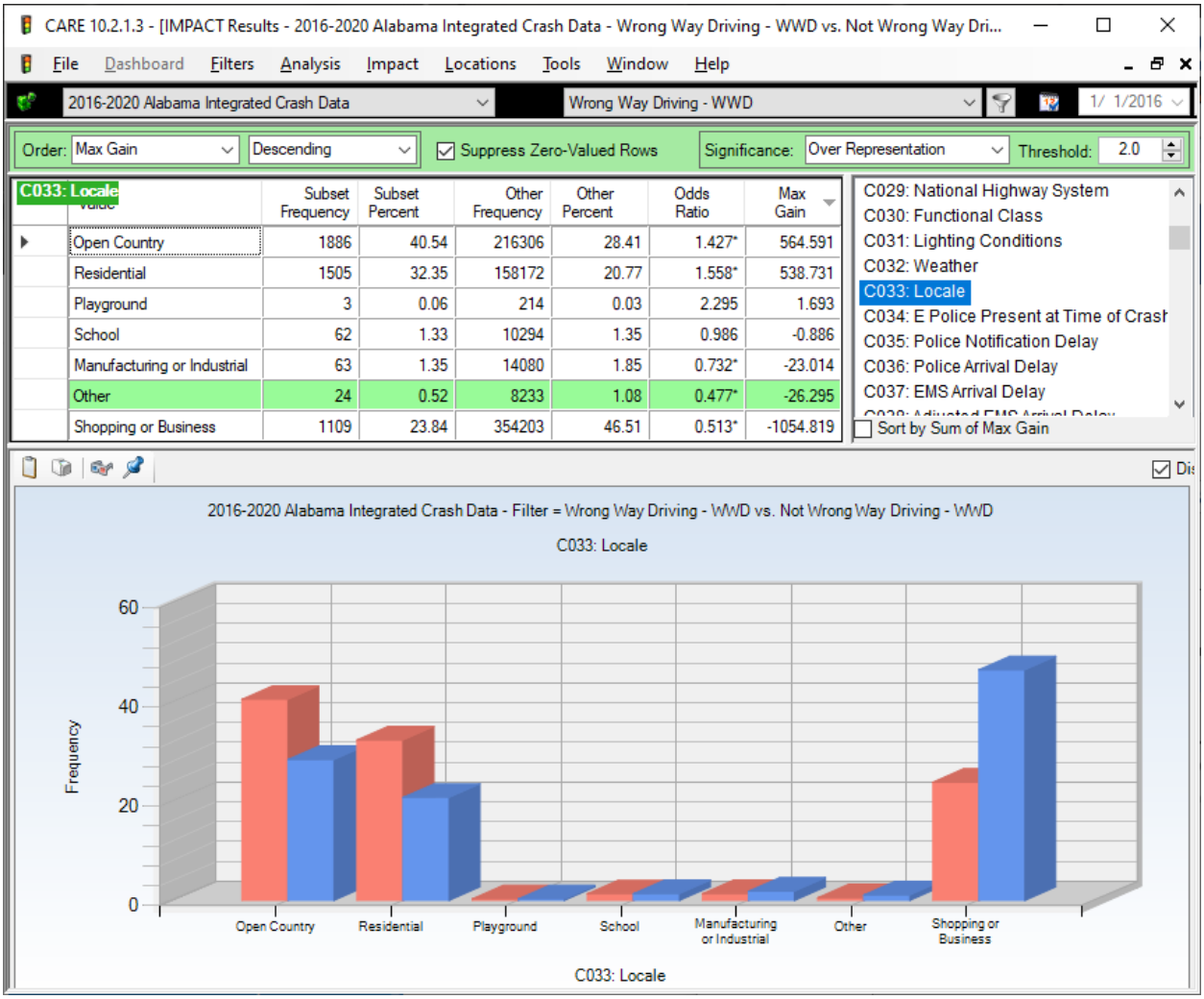
4.5 Highway Classification



Analysis of highway classifications indicates that WWD crashes had their greatest over-representation on county roads (Odds Ration 2.310 is over twice that that expected). None of the other road types are over-represented, and Private Property, State, Federal and Interstate are all significantly under-represented. Municipal roadways were very close to that expected from the non-WWD proportion.

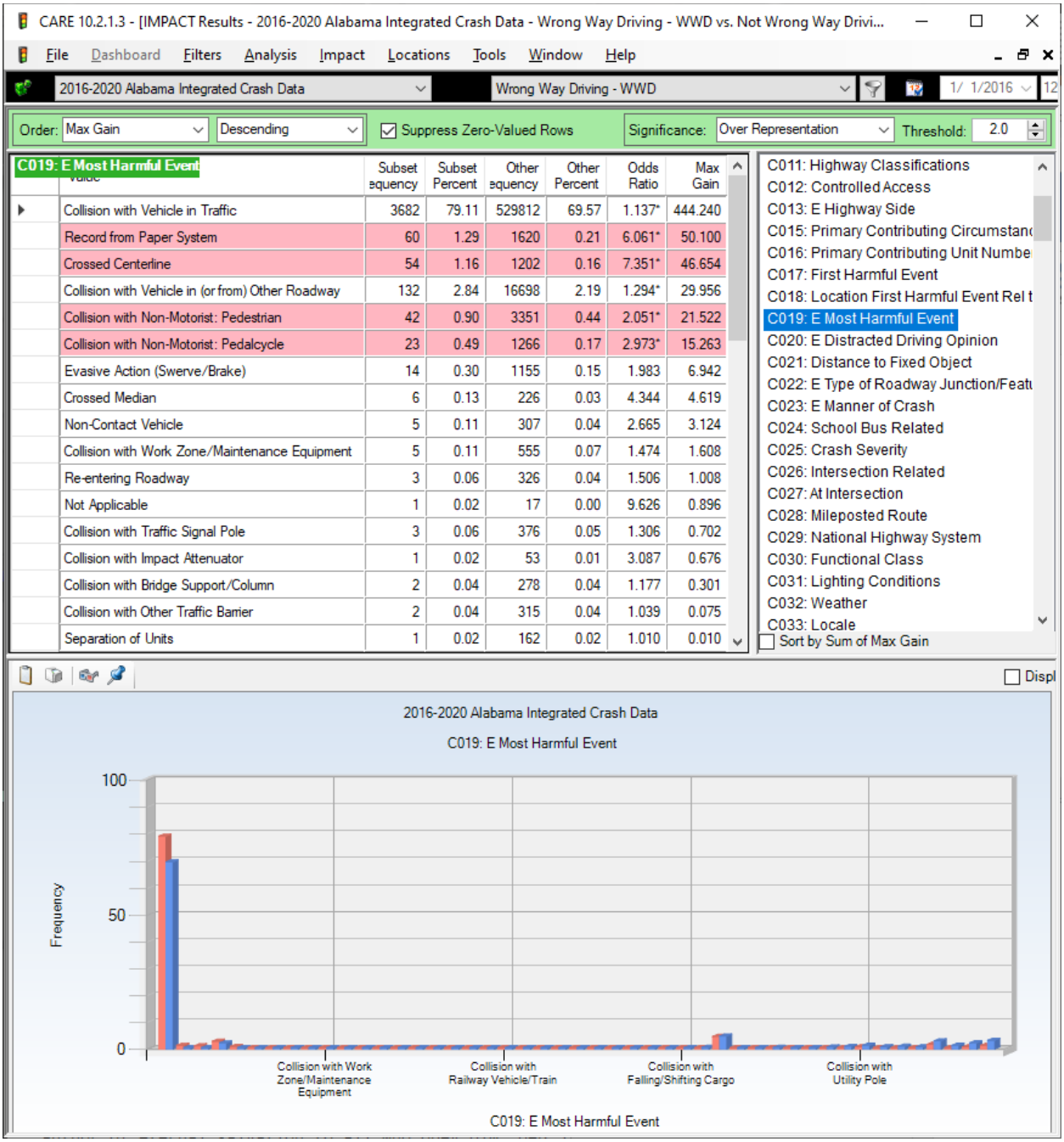
It is recommended that hotspot analysis be performed to identify the specific county roads that are most highly over-represented, and that some enforcement activities be conducted on the county roads in an attempt to move this traffic onto the safer (more forgiving) roadways. Law enforcement presence alone could have a major effect here, since a major problem is speed, and will be shown below (Section 6.2).

4.6 Locale



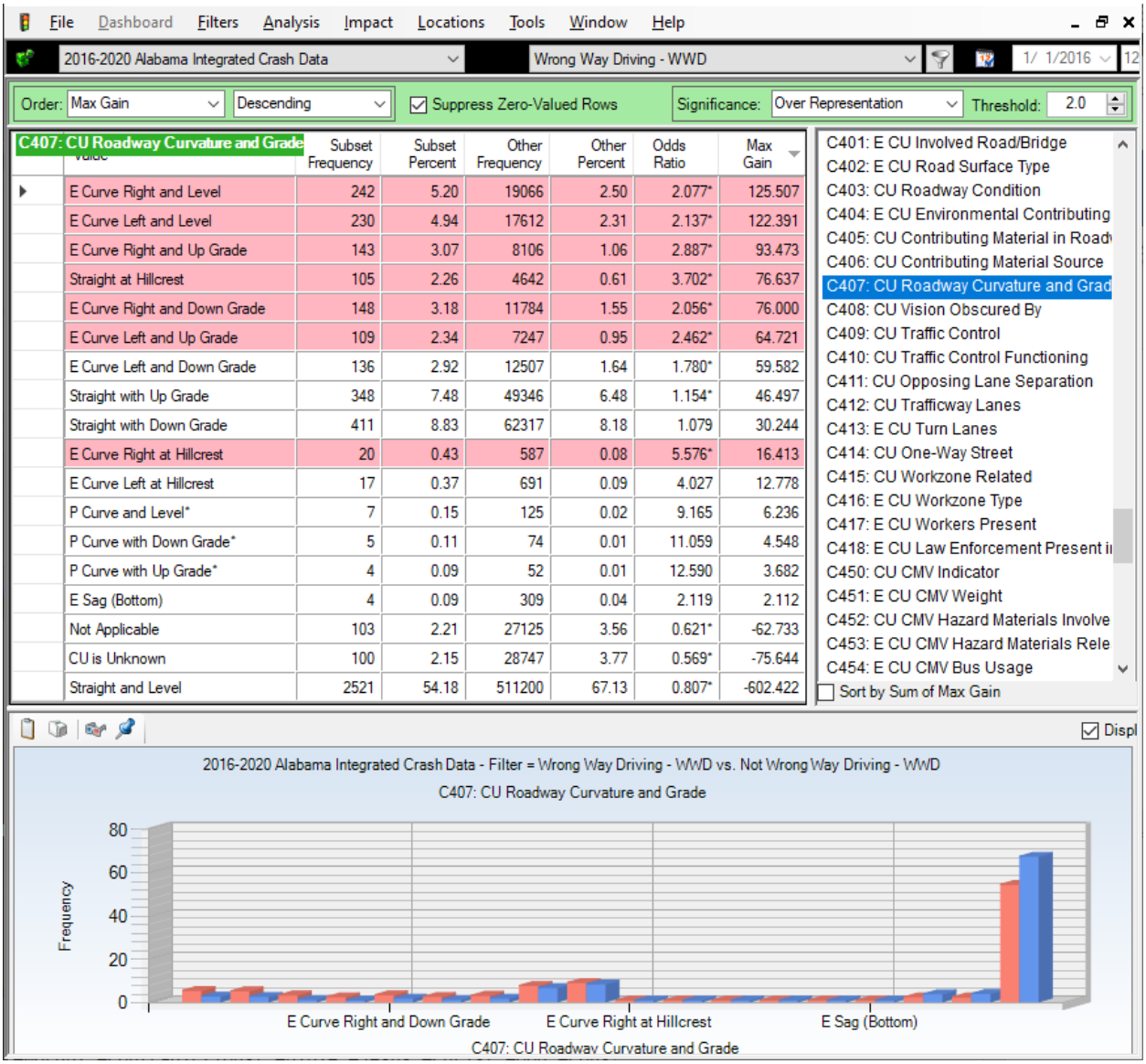
Open Country and Residential roadways show a higher level of over-representation as compared to the more urbanized classifications. This is quite consistent with the rural/urban comparison given above. There are considerable "Open Country" areas within the formal city limits of most cities, and this seems to be where many of the WWD crashes are occurring.

4.7 Most Harmful Event



The display above is for all positive Max Gains. Head-on collisions are the most deadly, and this display indicates that WWD often ends up in such crashes. In the majority of crashes involving pedestrians and pedacycles, it is the non-motorist that is on the wrong side of the roadway. Note how both of these are very highly over-represented in WWD and WWWalking.

