



UNITED STATES  
CONSUMER PRODUCT SAFETY COMMISSION  
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Memorandum

Date: November 13, 2018

TO : The Commission  
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THROUGH: Mary T. Boyle, Executive Director  
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SUBJECT: The 2017 NEISS Table Saw Special Study<sup>1</sup>

This briefing package contains the results of the 2017 NEISS special study for table saw blade-contact injuries. There are three tabs summarizing the study's results:

Tab A: Garland, S. and Tu, Y. *Table Saw Blade-Contact Injuries Special Study Report, 2017*. U.S. Consumer Product Safety Commission, November 2018.

In this report, Directorate for Epidemiology staff summarizes the 2017 Table Saw Special Study's background, design, and the methodology to generate national emergency department-treated, table saw blade-contact, injury estimates. It also provides the response rates, reports the national injury estimates and risk estimates, and contains results of a case-level analysis completed by staff.

Tab B: Goldsmith, J. *Table saw blade-contact injuries*. Memorandum, U.S. Consumer Product Safety Commission, November, 13, 2018.

In this memorandum, Directorate for Health Sciences staff discusses the findings of the analysis of the 2017 NEISS data in terms of the injury diagnoses and provides the reasoning for the review team's decision to change injury diagnoses in some cases to characterize more accurately the injuries sustained.

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<sup>1</sup> This analysis was prepared by CPSC staff. It has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

Tab C: Bailey, M. *Table Saw Population Estimates for 2017*. Memorandum, U.S. Consumer Product Safety Commission, November 13, 2018.

In this memorandum, Directorate for Economic Analysis staff provides estimates of the number of table saws in use in 2017 and estimates the proportion that were equipped with the modular blade guards required under the 7<sup>th</sup> edition of UL 987. This memorandum presents an overview of the data used in the analysis and describes the methodology and results of the analysis. Additionally, an appendix presents an analysis evaluating the sensitivity of the risk findings developed by the Directorate for Epidemiology to possible variations in the estimated proportion of table saws equipped with the modular blade guard systems.

### Recommendation

CPSC staff recommends publishing a *Federal Register* notice indicating the availability of the study results (*i.e.*, this briefing package) on CPSC.gov with a 60-day public comment period.

# Tab A



# Table Saw Blade-Contact Injuries Special Study Report, 2017

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November 2018

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## I. Executive Summary

In January 2017, CPSC staff initiated a special study to obtain emergency department-treated, table saw blade-contact injury estimates for saw, incident, and injury characteristics, which are otherwise not available in the standard NEISS data collections. In April 2017, the Commission directed staff to publish the results for comment after the study's completion and analysis. This report provides the results of this study.

### Study Response Rates

- For the product codes 0841 (table saws), 0845 (saws, not specified), and 0895 (power saws, other or not specified), there were 1,342 cases identified in the NEISS, with treatment dates between January 1, 2017 and December 31, 2017, and with a final weight greater than zero.<sup>2</sup>
  - There were 202 cases from “non-participating” hospitals. Because non-participating hospitals do not provide patient identification, staff excluded these hospitals’ case from follow-up investigations.<sup>3</sup>
  - For the eligible 1,140 cases from “participating hospitals”:
    - 246 cases did not have to be assigned because the NEISS narrative indicated that a table saw was not involved or blade contact did not occur;
    - 128 cases did not provide victim contact information;
    - CPSC Field staff terminated 476 cases where no patient contact was made, the victim refused to participate, or the case did not meet study criteria; and
    - Field staff completed investigations for 290 cases.
- The overall response rate for the entire study was 39.9 percent.
- For the cases where CPSC staff requested In-Depth Investigations (IDIs) to be attempted, the response rate was 32.4 percent.
- Of the 290 completed IDIs, 161 involved a table saw blade-contact injury.

### Estimated Table Saw Blade-Contact Injuries, 2017

- In 2017, there were an estimated 26,500 table saw blade-contact, emergency department-treated injuries, with a 95 percent confidence interval of 25,200–27,800.
- Of the estimated 26,500 table saw blade-contact injuries, the table saw type distribution is:
  - bench saws were an estimated 60.7 percent of the injuries (16,100);
  - contractor saws were an estimated 26.6 percent of the injuries (7,000); and
  - cabinet saws were an estimated 9.2 percent of the injuries (2,400).
- Of the estimated 26,500 table saw blade-contact injuries, the blade guard use distribution is:
  - the blade guard was not in use in an estimated 88.9 percent of injuries (23,600);
  - the blade guard was in use in an estimated 6.3 percent of injuries (1,700); and
  - unknown blade guard use or situations where blade guard use is not applicable were the remaining proportion of injuries.
- Of the estimated 26,500 table saw blade-contact injuries:
  - the largest estimated proportion of injuries was for the disposition of treated and released (86.4 percent; 22,900);
  - the largest estimated proportion of injuries was to males (91.9 percent; 24,400);
  - the largest estimated proportion of injuries was to the finger (96.4 percent; 25,600); and

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<sup>2</sup> See “The 2017 Study Description” section for a detailed explanation of the study design.

<sup>3</sup> A “participating hospital” is defined as an active NEISS hospital that provides patient identification, if available, on a case-by-case basis, as requested by CPSC staff. A “non-participating hospital” is an active NEISS hospital that never provides any patient identification to CPSC as part of their contract. See Section VI for details.

- the largest estimated proportion of injuries was to the ≥61 years age group (52.5 percent; 13,900).

#### *Diagnosis*

- There were 15 completed table saw blade-contact investigations where the corresponding NEISS diagnosis was inappropriate or incorrect (Goldsmith, 2018). The diagnoses in these cases were changed throughout all analyses in this report.
- The NEISS diagnosis options available also presented a challenge in characterizing table saw blade-contact injuries. The subject matter experts (SMEs) agreed to add a diagnosis of severe laceration. The details are found in Tab B of this package (Goldsmith, 2018). In this report, the estimated injury results are labeled as “reviewed diagnosis.”
- This report provides the estimated number of injuries and estimated proportions of the distribution of injuries for both the NEISS diagnosis and the reviewed diagnosis (Table 10).

#### Risk of Estimated Table Saw Blade-Contact Injuries, 2017

- In 2017, there were an estimated 6.9 million table saws in use, which leads to the estimated risk of 38.62 blade-contact injuries per 10,000 table saws in use (95 percent confidence interval of 36.76 to 40.47).
  - The estimated number of bench saws in use is 4.0 million, which gives the estimated risk as 40.11 bench saw blade-contact injuries per 10,000 bench saws in use.
  - The estimated number of contractor saws in use is 1.4 million, which gives the estimated risk as 50.19 contractor saw blade-contact injuries per 10,000 contractor saws in use.
  - The estimated number of cabinet saws in use is 1.4 million, which gives the estimated risk as 16.91 cabinet saw blade-contact injuries per 10,000 cabinet saws in use.
- In 2017, the estimated number of table saws in use that conform to UL 987, 7<sup>th</sup> edition (conforming saws), is 3.9 million (57 percent). The indicator of a conforming saw in this injury study was a saw manufactured with a modular blade guard.
  - The estimated number of injuries associated with a conforming table saw is 3,200, which is 12.2 percent of the total 26,500 estimated table saw blade-contact injuries.
  - Of the estimated 21,000 injuries where the type of blade guard manufactured with the saw is known, the estimated proportion of injuries for conforming saws is 15.4 percent.
  - There is a significant proportion of injuries associated with “unknown” blade guard type as manufactured with the table saw (19.6 percent; 5,200).
  - The estimated risk of blade-contact injury associated with conforming table saws is 8.19 per 10,000 conforming saws. The estimated risk of blade-contact injury with a saw manufactured with a traditional blade guard is 60.76 per 10,000 table saws with a traditional blade guard.
  - In 2017, the estimated relative risk of a blade-contact injury is 7.19 times more on a saw with a traditional blade guard than on saw with a modular blade guard.

#### Case-Level Incident Analysis

- Section IX of this report summarizes the results of 161 investigations completed by CPSC Field staff for injury cases involving table saw blade contact, which inform the estimated injuries. A team of CPSC SMEs reviewed each incident in the study, and coded variables regarding the product involved, the injury, and the incident scenario.

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## V. Introduction

On April 27, 2017, the CPSC held a decisional hearing on a notice of proposed rulemaking (NPR) regarding the safety standard for table saw blade-contact injuries. In their briefing package to the Commission, staff provided the statistical analysis of the NEISS cases for product code 0841 (table saws).<sup>4</sup> Staff also provided a history and timeline of prior statistical studies for table saw-related injuries, and explained why staff was not relying on those prior studies for the briefing package. For the history of table saw injury studies conducted by the CPSC, see Tab B of the NPR briefing package. CPSC staff noted in the briefing package that the lack of injury estimates by type of saw negatively impacts the ability of staff to complete a full benefit-cost analysis. Therefore, in addition to the table saw injury analysis provided in staff's NPR briefing package, Tab B, CPSC staff developed a new study based on the NEISS and conducted by CPSC Field staff investigators. CPSC staff called this study the 2017 NEISS Table Saw Special Study (2017 Study). The goals of the study were: (1) to obtain information regarding the type of table saws involved in the cases to generate national estimates by saw type and the estimated risk of injury associated with each table saw type, (2) to gain information regarding the type and usage pattern of the blade guard, and (3) to collect additional injury and incident details. The study began in January 2017. At the public hearing on April 27, 2017, the Commission directed staff to complete the study and provide a notice in the FR.

This report summarizes the 2017 Study's design and the methodology developed by staff to generate national estimates; it provides the response rates, and it reports the national estimates and risk estimates, as indicated in the goals above.

Although this report summarizes the statistical results from the 2017 Study, another dimension of the information collected in the study is the specific data regarding the injuries for table saw blade contact. Thus, included as part of the results of this 2017 Study is an injury analysis completed by CPSC's Directorate for Health Sciences (Goldsmith, 2018). For risk estimates, CPSC's Directorate for Economic Analysis completed an analysis of estimated table saw in use (Bailey, 2018), which is provided as part of the results of this analysis.

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<sup>4</sup> <https://cpsc.gov/s3fs-public/Proposed%20Rule%20-%20Safety%20Standard%20for%20Blade-Contact%20Injuries%20on%20Table%20Saws%20-%20January%2017%202017.pdf>

## VI. The 2017 Study

### The 2017 Study Description

The NEISS is a national stratified probability sample of hospitals in the United States and its territories. There are five strata in the NEISS: children’s hospitals, small hospitals, medium hospitals, large hospitals, and very large hospitals. Within each stratum is a sample of hospitals that makes up the primary sampling units (PSUs) of the NEISS. For each hospital in the sample, every emergency department visit that is associated with a consumer product is recorded. To facilitate injury estimates associated with a product or product group, each injury has a product code that identifies the type of product involved, and weight (*i.e.*, the inverse of the probably of selection, adjusted for any nonresponse), which gives the numerical representation of each case to the number of people that that case represents. Other product-specific information, such as the name of the manufacturer, is not recorded in the NEISS. Information recorded for each injury includes sex, age, diagnosis, disposition, and body part, among other information. The information on stratum, hospital, age, and sex of the patient is known for all observations in this study. Additional information about the NEISS can be found online at: <http://www.cpsc.gov/library/neiss.html>.

When resources allow, follow-up special studies are performed based on the NEISS data collected. These special studies are often focused on a product or group of products and are used to gather more specific information about the product(s) involved and the hazard scenario surrounding incidents. Almost all recent special studies have used computer-assisted telephone interview (CATI) surveys to collect information about the incident from the patient, or someone closely associated with the patient with knowledge of the incident, such as a family member. However, due to table saw data-collection issues documented previously, which included significant interviewer effects in several questions from the survey,<sup>5</sup> in January 2017, CPSC staff began a NEISS special study collecting additional incident data from CPSC field staff IDIs for in-scope table saw cases treated in hospitals in the year 2017, instead of using formal survey data collection methods. This is the 2017 Study that is the subject of this report. Appendix C describes the SME review process and final analytic data set obtained from the 2017 Study for the set of table saw completed IDIs.

There is a product code for table saws specifically in the NEISS (0841); however, hospital coders can only use this code if the patient used the words “table saw,” and the words “table saw” were recorded in the hospital record. If a less-specific description is used, then a less-specific product code is used: either 0845 (saws, not specified), or 0895 (power saws, other or not specified). Cases using the less-specific product codes (0845 and 0895) could include table saws, although the proportion of table saw cases may be small. Nevertheless, all cases required review or investigation to discover whether the case involved a table saw and met the study’s design requirements for the goal of obtaining accurate estimates of table saw blade-contact injuries. Thus, staff set the initial scope of the study to review all cases with the product codes 0841, 0845, and 0895. This covered 1,342 cases for treatment dates January 1, 2017 through December 31, 2017, with final weight greater than zero.

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<sup>5</sup> <https://cpsc.gov/s3fs-public/Proposed%20Rule%20-%20Safety%20Standard%20for%20Blade-Contact%20Injuries%20on%20Table%20Saws%20-%20January%202017%202017.pdf> (Tab B)

## Eligible Study Cases

Weekly during the study, CPSC staff reviewed incoming cases from the hospitals in the NEISS with the product codes 0841 (table saws), 0845 (saws, not specified), and 0895 (power saws, other or not specified), to determine whether a follow-up investigation was applicable for the case, based on the study criteria (the case from a “participating hospital” could have involved table saw blade contact). If staff determined a case met the study criteria for a follow-up investigation, staff submitted the investigation request and the process of obtaining patient identification from the treating hospital began. This section summarizes the results of this process.

Altogether, there were 1,342 cases identified in the NEISS, with treatment dates between January 1, 2017 and December 31, 2017; product codes of 0841 (table saws), 0845 (saws, not specified), or 0895 (power saws, other or not specified); and with a final weight greater than zero. Table 1 provides the product code breakdown for the initial set of cases with at least one of the three product codes in the 2017 treatment timeframe.

**Table 1: NEISS Product Codes for Initial Scope of Table Saw Studies**

Product Code	Number of Cases*
<i>0841 (Table Saws)</i>	691
<i>0845 (Saws, not specified)</i>	300
<i>0895 (Power Saws, other or not specified)</i>	351
<b>Total</b>	<b>1,342</b>

\*There were two cases in the study period that were associated with both product code 0841 and 0895; these two cases are counted in the 0841 product code category only in this table.

Not all of the 1,342 cases were considered eligible for an IDI, although they all inform the study results in some manner (Appendix A). Not all of the NEISS hospitals participate in providing contact information for cases they have submitted. Accordingly, cases from non-participating hospitals had to be removed as eligible study cases because CPSC cannot follow up where no contact information is provided. There were 202 cases from these non-participating hospitals (Table 2); thus, 202 cases were excluded from the possibility of a follow-up investigation.