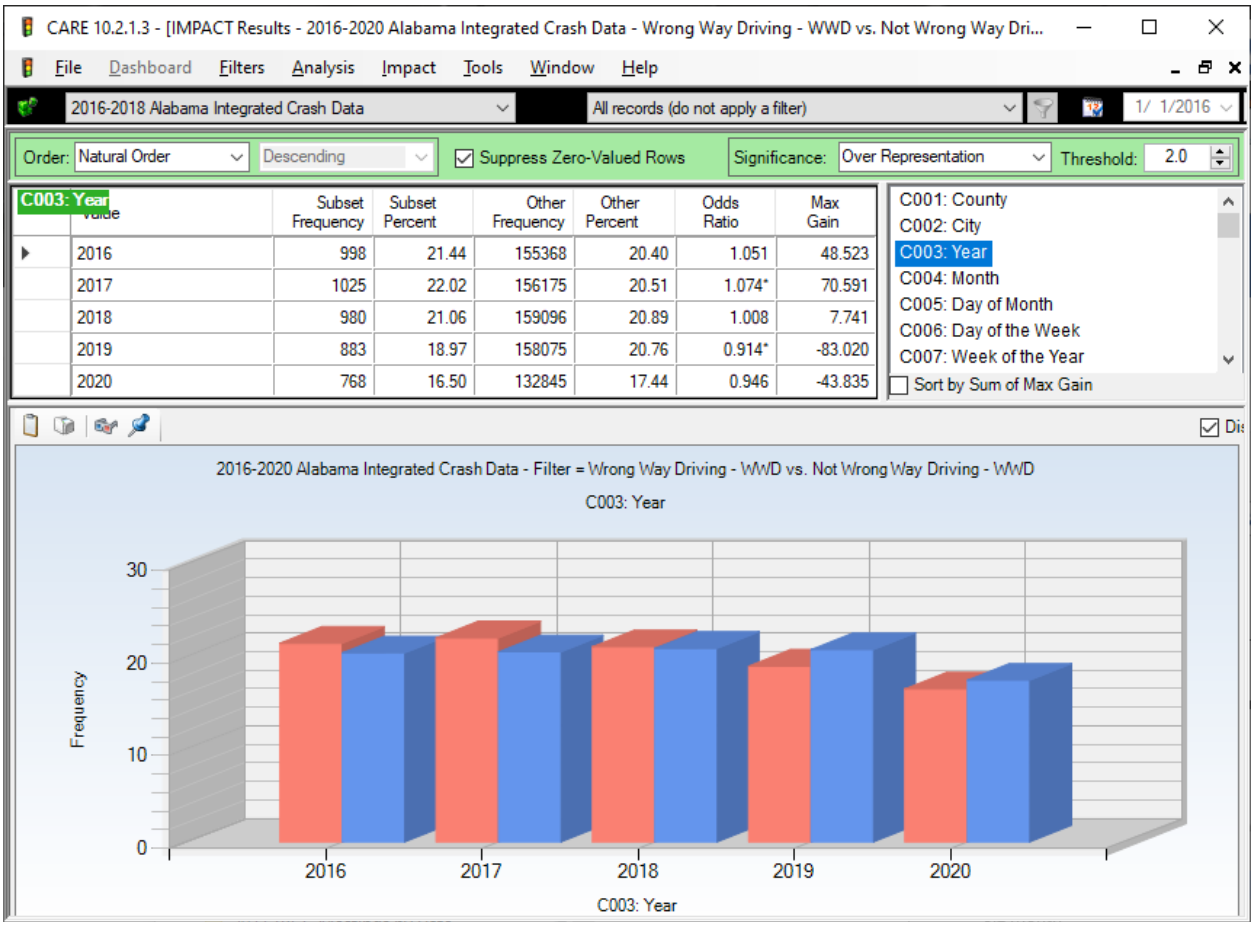
4.8 CU Roadway Curvature and Grade



The display above is in Max Gain order. It is not surprising that WWD crashes are dramatically over-represented on all types of curves. The most under-represented item is Straight and Level, and the high bars to the right represent 511,200 (67.13%) of non-WWD crashes and 2521 (54.18%) WWD crashes. Right curves tend to throw these vehicles into the oncoming traffic lane on two-lane roads (almost all County Roads – see Section 4.5). For example, someone dozing would have a more difficulty staying in their lane on a right curve than on a left curve, although the numbers above do not show a great variation in this regard. The close frequencies illustrate the reality that for every right curve there is an accompanying left curve.

5.0 Time Factors

5.1 Year

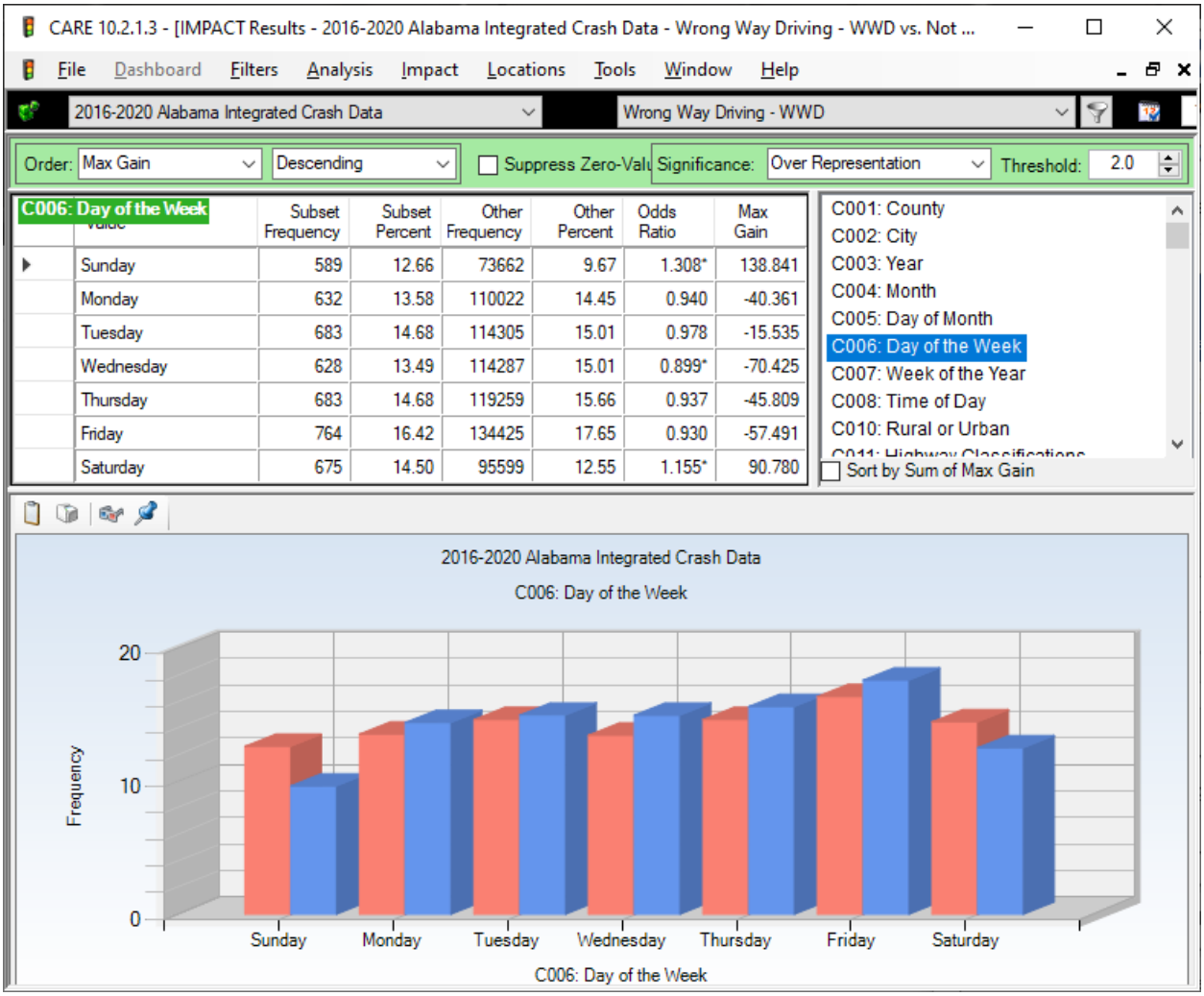


The chart above is useful for tracking the relative changes by directly comparing the number of WWD crashes to the non-WWD crashes by year. Years 2016, 2017 and 2018 had a significantly larger proportion than the non-WWD. The other two, 2019 and 2020, had a smaller proportion than expected. So the general trend based on these gross numbers would seem to be a reducing number of WWD crashes with time in 2019 and 2020.

5.2 Month

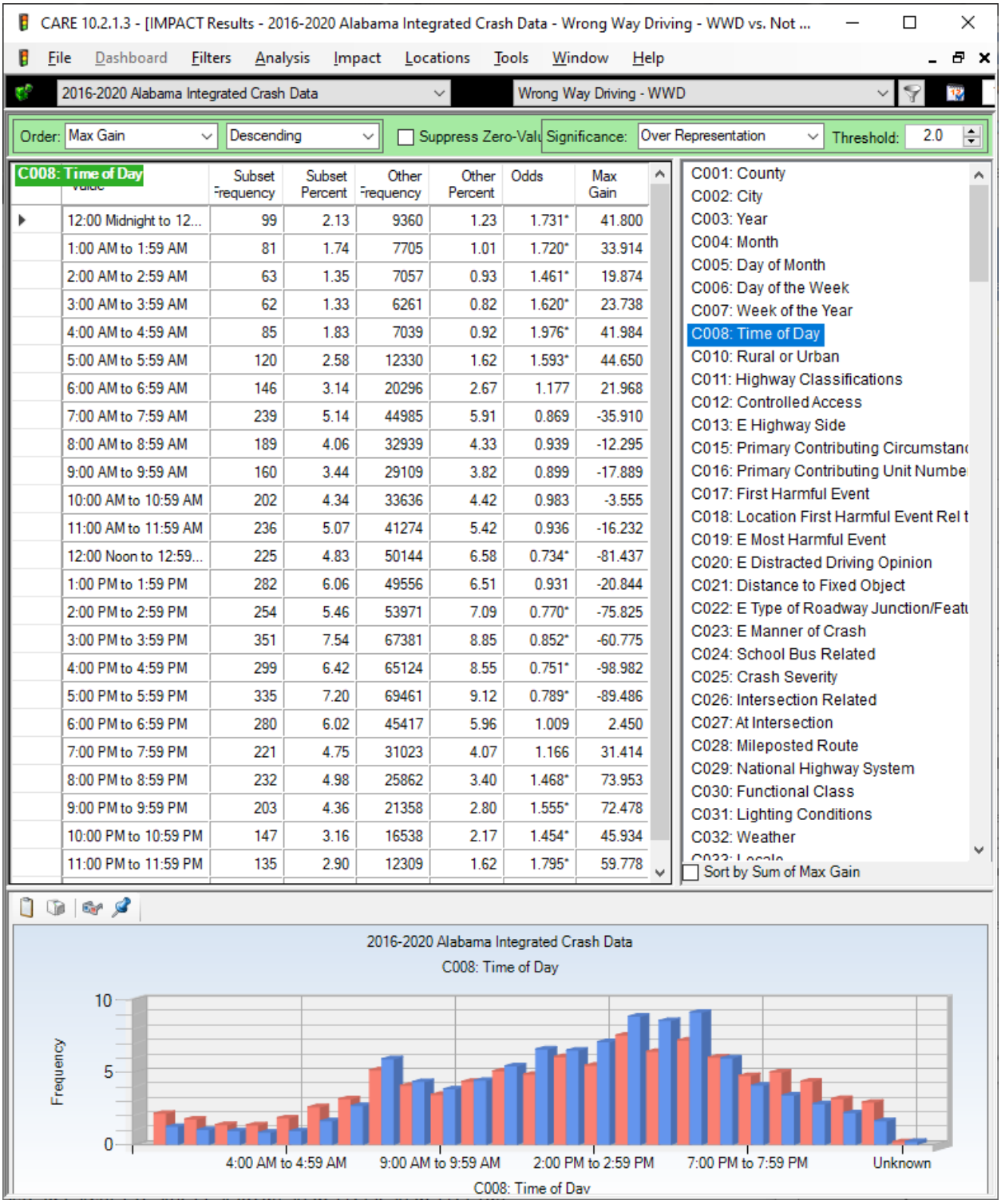
No significant over- or under-representations by month were found, and it is reasonable that WWD crash frequencies are not dependent on the time of the year.

5.3 Day of the Week



Weekend days and nights (especially Sundays) are over-represented in DDW crashes. The above is a well-established and recognized pattern for Impaired Driving (ID) crashes, with their concentrations on the weekend periods. This indicates that ID is a major central cause for WWD crashes, which will be explored in more detail below (Sections 8.2-8.5).

5.4 Time of Day



5.5 Discussion on Time of Day by Day of the Week (Section 5.6)

It is no surprise to find WWD crashes over-represented during the late night/early morning hours, since their other correlations with aspects of Impaired Driving (ID) is clear. In addition, night-time darkness itself may well increase the number of WWD crashes.

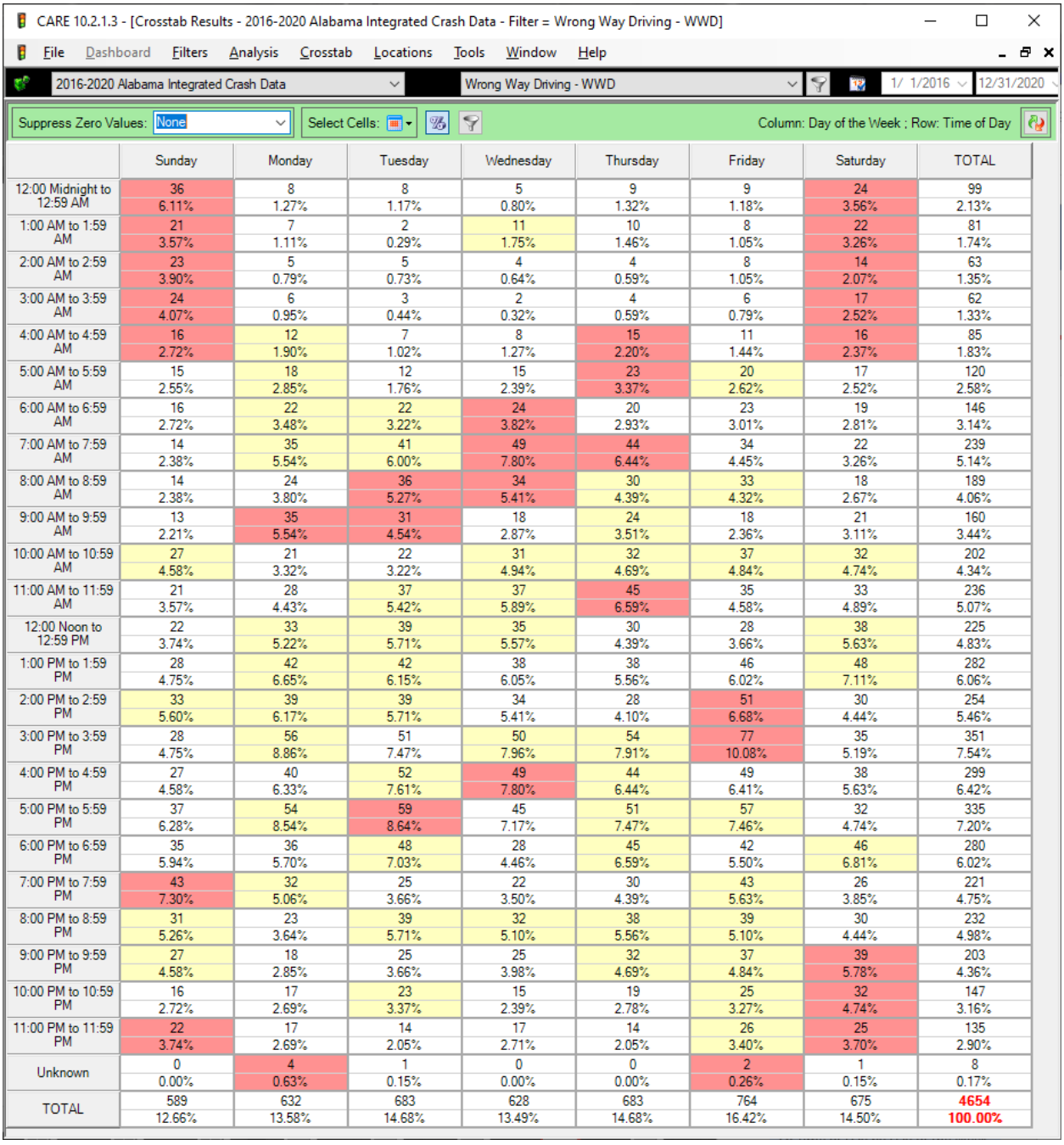
The following narrative was developed with regard to a special study that was done for ID. We include it here because of it relevance to WWD crashes. These considerations are also applicable to drowsiness and falling asleep at the wheel, which we will see are also quite relevant.