**Table 2: Case Distribution for Participating (Provides Victim Contact, if Available) Versus Non-Participating NEISS Hospitals**

Case from a Participating Hospital	Number of Cases
<i>No</i>	202
<i>Yes</i>	1,140
<b>Total</b>	<b>1,342</b>

Once the cases from non-participating hospitals were removed, CPSC staff reviewed the remaining 1,140 cases and did not assign for follow-up investigation those that were clearly not table saw injuries or were clearly injuries not resulting from table saw blade contact.<sup>6</sup> CPSC staff completed this step by reviewing, weekly for the entire year, a total of 1,140 NEISS cases and removing any cases that

<sup>6</sup> Due to the increase in resources required for a Field staff investigation-based study compared to a CATI-based study, where all cases would be assigned for further data collection, CPSC staff did not request investigations for these cases. However, the non-assigned cases play an integral role in the analysis methodology; see Appendices A and B for details.

indicated, or for which staff could assume reasonably, that a table saw was not involved (e.g., cases indicating the victim was trimming a tree) or where no blade contact occurred (e.g., corneal abrasions due to debris while using a table saw). This left 894 cases eligible for investigation assignment requests (Table 3); that is, 894 cases that came from a hospital that could provide contact information, if available, and the emergency department visit could be from a table saw blade-contact incident, which qualifies the case for a follow-up investigation to gather more specific, objective product information. CPSC staff submitted requests for CPSC Field staff investigations on a weekly schedule throughout the study.

**Table 3: Eligible Cases Distribution**

<b>Case Eligible for Assignment (based on staff case review)</b>	<b>Number of Cases</b>
<i>No</i>	246
<i>Yes</i>	894
<b>Total</b>	<b>1,140</b>

### [The 2017 Study Response Rates](#)

Table 4 provides the number of cases and percentage of cases for each type of response available in the 2017 Study, for all 1,342 cases for product codes 0841 (table saws), 0845 (saws, not specified), and 0895 (power saws, other or not specified), with a final NEISS weight greater than zero. As discussed in the previous section, not all cases were eligible for follow-up investigation, although these cases inform the final analysis of the study, as part of the denominator of the level 1 correction factor as cases that did not involve table saw blade contact. Because the NEISS design captures only the first emergency department visit for each incident and patient, duplicate cases (*i.e.*, re-visits for the same patient and incident) are considered out of scope for the NEISS and removed from the analyses altogether. However, two cases involved the same victim, but for two separate incidents. Both of these cases are in-scope for the study; CPSC Field staff completed only one IDI for both incidents (each incident is listed separately within the IDI). There are two unique identifiers in the NEISS representing each incident, but only one identifier for the IDI associated with these two cases. Each NEISS case is considered a “completed IDI” in Table 4. The final total case count is 1,342 with 290 completed IDIs.

**Table 4: Investigation Response Types and Results**

Status	Number of Cases	Percent of Total <sup>7</sup>
<b>Nonresponses</b>		
<i>Non-participating hospital</i>	202	15%
<i>No patient contact information available</i>	128	10%
<i>Terminated by Field staff</i>	467	35%
<i>Completed IDI, but count as nonresponse<sup>8</sup></i>	9	1%
<b>Responses</b>		
<i>Not a table saw; Unknown if table saw, but no blade contact; or Table saw, but no blade contact (not assigned for investigation)</i>	246	18%
<i>Completed IDI</i>	290	22%
<b>Total</b>	<b>1,342</b>	<b>100%</b>

For the 1,140 investigation-eligible cases, 246 cases did not have to be assigned because the NEISS narrative regarding the incident indicated that a table saw was not involved or blade contact did not occur. The 246 non-assigned cases are counted as responses because they are used within the analytic methodology to answer part of the study’s overall questions. There were 128 cases without victim contact information available from participating hospitals. Field staff terminated 467 cases when they were unable to make contact with the patient, the victim refused to participate, or was unable to meet study criteria (e.g., instructions to investigators included a description of when one could justify a termination even with patient contact, because the required information would be unattainable in some scenarios; for example, when the contact is hostile and no information that is of interest to the study is obtained during contact).<sup>9</sup> In two of the terminated cases, the cases were received by CPSC staff after the study’s data cut-off deadline, but were determined eligible for assignment. Thus, CPSC staff classified these two cases in the “Terminated” category, although they were not assigned to the Field. Field staff completed investigations for 290 cases. Thus, the overall response rate for the entire study was 39.9 percent.<sup>10</sup>

Of the 894 cases that were assigned for investigation, the hospital could not provide contact information in 128; Field staff terminated 467 investigations and completed 290 investigations. Thus, for the cases where CPSC staff requested that investigations be attempted, the response rate for cases with investigations requested was 32.4 percent.<sup>11</sup>

<sup>7</sup> Throughout all tables of this report, percentages may not sum to 100 percent, due to rounding.

<sup>8</sup> There were nine completed IDIs that the SME review team marked as a nonresponse, due to the incorrect set of questions being asked of a victim, the inability to ask most questions of the victim (e.g., a highly reluctant respondent who essentially refused to participate, and extremely limited information gained), or other similar circumstances. Thus, these nine IDIs did not meet the study criteria, and these nine cases are included in the nonresponse category.

<sup>9</sup> Unit nonresponse occurs when a case is from a hospital that does not participate in providing victim identification, no contact was established, victim’s participation refusal, or the study’s criteria is not met.

<sup>10</sup> *overall study (level 1) response rate* =  $\frac{290+246}{1342} = \frac{536}{1342} = 39.9\%$ . This corresponds to the Level 1 estimates in the methodology provided in Appendix A, which includes table saw blade-contact estimates.

<sup>11</sup> *investigation (level 2) response rate* =  $\frac{290}{128+467+9+290} = \frac{290}{894} = 32.4\%$ . This corresponds to the Level 2 estimates in the methodology provided in Appendix A, which includes table saw type estimates.

## Completed IDI Product Identification and Blade-Contact Status

As previously noted, the study's goals include obtaining additional table saw blade-contact injury information and extrapolating the data to generate national estimates. The study was initiated with a broader scope from which one can extrapolate to the specific scope of table saw blade-contact injuries. This section summarizes the 290 completed IDIs from the study at the product level. This section aims to give a high-level summary of the completed investigations for the types of products identified and, for the table saws identified, provide the blade-contact status. Detailed analyses of the table saw cases are given throughout the remainder of this report.

Table 5 provides the products identified in the 290 completed IDIs cases. There were 180 completed IDIs that identified a table saw as the product involved in the incident. SMEs determined that blade contact occurred as the injury mechanism in 161 of the 180 completed IDI table saw cases (Table 6).

**Table 5: Product and Scope Identification for All Completed IDIs**

<b>Product Type</b>	<b>Frequency</b>	<b>Percent of Total Completed IDIs</b>
<i>Table saw</i>	180	62.1%
<i>Circular saw</i>	41	14.1%
<i>Powered miter saw/Chop saw</i>	17	5.9%
<i>Manual hand saw</i>	10	3.4%
<i>Grinder</i>	8	2.8%
<i>Reciprocating saw</i>	6	2.1%
<i>Unspecified, handheld, power saw</i>	5	1.7%
<i>Band saw</i>	4	1.4%
<i>No saw involved</i>	4	1.4%
<i>Jigsaw</i>	3	1.0%
<i>Not a table saw, but also out of scope for the NEISS as a work-related incident</i>	3	1.0%
<i>Radial arm saw</i>	2	0.7%
<i>Biscuit joiner</i>	1	0.3%
<i>Chain saw</i>	1	0.3%
<i>Jointer</i>	1	0.3%
<i>Powered hedge trimmer</i>	1	0.3%
<i>Unspecified power saw</i>	1	0.3%
<i>Unspecified handheld saw</i>	1	0.3%
<i>Unknown saw type</i>	1	0.3%
<b>Total</b>	<b>290</b>	<b>100%</b>

In calculating the Level 1 adjustment factor estimates (the estimated proportion of table saw blade-contact injuries of the total 0841, 0845, 0895 estimated injuries), the 161 completed IDIs identified as blade contact in Table 6 inform the numerator through the methodology described in the following sections and in Appendix A. The denominator includes the 290 cases in Table 5, and also the 246 cases that were not assigned (Table 4), due to scope knowledge available at the NEISS case level. These 161 cases move to inform the denominator of the Level 2 adjustment factor estimates, as described in the following section and Appendix A, while a subset of the 161 inform the numerator, depending on the Level 2 adjustment factor estimated under consideration.

**Table 6: Blade Contact and Scope Identification for the 180 Completed Table Saw IDIs**

Completed Table Saw IDI Scope	Frequency	Percent of Total
<i>In-scope blade-contact Injury</i>	161	89%
<i>Not a blade-contact injury</i>	13	7%
<i>Out-of-scope (Occupational injury)</i>	4	2%
<i>Out-of-scope (Homemade table saw)</i>	2	1%
<b>Total</b>	<b>180</b>	<b>100%</b>

## VII. Estimated Emergency Department-Treated, Table Saw Blade-Contact Injuries, 2017<sup>12</sup>

Appendix A describes the full mathematical details for calculating injury estimates and associated variance estimates for each level of incident characteristics. This section describes, more generally, the process of obtaining injury estimates, and provides the resulting injury estimates for the year 2017.

As noted in *The 2017 Study Description* section, only table saw blade-contact injuries were the focus of the study. Therefore, this study can only generate estimates specifically for blade-contact injuries for table saws, not all injuries. However, to obtain the table saw blade-contact injury estimates, the process is not simply taking the cases that are table saw blade-contact and summing the weights to obtain estimates (*i.e.*, the standard method of point estimate calculations for the NEISS). As noted in the description in Appendix A, the methodology generates a set of adjustment factors (*i.e.*, estimated proportions that can be applied to a known estimate), to calculate the estimated number of emergency department-treated injuries for a particular characteristic.

In this study, the known injury estimate (*i.e.*, estimate derived without a special study) is all injuries related to products in the codes 0841 (table saws), 0845 (saws, not specified), and 0895 (power saws, other or not specified). The estimated number of injuries from these three product codes, along with the associated variance estimated, is obtained first through the typical methodology used for obtaining injury estimates from the NEISS. This is the top-level injury estimate that can be obtained for any year of the NEISS, not just the special study year, given certain assumptions. In Appendix A, this estimate is called  $\hat{\tau}$  (pronounced “tau-hat”). Adjustment factors will be applied to this estimate to obtain estimated injuries for specific incident characteristics. Although this process can be completed for any year of the NEISS, this section will focus on the year 2017. Table 7 provides the 2017 estimated injuries, with the 95

<sup>12</sup> Estimates are rounded to the nearest 100 injuries. Estimated injuries may not sum to subtotal or total due to rounding. All estimated percentages and proportions are based on unrounded estimates.

percent confidence interval for the injury estimate, as obtained from the NEISS, for product codes 0841, 0845, and 0895. In 2017, there are an estimated 64,000 injuries related to products in these three product codes ( $\hat{\tau}$ ), with a 95 percent confidence interval of 55,500 to 72,400.<sup>13</sup>

**Table 7: 2017 NEISS Estimated Injuries for Product Codes 0841, 0845, 0895**

Product Codes	2017 Injury Estimate ( $\hat{\tau}$ )	95% Confidence Interval for the 2017 Injury Estimate ( $\hat{\tau}$ )
0841, 0845, 0895 (All cases)	64,000	55,500 – 72,400

To obtain the estimated number of table saw blade-contact injuries, an adjustment factor is applied to the 64,000 estimate (*i.e.*, 64,000 is multiplied by an estimated proportion to reduce the estimate to the measure of interest, in this case, table saw blade-contact injuries). The adjustment factor for table saw blade-contact injuries is the Level 1 estimate,  $\hat{\theta}_{L_1}^*$  (pronounced “theta-L-one-star-hat”), in Appendix A. The adjustment factor calculated is 0.414, which reduces the  $\hat{\tau} = 64,000$  estimate to 26,500, which is called  $\hat{\phi}_{L_1}$  (pronounced “phi-L-one-hat”) in Appendix A.<sup>14</sup> The  $\hat{\phi}_{L_1}$  is 26,500, which is the estimated number of table saw blade-contact injuries. Table 8 summarizes this process with the results.

**Table 8: Estimated 2017 Emergency Department-Treated, Table Saw Blade-Contact Injuries (Level 1)**

	Adjustment Factor Estimate	95% Confidence Interval for $\hat{\theta}_{L_1}^*$	2017 Injury Estimate	95% Confidence Interval for the 2017 Injury Estimate
0841, 0845, 0895 (All Cases)	N/A	N/A	$\hat{\tau} = 64,000$	55,500 – 72,400
Table saw blade-contact injuries	$\hat{\theta}_{L_1}^* = 0.414$	0.395 – 0.434	$\hat{\phi}_{L_1} = 26,500$	25,200 – 27,800

To obtain the estimated number of table saw blade-contact injuries for each type of table saw, along with other characteristics of the incident, another level of adjustment factors is estimated and applied to the estimated number of table saw blade-contact injuries that is given in Table 8. The NEISS cannot collect information at the detailed level of the type of table saw, like a bench saw versus contractor or cabinet saw, so estimates at this level of detail must rely on data collected through a special study. To obtain the estimated blade-contact injuries specific for bench saws, the level 2 adjustment factor,  $\hat{\theta}_{L_2}^*$ , is applied to the  $\hat{\phi}_{L_1} = 26,500$ , reducing this table saw blade-contact injury estimate to represent only the bench saw blade-contact injuries. Thus, the table saw blade-contact injury estimate for any Level 2 characteristics is the  $\hat{\tau}$  estimate (the overall, unadjusted estimate for all three product codes), multiplied by both  $\hat{\theta}_{L_1}^*$  and  $\hat{\theta}_{L_2}^*$ . The combination (*i.e.*, multiplication) of these two correction factors is written as  $\hat{\theta}_C^*$ , as a combined adjustment factor to  $\hat{\tau}$ . This process is completed for any estimate related to a detail that can only be collected from a follow up with the patient determining further details regarding incident and injury (Level 2 in the Appendix B flow chart). This is the  $\hat{\phi}_{L_2}$  estimate in Appendix A. Table 9 provides the estimated number of table saw blade-contact injuries for estimates for Level 2 characteristics. Level 2 estimates provided are table saw blade-contact injuries by table saw type, guard

<sup>13</sup> All injury estimates in this report are rounded to nearest 100.

<sup>14</sup> All adjustment factor estimates in this report are rounded to the third decimal place. However, calculations of injury estimates and their 95% confidence intervals are based on unrounded estimates, and the results are then rounded for this report.



usage, guard type as manufactured with the saw, diagnosis, the NEISS disposition, injured body part, victim's age group, and victim's sex. Though other variables the SME review team coded in the study are considered Level 2 as well, the methodology from Appendix A is computationally intensive, so CPSC staff limited estimates to this specific set of characteristics, which meet the main goals of the study. Section IX provides the results of all study variables at the case level without extrapolation to national estimates.

Part of the first goal of the 2017 Study was to provide estimated injuries by table saw type. Of the estimated 26,500 table saw blade-contact injuries, an estimated 16,100 (60.7 percent) and 7,000 (26.6 percent) are bench and contractor saws, respectively. The remaining part of the estimated blade-contact injuries are for cabinet saws and table saws where a type of saw cannot be determined.

Blade guard use was also another area of interest to understand as part of the 2017 Study. In 2017, of the estimated 26,500 table saw blade-contact injuries, 23,600 (88.9 percent) occurred without a blade guard in use, while 1,700 occurred with a blade guard in use (6.3 percent). For a more detailed case-level analysis concerning blade guard use, see Section IX of this report.

In 2017, of the 26,500 estimated table saw blade-contact injuries, an estimated 17,800 (67.0 percent) occurred on a saw manufactured with a traditional blade guard, while an estimated 3,200 injuries occurred on a table saw manufactured with a modular blade guard (12.2 percent). A non-trivial proportion (an estimated 19.6 percent or an estimated 5,200 injuries) of the estimated blade-contact injuries occurred on a table saw where the type of blade guard manufactured with the saw could not be determined. With this in mind, considering the estimated injuries where the blade guard type that was manufactured with the saw was known (21,000), the majority (84.6 percent) of the estimated injuries are for saws manufactured with a traditional blade guard, and saws manufactured with a modular blade guard are an estimated 15.4 percent. Note that from a statistical perspective, the breakdown of the type of blade guard by whether the blade guard is in use is not possible due to the small sample sizes; however, this additional breakdown is provided at the case level in Section IX.

A majority of the estimated 26,500 table saw blade-contact injuries were treated and released in the emergency department (22,900; 86.4 percent), while an estimated 11.7 percent (3,100) were hospitalized (*i.e.*, treated and transferred or treated and admitted).

A majority of the estimated 26,500 table saw blade-contact injuries occurred to at least one finger (24,400; 91.9 percent) and to males (25,600; 96.4 percent).

About half of the estimated 26,500 table saw blade-contact occurred to the  $\geq 61$  age group (52.5 percent; 13,900), while the 41-60 age group and  $\leq 40$  age group had an estimated 35.1 percent and 12.4 percent of the injuries (9,300 and 3,300), respectively.

**Table 9: 2017 Estimated Emergency Department-Treated Injuries by Category (Level 2)**

Table Saw Blade-Contact Injuries <sup>15</sup>	$\hat{\theta}_{L_2}^*$ Estimate	$\hat{\theta}_C^*$ Estimate	2017 Injury Estimate, $\hat{\phi}_{L_2}$	95% CI for the 2017 Injury Estimate
Table Saw Type				
<i>Bench</i>	0.607	0.252	16,100	15,300 – 16,900
<i>Contractor</i> <sup>16</sup>	0.266	0.110	7,000	6,600 – 7,500
<i>Cabinet</i>	0.092	0.038	2,400	2,200 – 2,700
<i>Unknown</i>	*	*	*	*
Blade Guard Use				
<i>No</i>	0.889	0.368	23,600	22,400 – 24,800
<i>Yes</i>	0.063	0.026	1,700	1,500 – 1,900
<i>Unknown</i>	*	*	*	*
<i>N/A</i>	*	*	*	*
Guard Type Manufactured with Saw				
<i>Traditional</i>	0.670	0.278	17,800	16,800 – 18,700
<i>Modular</i>	0.122	0.050	3,200	2,900 – 3,500
<i>Unknown</i>	0.196	0.081	5,200	4,500 – 5,900
<i>None</i>	*	*	*	*
Disposition				
<i>Treated and Released</i>	0.864	0.358	22,900	21,700 – 24,100
<i>Hospitalized</i> <sup>17</sup>	0.117	0.048	3,100	2,800 – 3,400
<i>Other</i>	*	*	*	*
Body Part				
<i>Finger</i>	0.919	0.381	24,400	23,100 – 25,600
<i>Hand</i>	0.073	0.030	1,900	1,700 – 2,200
<i>Other</i>	*	*	*	*
Sex				
<i>Male</i>	0.964	0.399	25,600	24,300 – 26,800
<i>Female</i>	*	*	*	*
Age Group				
<i>≤40</i>	0.124	0.051	3,300	2,600 – 4,000
<i>41-60</i>	0.351	0.145	9,300	8,800 – 9,800
<i>≥61</i>	0.525	0.217	13,900	13,200 – 14,600

\*Indicates an injury estimate that is considered unstable; thus, is not reported in this table.

<sup>15</sup> There are 10 cases with completed IDIs that inform the table saw type = “Cabinet” estimate, and similarly, 10 cases for table saw type=“Unknown,” 14 cases for blade guard use = “Yes,” and 15 cases for body part = “Hand.” Typically, this is a smaller number of cases than usual for producing a stable estimate with the NEISS; however, the methodology applied here is not the methodology used to generate the reporting criteria for the NEISS. These estimates otherwise meet the standard NEISS stability criteria, except for table saw type = “Unknown.” These estimates are reported here, but with this note. However, if an estimate failed a second reporting criteria, as with table saw type = “Unknown,” the estimate is not reported.

<sup>16</sup> The contractor saw category includes contractor saws and hybrid table saws. See Section IX (Table 16).

<sup>17</sup> The “Hospitalized” category includes the NEISS dispositions of admitted and transferred.

In reviewing the additional information obtained through the IDIs, the SME review team determined that the injuries sustained in these incidents were not easily captured by a single diagnosis code available in the NEISS (See the “Case-Level Incident Analysis” section of this report and Tab B (Goldsmith, 2018) for additional details). The injuries were, at times, severe lacerations that the NEISS had captured through various diagnosis codes, but those single diagnosis codes did not describe the full extent of the injuries. Additionally, the SME review team determined the NEISS diagnosis was inappropriate or incorrect in 15 cases. Thus, the SME review team reviewed the information available and made a determination about the NEISS injury code. This report does not go into the details of these injuries, but refers the reader to the Directorate for Health Science’s memorandum (Tab B), which is part of this package and provides a detailed analysis of table saw blade-contact injuries from the 2017 Study (Goldsmith, 2018). The estimated injuries for the NEISS diagnosis and the Reviewed Diagnosis (a classification that captures more of the extent of the injury), but both incorporating the corrected value for the 15 inappropriate or incorrect cases, are given in Table 10.

While the laceration diagnosis remained the prevalent diagnosis in table saw blade-contact injuries, regardless of the classification method, the SME review team’s “reviewed diagnosis” captured severe lacerations at an estimated 15.1 percent of the estimated 26,500 table saw blade-contact injuries, and lacerations at an estimated 53.2 percent (estimates of 4,000 and 14,100, respectively). There is a statistically significant difference between the laceration diagnosis from the NEISS diagnosis and the reviewed diagnosis of laceration, and the severe laceration classification cannot be compared between the two, as the severe laceration classification is unique to the 2017 Study, as described.

The amputation diagnosis represents 10.7 percent of the estimated table saw blade-contact injuries for the NEISS diagnosis, and 13.3 percent of the reviewed diagnosis; there is not a statistically significant difference between these two estimates. Fracture diagnoses within the NEISS diagnosis often shifted to the severe laceration category in the reviewed diagnosis; thus, a significant change is seen in the fracture and other classifications between NEISS diagnosis and reviewed diagnosis. An estimated 20.6 percent of the table saw blade-contact injuries within the NEISS diagnosis are fractures, while fractures had to be combined with the avulsion diagnosis to yield statistical results in the reviewed diagnosis. See Table 13 in Section IX for the comparison of the NEISS diagnosis to the reviewed diagnosis, and see (Goldsmith, 2018) for a detailed analysis of the injuries in the 2017 Study.

**Table 10: Estimated Emergency Department-Treated Injuries by Category (Level 2), Diagnosis**

Table saw blade-contact Injuries <sup>18</sup>	$\hat{\theta}_{L_2}^*$ Estimate	$\hat{\theta}_C^*$ Estimate	2017 Injury Estimate, $\hat{\phi}_{L_2}$	95% CI for the 2017 Injury Estimate
NEISS Diagnosis				
<i>Laceration</i>	0.609	0.252	16,100	15,200 – 17,100
<i>Fracture</i>	0.206	0.085	5,500	5,100 – 5,800
<i>Amputation</i>	0.107	0.044	2,800	2,600 – 3,100
<i>Other</i>	0.078	0.032	2,100	1,800 – 2,300
Reviewed Diagnosis				
<i>Laceration</i>	0.532	0.220	14,100	13,200 – 15,000
<i>Severe Laceration</i>	0.151	0.063	4,000	3,600 – 4,400
<i>Amputation</i>	0.133	0.055	3,500	3,200 – 3,800
<i>Fracture or Avulsion</i>	0.184	0.076	4,900	4,500 – 5,200

<sup>18</sup>  $\hat{\phi}_{L_1}$  from Table 6 ( $\hat{\phi}_{L_1} = 26,500$ ).

## VIII. Estimated Risk of Emergency Department-Treated, Table Saw Blade-Contact Injuries, 2017

In the previous section, Table 8 gives the estimated number of table saw blade-contact injuries in 2017. Table 9 breaks down that estimate for each type of table saw, whenever it is possible. In this section, the estimated number of injuries is divided by the estimated number of table saws in use<sup>19</sup> to obtain the estimated risks of injury. Confidence intervals are also provided to understand the results.<sup>20</sup>

Table 11 provides the estimated number of table saws in use for all table saw types and by type of table saw.<sup>21</sup> This estimated number of table saws in use becomes the denominator for the risk of table saw blade-contact injuries, which is provided as the estimated number of blade-contact injuries per 10,000 table saws in use. For all types of table saws, the estimated risk is 38.62 blade-contact injuries per 10,000 table saws in use, with a 95 percent confidence interval of 36.76 to 40.47.

Bench saws are estimated at approximately 60 percent of the total estimated number of table saws in use, and contractor and cabinet saws comprise approximately 20 percent each. The estimated risk is 40.11 blade-contact injuries per 10,000 bench saws in use, 50.19 per 10,000 contractor saws in use, and 16.91 per 10,000 cabinet saws in use. The risk of blade-contact injury is highest for contractor saws, and lowest for cabinet saws, with all risk comparisons being statistically different.

The proportions of the estimated number of table saws in use for bench and contractor saws (58.5 percent and 20.4 percent, respectively) is similar to the proportions of blade-contact injuries for bench and contractor saw blade contact injuries (60.7 percent and 26.6 percent for bench and contractor saw injuries, respectively). For cabinet saws, there is observable difference in the proportion of estimated table saws in use (21.1% of all table saws in use) versus the proportion of blade contact injuries (9.3% of table saw blade contact injuries).

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<sup>19</sup> The term “in use” does not refer to the frequency of use, but to the number of units available for use.

<sup>20</sup> The variance estimate for the risk estimates are assumed to be the same as the variance for the corresponding injury estimate. This is not likely the case in reality; however, there is not a closed form of the variance estimator for the denominator, and it is unlikely that there would be enough of an impact on the confidence interval calculations for any conclusions to be affected.

<sup>21</sup> CPSC’s Directorate for Economics provided the estimated number of table saws in use for this analysis; details are provided in (Bailey, 2018), which is Tab C of this briefing package.

**Table 11: Estimated Risk of Table Saw Blade-Contact Injury by Table Saw Type, 2017**

Table Saw Type	2017 Injury Estimates		Estimated Number of Saws in Use (in 10,000's)* <sup>22</sup>	Risk of Table saw blade-contact Injury per 10,000 Table Saws in Use	
	Estimate	95% CI		Estimate	95% CI
<i>Table Saw Blade-Contact (All Table Saw Types)</i>	26,500	25,200 – 27,800	686.32	38.62	36.76 – 40.47
Type of Table Saw					
<i>Bench Saw</i>	16,100	15,300 – 16,900	401.28	40.11	38.02 – 42.20
<i>Contractor Saw</i>	7,000	6,600 – 7,500	140.26	50.19	46.84 – 53.54
<i>Cabinet Saw</i>	2,400	2,200 – 2,700	144.78	16.91	15.15 – 18.67
<i>Unknown</i>	*	*	N/A	N/A	N/A

\* See (Bailey, 2018), Tab C of this briefing package.

Table 12 considers the risk of injury for table saws in use that conform to UL 987, 7<sup>th</sup> edition, which requires modular blade guards. For injuries, the assumption is that if a table saw was manufactured with a modular blade guard, then it is conforming to UL 987, 7<sup>th</sup> edition (conforming saws). Although this may not be true in 100 percent of the cases, it is a reasonable assumption. Table saws manufactured with a traditional blade guard are nonconforming saws.

Of the estimated 686,320 table saws available for consumer use in 2017, table saws (all types) conforming to UL 987, 7<sup>th</sup> edition comprise an estimated 57 percent of table saws in use. The estimated proportion of blade-contact injuries associated with conforming table saws in 2017 is 12.2 percent (Table 9); however, there is a significant proportion of blade-contact injuries (19.6 percent) where the manufacturer-supplied guard type is “unknown.” Thus, considering only estimated blade-contact injuries where blade guard type is known (21,000), an estimated 15.4 percent (3,200) of blade-contact injuries are associated with table saws conforming to the voluntary standard, while, of course, the proportion of table saws in use that are conforming remains at the estimated 57 percent mentioned above.

In 2017, the estimated risk of a table saw blade-contact injury per 10,000 saws in use that were manufactured with a traditional blade guard is 60.75, while the estimated risk of a blade-contact injury per 10,000 modular blade guard saws is 8.19. This gives an estimated relative risk for 2017 of 7.19, which means that the risk of injury on a saw with a traditional blade guard is about 7 times greater than on a saw with a modular blade guard.

<sup>22</sup> The term “in use” does not refer to the frequency of use, but to the number of units available for use.

**Table 12: Estimated Risk of Table Saw Blade-Contact Injury by Guard Type, 2017**

Table Saw Type	2017 Injury Estimates		Estimated Number of Saws in Use (in 10,000's)* <sup>23</sup>	Risk of Table Saw Blade-Contact Injury per 10,000 Table Saws in Use	
	Estimate	95% CI		Estimate	95% CI
<i>Table Saw Blade-Contact (All Table Saw Types)</i>	26,500	25,200 – 27,800	686.32	38.62	36.76 – 40.47
Type of Guard Manufactured with Saw					
<i>Traditional</i>	17,800	16,800 – 18,700	292.19	60.75	57.53 – 63.99
<i>Modular</i>	3,200	2,900 – 3,500	394.12	8.19**	7.48 – 8.90
<i>Unknown</i>	5,200	4,500 – 5,900	N/A	N/A	N/A
<i>None<sup>24</sup></i>	*	*	N/A	N/A	N/A

\* See (Bailey, 2018), Tab C of this briefing package.

\*\*There is a significant proportion of blade contact injuries for which the blade guard type manufactured with the table saw is “unknown.” This should be considered in understanding the risk of blade-contact associated with conforming versus nonconforming table saws.

<sup>23</sup> The term “in use” does not refer to the frequency of use, but to the number of units available for use.

<sup>24</sup> For the “None” category, the saw in this incident, there was no evidence from the investigation that the saw was originally manufactured with a blade guard, given the saw’s age and reported information regarding the saw (see Case-Level Incident Analysis for counts of cases for each level).

## IX. Case-Level Incident Analysis

Previous sections provide national injury estimates based on the results of the 2017 Study. As part of the study, CPSC Field staff completed 161 investigations for injury cases involving table saw blade contact.<sup>25</sup> A team of CPSC SMEs reviewed each completed IDI in the study, and the team coded variables regarding the product involved, the injury, and the incident scenario. This section summarizes the findings from completed IDIs associated with table saw blade-contact injuries based on the staff review. Appendix C provides the data review and coding process, and also provides variable definitions and categories for variables, as applicable.

The 161 completed IDIs on table saw blade-contact injuries informed the adjustment factors for the table saw blade-contact estimates that were calculated and applied in the prior sections of this report. This section is not intended to provide national estimates for all the characteristics of these incidents; instead, this section provides an analysis to understand the types of incidents that have informed the nationally representative injury estimates set forth in Sections VII and VIII of this report. Neither case weights, nor adjustment factors, are applied in this section; all frequency and percentages reported are at the case (anecdotal) level. Thus, the reader should not expect that the percentages presented in this section match percentages of national estimates provided. To the contrary, the percentages in this section most likely do not match national estimate proportions, but may be similar, or not, depending on a number of factors.

Table 13 provides the breakdown of the 161 table saw blade-contact injury, completed IDI cases for the variables age group, sex, diagnosis, disposition, and body part.