The extent of these over-representations is quite amazing. The blue bars above follow the typical traffic patterns of high traffic in the morning and afternoon rush hours. ID, and thus WWD crashes, are just getting started in the afternoon rush hours and they continue to grow in their proportions through midnight and the early morning hours, not tapering off until about 7:00 AM. It is clear that if selective enforcement is going to have an effect on ID (indirectly on WWD) crashes, it would have to be conducted at the times when these crashes are most occurring. Optimal times for Friday enforcement would start immediately following any rush hour details, and would continue through at least 2:00 AM.

The *Time of Day by Day of the Week* cross-tabulation (given in the next section for WWD crashes only) shows the optimal times for selective enforcement. Generally, the highest WWD times in any day are given in red for that day. This works well for Saturday and Sunday mornings, but not too well for Friday night. The reason is that proportions on Saturday night, eclipsed the Friday numbers, even though they were higher than any other day except Saturday.

This is an excellent example to demonstrate how the color coding of CARE cross-tabulations can be misleading in some special cases. The red background indicates that the over-representation of the cell is greater than expected. The expected proportion for all cells in a given row is given at the extreme right in the total row percentage for that row. If there were absolutely no over-representations across the columns, then all of the proportions for those cells would be identical to the one for the total. Notice for example, the 7 AM to 7:59 AM row has a total percentage value of 4.50%. Those that are under this value have a neutral (white) background. Those that are higher, but not more than 10% of the proportion are yellow; and those above 10% of the proportion are red.

5.6 Time of Day by Day of the Week



CARE 10.2.1.3 - [Crosstab Results - 2016-2020 Alabama Integrated Crash Data - Filter = Wrong Way Driving - WWD]

File Dashboard Filters Analysis Crosstab Locations Tools Window Help

2016-2020 Alabama Integrated Crash Data | Wrong Way Driving - WWD | 1/ 1/2016 | 12/31/2020

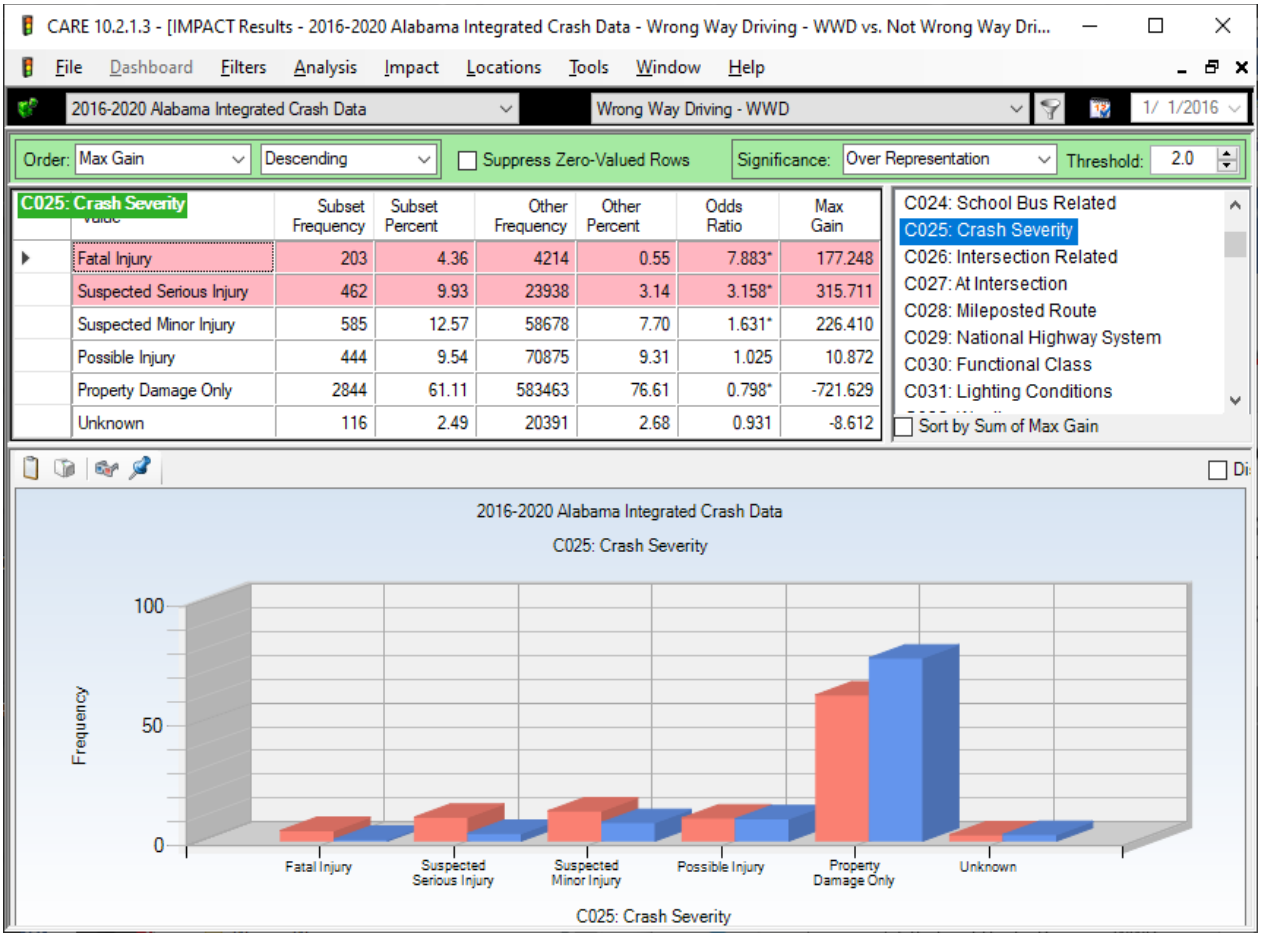
Suppress Zero Values: None | Select Cells: | Column: Day of the Week ; Row: Time of Day

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	TOTAL
12:00 Midnight to 12:59 AM	36 6.11%	8 1.27%	8 1.17%	5 0.80%	9 1.32%	9 1.18%	24 3.56%	99 2.13%
1:00 AM to 1:59 AM	21 3.57%	7 1.11%	2 0.29%	11 1.75%	10 1.46%	8 1.05%	22 3.26%	81 1.74%
2:00 AM to 2:59 AM	23 3.90%	5 0.79%	5 0.73%	4 0.64%	4 0.59%	8 1.05%	14 2.07%	63 1.35%
3:00 AM to 3:59 AM	24 4.07%	6 0.95%	3 0.44%	2 0.32%	4 0.59%	6 0.79%	17 2.52%	62 1.33%
4:00 AM to 4:59 AM	16 2.72%	12 1.90%	7 1.02%	8 1.27%	15 2.20%	11 1.44%	16 2.37%	85 1.83%
5:00 AM to 5:59 AM	15 2.55%	18 2.85%	12 1.76%	15 2.39%	23 3.37%	20 2.62%	17 2.52%	120 2.58%
6:00 AM to 6:59 AM	16 2.72%	22 3.48%	22 3.22%	24 3.82%	20 2.93%	23 3.01%	19 2.81%	146 3.14%
7:00 AM to 7:59 AM	14 2.38%	35 5.54%	41 6.00%	49 7.80%	44 6.44%	34 4.45%	22 3.26%	239 5.14%
8:00 AM to 8:59 AM	14 2.38%	24 3.80%	36 5.27%	34 5.41%	30 4.39%	33 4.32%	18 2.67%	189 4.06%
9:00 AM to 9:59 AM	13 2.21%	35 5.54%	31 4.54%	18 2.87%	24 3.51%	18 2.36%	21 3.11%	160 3.44%
10:00 AM to 10:59 AM	27 4.58%	21 3.32%	22 3.22%	31 4.94%	32 4.69%	37 4.84%	32 4.74%	202 4.34%
11:00 AM to 11:59 AM	21 3.57%	28 4.43%	37 5.42%	37 5.89%	45 6.59%	35 4.58%	33 4.89%	236 5.07%
12:00 Noon to 12:59 PM	22 3.74%	33 5.22%	39 5.71%	35 5.57%	30 4.39%	28 3.66%	38 5.63%	225 4.83%
1:00 PM to 1:59 PM	28 4.75%	42 6.65%	42 6.15%	38 6.05%	38 5.56%	46 6.02%	48 7.11%	282 6.06%
2:00 PM to 2:59 PM	33 5.60%	39 6.17%	39 5.71%	34 5.41%	28 4.10%	51 6.68%	30 4.44%	254 5.46%
3:00 PM to 3:59 PM	28 4.75%	56 8.86%	51 7.47%	50 7.96%	54 7.91%	77 10.08%	35 5.19%	351 7.54%
4:00 PM to 4:59 PM	27 4.58%	40 6.33%	52 7.61%	49 7.80%	44 6.44%	49 6.41%	38 5.63%	299 6.42%
5:00 PM to 5:59 PM	37 6.28%	54 8.54%	59 8.64%	45 7.17%	51 7.47%	57 7.46%	32 4.74%	335 7.20%
6:00 PM to 6:59 PM	35 5.94%	36 5.70%	48 7.03%	28 4.46%	45 6.59%	42 5.50%	46 6.81%	280 6.02%
7:00 PM to 7:59 PM	43 7.30%	32 5.06%	25 3.66%	22 3.50%	30 4.39%	43 5.63%	26 3.85%	221 4.75%
8:00 PM to 8:59 PM	31 5.26%	23 3.64%	39 5.71%	32 5.10%	38 5.56%	39 5.10%	30 4.44%	232 4.98%
9:00 PM to 9:59 PM	27 4.58%	18 2.85%	25 3.66%	25 3.98%	32 4.69%	37 4.84%	39 5.78%	203 4.36%
10:00 PM to 10:59 PM	16 2.72%	17 2.69%	23 3.37%	15 2.39%	19 2.78%	25 3.27%	32 4.74%	147 3.16%
11:00 PM to 11:59 PM	22 3.74%	17 2.69%	14 2.05%	17 2.71%	14 2.05%	26 3.40%	25 3.70%	135 2.90%
Unknown	0 0.00%	4 0.63%	1 0.15%	0 0.00%	0 0.00%	2 0.26%	1 0.15%	8 0.17%
TOTAL	589 12.66%	632 13.58%	683 14.68%	628 13.49%	683 14.68%	764 16.42%	675 14.50%	4654 100.00%

6.0 Factors Affecting Severity

6.1 WWD Crash Severity Compared to Non-WWD

See Section 4.7 for the most harmful events in WWD crashes. The following compares crash severities for WWD (Subset, red bars) vs. Non-WWD crashes (Other, blue bars).



The rate of fatal injury crashes and the two highest injury classifications are consistently higher in WWD crashes than that of non-WWD crashes. Fatality crashes have almost eight (7.883) times their expected proportion, while the next highest non-fatal injury classifications has 3.158 times their expected proportions when compared with non-Wrong Way Driving (non-WWD) crashes. The Speed-at-Impact variable, considered next, indicates one of the primary reasons for this. However, the greatest cause of WWD increased severity and death is the vicious nature of the WWD crash itself, since the speed at impact is essentially the sum of the speed of both vehicles.

6.2 Speed at Impact

2016-2020 Alabama Integrated Crash Data | Wrong Way Driving - WWD | 1/ 1/2016 | 12/31/2

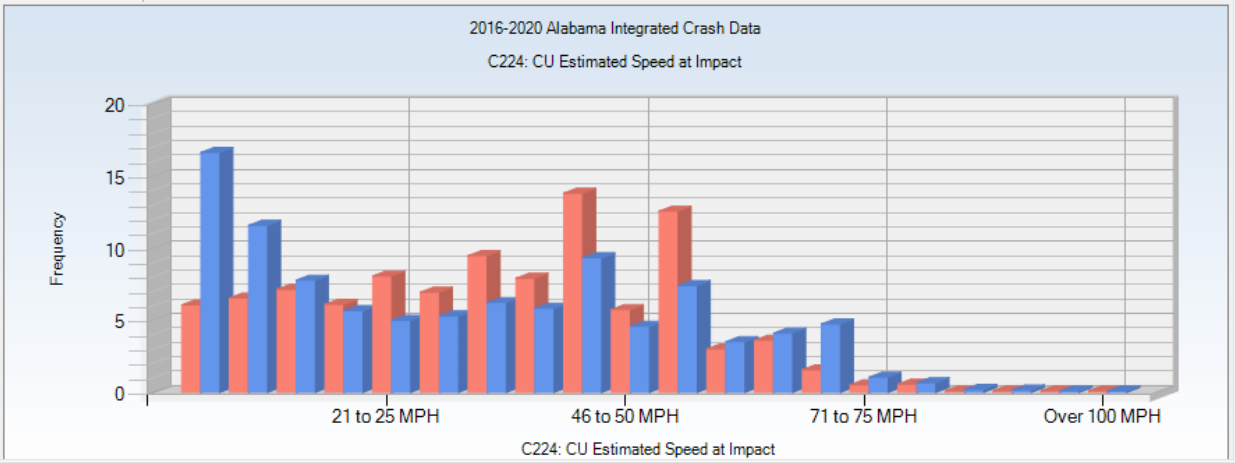
Order: Max Gain | Descending | Suppress Zero-Valued Rows | Significance: Over Representation | Threshold: 2.0

C224: CU Estimated Speed at Impact	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds Ratio	Max Gain
1 to 5 MPH	151	6.07	63219	16.64	0.365*	-263.257
6 to 10 MPH	163	6.55	44015	11.59	0.565*	-125.418
11 to 15 MPH	178	7.15	29561	7.78	0.919	-15.705
16 to 20 MPH	152	6.11	21491	5.66	1.079	11.175
21 to 25 MPH	201	8.08	18984	5.00	1.616*	76.603
26 to 30 MPH	173	6.95	20152	5.31	1.310*	40.949
31 to 35 MPH	236	9.48	23619	6.22	1.525*	81.231
36 to 40 MPH	197	7.91	22155	5.83	1.357*	51.824
41 to 45 MPH	344	13.82	35459	9.34	1.481*	111.647
46 to 50 MPH	143	5.75	17385	4.58	1.255*	29.081
51 to 55 MPH	313	12.58	28178	7.42	1.695*	128.357
56 to 60 MPH	75	3.01	13354	3.52	0.857	-12.505
61 to 65 MPH	90	3.62	15598	4.11	0.881	-12.209
66 to 70 MPH	39	1.57	17998	4.74	0.331*	-78.936
71 to 75 MPH	13	0.52	3994	1.05	0.497	-13.172
76 to 80 MPH	14	0.56	2535	0.67	0.843	-2.611
81 to 85 MPH	1	0.04	789	0.21	0.193	-4.170
86 to 90 MPH	2	0.08	630	0.17	0.484	-2.128
96 to 100 MPH	2	0.08	373	0.10	0.818	-0.444
Over 100 MPH	2	0.08	216	0.06	1.413	0.585

C224: CU Estimated Speed at Impact

Sort by Sum of Max Gain

Display Fi



It should be noted that the speed limit on County roads is generally 45 MPH, and it is generally lower on Municipal roads, where these two roadway types combined account for about 70% of WWD crashes. All impact speeds 21 to 55 MPH are significantly over-represented, and they are under-representation at higher impact speeds. The next cross-tabulation quantifies how this relates to the severity in the special case of WWD crashes.