There were 15 cases where the NEISS diagnosis code was determined to be inappropriate or incorrect, and these 15 cases are reflected in this analysis based on the corrected diagnosis, in both the NEISS diagnosis variable and in the Reviewed Diagnosis variable. While the Reviewed Diagnosis variable created a way for the review team to capture the table saw blade-contact injuries in a repeatable and more descriptive way, these 15 cases were unique. These 15 cases were inappropriate or incorrect in the original NEISS, and not just inadequate in their description of the injuries; thus, these 15 cases reflect the corrected diagnosis in both the NEISS Diagnosis variable and Reviewed Diagnoses variable (Goldsmith, 2018). Similarly, there was one case where the body part coded in the NEISS was not correct; the body part results throughout this analysis reflect the corrected body part code for the case.

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<sup>25</sup> As noted in Section VI, there was a total of 290 completed investigations for the whole study. Of these 290 completed IDIs, 129 did not involve a table saw blade-contact injury. Of the 180 table saw completed IDIs, 19 did not involve blade contact.

**Table 13: NEISS Variables in Table Saw Blade-Contact Injury Completed IDIs**

<b>Variable</b>	<b>Frequency</b>	<b>Percent of Total</b>
<b>Age Group</b>		
<i>≤40</i>	25	15.5
<i>41-60</i>	55	34.2
<i>≥61</i>	81	50.3
<b>Sex</b>		
<i>Male</i>	153	95.0
<i>Female</i>	8	5.0
<b>NEISS Diagnosis</b>		
<i>Laceration</i>	105	65.2
<i>Amputation</i>	19	11.8
<i>Fracture</i>	29	18.0
<i>Avulsion</i>	7	4.4
<i>Nerve Damage</i>	1	0.6
<b>Disposition</b>		
<i>Treated and Released</i>	132	82.0
<i>Hospitalized<sup>26</sup></i>	26	16.1
<i>Other</i>	3	1.9
<b>Body Part</b>		
<i>Finger</i>	145	90.1
<i>Hand</i>	15	9.3
<i>Lower Arm</i>	1	0.6

As described, in reviewing the additional information obtained through the IDIs, the SME review team often determined that the injuries sustained in these incidents were not easily captured by a single diagnosis code in the NEISS. As described in Goldsmith, 2018; section 3, provided as Tab B of this briefing package, some of the limitations arise from the single diagnosis construct of the NEISS. Additionally, the injuries were, at times, severe lacerations that the NEISS had captured through various diagnosis codes, but for which no single diagnosis code was sufficient to explain the full extent of the injuries. Thus, the SME review team reviewed the information available and made a determination about the NEISS injury code. Table 14 shows the original NEISS diagnosis code compared to the SME review team’s reviewed-diagnosis determinations. As mentioned previously, there were 15 cases that the review team determined to be inappropriate or incorrect diagnosis codes in the NEISS, and the diagnosis has been corrected throughout this analysis and report. There were 29 cases with a reviewed diagnoses of laceration that the team determined to be an extreme severity. This report does not go into the details of these injuries, but refers the reader to the Directorate for Health Science’s memorandum, which is part of this package (Tab B) and provides a detailed analysis of table saw blade-contact injuries from the 2017 Study (Goldsmith, 2018).

<sup>26</sup> The “Hospitalized” category includes the NEISS dispositions of admitted and transferred.



**Table 14: NEISS Diagnosis Versus SME Additional Analysis of Injury Diagnosis in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	SME Reviewed Diagnosis					Total
	<i>Laceration</i>	<i>Severe Laceration</i>	<i>Amputation</i>	<i>Fracture</i>	<i>Avulsion</i>	
<i>Laceration</i>	80 76.2	22 21.0	0 0.0	2 1.9	1 1.0	<b>105</b>
<i>Amputation</i>	0 0.0	0 0.0	19 100.0	0 0.0	0 0.0	<b>19</b>
<i>Fracture</i>	5 17.2	6 20.7	5 17.2	13 44.8	0 0.0	<b>29</b>
<i>Avulsion</i>	1 14.3	0 0.0	0 0.0	0 0.0	6 85.7	<b>7</b>
<i>Nerve Damage</i>	0 0.0	1 100.0	0 0.0	0 0.0	0 0.0	<b>1</b>
<b>Total</b>	<b>86</b> <b>53.4</b>	<b>29</b> <b>18.0</b>	<b>24</b> <b>14.9</b>	<b>15</b> <b>9.3</b>	<b>7</b> <b>4.4</b>	<b>161</b>

\*Includes the corrected diagnosis to 15 cases, as described in the text.

Of the 161 completed IDIs that are in-scope for table saw blade-contact injuries, the operator of the table saw was the injured person in 160 (99.4 percent) of the cases, while one case involved a bystander or assistant. Most cases did not involve more than one person, regardless of injured party.

Table 15 shows the cross-tabulation for the victim’s dominant hand versus injured hand in the 161 table saw blade-contact completed IDIs. In the 161 cases, 127 victims reported as right-handed (78.9 percent), 10 as left-handed (6.2 percent), and nine as ambidextrous (5.6 percent). The remaining 15 cases have an unknown dominant hand for the victim. Of the 137 completed IDIs where the victim reported to be left- or right-hand dominant, 91 cases involved the injury occurring to the victim’s non-dominant hand (66.4 percent).

**Table 15: Hand Injury Variables in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	Injured Hand			Total
	<i>Left</i>	<i>Right</i>	<i>Unknown</i>	
<i>Left</i>	4 40.0	6 60.0	0 0.0	<b>10</b>
<i>Right</i>	85 66.9	42 33.1	0 0.0	<b>127</b>
<i>Ambidextrous</i>	9 100	0 0.0	0 0.0	<b>9</b>
<i>Unknown</i>	8 53.3	2 13.3	5 33.3	<b>15</b>
<b>Total</b>	<b>106</b> <b>65.8</b>	<b>50</b> <b>31.1</b>	<b>5</b> <b>3.1</b>	<b>161</b>

Table 16 provides the distribution of the 161 table saw blade-contact injury, completed IDIs for the table saw type, the guard type the saw was manufactured with, the guard type the operator received when the saw was acquired, and the operator’s use frequency of the saw involved in the incident.

Of the 161 table saw blade-contact injury cases, bench saws were involved in 100 cases (62.1 percent), while contractor saws were involved in 41 cases (25.5 percent). Cabinet saws and unknown saw type are both associated with 10 cases each (both 6.2 percent).

A table saw is expected, for the most part, to have been manufactured and sold with a blade guard, and that blade guard will be either the traditional type or the modular type of blade guard. However, saws not only are purchased new by consumers, but also are purchased used, given away, borrowed, passed down, or shared by a group of users. Accordingly, the blade guard that was manufactured with the saw does is not necessarily available for use for the operator. For the 161 table saw blade-contact injury completed IDIs in the 2017 Study, 35 (21.7 percent) involved a situation where the operator did not receive a blade guard when the saw was acquired for use by the operator.

Of the 161 table saw blade-contact injury completed IDI cases, the majority of operators reported using the incident saw daily to weekly or weekly to monthly (33.5 and 27.3 percent, respectively).

**Table 16: Table Saw Variables in Table Saw Blade-Contact Injury Completed IDIs**

<b>Variable</b>	<b>Frequency</b>	<b>Percent of Total</b>
<b>Total</b>	<b>161</b>	<b>100%</b>
<b>Table Saw Type</b>		
<i>Bench</i>	100	62.1
<i>Contractor<sup>27</sup></i>	41	25.5
<i>Cabinet</i>	10	6.2
<i>Unknown</i>	10	6.2
<b>Guard Type Manufactured with Saw</b>		
<i>Traditional</i>	102	63.4
<i>Modular</i>	25	15.5
<i>None</i>	1	0.6
<i>Unknown</i>	33	20.5
<b>Guard Type Received by Operator when Saw Acquired</b>		
<i>Traditional</i>	76	47.2
<i>Modular</i>	24	14.9
<i>N/A-None</i>	35	21.7
<i>Unknown</i>	26	16.2
<b>Operator's Use Frequency of the Saw</b>		
<i>First Time</i>	3	1.9
<i>Daily to Weekly</i>	54	33.5
<i>Weekly to Monthly</i>	44	27.3
<i>Monthly to Yearly</i>	28	17.4
<i>Yearly</i>	5	3.1
<i>Other</i>	12	7.5
<i>Unknown</i>	15	9.3

<sup>27</sup> Hybrid table saws account for 2 of total 41 in the "Contractor" table saw type category.

Table 17 provides the breakdown of the table saw type with the operator’s frequency of use. Contractor use frequency is distributed more towards the higher available use frequency categories, while bench saws had a more even spread throughout the use frequencies. Cabinet saws are shifted towards the higher use frequency categories.

**Table 17: Table Saw Type Versus Operator’s Use Frequency of the Saw in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	Operator’s Use Frequency of the Saw							Total
	Daily to Weekly	Weekly to Monthly	Monthly to Yearly	Yearly	First Time	Other	Unknown	
<i>Bench</i>	29 29.0	26 26.0	21 21.0	4 4.0	2 2.0	8 8.0	10 10.0	<b>100</b>
<i>Contractor</i>	16 41.0	13 33.3	6 14.6	0 0.0	1 2.6	3 7.3	1 2.4	<b>39</b>
<i>Cabinet</i>	6 60.0	1 10.0	0 0.0	1 10.0	0 0.0	1 10.0	1 10.0	<b>10</b>
<i>Unknown</i>	2 20.0	4 40.0	1 10.0	0 0.0	0 0.0	0 0.0	3 30.0	<b>10</b>
<b>Total</b>	<b>54</b>	<b>44</b>	<b>28</b>	<b>5</b>	<b>3</b>	<b>12</b>	<b>15</b>	<b>161</b>

Table 18 gives the cross-tabulation for the manufactured guard type by the type of guard received by the operator when the saw was acquired or used. In 20.5 percent of the 161 cases, the type of guard manufactured with the saw was unknown; and in 16.2 percent of the cases, it was unknown if or what type of guard was received by the operator with the saw (Table 16). Although the “Unknown” category is a significant proportion in each, of the saws in the 102 blade-contact injury cases known to be with a saw manufactured with a traditional blade guard, the blade guard was received with the saw at the time of acquisition in 76 cases (74.5 percent); while in 20 cases (19.6 percent), the operator did not receive the blade guard when the saw was acquired. In the 25 cases with saws identified as being manufactured with a modular blade guard, in 24 cases (96.0 percent) the operator did receive the blade guard when the saw was acquired.

**Table 18: Manufactured Guard Type Versus Guard Type Received By the Operator in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	Guard Type Received by Operator when Saw Acquired				Total
	Traditional	Modular	Unknown	N/A-None	
<i>Traditional</i>	76 74.5	0 0.0	6 5.9	20 19.6	<b>102</b>
<i>Modular</i>	0 0.0	24 96.0	0 0.0	1 4.0	<b>25</b>
<i>Unknown</i>	20 60.6	0 0.0	0 0.0	13 39.4	<b>33</b>
<i>None</i>	0 0.0	0 0.0	0 0.0	1 100.0	<b>1</b>
<b>Total</b>	<b>76</b>	<b>24</b>	<b>26</b>	<b>35</b>	<b>161</b>

Table 19 provides the cross-tabulation of type of guard manufactured with the saw versus the SME review team diagnosis classification, regardless of whether the blade guard was in use at the time of the incident. Due to the small number of cases with modular blade guards, and those cases being spread across several diagnoses, staff recommends limiting conclusions being drawn from this table. That being said, cases for saws manufactured with a modular blade guard seem to veer towards less severe diagnosis compared to the distribution of cases for traditional blade guard saws.

**Table 19: Manufactured Guard Type Versus SME Reviewed Diagnosis in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	SME Reviewed Diagnosis					Total
	<i>Laceration</i>	<i>Severe Laceration</i>	<i>Amputation</i>	<i>Fracture</i>	<i>Avulsion</i>	
<b>Guard Type Manufactured with Saw</b>						
<i>Traditional</i>	50 49.0	19 18.6	19 18.6	9 8.8	5 4.9	<b>102</b>
<i>Modular</i>	15 60.0	6 24.0	2 8.0	2 8.0	0 0.0	<b>25</b>
<i>None</i>	0 0.0	0 0.0	0 0.0	0 0.0	1 100.0	<b>1</b>
<i>Unknown</i>	21 63.6	4 12.1	3 9.1	4 12.1	1 3.0	<b>33</b>
<b>Total</b>	<b>86</b> <b>53.4</b>	<b>29</b> <b>18.0</b>	<b>24</b> <b>14.9</b>	<b>15</b> <b>9.3</b>	<b>7</b> <b>4.4</b>	<b>161</b>

Table 20 provides the distributions for blade guard use, and for those cases where the blade guard was not in use, the table provides a summary of why the guard was not in use and when the guard was removed. In the 161 table saw blade-contact injury cases with completed IDIs, the majority, 141 cases (87.6 percent), did not involve the use of a blade guard, for a variety of reasons. The most common category (44.7 percent of the 141 cases without a blade guard in use) for blade guard removal included reports of the blade guard being inconvenient, blocking the view of the cut, the stock size, the cut type, or a combination of these. The second most common category was having not received a blade guard when the saw was acquired (35 cases, 24.8 percent).

**Table 20: Blade Guard Variables in Table Saw Blade-Contact Injury Completed IDIs**

<b>Variable</b>	<b>Frequency</b>	<b>Percent of Total</b>
<b>Blade Guard Use</b>		
<i>Yes</i>	14	8.7
<i>No</i>	141	87.6
<i>Unknown</i>	5	3.1
<i>N/A</i>	1	0.6
<b>Total</b>	<b>161</b>	<b>100%</b>
<b>When was the guard removed? (for guard in use = no)</b>		
<i>Removed prior to the operator acquiring the saw (i.e., the operator did not receive a blade guard with the saw)</i>	35	24.8
<i>Never installed</i>	23	16.3
<i>Removed for some reason after the operator acquired the saw</i>	50	35.5
<i>The guard was in the up position, not removed entirely</i>	8	5.7
<i>Unknown</i>	25	17.7
<b>Total</b>	<b>141</b>	<b>100%</b>
<b>Why was no guard in use? (for guard in use = no)</b>		
<i>Inconvenient/visibility/cut type/stock size</i>	63	44.7
<i>Did not receive a guard when saw acquired</i>	35	24.8
<i>Broken</i>	6	4.3
<i>Lost</i>	2	1.4
<i>Difficulty installing</i>	2	1.4
<i>Broken; Lost; Inconvenient/visibility/cut type/stock size</i>	1	0.7
<i>Difficulty installing; Inconvenient/visibility/cut type/stock size</i>	1	0.7
<i>Other</i>	9	6.4
<i>Unknown</i>	22	15.6
<b>Total</b>	<b>141</b>	<b>100%</b>

Table 21 gives the cross-tabulations for blade guard use at the time of the incident versus the type of guard manufactured with the saw, the guard type received with the saw, the table saw type, and the SME reviewed diagnosis. The proportion of blade guards not in use for the 161 blade-contact cases is fairly even across the type of blade guard manufactured with the saw (89.2, 88.0, and 81.8 percent for traditional, modular, and unknown blade guard types, respectively). And similarly, for the type received, the majority of blade guards were not in use across all blade guard type categories (85.5, 87.5, and 76.9 percent for traditional, modular, and unknown, respectively). The guard was not in use in 100 percent of the cases where the operator did not receive a blade guard when the saw was acquired.

The blade guard was not in use in the majority of cases across each type of saw (87.0, 82.9, and 100.0 percent for bench, contractor/hybrid, and contractor saws respectively). There were 10 cases where the type of saw was unknown, and the blade guard was not in use in any of these 10 cases.

**Table 21: Guard Use by Table Saw and Guard Characteristics in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	Guard Use				Total
	Yes	No	Unknown	N/A	
<b>Manufactured Guard Type</b>					
<i>Traditional</i>	9 8.8	91 89.2	1 1.0	1 1.0	<b>102</b>
<i>Modular</i>	3 12.0	22 88.0	0 0.0	0 0.0	<b>25</b>
<i>Unknown</i>	2 6.1	27 81.8	4 12.1	0 0.0	<b>33</b>
<i>None</i>	0 0.0	1 100.0	0 0.0	0 0.0	<b>1</b>
<b>Total</b>	<b>14</b>	<b>141</b>	<b>5</b>	<b>1</b>	<b>161</b>
<b>Received with Saw Guard Type</b>					
<i>Traditional</i>	9 11.8	65 85.5	1 1.3	1 1.3	<b>76</b>
<i>Modular</i>	3 12.5	21 87.5	0 0.0	0 0.0	<b>24</b>
<i>Unknown</i>	2 7.7	20 76.9	4 15.4	0 0.0	<b>26</b>
<i>N/A-None</i>	0 0.0	35 100.0	0 0.0	0 0.0	<b>35</b>
<b>Total</b>	<b>14</b>	<b>141</b>	<b>5</b>	<b>1</b>	<b>161</b>
<b>Table Saw Type</b>					
<i>Bench</i>	10 10.0	87 87.0	3 3.0	0 0.0	<b>100</b>
<i>Contractor/Hybrid</i>	4 9.8	34 82.9	2 4.9	1 2.4	<b>41</b>
<i>Cabinet</i>	0 0.0	10 100.0	0 0.0	0 0.0	<b>10</b>
<i>Unknown</i>	0 0.0	10 100.0	0 0.0	0 0.0	<b>10</b>
<b>Total</b>	<b>14</b>	<b>141</b>	<b>5</b>	<b>1</b>	<b>161</b>
<b>SME Reviewed Diagnosis</b>					
<i>Laceration</i>	8 9.3	77 89.5	1 1.2	0 0.0	<b>86</b>
<i>Severe Laceration</i>	4 13.8	25 86.2	0 0.0	0 0.0	<b>29</b>
<i>Amputation</i>	2 8.3	20 83.3	1 4.2	1 4.2	<b>24</b>
<i>Fracture</i>	0 0.0	14 93.3	1 6.7	0 0.0	<b>15</b>
<i>Avulsion</i>	0 0.0	5 71.4	2 28.6	0 0.0	<b>7</b>
<b>Total</b>	<b>14</b>	<b>141</b>	<b>5</b>	<b>1</b>	<b>161</b>

Table 22 provides the cross-tabulated distributions for the type of guard manufactured with the saw by when the guard was removed. For the 141 cases where the blade guard was not in use, the distributions for when the blade guard was removed differ somewhat for the different type of blade guards. The blade guard was removed after the saw was acquired in about 40 percent of the cases for both traditional and modular blade guards. For the traditional blade guards, 22.0 percent were removed before the saw was acquired while for modular blade guards, removal was at 4.6 percent. Modular blade guards had a larger proportion that were never installed by the operator (36.4 percent versus 13.2 for traditional blade guards).

**Table 22: Guard Manufactured with Saw by When the Guard Was Removed in Table Saw Blade-Contact Injury Completed IDIs Where the Blade Guard Was Not in Use (n = 141)**

n Row %	When was the guard removed? (for guard in use = no)					Total
	<i>Prior to the operator acquiring the saw<sup>28</sup></i>	<i>Never installed by operator</i>	<i>After the operator acquired the saw</i>	<i>Up position, not removed entirely</i>	<i>Unknown</i>	
<i>Traditional</i>	20 22.0	12 13.2	38 41.8	5 5.5	16 17.6	<b>91</b>
<i>Modular</i>	1 4.6	8 36.4	9 40.9	2 9.1	2 9.1	<b>22</b>
<i>None</i>	1 100.0	0 0.0	0 0.0	0 0.0	0 0.0	<b>1</b>
<i>Unknown</i>	13 48.2	3 11.1	3 11.1	1 3.7	7 25.9	<b>27</b>
<b>Total</b>	<b>35</b>	<b>23</b>	<b>50</b>	<b>8</b>	<b>25</b>	<b>141</b>

<sup>28</sup> *i.e.*, the operator did not receive a blade guard with the saw.



The blade guard cannot be used in some types of cuts, such as when making a non-through cut. This is not necessarily the reason the blade guard was or was not in use; see Table 20 for more information about the reasons for blade guard removal. In Table 23, for the 141 blade-contact cases where the blade guard was not in use, the guard type is cross-tabulated with the classification of through or non-through cuts. Of the 22 cases with a table saw known to be manufactured with a modular blade guard, 4 cases (18.2 percent) involved a non-through cut. For the 91 cases known to be associated with a saw manufactured with a traditional blade guard, but no blade guard was in use at the time of the incident, 7 cases (7.7 percent) involved a non-through cut.

**Table 23: Guard Manufactured with Saw by Through/Non-through Cuts in Table Saw Blade-Contact Injury Completed IDIs Where the Blade Guard Was Not in Use (n = 141)**

n Row %	Through Versus Non-Through Cuts (for guard in use = no)					Total
	<i>Through</i>	<i>Non-Through</i>	<i>Other</i>	<i>Unknown</i>	<i>N/A</i> <sup>29</sup>	
<b>Guard Type Manufactured with Saw</b>						
<i>Traditional</i>	71 78.0	7 7.7	1 1.1	11 12.1	1 1.1	<b>91</b>
<i>Modular</i>	14 63.6	4 18.2	0 0.0	4 18.2	0 0.0	<b>22</b>
<i>Unknown</i>	19 70.4	2 7.4	0 0.0	5 18.5	1 3.7	<b>27</b>
<i>None</i>	1 100.0	0 0.0	0 0.0	0 0.0	0 0.0	<b>1</b>
<b>Total</b>	<b>105</b>	<b>13</b>	<b>1</b>	<b>20</b>	<b>2</b>	<b>141</b>

<sup>29</sup> "N/A" indicates that a cut was not being performed at the time of the incident. For example, one incident occurred while the operator was cleaning saw dust from under the table top.

Table 20 shows that for 14 blade-contact injuries the blade guard was in use at the time of the injury, and 141 blade-contact injuries occurred without a blade guard in use (while 5 were unknown if a blade guard was in use and 1 where blade guard use was not applicable to the incident). Figure 1 summarizes the usage of other safety devices that are part of the blade guard system, for cases with known blade guard use. For the 141 without the blade guard in use, the majority were not using any other safety devices as part of the system (53.2 percent), and 36.2 percent were unknown if any other device was in use.

**Figure 1: Saw Safety Devices by Blade Guard in Table Saw Blade-Contact Completed IDIs, when Blade Guard Use is Applicable and Known (n=155 of the 161 cases)**

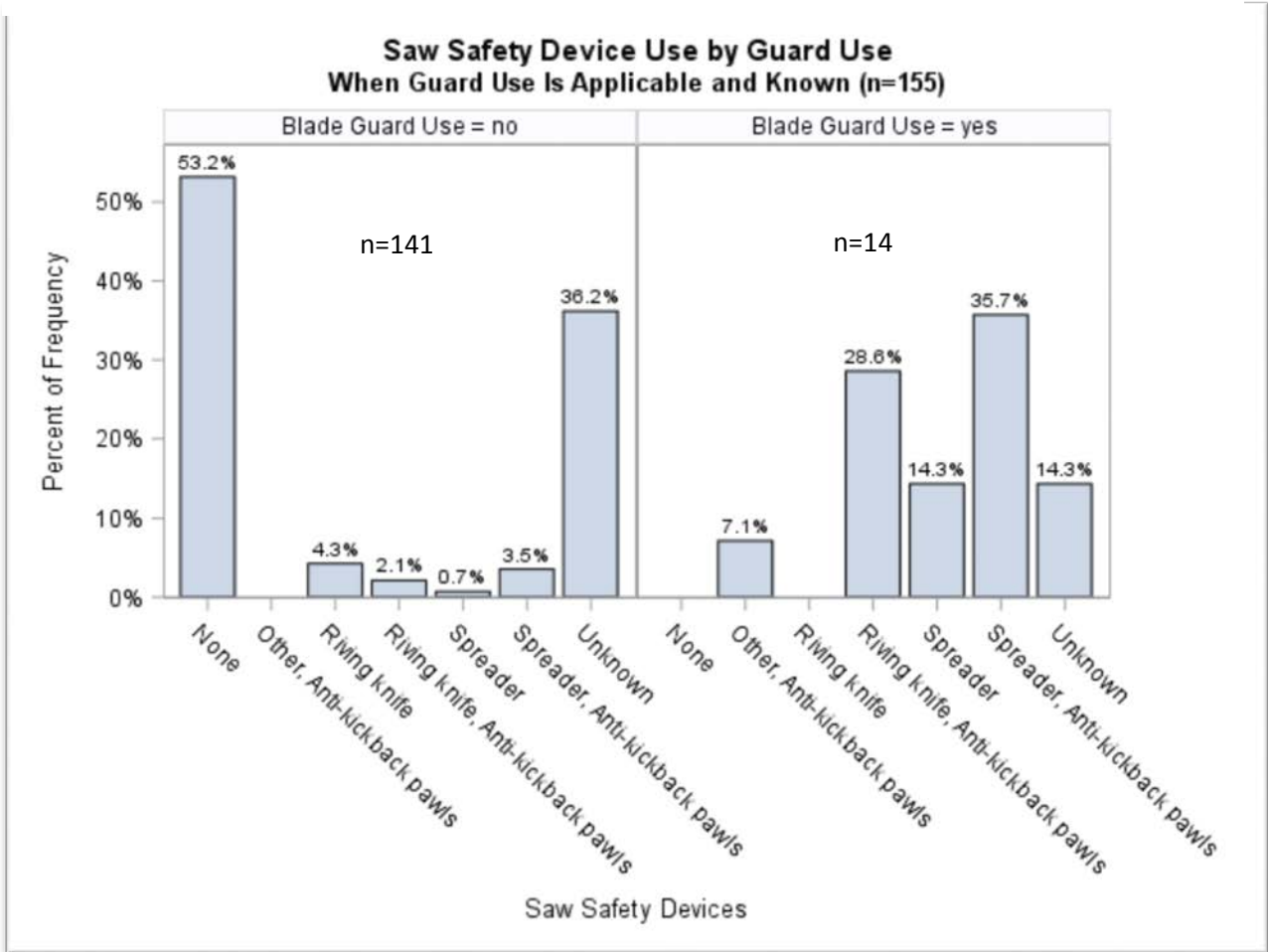


Figure 2 shows the distribution for the operator personal protective equipment (PPE) in use at the time of the incident. For the 161 table saw blade-contact injury completed IDIs, the operator wore eyeglasses or safety goggles or safety glasses in 45 percent of the incidents. Eyeglasses were the most commonly reported item (26 percent), and safety goggles or glasses were reported in 19 percent of the cases (see Appendix C for details on how PPE information was collected). In 11 percent of incidents, the operator was wearing or using multiple items. In 28 percent of incidents, the operator was reported to not be using any additional PPE. Other types of PPE apart from safety glasses and eyeglasses, include, for example, gloves and hearing protection.

**Figure 2: Operator Personal Protective Equipment in Table Saw Blade-Contact Injury Completed IDIs**

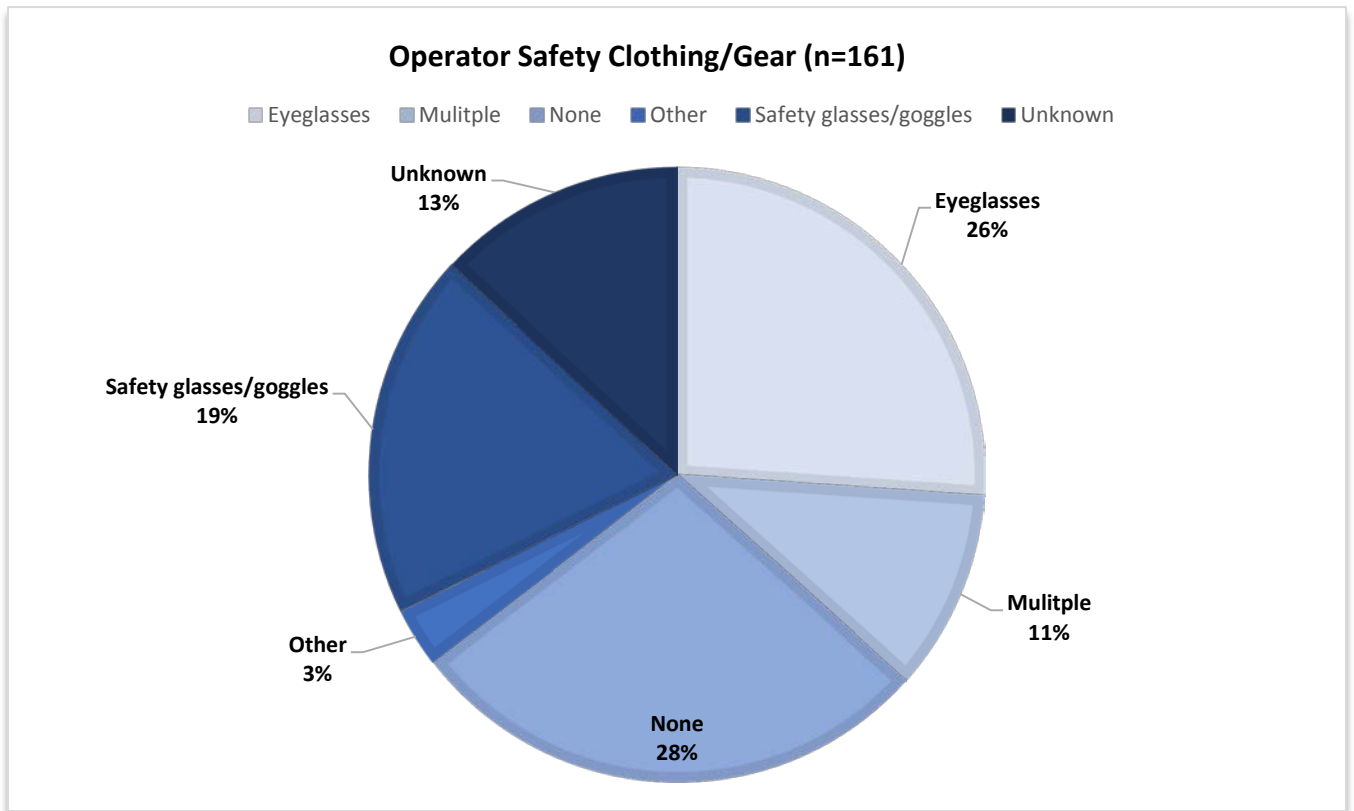


Table 24 shows the distributions of the alignment device use, how the stock was being pushed, the type of cut, and the type of stock. Of the 161 table saw blade-contact injury completed IDIs, 84 (52.2 percent) reported to be using a rip fence, while 40 (24.8 percent) reported not to be using any alignment device. There were 27 (16.8 percent) of the incidents with unknown alignment device use. The majority of incidents involved the operator using their hand(s) to push (and in some cases, pull) the stock through the cut, while 32 (19.9 percent) used a push stick or push block to push the stock through the cut. The most common cut performed in the 161 incidents was a through/rip cut (102 cases, 63.4 percent), and wood was the identified stock type in 143 (88.8 percent) of the 161 cases.