6.3 Severity by Impact Speed Cross-Tabulation

CARE 10.2.1.3 - [Crosstab Results - 2016-2020 Alabama Integrated Crash Data - Filter = Wrong Way Driving - WWD]

File Dashboard Filters Analysis Crosstab Locations Tools Window Help

2016-2020 Alabama Integrated Crash Data | Wrong Way Driving - WWD | 1/ 1/2016 | 12/31/2

Suppress Zero Values: None | Select Cells: | Column: Crash Severity ; Row: CU Estimated Speed at Impact

	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Property Damage Only	Unknown	TOTAL
0 MPH	0 0.00%	0 0.00%	1 0.17%	1 0.23%	3 0.11%	0 0.00%	5 0.11%
1 to 5 MPH	0 0.00%	2 0.43%	11 1.88%	9 2.03%	129 4.54%	0 0.00%	151 3.25%
6 to 10 MPH	0 0.00%	2 0.43%	12 2.05%	6 1.35%	140 4.92%	3 2.59%	163 3.50%
11 to 15 MPH	2 0.99%	6 1.30%	8 1.37%	14 3.16%	148 5.21%	0 0.00%	178 3.83%
16 to 20 MPH	1 0.49%	6 1.30%	17 2.91%	10 2.26%	116 4.08%	2 1.72%	152 3.27%
21 to 25 MPH	0 0.00%	9 1.95%	23 3.93%	18 4.06%	149 5.24%	2 1.72%	201 4.32%
26 to 30 MPH	4 1.97%	12 2.60%	17 2.91%	17 3.84%	122 4.29%	1 0.86%	173 3.72%
31 to 35 MPH	3 1.48%	17 3.68%	35 5.98%	28 6.32%	150 5.28%	3 2.59%	236 5.07%
36 to 40 MPH	5 2.46%	25 5.41%	30 5.13%	24 5.42%	112 3.94%	1 0.86%	197 4.23%
41 to 45 MPH	9 4.43%	61 13.20%	68 11.62%	23 5.19%	178 6.26%	5 4.31%	344 7.39%
46 to 50 MPH	12 5.91%	27 5.84%	39 6.67%	11 2.48%	53 1.86%	1 0.86%	143 3.07%
51 to 55 MPH	40 19.70%	84 18.18%	53 9.06%	17 3.84%	115 4.05%	4 3.45%	313 6.73%
56 to 60 MPH	12 5.91%	16 3.46%	12 2.05%	8 1.81%	27 0.95%	0 0.00%	75 1.61%
61 to 65 MPH	20 9.85%	38 8.23%	8 1.37%	7 1.58%	16 0.56%	1 0.86%	90 1.93%
66 to 70 MPH	14 6.90%	14 3.03%	6 1.03%	2 0.45%	**3** **0.11%**	0 0.00%	39 0.84%
71 to 75 MPH	3 1.48%	6 1.30%	1 0.17%	0 0.00%	3 0.11%	0 0.00%	13 0.28%
76 to 80 MPH	7 3.45%	3 0.65%	1 0.17%	0 0.00%	3 0.11%	0 0.00%	14 0.30%
81 to 85 MPH	0 0.00%	0 0.00%	1 0.17%	0 0.00%	0 0.00%	0 0.00%	1 0.02%
86 to 90 MPH	1 0.49%	0 0.00%	0 0.00%	1 0.23%	0 0.00%	0 0.00%	2 0.04%
91 to 95 MPH	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%
96 to 100 MPH	0 0.00%	0 0.00%	0 0.00%	1 0.23%	0 0.00%	1 0.86%	2 0.04%
Over 100 MPH	2 0.99%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	2 0.04%
E Stationary	0 0.00%	5 1.08%	6 1.03%	3 0.68%	34 1.20%	0 0.00%	48 1.03%
Unknown	54 26.60%	98 21.21%	197 33.68%	211 47.63%	1187 41.75%	84 72.41%	1831 39.36%
Not Applicable	1 0.49%	5 1.08%	5 0.85%	10 2.26%	54 1.90%	6 5.17%	81 1.74%
CU is Not a Vehicle	12 5.91%	25 5.41%	27 4.62%	15 3.39%	18 0.63%	1 0.86%	98 2.11%
CU is Unknown	1 0.49%	1 0.22%	7 1.20%	7 1.58%	83 2.92%	1 0.86%	100 2.15%
TOTAL	203 4.36%	462 9.93%	585 12.58%	443 9.52%	2843 61.11%	116 2.49%	**4652** **100.00%**

6.4 Discussion of Severity vs Speed at Impact Cross-Tabulation

The display above presents information on the effect of increased impact speed on the severity of WWD crashes. Notice the red in the Fatality and Serious Injury cells as speeds increase. More enlightening is the probability that the crash results in a fatality as a function of impact speed of the causal driver, which is most often the vehicle of the higher speed. This is given in the following table:

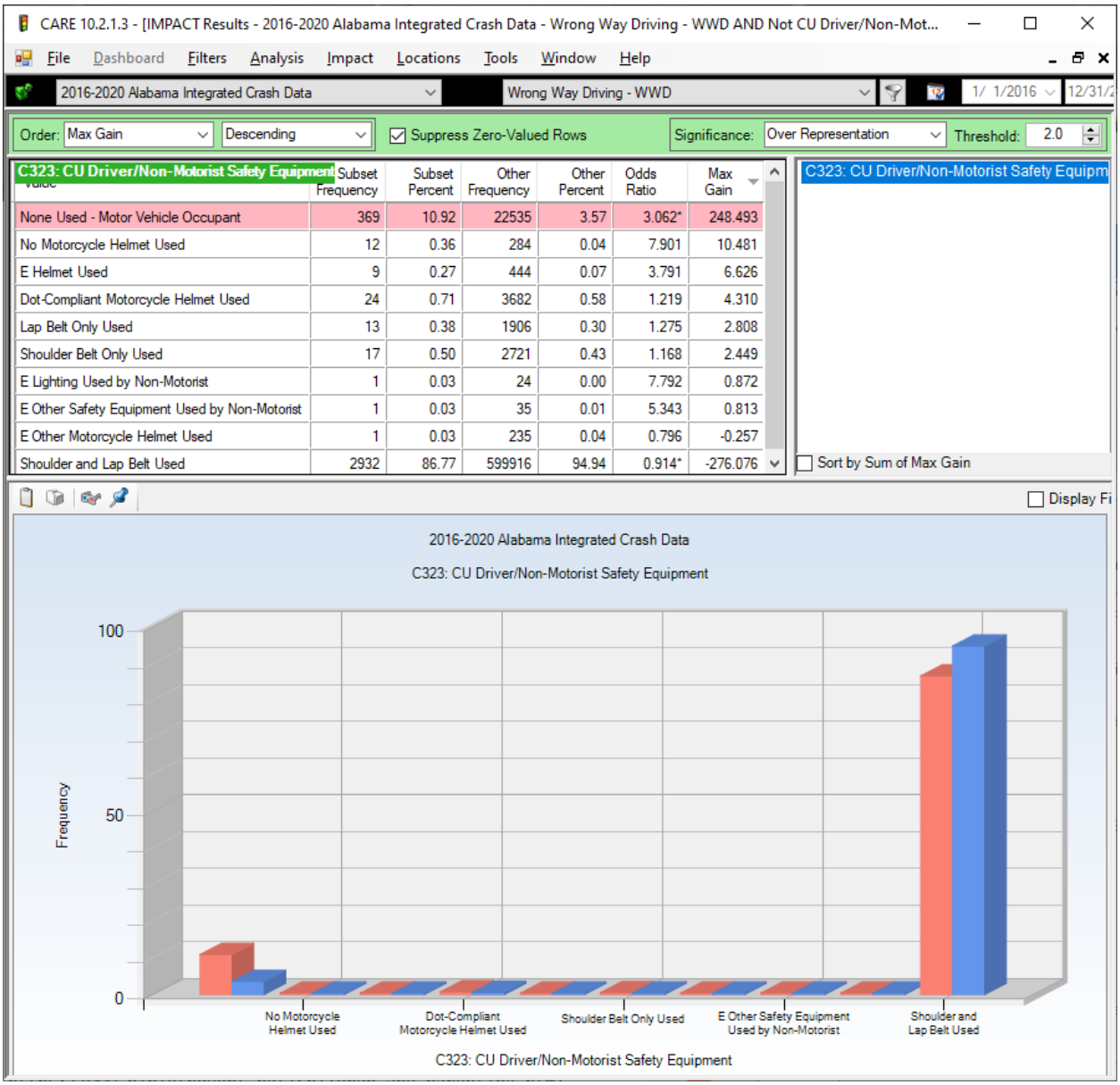
Speed at Impact	Fatality Odds (1 in …)	Increase Probability above 31-35
31-35	79	1.0
36-45	39	2.0
46-55	9	8.7
56-65	5	15.8
66-75	3	26.3
76-85	2.14	36.9
86-95 and above	2.00	39.5

Obviously, speed kills, and a reduction in speed at impact by as little as 5 MPH can have a major effect on whether or not that crash will be fatal. A reduction in impact speeds by 10 MPH has generally been found to cut the number of fatal crashes in half. This is the reason that selective enforcement is effective, since it has the effect of reducing a major proportion of speeding vehicles in addition to those ticketed. Interestingly, the fatal probabilities for WWD crashes were effectively the same as those of comparable speeds for causal drivers in single-vehicle crashes. However, approximately 38% of the fatalities were in the victim vehicle as opposed to the causal vehicle.

There is another major factor in effect here as well – the failure of WWD drivers to be properly restrained, which will be covered in the next separate attribute below (6.5; Restraint Use by Causal Drivers in WWD Crashes), which is also a major problem with Impaired Drivers, since ID drivers fail to buckle up about half the time.

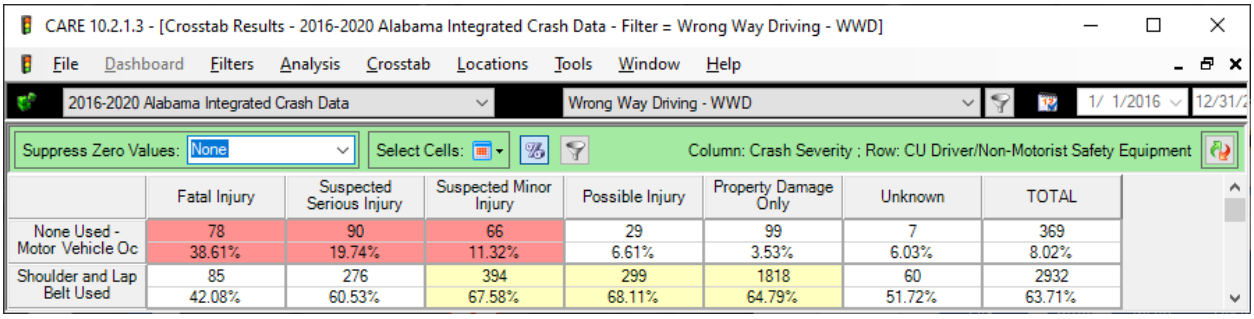
6.5 Restraint Use by Drivers in WWD Crashes

The following display presents a comparison of WWD-crash driver safety belt use against those who were not WWD over the same five-year time period.



Risk-taking involved in most of the WWD causes does not stop with excess speed; it extends to not being properly restrained. The above analysis demonstrates that the causal driver in a WWD crash is over three (3.062) times more likely to be unrestrained than in the non-WWD crash. The next analysis demonstrates how this contributes to crashes becoming fatal.

6.6 Crash Severity by Restraint Use (C323) for WWD Crash CU Drivers

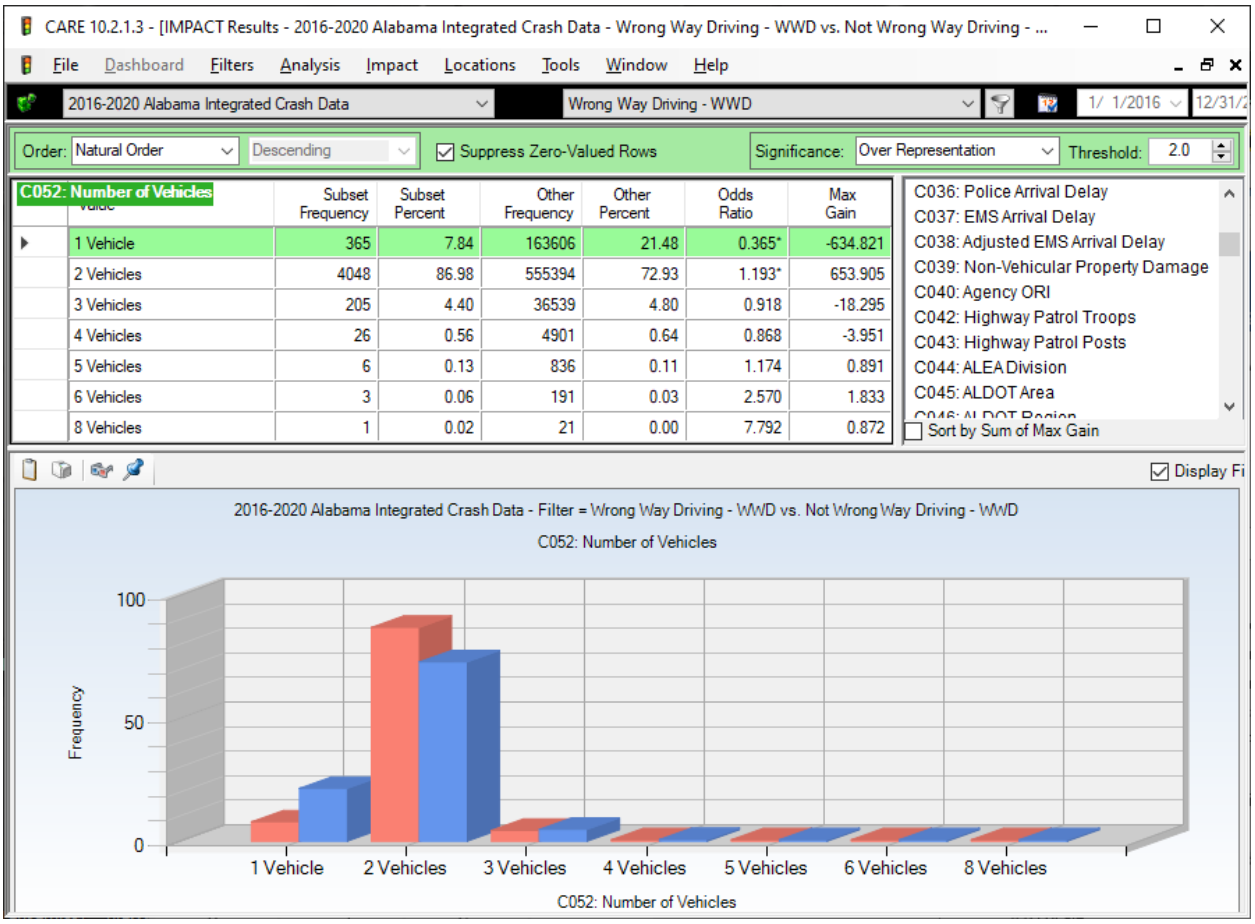


	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Property Damage Only	Unknown	TOTAL
None Used - Motor Vehicle Oc	78	90	66	29	99	7	369
	38.61%	19.74%	11.32%	6.61%	3.53%	6.03%	8.02%
Shoulder and Lap Belt Used	85	276	394	299	1818	60	2932
	42.08%	60.53%	67.58%	68.11%	64.79%	51.72%	63.71%

A comparison of the probability of a fatal crash for the two restraint categories of WWD crashes indicates that a fatality is about seven times (7.34) more likely if the WWD causal driver is not properly restrainted. The probability is estimated by 75 fatality crashes out of 369 when restraints were not used (1 in 4.7 crashes), as opposed to only 85 fatal crashes out of 2,932 crashes when restraints were used (1 in about 34.5 crashes). So the combined effect of lower restraint use and higher speed is a devastating combination that accounts for some of the high lethality of WWD crashes. Of course, it is the devastating "double impact" of a head-on collision that could kill even when a driver is properly restrained.

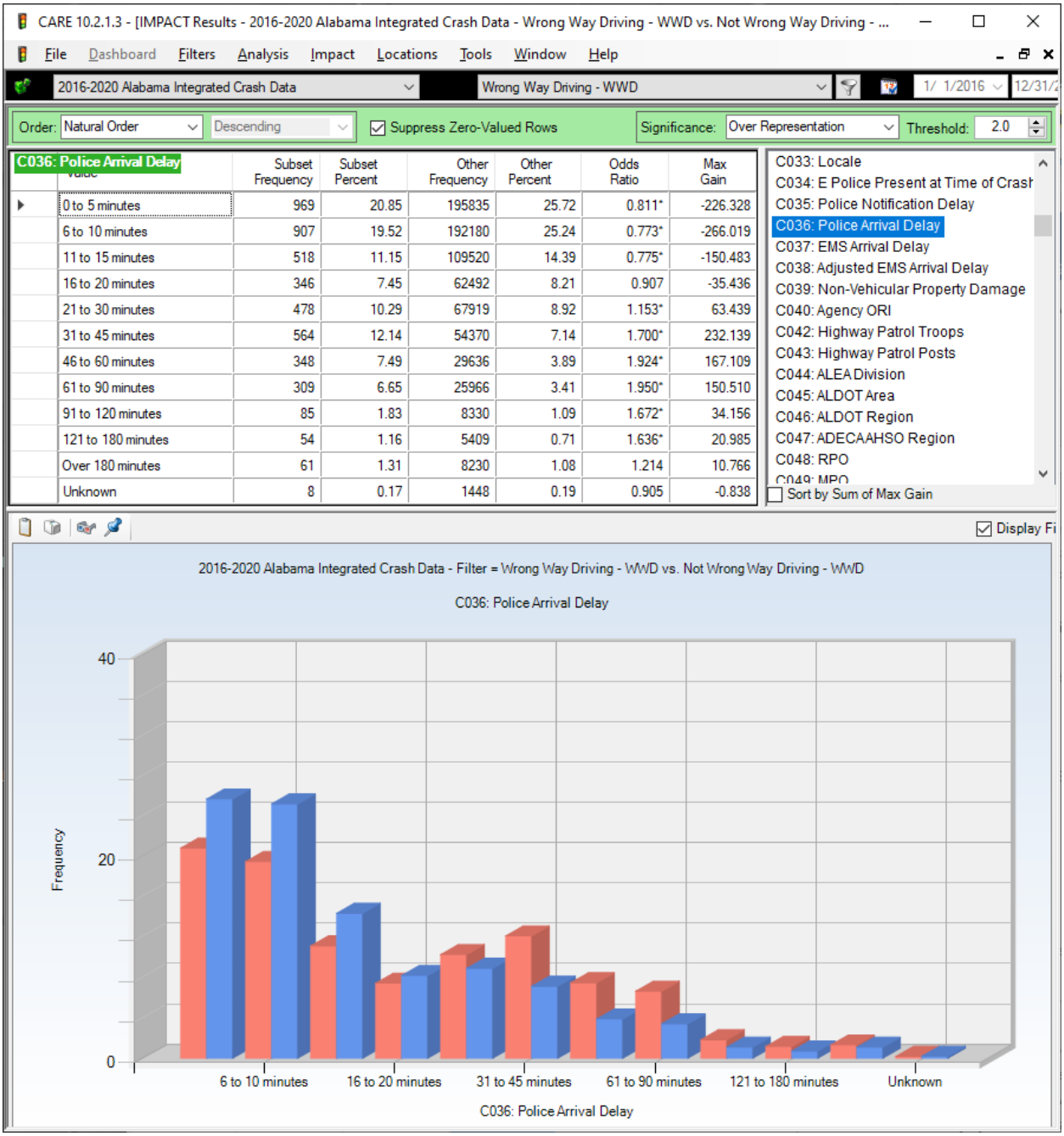
6.7 Number of Vehicles Involved

The following display presents a comparison of WWD crash number of vehicles against number of vehicles in non-WWD crashes over the five year time period of the study.



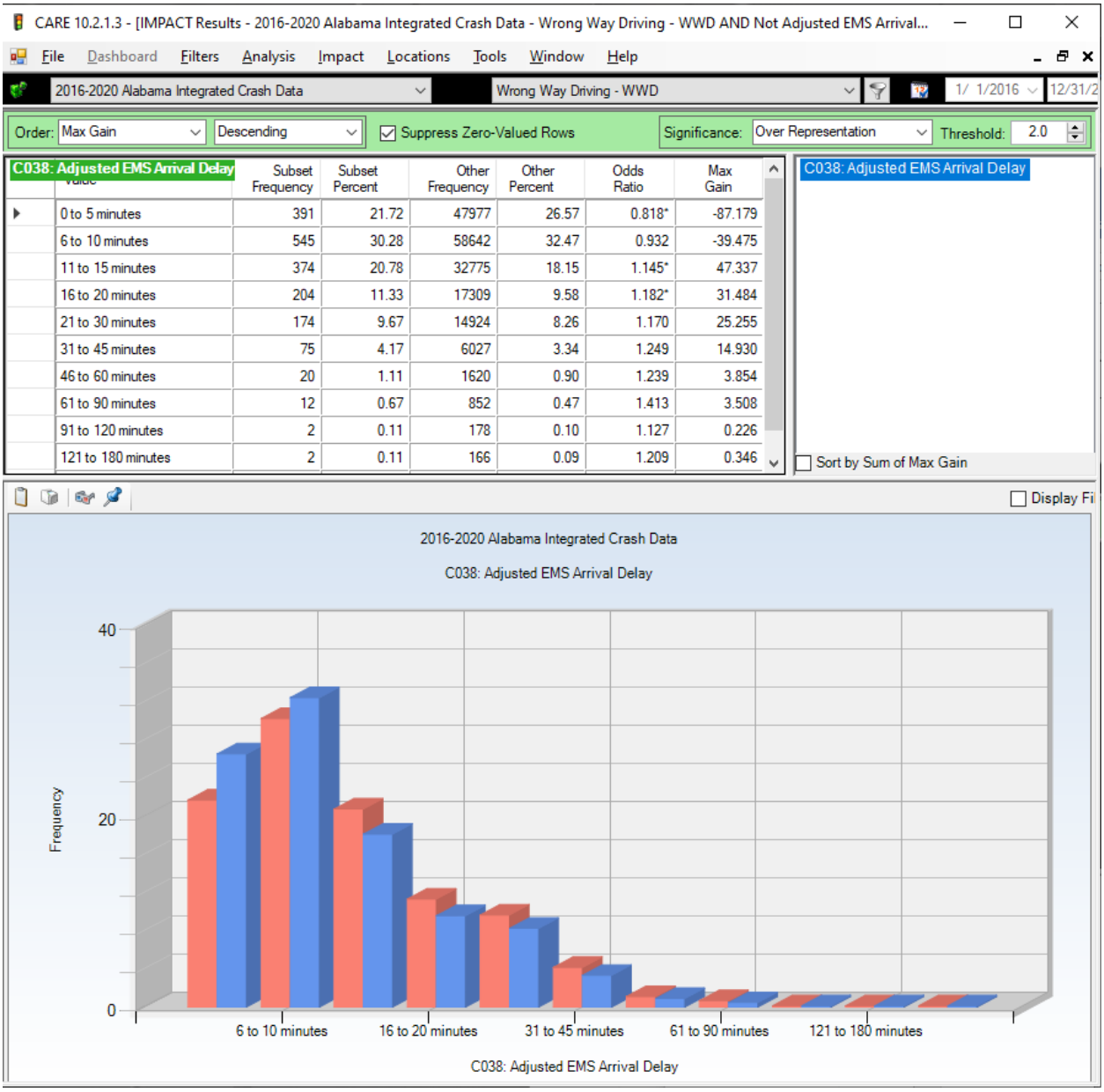
The above shows that the number of single vehicle WWD crashes is under-represented by an Odds Ratio of 0.368 (proportion was only a little over a third of that expected). Close to 9 out of 10 (86.98%) of the WWD crashes were single vehicle. This would be expected when most of the crashes involved the causal vehicle intruding into the opposing traffic lane and crashing into an oncoming vehicle.

6.8 Police Arrival Delay



WWD crashes police arrival delays were significantly longer up until 20 minutes. As would be expected, all arrival delays over 20 minutes were over-represented, most of them significantly. There can be little doubt that this has to do with the late-night timing of these crashes.

6.9 EMS Arrival Delay

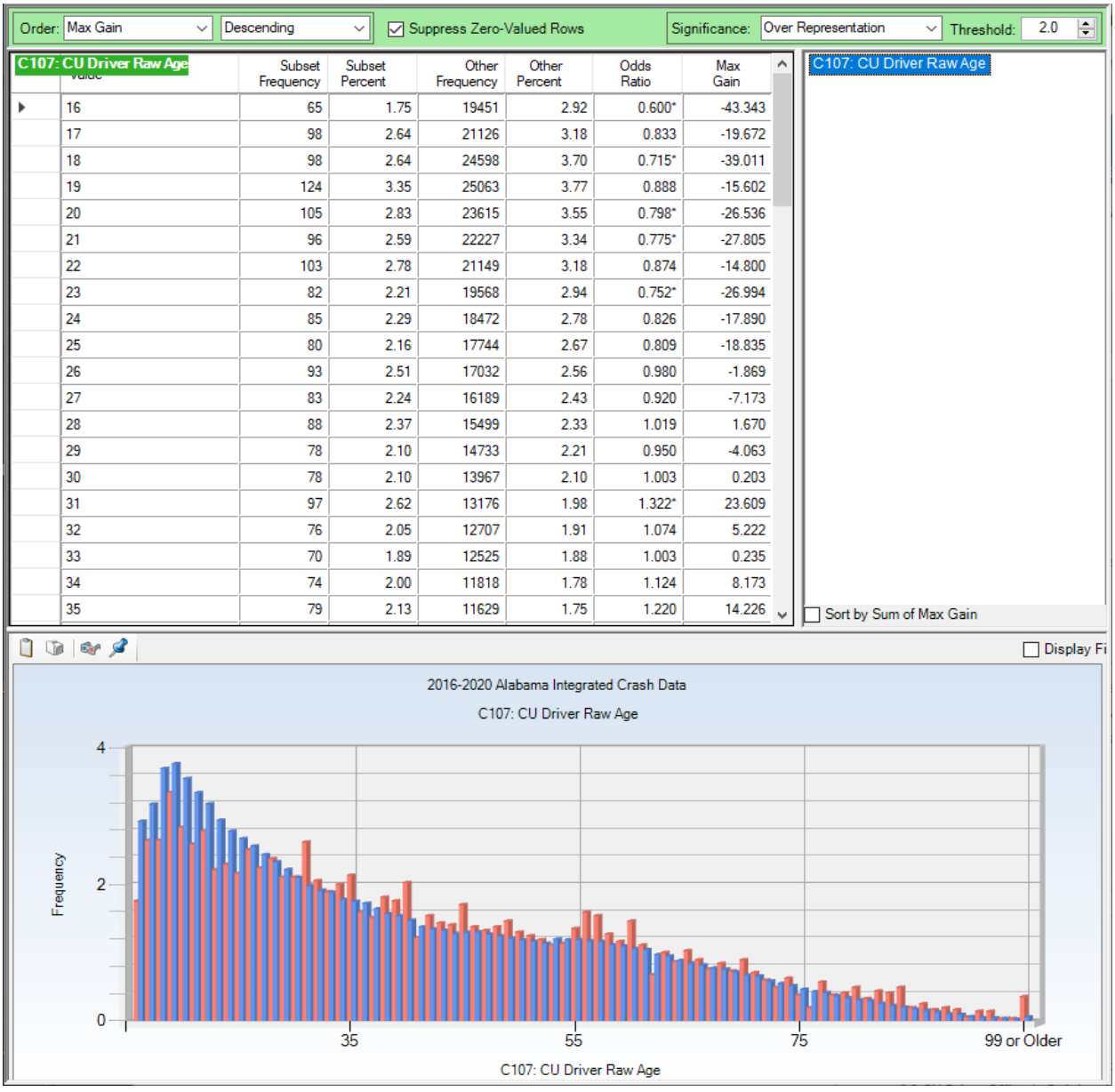


C038: Adjusted EMS Arrival Delay	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds Ratio	Max Gain
0 to 5 minutes	391	21.72	47977	26.57	0.818*	-87.179
6 to 10 minutes	545	30.28	58642	32.47	0.932	-39.475
11 to 15 minutes	374	20.78	32775	18.15	1.145*	47.337
16 to 20 minutes	204	11.33	17309	9.58	1.182*	31.484
21 to 30 minutes	174	9.67	14924	8.26	1.170	25.255
31 to 45 minutes	75	4.17	6027	3.34	1.249	14.930
46 to 60 minutes	20	1.11	1620	0.90	1.239	3.854
61 to 90 minutes	12	0.67	852	0.47	1.413	3.508
91 to 120 minutes	2	0.11	178	0.10	1.127	0.226
121 to 180 minutes	2	0.11	166	0.09	1.209	0.346

For much the same reasons as the police arrival delays, EMS delays were significantly over-represented for Wrong Way Driving (WWD) crashes in the 0-5 and 6-10 minute categories. All longer delay times were over-represented. There were relatively few in these very long categories, which were probably caused by some of the vehicles not being discovered late at night.