**Table 24: Incident Characteristics in Table Saw Blade-Contact Injury Completed IDIs**

<b>Variable</b>	<b>Frequency</b>	<b>Percent of Total</b>
<b>Total</b>	<b>161</b>	<b>100%</b>
<b>Alignment Device in Use</b>		
<i>None (free hand)</i>	40	24.8
<i>Rip fence</i>	84	52.2
<i>Miter gauge</i>	1	0.6
<i>Other</i>	7	4.4
<i>Unknown</i>	27	16.8
<i>N/A</i>	2	1.2
<b>How was the stock being pushed through the blade?</b>		
<i>Hand(s)</i>	102	63.4
<i>Push stick</i>	31	19.3
<i>Push block</i>	1	0.6
<i>Other</i>	6	3.7
<i>Unknown</i>	18	11.2
<i>N/A</i>	3	1.9
<b>Type of Cut</b>		
<i>Through/rip</i>	102	63.4
<i>Through/cross</i>	12	7.5
<i>Through/other</i>	6	3.7
<i>Non-through/rip</i>	12	7.5
<i>Non-through/other</i>	3	1.9
<i>Other</i>	1	0.6
<i>Unknown/rip</i>	6	3.7
<i>Unknown</i>	16	9.9
<i>N/A</i>	3	1.9
<b>Stock Type</b>		
<i>Wood</i>	143	88.8
<i>Other</i>	11	6.8
<i>Unknown</i>	4	2.5
<i>N/A</i>	3	1.9

Table 25 provides summary statistics for the reported dimensions of the stock being cut in table saw blade-contact injury completed IDIs. The SME review team coded the dimensions in descending order for length, width, and thickness of the recorded dimensions, not in relation to the type of cut being made. In other words, the length is always the longest dimension in each case. Thus, this gives a sense to the size of the stock in these injury cases, but not how these dimensions relate to the cut that was being performed. The number of missing cases is 41, 35, and 36 for length, width, and thickness, respectively, in the 161 cases.

**Table 25: Stock Dimensions in Table Saw Blade-Contact Injury Completed IDIs**

<b>Stock Dimension</b>	<b>n</b>	<b>n missing</b>	<b>minimum</b>	<b>25<sup>th</sup> percentile</b>	<b>median</b>	<b>75<sup>th</sup> percentile</b>	<b>maximum</b>
<i>Length</i>	120	41	3.00	12.0	24.0	48.0	144.00
<i>Width</i>	126	35	0.25	2.00	4.00	5.50	36.00
<i>Thickness</i>	125	36	0.13	0.50	0.75	1.33	4.00

Table 26 summarizes in a general manner classification how blade contact occurred in the 161 cases of table saw blade-contact completed IDIs, and then provides the additional details the SMEs coded for the cases where the victim’s hand was not pulled into the blade. In the majority of cases, 56.6 percent, blade contact did not involve the victim’s hand being pulled into the blade (91 cases). In 45 of the 161 cases (28.0 percent), blade contact occurred by the victim’s hand being pulled into the blade during the incident, and in 24 cases (14.9 percent) how the victim’s hand made contact with the blade could not be determined. Among the 91 cases where the victim’s hand was not pulled into the blade, the SME review team determined that the victim was reaching to do, or for, something in 46.2 percent of the cases, and the victim’s hand was fed into the blade in 17.6 percent of the cases. The remaining cases for the victim’s hand not pulled into the blade, and for which details were available to further classify the blade contact, included situations where the victim inadvertently moved his/her hand into the blade, the hand slipped or dropped off the workpiece, or some other scenario.

**Table 26: How Blade Contact Occurred in Table Saw Blade-Contact Injury Completed IDIs**

Variable	Frequency	Percent of Total
<b>How did blade contact occur? (High-level categories)</b>		
<i>Hand not pulled into blade</i>	91	56.5
<i>Hand pulled into blade<sup>30</sup></i>	45	28.0
<i>Other</i>	1	0.6
<i>Unknown</i>	24	14.9
<b>Total</b>	<b>161</b>	<b>100%</b>
<b>Hand not pulled into blade (additional details)</b>		
<i>Hand fed into blade (with workpiece)</i>	16	17.6
<i>Hand slipped or dropped off workpiece</i>	7	7.7
<i>Inadvertently moved hand into blade</i>	12	13.2
<i>Hand reached</i>	42	46.2
<i>Other</i>	5	5.5
<i>Additional details unknown</i>	9	9.9
<b>Total</b>	<b>91</b>	<b>100%</b>

Table 27 provides the breakdown of blade-contact, completed IDI cases by type of guard manufactured with the saw by how blade contact occurred (using the high-level categories), regardless of whether the guard was in use at the time of the incident. For saws manufactured with a traditional blade guard, in 55.9 percent of the cases, the victim’s hand was not pulled into the blade, while in 32.4 percent of the cases, the victim’s hand was pulled into the blade. Saws manufactured with a modular blade guard had a similar breakdown into how blade contact occurred (56.0 percent of cases the victim’s hand was not pulled into the blade and 28.0 percent of the cases, the hand was pulled into the blade). As previously noted, there is a small number of cases for modular blade guard saws, in general, so caution should be used in drawing conclusion by taking this into account.

**Table 27: Manufactured Guard Type Versus How Blade Contact Occurred (High-Level Categories) in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	How did blade contact occur? (High-level categories)				Total
	<i>Hand not pulled into blade</i>	<i>Hand pulled into blade</i>	<i>Other</i>	<i>Unknown</i>	
<b>Guard Type Manufactured with Saw</b>					
<i>Traditional</i>	57 55.9	33 32.4	1 1.0	11 10.8	<b>102</b>
<i>Modular</i>	14 56.0	7 28.0	0 0.0	4 16.0	<b>25</b>
<i>None</i>	0 0.0	0 0.0	0 0.0	1 100.0	<b>1</b>
<i>Unknown</i>	20 60.6	5 15.2	0 0.0	8 24.2	<b>33</b>
<b>Total</b>	<b>91 56.5</b>	<b>45 28.0</b>	<b>1 0.6</b>	<b>24 14.9</b>	<b>161</b>

<sup>30</sup> One case involved the victim’s arm being pulled into the blade. This case is in the “hand pulled into blade” category because it fits the general pattern of being pulled, with the only distinguishing feature being that an arm was pulled instead of a hand. The “circumstance” variable captures the unique aspect of this case.

Table 28 provides the breakdown of the 161 table saw blade-contact injuries by whether unexpected workpiece movement occurred prior to blade contact. Unexpected workpiece movement includes, but is not limited to, kickback. Unexpected workpiece movement did not occur in 47.8 percent of the incidents, did occur in 39.8 percent, and was unknown in 10.6 percent of the incidents.

**Table 28: Unexpected Workpiece Movement in Table Saw Blade-Contact Injury Completed IDIs**

<b>Unexpected Stock Movement</b>	<b>Frequency</b>	<b>Percent of Total</b>
<i>Yes</i>	64	39.8
<i>No</i>	77	47.8
<i>Unknown</i>	17	10.6
<i>N/A</i>	3	1.9
<b>Total</b>	<b>161</b>	<b>100%</b>

Table 29 provides the cross-tabulation of type of guard manufactured with the table saw versus whether unexpected workpiece movement occurred during the incident, for all blade-contact completed IDIs, regardless of whether the guard was in use or not at the time of the incident. For traditional blade guards, unexpected workpiece movement was reported to have occurred in the same number of cases as when unexpected workpiece movement was not reported to have occurred (45.1 percent for traditional blade guard saws); for modular blade guard saws, unexpected workpiece movement was reported in 9 cases and in 13 cases (36.0 percent and 52.0 percent of modular blade guard saws respectively).

**Table 29: Manufactured Guard Type Versus Unexpected Workpiece Movement in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	Unexpected Stock Movement				Total
	<i>Yes</i>	<i>No</i>	<i>Unknown</i>	<i>N/A</i>	
<b>Guard Type Manufactured with Saw</b>					
<i>Traditional</i>	46 45.1	46 45.1	8 7.8	2 2.0	<b>102</b>
<i>Modular</i>	9 36.0	13 52.0	3 12.0	1 3.0	<b>25</b>
<i>None</i>	0 0.0	0 0.0	1 100	0 0.0	<b>1</b>
<i>Unknown</i>	9 27.3	18 54.6	5 15.2	1 3.0	<b>33</b>
<b>Total</b>	<b>64 39.8</b>	<b>77 47.8</b>	<b>17 10.6</b>	<b>3 1.9</b>	<b>161</b>

To further understand how blade contact occurred, the unexpected workpiece movement variable is evaluated in additional detail in Tables 30, 31, and 32, and in Figure 3.

Table 30 considers how blade contact occurred in general with whether there was unexpected workpiece movement during the incident. For incidents where the hand was not pulled into the blade, the majority of incidents (75.8 percent) did not involve unexpected workpiece movement; in incidents where the hand was pulled into the blade, the majority of incidents involved unexpected workpiece movement.

**Table 30: How Blade Contact Occurred Versus Unexpected Workpiece Movement in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	Unexpected Workpiece Movement				Total
	Yes	No	Unknown	N/A	
<b>How did blade contact occur? (High-level categories)</b>					
<i>Hand not pulled into blade</i>	15 16.5	69 75.8	4 4.4	3 3.3	<b>91</b>
<i>Hand pulled into blade</i>	41 91.1	3 6.7	1 2.2	0 0.0	<b>45</b>
<i>Other</i>	0 0.0	1 100.0	0 0.0	0 0.0	<b>1</b>
<i>Unknown</i>	8 33.3	4 16.7	12 50.0	0 0.0	<b>24</b>
<b>Total</b>	<b>64</b>	<b>77</b>	<b>17</b>	<b>3</b>	<b>161</b>

Table 31 provides how blade contact occurred with the use of a blade guard. Only 14 of the 161 incidents occurred with the blade guard in use, so any comparisons are quite limited here. However, note that the proportion of cases in which the blade guard was not in use is similar for both the hand pulled and not pulled into the blade categories.

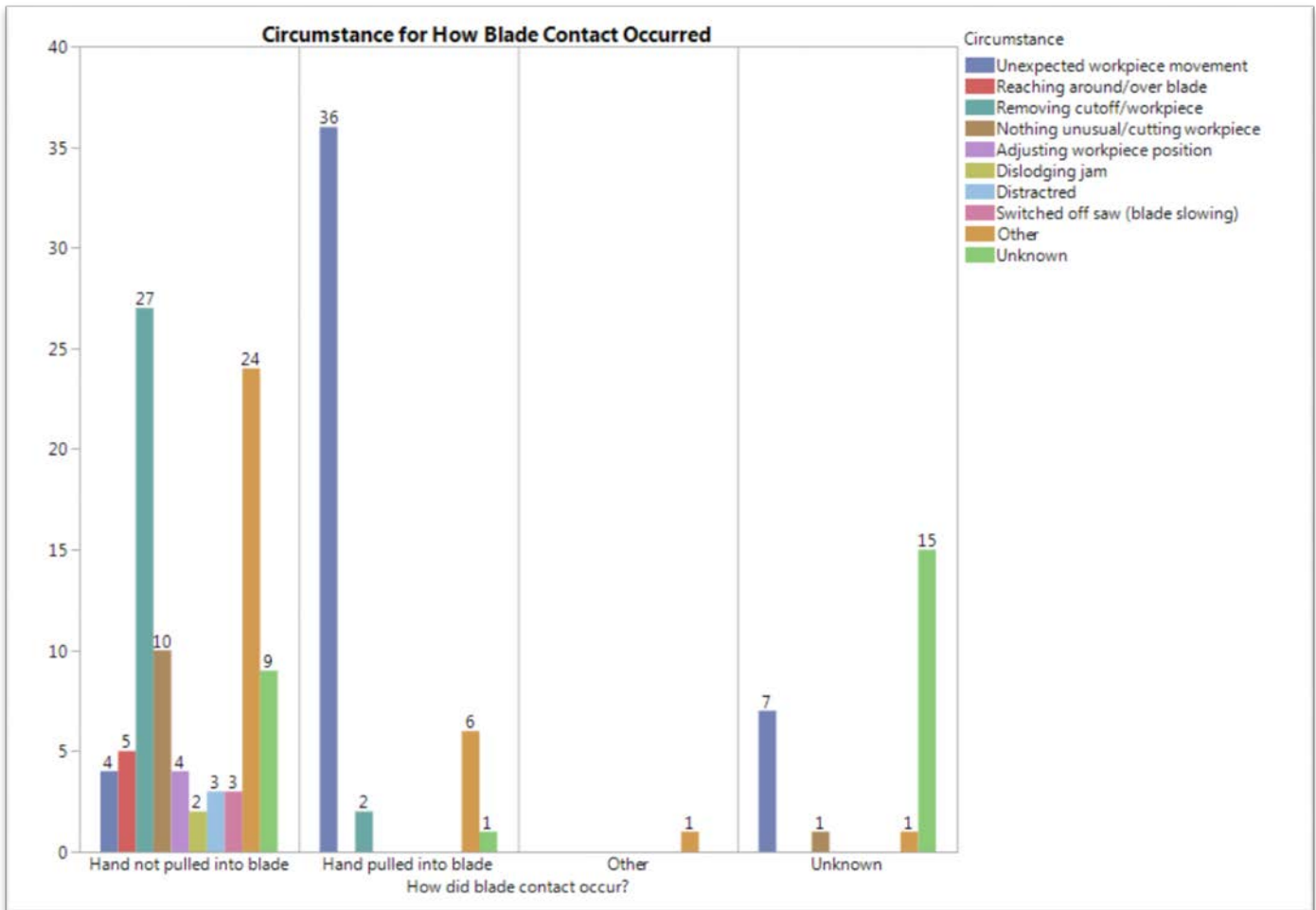
**Table 31: How Blade Contact Occurred Versus Blade Guard Use in Table Saw Blade-Contact Injury Completed IDIs**

n Row %	Blade Guard Use				Total
	Yes	No	Unknown	N/A	
<b>How did blade contact occur?</b>					
<i>Hand not pulled into blade</i>	6 6.6	80 87.9	4 4.4	1 1.1	<b>91</b>
<i>Hand pulled into blade</i>	5 11.1	39 86.7	1 2.2	0 0.0	<b>45</b>
<i>Other</i>	0 0.0	1 100.0	0 0.0	0 0.0	<b>1</b>
<i>Unknown</i>	3 12.5	21 87.5	0 0.0	0 0.0	<b>24</b>
<b>Total</b>	<b>14</b>	<b>141</b>	<b>5</b>	<b>1</b>	<b>161</b>



Figure 3 and Table 32 provide similar information, with the circumstance that the SME review team determined to correspond to how blade contact occurred. For the hand being pulled into the blade, the SME review team determined unexpected workpiece movement to be the most significant event or cause leading to blade contact; in incidents where the hand was not pulled into the blade, removing the workpiece or cutoff, or some other action, are the most common significant event or cause leading to the blade contact. This does not mean that unexpected workpiece movement did or did not occur in any given case; there is another variable capturing the event of unexpected workpiece movement (see Table 28). As seen in Table 32, different circumstances stand out for different categories of the hand not being pulled into the blade.