7.0 Driver and Vehicle Demographics

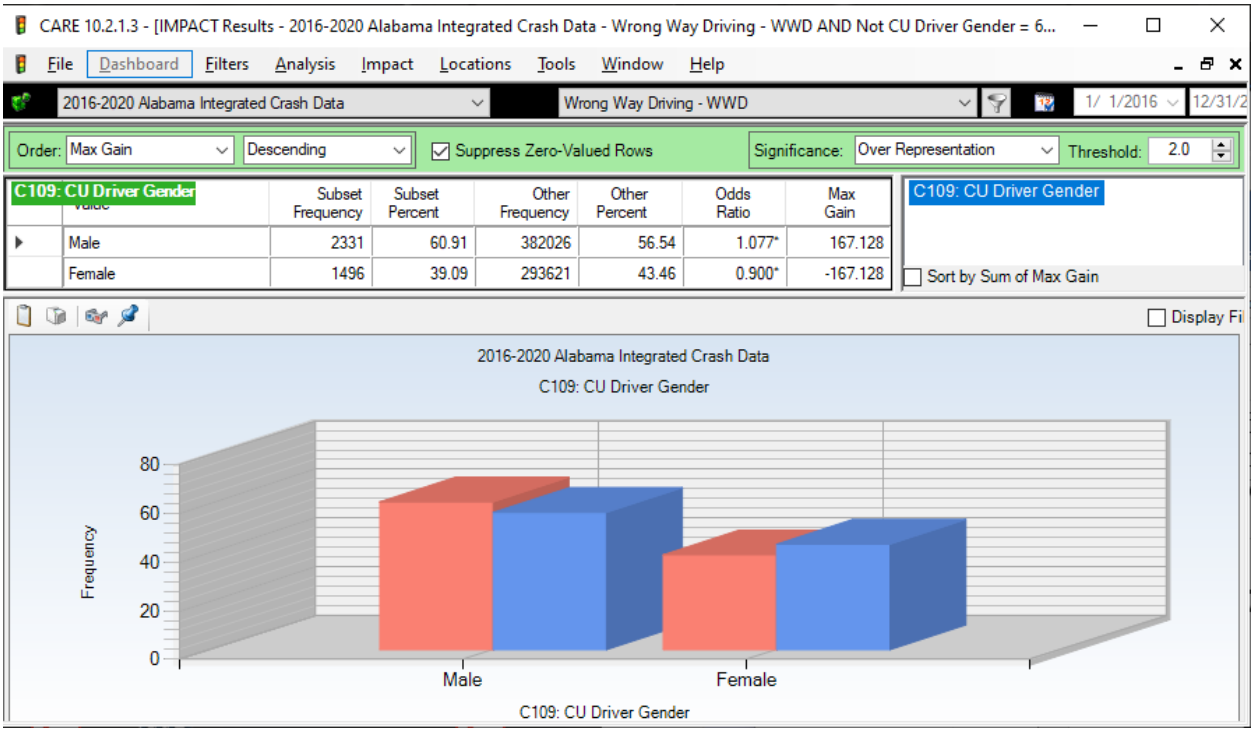
7.1 Driver Age for WWD Crashes



The table display above presents a comparison of WWD crash causal driver age against the same for crashes that were not WWD. The blue (non-RC) bars illustrate the problems that 16-20-year-

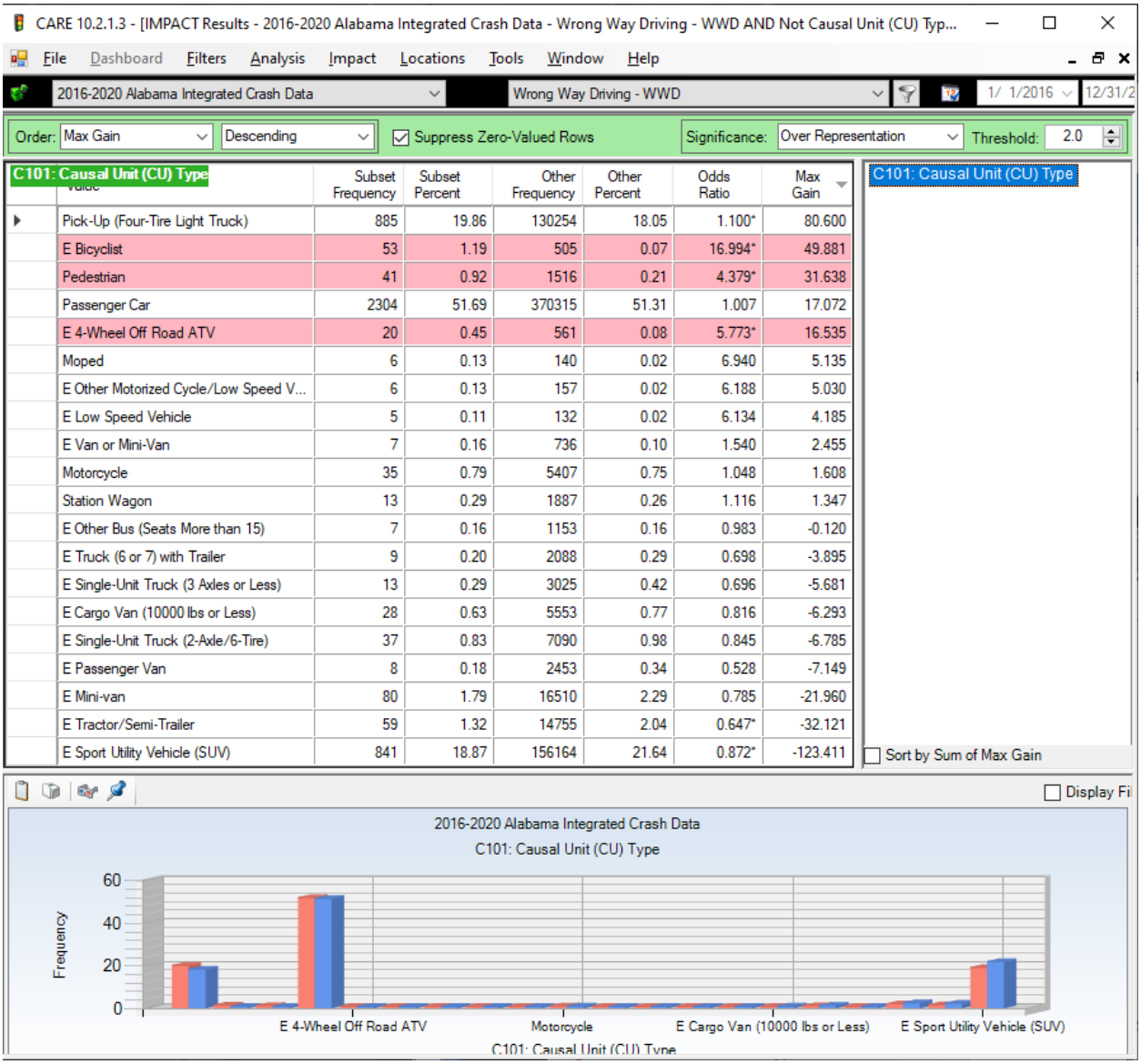
old drivers have in general, and the red bars show that older drivers are over-represented in WWD crashes over a broad range.

7.2 Driver Gender for WWD Crashes



The percentages for the red bars and the blue bars each sum to 100%. So the breakdown in WWD causal drivers is 60.91% male and 39.09% female. For non-RC, the percentage is 56.54 male and 43.46 female, which also gives a good estimate for male/female drivers in general. These differences in proportions certainly indicate that males are a greater cause of the WWD problems. If there are countermeasures that can be directed toward male drivers, doing so would be much more cost-effective than those directed toward all drivers, all other things being equal.

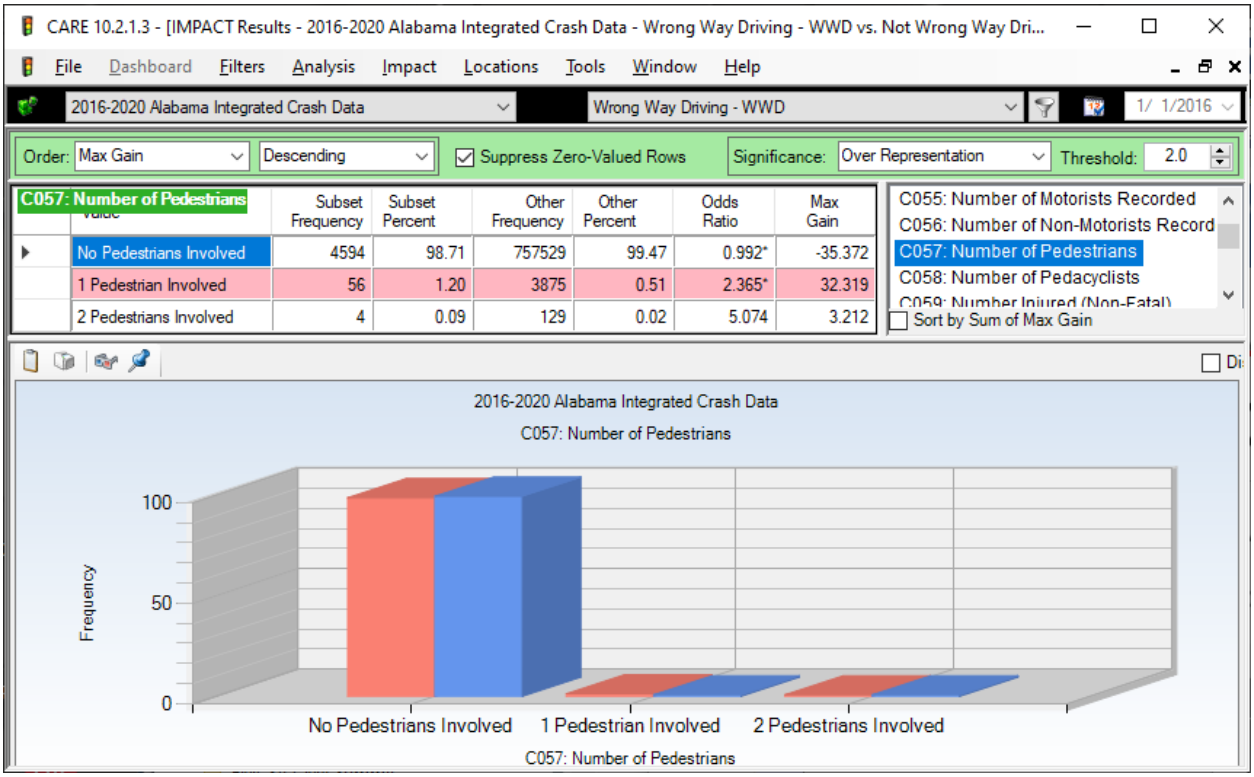
7.3 Causal Vehicle Types with 5 or more Crashes



C101: Causal Unit (CU) Type	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds Ratio	Max Gain
Pick-Up (Four-Tire Light Truck)	885	19.86	130254	18.05	1.100*	80.600
E Bicyclist	53	1.19	505	0.07	16.994*	49.881
Pedestrian	41	0.92	1516	0.21	4.379*	31.638
Passenger Car	2304	51.69	370315	51.31	1.007	17.072
E 4-Wheel Off Road ATV	20	0.45	561	0.08	5.773*	16.535
Moped	6	0.13	140	0.02	6.940	5.135
E Other Motorized Cycle/Low Speed V...	6	0.13	157	0.02	6.188	5.030
E Low Speed Vehicle	5	0.11	132	0.02	6.134	4.185
E Van or Mini-Van	7	0.16	736	0.10	1.540	2.455
Motorcycle	35	0.79	5407	0.75	1.048	1.608
Station Wagon	13	0.29	1887	0.26	1.116	1.347
E Other Bus (Seats More than 15)	7	0.16	1153	0.16	0.983	-0.120
E Truck (6 or 7) with Trailer	9	0.20	2088	0.29	0.698	-3.895
E Single-Unit Truck (3 Axles or Less)	13	0.29	3025	0.42	0.696	-5.681
E Cargo Van (10000 lbs or Less)	28	0.63	5553	0.77	0.816	-6.293
E Single-Unit Truck (2-Axle/6-Tire)	37	0.83	7090	0.98	0.845	-6.785
E Passenger Van	8	0.18	2453	0.34	0.528	-7.149
E Mini-van	80	1.79	16510	2.29	0.785	-21.960
E Tractor/Semi-Trailer	59	1.32	14755	2.04	0.647*	-32.121
E Sport Utility Vehicle (SUV)	841	18.87	156164	21.64	0.872*	-123.411

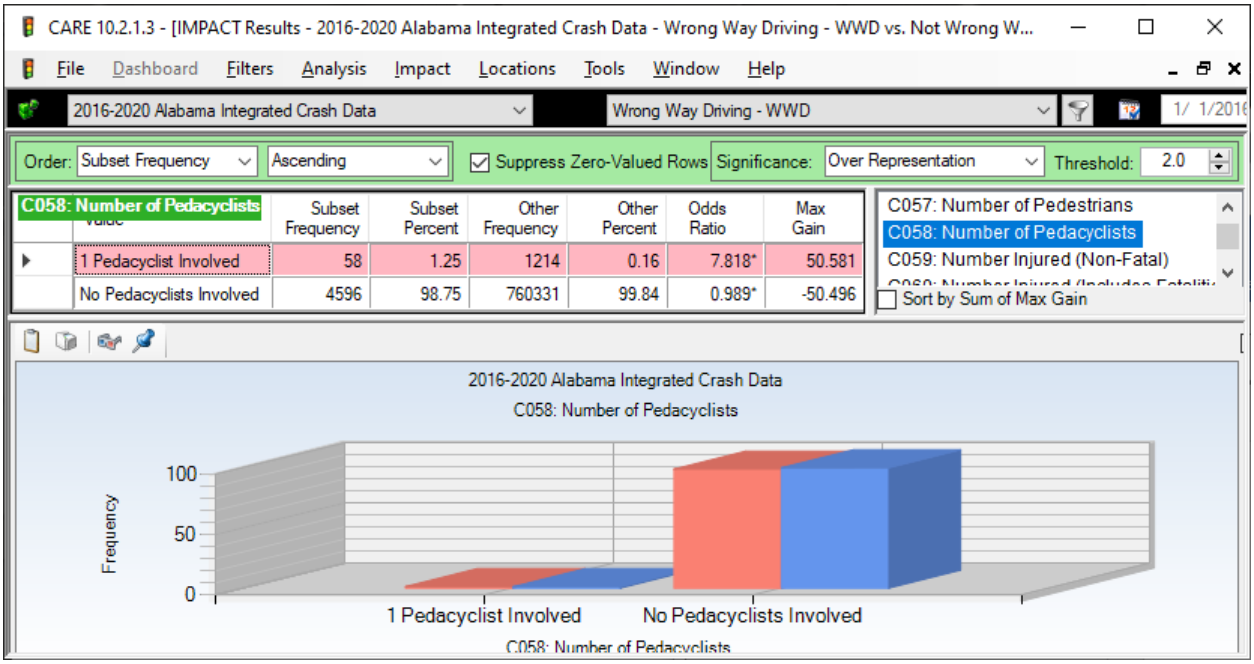
The display above presents a comparison of WWD crash causal unit type against the same for crashes that were non-WWD. Vehicles types with less than 5 crashes in the WWD dataset were removed for the above display. Pick-ups have the highest for potential crash reduction according to the Max Gain. However, Bicycles, Pedestrians and 4-Wheel Off Road ATVs all have much higher Odds Ratios. Passenger Cars are by far the highest frequency that pushes their Max Gain up, but their Odds Ratio (1.007) indicates that their overall frequency on the roadway makes this degree of involvement about as expected. The extremely high odds ratios for bicyclists and pedestrians should make quite clear the danger of not following the law is this regard.

7.4 Number of Pedestrians



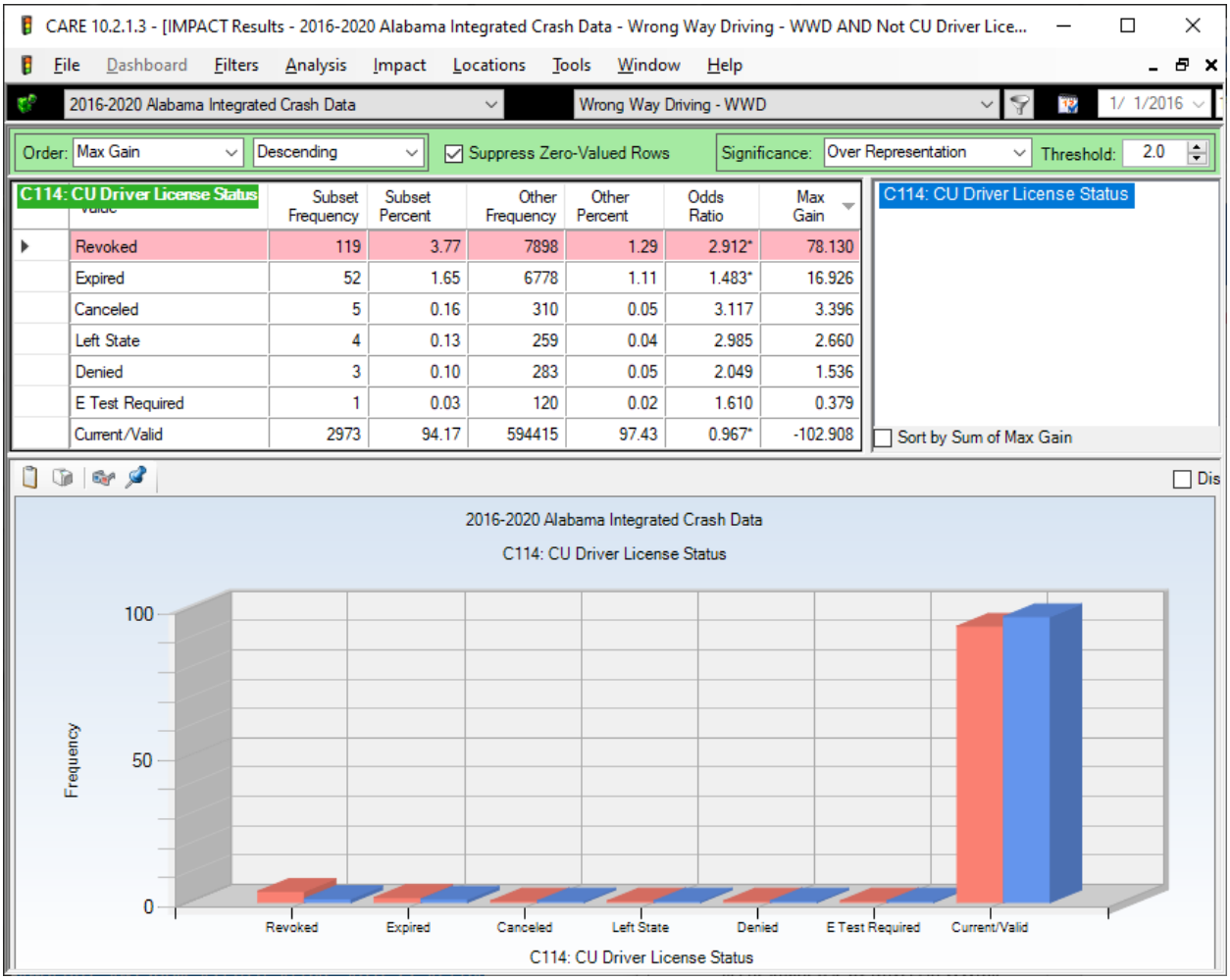
WWD here is actually Wrong Way Walking. Pedestrians are generally over-represented in WWD crashes, indicating that a large proportion of pedestrian crashes involved them walking on the wrong side of the roadway. This finding may be useful in pedestrian countermeasures. More intensive enforcement of laws against pedestrians walking in the same direction as traffic should be considered. These crashes resulted in 14 pedestrian fatalities.

7.5 Number of Pedalcycles



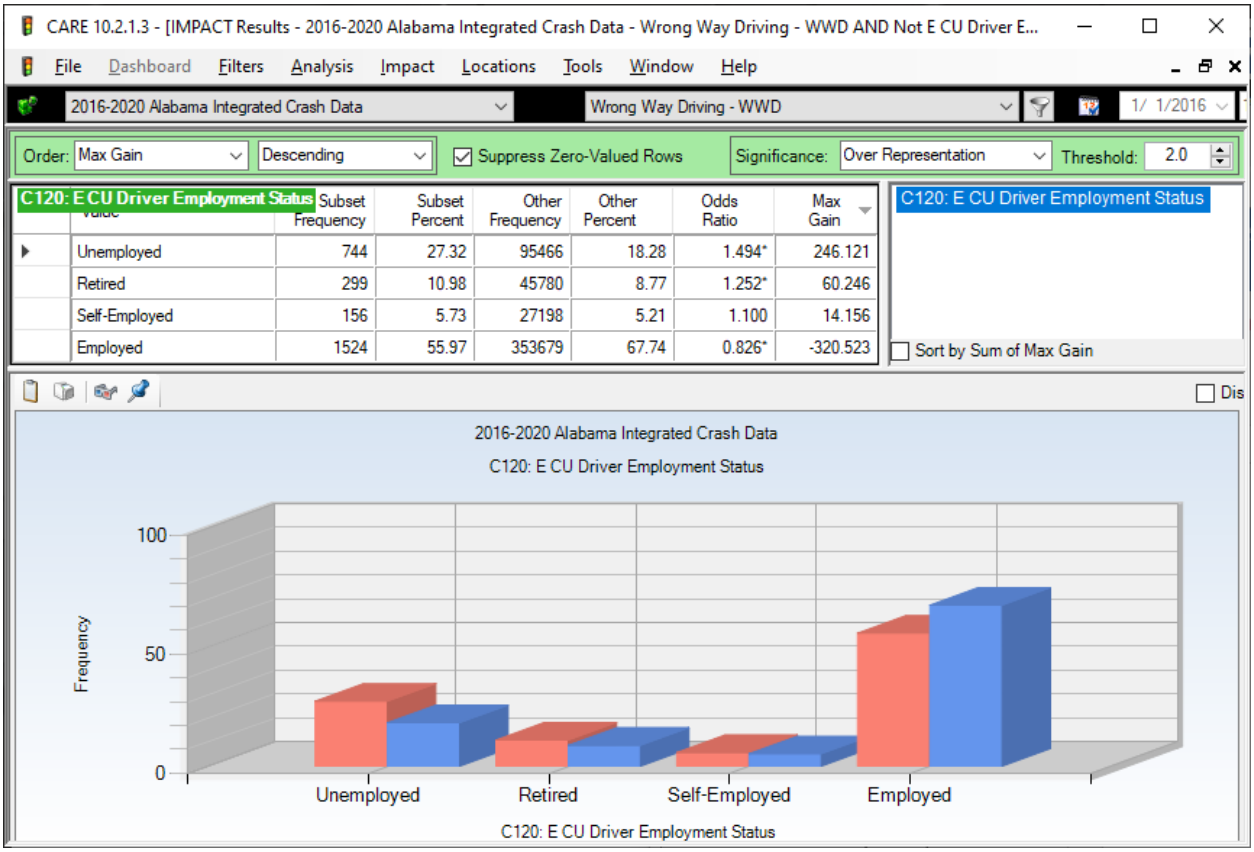
The number of crashes here is very close to that of pedestrians. However, none of pedalcycle WWD crashes resulted in a fatality. Pedalcycle WWD would be riding against traffic (as opposed to pedestrian WW Walking). While not fatal, high severities of injuries were significantly greater than expected with 15 Suspected Serious Injury, 20 Suspected Minor Injury, and 12 Possible Injury Crashes.

7.6 Driver License Status



Clearly WWD crashes are over-represented in WWD causal drivers being without legitimate licenses. They make up about 15% of WWD causal drivers. Items with less than 20 crashes in either "Subset" or "Other" are not subjected to statistical tests because of the low sample sizes. WWD drivers were highly significantly over-represented in having Revoked licenses, being close to three times its expected value (in comparison with non-WWD crashes). It is expected that the same infractions that cause them to be deficient in their licensing would cause them to drive the wrong way (e.g., a history of DUI Drugs/Alcohol).

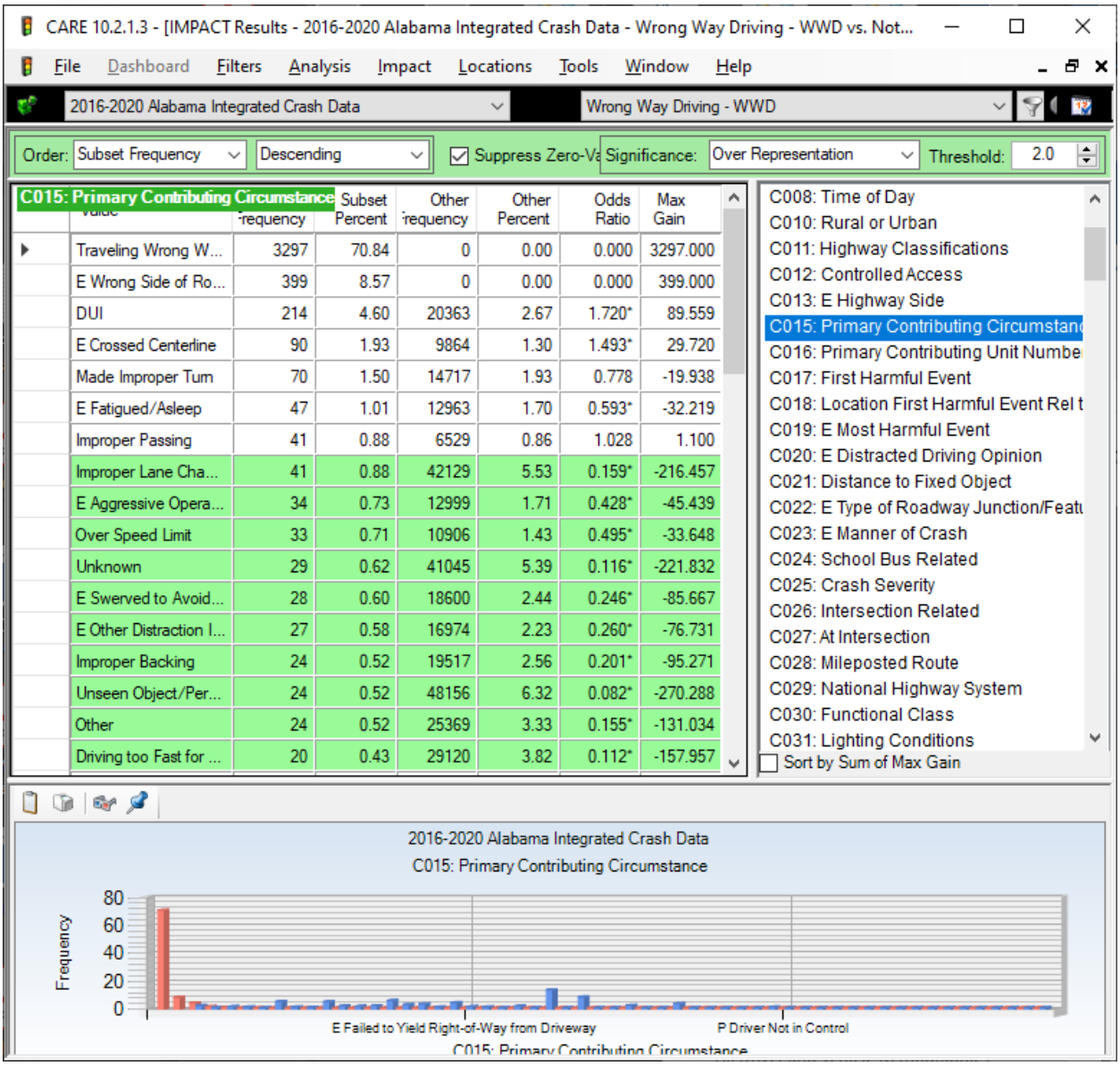
7.7 Driver Employment Status



Why would the employment status of the driver be of concern? In our current era when the economy and gas prices are playing such a big role in traffic safety, the quantification and tracking of the employment proportion of drivers involved in WWD crashes is important. This indicates that their unemployment rate proportion is close to 50% higher than expected in comparison with non-WWD crashes. This relationship is not surprising because of the underlying drug/alcohol root cause of many WWD crashes (see 8.3-8.4). The correlation between not having a job and being involved in an WWD crash should be watched carefully going forward in that it could affect the type and location for countermeasures. Some of these could be suicides, but no detailed investigations for this are typically performed.