**Figure 3: Circumstance for How Blade Contact Occurred in Table Saw Blade-Contact Injury Completed IDIs**



**Table 32: Circumstances Leading to Blade Contact in Table Saw Blade-Contact Injury Completed IDIs**

<b>How did blade contact occur?</b>	<b>Circumstances Leading to Blade Contact</b>	<b>Frequency</b>	<b>Percent of Blade Contact Category</b>	<b>Percent of Total (n=161)</b>
<i>Hand not pulled into blade/ hand fed into blade (with workpiece)</i>	<i>Adjusting workpiece position</i>	2	12.5	1.2
	<i>Distracted</i>	1	6.3	0.6
	<i>Nothing unusual/cutting workpiece</i>	10	62.5	6.2
	<i>Other</i>	3	18.8	1.9
	<b>Total</b>	<b>16</b>	<b>100%</b>	<b>9.9%</b>
<i>Hand not pulled into blade/ hand reached</i>	<i>Adjusting workpiece position</i>	2	4.8	1.2
	<i>Dislodging jam</i>	2	4.8	1.2
	<i>Other</i>	9	21.4	5.6
	<i>Reaching around/over blade</i>	5	11.9	3.1
	<i>Removing cutoff/workpiece</i>	23	54.8	14.3
	<i>Unknown</i>	1	2.4	0.6
	<b>Total</b>	<b>42</b>	<b>100%</b>	<b>26.1%</b>
<i>Hand not pulled into blade/ hand slipped or dropped off workpiece</i>	<i>Distracted</i>	1	14.3	0.6
	<i>Other</i>	2	28.6	1.2
	<i>Switching off saw (blade slowing)</i>	4	57.1	2.5
	<b>Total</b>	<b>7</b>	<b>100%</b>	<b>4.3%</b>
<i>Hand not pulled into blade/ inadvertently moved hand into blade</i>	<i>Distracted</i>	1	8.3	0.6
	<i>Other</i>	7	58.3	4.4
	<i>Removing cutoff/workpiece</i>	1	8.3	0.6
	<i>Switched off saw (blade slowing)</i>	3	25.0	1.9
	<b>Total</b>	<b>12</b>	<b>100%</b>	<b>7.5%</b>
<i>Hand not pulled into blade/ other</i>	<i>Removing cutoff/workpiece</i>	3	60.0	1.9
	<i>Other</i>	2	40.0	1.2
	<b>Total</b>	<b>5</b>	<b>100%</b>	<b>3.1%</b>
<i>Hand not pulled into blade/ additional details unknown</i>	<i>Other</i>	1	11.1	0.6
	<i>Unknown</i>	8	88.9	5.0
	<b>Total</b>	<b>9</b>	<b>100%</b>	<b>5.6%</b>
<i>Hand pulled into blade</i>	<i>Removing cutoff/workpiece</i>	2	4.4	1.2
	<i>Unexpected workpiece movement</i>	36	80.0	22.4
	<i>Other</i>	6	13.3	3.7
	<i>Unknown</i>	1	2.2	0.6
	<b>Total</b>	<b>45</b>	<b>100%</b>	<b>28.0%</b>
<i>Other</i>	<i>Other</i>	1	100	0.6
	<b>Total</b>	<b>1</b>	<b>100%</b>	<b>0.6%</b>
<i>Unknown</i>	<i>Nothing unusual/cutting workpiece</i>	1	4.2	0.6
	<i>Unexpected workpiece movement</i>	7	29.2	4.4
	<i>Other</i>	1	4.2	0.6
	<i>Unknown</i>	15	62.5	9.3
	<b>Total</b>	<b>24</b>	<b>100%</b>	<b>14.9%</b>

## X. Appendix A: Estimation Methodology for a Field Staff Investigation Study of the NEISS

The 2017 Study is the first study of its type that CPSC has undertaken. CPSC staff designed the study to address an inability to identify specific table saw type in injury data, among other data collection goals (see the “Introduction” section for study goals).<sup>31,32</sup> The study’s design uses the statistical structure of the NEISS, while incorporating non-survey-based CPSC Field staff investigations for follow-up data collection, which potentially opens multiple sources of variation that cannot be measured individually, and therefore, cannot be accounted for directly in the variance calculations.

Staff reviewed each NEISS case in the timeframe set for product codes 0841 (table saws), 0845 (saws, not specified), and 0895 (power saws, other or not specified). A case was assigned for investigation follow-up, if staff determined that the injury could have been a table saw blade-contact injury, or if unknown as table saw blade-contact injury. Thus, the methodology to analyze the results needed to leverage the complex survey structure of the NEISS, incorporating the structure that most cases were assigned, but not all cases (thus, information for the questions at hand come from multiple stages of the study, see *Appendix B* for the flow chart of data collection and connection to estimation methodology), and incorporating the Field investigation-based data collection. No investigation was requested on the cases where the information in the NEISS case indicated that there was no blade contact or no table saw involved, due to the increase in resources required for a Field investigation-based study. In a CATI-based survey, all cases would be assigned for further data collection, due to the minimal costs and simplification of the methodology needed. However, the cases not assigned for investigation, because it is known from the NEISS narrative to have *not* involved either a table saw or blade contact, remain vital to the analysis process, because the goal is to estimate adjustment factors that can be employed across multiple years of the NEISS, not to generate an estimate for one year. This also means that CPSC’s typical survey methods cannot be used for analyzing the study’s entirety. Therefore, CPSC staff developed a new methodology specifically to analyze this type of study, using statistical methods for surveys (incorporating the complex survey structure of the NEISS structure) and investigation-based data collections.

The following summarizes the methodology developed by staff to analyze a CPSC Field data collection of a NEISS-based study. The methodology description here incorporates the language of the 2017 Study; however, as noted above, the generalized methodology can be applied to any study similarly designed. All resulting 95 percent confidence intervals are obtained assuming a normal distribution.

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<sup>31</sup> Garland, Sarah. “Addendum to ‘Survey of Injuries Involving Stationary Saws: Table and Bench Saws, 2007–2008: Evaluation of Response Integrity and Resulting Estimates for Types of Saws and Types of Drives’” Memorandum to Caroleene Paul, April 14, 2014. Consumer Product Safety Commission. <http://www.cpsc.gov//Global/Research-and-Statistics/Injury-Statistics/Home%20Maintenance%20and%20Construction/CoverpageandMemoofStaffAnalysisofTableSawTypeinNEISSSpecialStudy.pdf>

<sup>32</sup> Stralka, Kathleen. “2014-2015 Table Saw Special Study Cautionary Statement” Memorandum to Caroleene Paul, November 21, 2016. Consumer Product Safety Commission, Table Saw NPR Briefing Package, Tab F. <https://www.cpsc.gov/s3fs-public/Proposed%20Rule%20-%20Safety%20Standard%20for%20Blade-Contact%20Injuries%20on%20Table%20Saws%20-%20January%2017%202017.pdf>

## Statistical Estimation Methodology Using CPSC's Field Investigations Follow-Ups for NEISS Cases

### Notations

$n_h$	Number of hospitals in stratum $h$
$m_{hi}$	Number of cases in hospital $i$ in stratum $h$
$B$	Number of bootstrap samples
$w_{hij}$	Weight for case $j$ in hospital $i$ in stratum $h$ ; adjusted weights donated by prime and double prime depending on the stage adjustment is made ( $w'_{hij}$ and $w''_{hij}$ )
$\hat{\theta}_{L_1}^*$	Bootstrap estimate of the proportion for Level-1 questions <sup>33</sup>
$\hat{\theta}_{L_2}^*$	Bootstrap estimate of the proportion for Level-2 questions <sup>34</sup>
$\hat{t}$	NEISS injury estimate
$\hat{\phi}_{L_1}$	Injury estimate for Level-1 questions
$\hat{\phi}_{L_2}$	Injury estimate for Level-2 questions
$S_h$	Set of hospitals in stratum $h$
$S_h^{*(b)}$	Set of hospitals for bootstrap sample $b$ in stratum $h$
$\delta_{hij}$	Indicator variable for case $j$ in hospital $i$ in stratum $h$
$\theta_h^{*(b)}$	Proportion for bootstrap sample $b$ in stratum $h$
$\bar{\theta}_h^*$	Mean of the proportion within stratum $h$ for all bootstrap samples
$\theta^{*(b)}$	Proportion for bootstrap sample $b$
$\hat{\theta}^*$	Bootstrap estimate of the proportion

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<sup>33</sup> Level 1 questions are evaluated using the NEISS case information when a case was not assigned for investigation as a “no” in the yes/no response of the question, and the “yes” and “unknown” are assigned for follow-up investigations. Thus, data to answer the question come from two stages in the study, either from the NEISS case, or the completed investigation. For example, was the injury related to blade contact on a table saw?

<sup>34</sup> Level 2 questions can only be answered through the set of completed investigations, which is a subset of the cases for the Level 1 questions. For example, what type of table saw was involved in the table saw blade-contact injury?

- (1) Adjust NEISS weights to account for non-participating NEISS hospitals<sup>35</sup> (*i.e.*, NEISS hospitals that do not provide victim contact information *a priori*).

The adjusted weight can be written as

$$w'_{hij} = a_{hij}w_{hij}I_i$$

where

$$I_i = \begin{cases} 1, & \text{if } i^{\text{th}} \text{ hospital participates in special studies} \\ 0, & \text{if } i^{\text{th}} \text{ hospital does not participate} \end{cases}$$

and  $a_{hij}$  is the adjustment calculated based on post-stratification/raking. This has been simplified for reading ease here; exactly how hospital/unit nonresponse is handled is developed based on the specifics of a given study. For the 2017 Study, post-stratification was applied to rake to each stratum's marginal totals.

$w'_{hij}$  can be written as

$$w'_{hij} = \begin{cases} w_{hij}, & \text{if } i^{\text{th}} \text{ hospital is participating} \\ 0, & \text{if } i^{\text{th}} \text{ hospital is non – participating.} \end{cases}$$

Thus, subsequent steps only use the set of cases with a non-zero  $w'_{hij}$ .

- (2) Determine datasets to use for estimation process and rake/post-stratify for Level 1 and Level 2 estimates (See *Appendix B* for a flow chart of information collection for Level 1 and Level 2 estimates).

For each level estimate, incorporating the information that comes from both NEISS case records and completed IDIs, proportionally allocate (*i.e.*, post-stratify or rake) “No ID Received” cases and “Terminated” cases (nonresponse) to the set of cases of the most appropriate completed set, depending on the study details and estimate levels. For the cases that a request for investigation was submitted, investigation-unit nonresponse for the 2017 Study, post-stratification/raking was applied using the variables stratum, age group, product code (0841 versus not), and diagnosis from the NEISS, as these variables showed a difference in response propensities for all strata except children's stratum. The children's stratum only had 2 completed IDIs; thus, the children's strata was raked to the marginal total for the stratum without any other variables.

See *Appendix B* for additional details of the information collection stages for this analysis process.

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<sup>35</sup> A “participating hospital” is defined as an active NEISS hospital that provides patient identification, if available, on a case-by-case basis, as requested by CPSC staff. A “non-participating hospital” is an active NEISS hospital that never provides any patient identification to CPSC as part of their contract.

Let

$$\hat{\tau} = \sum_{h=1}^5 \sum_{l=1}^{n_h} \sum_{j=1}^{m_{hl}} w_{hij}$$

where  $w_{hij}$  is the original weight all cases in product codes 0841, 0845, 0895.

Let  $\hat{\theta}_{L_1}^*$  be the estimated proportion of  $\hat{\tau}$  that are positive to be a table saw blade-contact injury.  $\hat{\theta}_{L_1}^*$  is independent of  $\hat{\tau}$ .

Let  $\hat{\phi}_{L_1}^*$  be the estimated number of table saw blade-contact, injuries, as

$$\hat{\phi}_{L_1} = \hat{\theta}_{L_1}^* \hat{\tau}$$

and

$$Var(\hat{\phi}_{L_1}) = \hat{\tau}^2 Var(\hat{\theta}_{L_1}^*) + (\hat{\theta}_{L_1}^*)^2 Var(\hat{\tau}) + Var(\hat{\tau}) Var(\hat{\theta}_{L_1}^*).$$

Questions that can only be answered through a completed investigation (*e.g.*, type of table saw and blade guard use) are Level-2 estimates, but are based on a subset of Level-1 data/estimates. Let  $\hat{\theta}_{L_2}^*$  be the proportion of  $\hat{\phi}_{L_1}$  that is positive for the Level-2 question.

Thus,  $\hat{\theta}_C^* = \hat{\theta}_{L_1}^* \hat{\theta}_{L_2}^*$  and

$$\hat{\phi}_{L_2} = \hat{\theta}_C^* \hat{\tau}.$$

$\hat{\tau}$  is independent of  $\hat{\theta}_C^*$ ,<sup>36</sup> however,  $\hat{\theta}_{L_1}^*$  and  $\hat{\theta}_{L_2}^*$  are dependent. Therefore,

$$Var(\hat{\phi}_{L_2}) = (\hat{\theta}_C^*)^2 Var(\hat{\tau}) + \hat{\tau}^2 Var(\hat{\theta}_C^*) + Var(\hat{\tau}) Var(\hat{\theta}_C^*)$$

and

$$\begin{aligned} Var(\hat{\theta}_C^*) &= Var(\hat{\theta}_{L_1}^* \hat{\theta}_{L_2}^*) \\ &= Cov[(\hat{\theta}_{L_1}^*)^2, (\hat{\theta}_{L_2}^*)^2] \\ &\quad + (Var(\hat{\theta}_{L_1}^*) + (\hat{\theta}_{L_1}^*)^2)(Var(\hat{\theta}_{L_2}^*) + (\hat{\theta}_{L_2}^*)^2) - [Cov(\hat{\theta}_{L_1}^*, \hat{\theta}_{L_2}^*) + \hat{\theta}_{L_1}^* \hat{\theta}_{L_2}^*]^2. \end{aligned}$$

All  $\hat{\theta}_{L_1}^*$  and  $\hat{\theta}_{L_2}^*$  are bootstrap estimates.<sup>37</sup> The same methodology is used to obtain each bootstrap estimate, so the notation of  $\hat{\theta}^*$  will be used through the bootstrap methodology, whenever the methodology is interchangeable for  $\hat{\theta}_{L_1}^*$  and  $\hat{\theta}_{L_2}^*$ .

<sup>36</sup> Independence does not mean the covariance must be zero. However, until otherwise known (testing can be completed by the analyst, as needed), the assumption is that the covariance between  $\hat{\tau}$  and  $\hat{\theta}_C^*$  is zero.

<sup>37</sup> Bootstrapping is a resampling with replacement technique that allows for an estimated distribution to be generated for a sample estimate, when the distribution cannot be assumed or calculated. Using the law of large numbers, inferences can then be made for the measure of interest.

$\hat{\theta}_{L_1}^*$  and  $\hat{\theta}_{L_2}^*$  estimates calculated from this study can be applied, with their associated variance estimates, to other NEISS years in the same manner as above, as deemed appropriate. The following steps provide the estimation methodology to obtain  $\hat{\theta}_{L_1}^*$  and  $\hat{\theta}_{L_2}^*$ .

(3) Obtain estimates  $\hat{\theta}_{L_1}^*$  and  $\hat{\theta}_{L_2}^*$  via bootstrapping at the PSU (hospital) level.