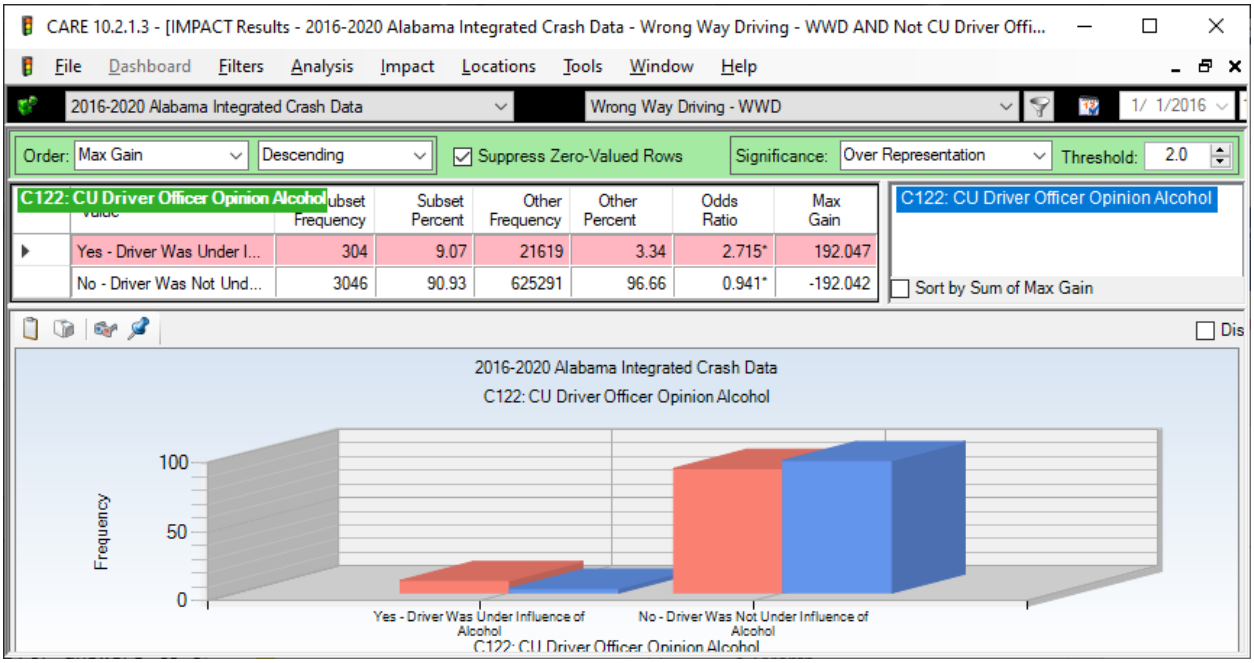
8.0 Driver Behavior

8.1 Primary Contributing Circumstances (RS & Items < 10 Crashes Removed)



The highest two items were "filtered in." The others show what was highly correlated in those that were not WWD in the *Primary* Contributing Circumstances (the attribute given above), but were found to be WWD in the *Causal Unit* Contributing Circumstances and the *V2* Contributing Circumstances. DUI is by far the highest of these attributes found, with several times the frequency of the other items below it.

8.2 CU Driver Officer's Opinion Alcohol



While Impaired Driving/Alcohol was indicated as the cause of the crash for only 9.07% of the WWD crashes, the fact that this proportion was over-represented by a factor of 2.715 (close to 3 times the expected from the non-WWD crashes indicates its importance. ID/DUI reports tend to be under-reported, but there is no doubt that its reduction would have a major impact on reducing the number of WWD crashes.

8.3 Severity of CU Driver by Officer's Opinion Alcohol Results

CARE 10.2.1.3 - [Crosstab Results - 2016-2020 Alabama Integrated Crash Data - Filter = Wrong Way Driving - WWD]

File Dashboard Filters Analysis Crosstab Locations Tools Window Help

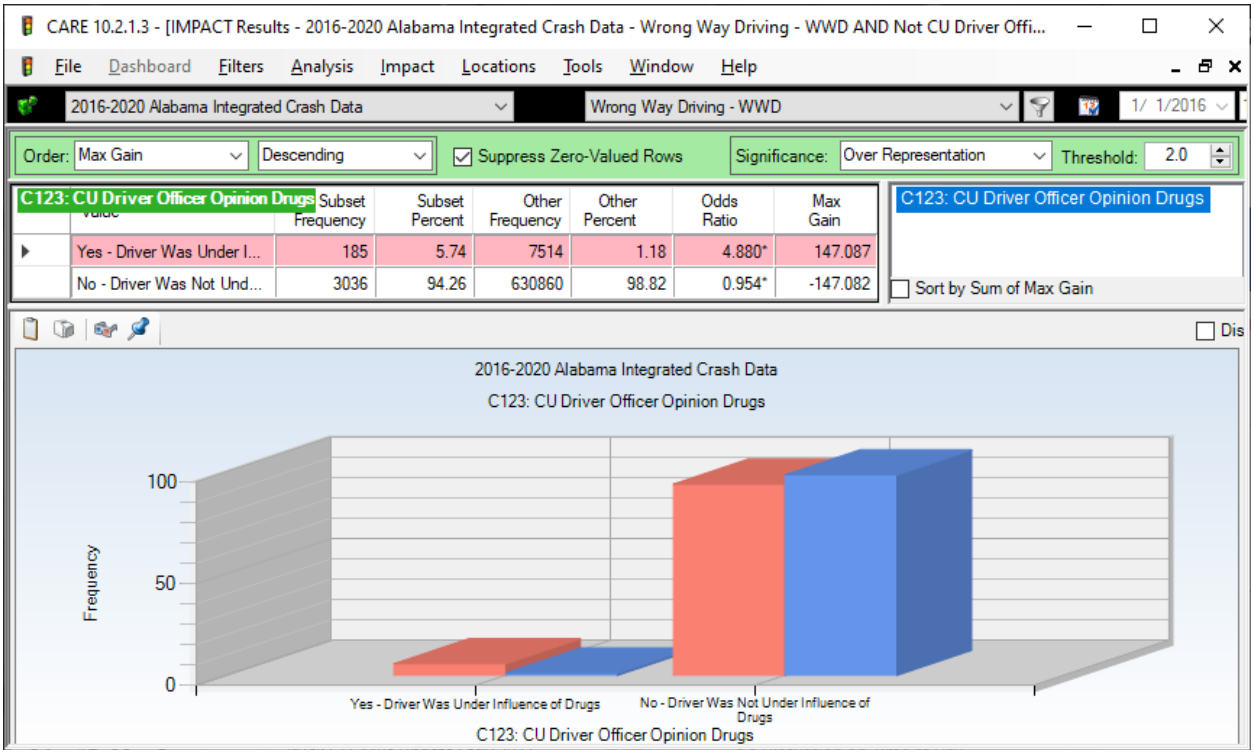
2016-2020 Alabama Integrated Crash Data | Wrong Way Driving - WWD | 1/ 1/2016

Suppress Zero Values: None | Select Cells: | Column: Crash Severity ; Row: CU Driver Officer Opinion Alcohol

	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Property Damage Only	Unknown	TOTAL
Yes - Driver Was Under Influence o	36 17.73%	52 11.26%	42 7.18%	29 6.53%	144 5.06%	1 0.86%	304 6.53%
No - Driver Was Not Under Influen	64 31.53%	304 65.80%	416 71.11%	311 70.05%	1880 66.10%	71 61.21%	3046 65.45%
Unknown	6 2.96%	12 2.60%	24 4.10%	12 2.70%	44 1.55%	3 2.59%	101 2.17%
Not Applicable	84 41.38%	68 14.72%	69 11.79%	70 15.77%	675 23.73%	39 33.62%	1005 21.59%
CU is Not a Vehicle	12 5.91%	25 5.41%	27 4.62%	15 3.38%	18 0.63%	1 0.86%	98 2.11%
CU is Unknown	1 0.49%	1 0.22%	7 1.20%	7 1.58%	83 2.92%	1 0.86%	100 2.15%
P Both Alcohol and Drugs	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%
TOTAL	203 4.36%	462 9.93%	585 12.57%	444 9.54%	2844 61.11%	116 2.49%	4654 100.00%

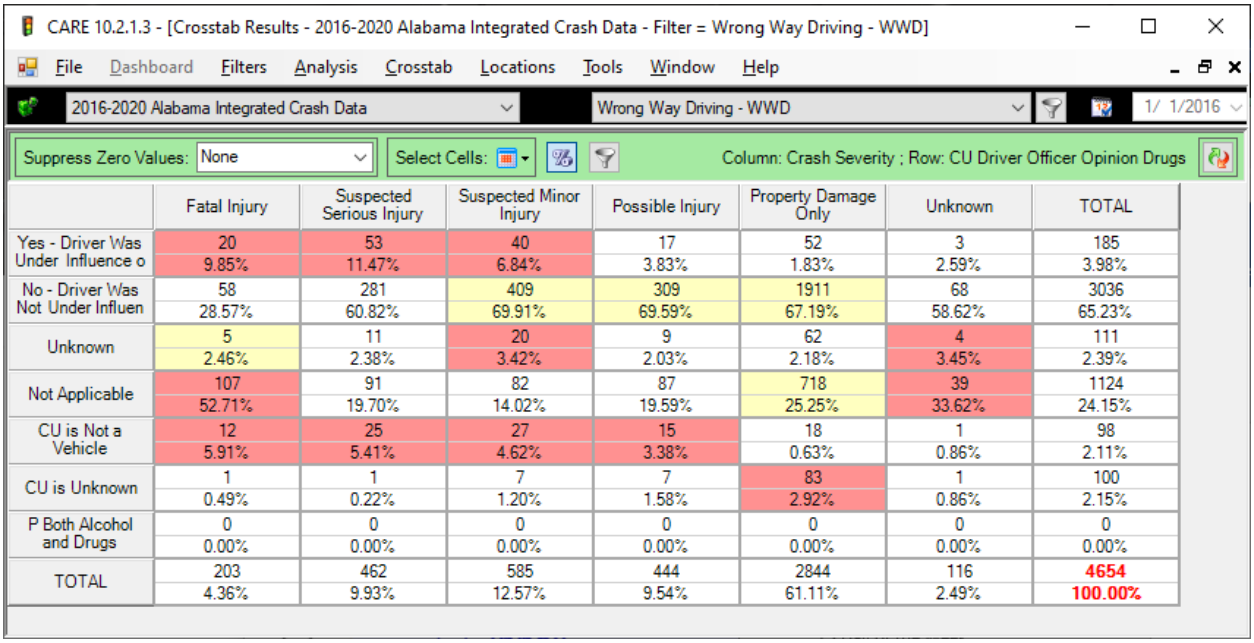
This cross-tabulation shows that those under the influence of alcohol have a one in 8.44 chance of being killed, while those who were sober had a one in 53.22 chance of being killed. This is a very highly significant difference and should discourage anyone who has had any alcohol at all from driving a motor vehicle.

8.4 CU Driver Officer's Opinion Drugs



While Impaired Driving/Drugs (non-alcohol drug) was indicated as the cause of the crash for only 5.74% of the WWD crashes, the fact that this proportion was over-represented by a factor of 4.880 (close to 5 times the expected from the non-WWD crashes) indicates its importance. While WWD ID-Drugs is only about half the frequency of WWD ID-Alcohol crashes, the over-representation is alarming, and it generally shows one reason there are as many WWD crashes as there are. In both cases (WWD and non-WWD), drug use is difficult to detect compared to alcohol, which has well-established tests for the blood-alcohol level that are relatively easy to administer. Our conclusion is that both alcohol and non-alcohol drug use are major contributors to increasing the frequency of WWD crashes, and their use is further compounded if they choose to avoid detection by using county roads. This is detailed further in the next display.

8.5 Severity of CU Drug Results



CARE 10.2.1.3 - [Crosstab Results - 2016-2020 Alabama Integrated Crash Data - Filter = Wrong Way Driving - WWD]

File Dashboard Filters Analysis Crosstab Locations Tools Window Help

2016-2020 Alabama Integrated Crash Data | Wrong Way Driving - WWD | 1/ 1/2016

Suppress Zero Values: None | Select Cells: | Column: Crash Severity ; Row: CU Driver Officer Opinion Drugs

	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Property Damage Only	Unknown	TOTAL
Yes - Driver Was Under Influence o	20	53	40	17	52	3	185
	9.85%	11.47%	6.84%	3.83%	1.83%	2.59%	3.98%
No - Driver Was Not Under Influen	58	281	409	309	1911	68	3036
	28.57%	60.82%	69.91%	69.59%	67.19%	58.62%	65.23%
Unknown	5	11	20	9	62	4	111
	2.46%	2.38%	3.42%	2.03%	2.18%	3.45%	2.39%
Not Applicable	107	91	82	87	718	39	1124
	52.71%	19.70%	14.02%	19.59%	25.25%	33.62%	24.15%
CU is Not a Vehicle	12	25	27	15	18	1	98
	5.91%	5.41%	4.62%	3.38%	0.63%	0.86%	2.11%
CU is Unknown	1	1	7	7	83	1	100
	0.49%	0.22%	1.20%	1.58%	2.92%	0.86%	2.15%
P Both Alcohol and Drugs	0	0	0	0	0	0	0
	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
TOTAL	203	462	585	444	2844	116	4654
	4.36%	9.93%	12.57%	9.54%	61.11%	2.49%	100.00%

The probability of driver death in any crash in which the driver been indulging in recognized drug use is one is 9.25. The death rate of those not under the influence of drugs is one in 52.34 DWD crashes, quite comparable to the results discussed in Section 8.3 for alcohol use.