Bootstrapping requires an independent and identical distribution. The NEISS hospitals are the primary sampling units (PSUs) in the NEISS, and also where the independent and identical distributions occur (only within stratum, not across strata). Independent and identical distributions do not occur at the individual case level, regardless of whether there is an investigation or not for the case.<sup>38</sup> Thus, when bootstrapping the NEISS, the hospitals (PSUs) are selected as the variable to bootstrap, then all cases from each PSU selected are included in the bootstrap sample to form the whole sample.

Let  $S_h = \{i | i = 1, \dots, n_h\}$  be the set of PSUs within stratum  $h$  where  $h = 1, \dots, 5$  and  $n_h$  is the number of PSUs within stratum  $h$ .

Let  $S_h^{*(b)} = \{i^{*(b)} | i^{*(b)} = 1, \dots, n_h\}$  be the  $b^{th}$  bootstrap sample of PSUs from  $S_h$ , where  $b = 1, \dots, B$ .<sup>39</sup>

3.1 Generate a bootstrap sample,  $S_h^{*(b)}$ , of size  $n_h$  from  $S_h$ , selecting  $i$  with replacement. Select all cases,  $j^* = 1, \dots, m_{hi}^*$  in each  $i^{*(b)}$  selected to form the full bootstrap sample. For the first pass through,  $b = 1$ .

3.2 To accommodate the strata structure of the NEISS for variance component calculations steps in 3.4 and 3.7, calculate the proportion of “yes” for  $S_h^{*(b)}$ ,  $b = 1, \dots, B$ .

$$\theta_h^{*(b)} = \frac{\sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} \delta_{hij} w_{hij}''}{\sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} w_{hij}''}$$

where

$$\delta_{hij} = \begin{cases} 1, & \text{Yes} \\ 0, & \text{No.} \end{cases}$$

3.3 Repeat steps 3.1 through 3.2  $B$  times.

3.4 To accommodate the strata structure in the NEISS for variance calculations in 3.7, calculate

$$\bar{\theta}_h^* = \frac{1}{B} \sum_{b=1}^B \theta_h^{*(b)}.$$

3.5 Repeat steps 3.1 through 3.4 until each stratum is completed,  $h = 1, \dots, 5$ .

<sup>38</sup> Givens, Geof and Hoeting, Jennifer A. Computational Statistics. Hoboken, NJ: John Wiley & Sons, Inc., 2005.

<sup>39</sup> For the 2017 Study,  $B=1000$ .

3.6 Combine all bootstrap samples from  $S_h^{*(b)}$  for  $h = 1, \dots, 5$  for each  $b, b = 1, \dots, B$ .

$$S^{*(b)} = \{S_1^{*(b)}, S_2^{*(b)}, S_3^{*(b)}, S_4^{*(b)}, S_5^{*(b)}\}$$

For  $b = 1, \dots, B$ , calculate

$$\theta^{*(b)} = \frac{\sum_h \sum_i \sum_j \delta_{hij} w''_{hij}}{\sum_h \sum_i \sum_j w''_{hij}}$$

where

$$\delta_{hij} = \begin{cases} 1, & \text{Yes} \\ 0, & \text{No.} \end{cases}$$

3.7 Calculate the bootstrap estimates

$$\hat{\theta}^* = \frac{1}{B} \sum_{i=1}^B \theta^{*(b)}$$

$$Var(\hat{\theta}^*) = \frac{1}{B-1} \sum_h \sum_b (\theta_h^{*(b)} - \bar{\theta}_h^*)^2$$

$$Cov(\hat{\theta}_{L_1}^*, \hat{\theta}_{L_2}^*) = \frac{1}{B-1} \sum_h \sum_b (\theta_{hL_1}^{*(b)} - \bar{\theta}_{hL_1}^*) (\theta_{hL_2}^{*(b)} - \bar{\theta}_{hL_2}^*).$$

For  $Cov[(\hat{\theta}_{L_1}^*)^2, (\hat{\theta}_{L_2}^*)^2]$ , the above is simply adjusted accordingly to incorporate the square terms. The notation gets too cluttered to read easily; however, the calculations follow easily from what is given.



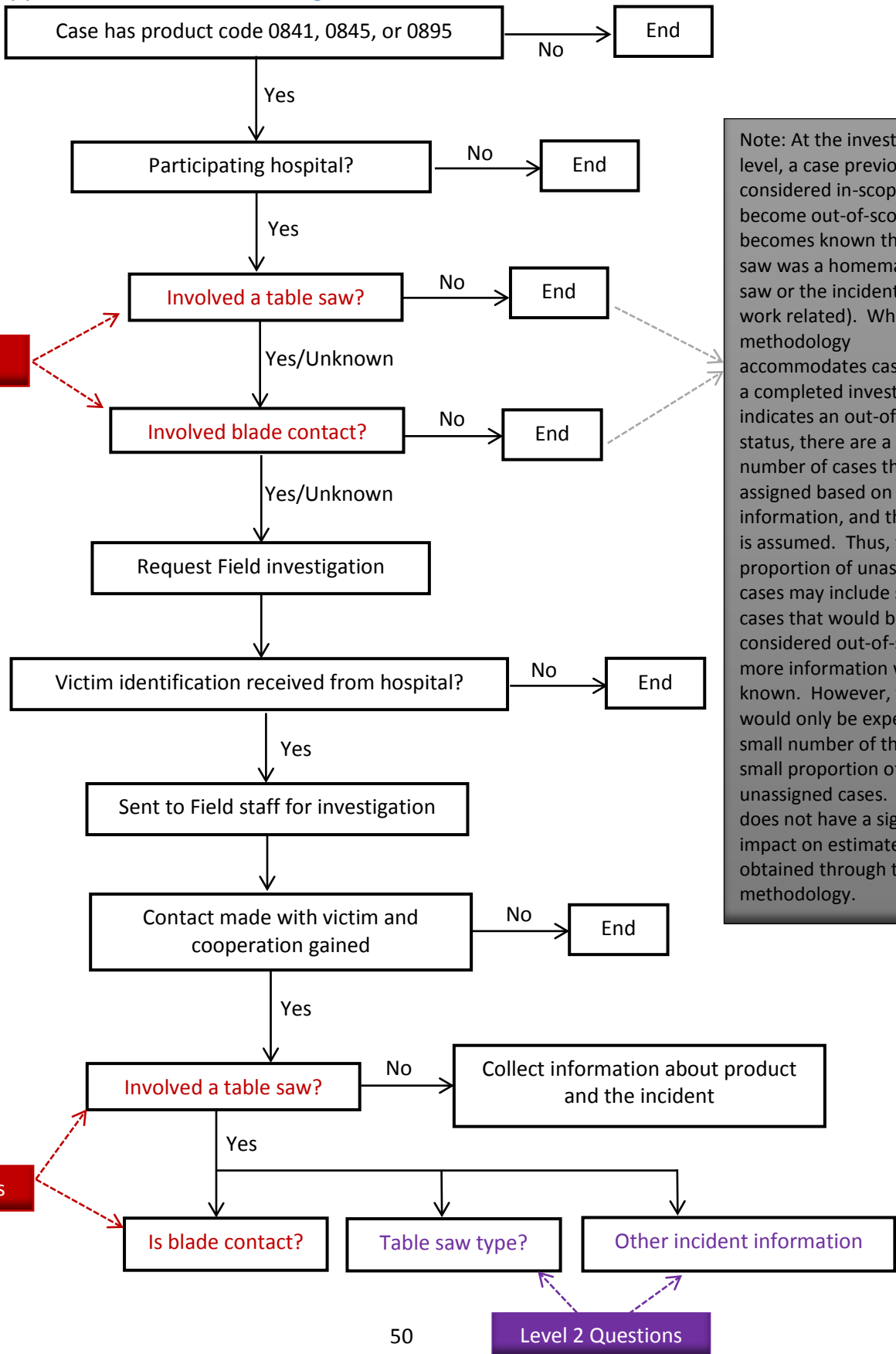
Table 29 provides the bootstrap bias estimates<sup>40</sup> for each of the bootstrap estimates obtained in the 2017 Study. Bootstrap bias estimates were small and did not affect the subsequent results of the study.

**Table 33: Bootstrap Bias Estimates for Level 1 and Level 2 Theta Estimates**

Bootstrap Estimate Identifier	Bootstrap Bias Estimate for $\hat{\theta}_{L_i}^*$	Bootstrap Estimate Identifier	Bootstrap Bias Estimate for $\hat{\theta}_{L_i}^*$
Table Saw Blade Contact (Level 1: $\hat{\theta}_{L_1}^*$ )	< 0.0001		
Table Saw Type (Level 2: $\hat{\theta}_{L_2}^*$ )		Disposition (Level 2: $\hat{\theta}_{L_2}^*$ )	
<i>Bench</i>	0.0007	<i>Treated and Released</i>	0.0008
<i>Contractor</i>	-0.0005	<i>Hospitalized</i>	-0.0006
<i>Cabinet</i>	-0.0004	<i>Other</i>	*
<i>Unknown</i>	*	Body Part (Level 2: $\hat{\theta}_{L_2}^*$ )	
Blade Guard Use (Level 2: $\hat{\theta}_{L_2}^*$ )		<i>Finger</i>	-0.0002
<i>No</i>	-0.0001	<i>Hand</i>	0.0001
<i>Yes</i>	0.0005	Sex (Level 2: $\hat{\theta}_{L_2}^*$ )	
<i>Unknown</i>	-0.0002	<i>Male</i>	-0.0001
<i>N/A</i>	*	<i>Female</i>	0.0001
Guard Type Manufactured with Saw (Level 2: $\hat{\theta}_{L_2}^*$ )		Age Group (Level 2: $\hat{\theta}_{L_2}^*$ )	
<i>Traditional</i>	-0.0015	$\leq 40$	-0.0008
<i>Modular</i>	0.0003	$41-60$	0.0003
<i>Unknown</i>	0.0010	$\geq 61$	0.0005
<i>N/A</i>	*		
Diagnosis (Level 2: $\hat{\theta}_{L_2}^*$ )			
<i>Laceration</i>	0.0013		
<i>Fracture</i>	-0.0006		
<i>Amputation</i>	-0.0004		
<i>Other</i>	-0.0003		
Reviewed Diagnosis (Level 2: $\hat{\theta}_{L_2}^*$ )			
<i>Laceration</i>	0.0010		
<i>Severe Laceration</i>	0.0005		
<i>Amputation</i>	-0.0006		
<i>Fracture or Avulsion</i>	-0.0008		

<sup>40</sup> A bootstrap estimator is a bias estimator, and it is possible to understand the bias for the bootstrap estimator, in particular in this study's application of the bootstrap methodology. In a bootstrap estimate, the bias is the difference between the original sample proportion and the average of all the bootstrap samples' proportions for the proportion of interest.

XI. Appendix B: NEISS Case Assignment Process Flow



Note: At the investigation level, a case previously considered in-scope can become out-of-scope (e.g., it becomes known that the saw was a homemade table saw or the incident was work related). While this methodology accommodates cases where a completed investigation indicates an out-of-scope status, there are a small number of cases that are not assigned based on the NEISS information, and the scope is assumed. Thus, this small proportion of unassigned cases may include some cases that would be considered out-of-scope if more information were known. However, this would only be expected for a small number of the already small proportion of unassigned cases. Thus, this does not have a significant impact on estimates obtained through this methodology.

## XII. Appendix C: SME IDI Review Process and Variable Descriptions

A team of CPSC SMEs reviewed each completed investigation in the 2017 special study. The team consisted of a mechanical engineer, a physiologist, a human factors engineer, an economist, and a statistician. This section describes the process for reviewing and coding completed IDIs from the 2017 Study and also describes the final set of variables coded by the review team and used for this report.

There were two types of completed investigations for the review team. One type is an investigation where the product was a table saw and the other is where the product was not a table saw. If the product was *not* a table saw, the review team ensured that there was consensus for the type of product involved, and nothing further was assessed in these investigations, though they play a vital role in the Appendix A methodology as part of the denominator for the Level 1 adjustment factor estimates and also in any future calculations for different product injury estimate analyses.

For investigations where a table saw was identified, the review process became more involved. Each SME independently reviewed all the available information for each case and coded each variable based on their review. The sets of coding from the SMEs were compared for each case and differences in coding identified. For any differences in coding, the SMEs discussed the details of the case and reached a consensus on any differences. The final set of coding reflects SME agreement on each variable for each case.

Also, the SMEs developed the list of variables and any categories within the variables. Not all categories for all variables are reported in the results sections, due to the lack of use of some categories in coding the incidents. The following are the descriptions of the variables used for completed investigations that identified a table saw within the 2017 special study that are used within this report. There were additional variables coded by the SMEs; however, they were not used directly or indirectly within this report, but are available for further understanding of the scenarios surrounding these incidents; these variables are free text in format and contain too wide a variety of input to categorize and subsequently summarize in this report.

The format for each variable described in this section is as follows:

Label (variable name, as in the analytic dataset): Description. (Format: Description).  
Categories listed.

### NEISS Variables

The NEISS captures data for several variables used in the results of this report. However, based on the additional information captured via an IDI, some cases required an adjustment to the recorded value of a NEISS variable. For example, the “type” variable (was the injury occupational-related?) records a “not work-related” or “unknown if work-related” value in the NEISS; however, upon interviewing the victim through the IDI process, additional information reveals that the injury was work-related. Therefore, the case should be considered as out-of-scope for the purposes of this report. Because the case still “lives” in the NEISS, and thus in any estimates that include it, it is not deleted from this analysis, but used to inform the analyses. Thus, this corrected value for “type” is captured in the “type\_correction” variable in the analytic dataset for this report. This report relies on the corrected values, not the original NEISS

coding. This section describes the NEISS variables used and the corresponding correction variables, if applicable.

For information on the values these variables can take and variable types related to these variables, the NEISS coding manual is available at CPSC.gov.<sup>41</sup> These variables are considered auxiliary variables in this analysis, because they are available for all cases, whether a follow-up investigation was completed or not. However, only completed IDIs can inform any correction variables' values.

Age Group (age\_group): The NEISS records age, not age group; however, for the purposes of this analysis, staff grouped ages as: ≤40, 41-60, and ≥61. (Format: Categorical)

Sex (sex): The NEISS variable that records the victim's sex. (Format: Categorical)

Body Part (bdpt): The body part as recorded in the NEISS. SME corrections to the body part involved are found in the body part correction variable in the analytic dataset for this report (bdpt\_correction). (Format: Categorical)

Diagnosis (diag): The diagnosis as recorded in the NEISS. SME corrections to the NEISS diagnosis are found in the diagnosis correction variable in the analytic dataset for this report (diag\_correction). (Format: Categorical)

Disposition (disp): The disposition as recorded in the NEISS. (Format: Categorical)

Occupational Injury (type): The occupational injury (type) identifier as recorded in the NEISS. SME corrections to the NEISS type are found in the type correction variable in the analytic dataset for this report (type\_correction). (Format: Categorical)

## Saw Variables

Product Involved (isTableSaw): This variable is only reported in Table 5 for all cases with completed IDIs, as part of the completed IDI tracking, and this variable is part of this tracking. Only the set of completed table-saw IDIs are in the analytic dataset, so "isTableSaw" has the values of "yes." However, this variable, as part of the completed IDI tracking process, is used throughout the report for calculations. (Format: Categorical). Table 5 contains the categories of this variable.

Homemade table saw identifier (scope): While the NEISS captures homemade table saws in the table saw product code (0841), though a rare event, for the purposes of rulemaking efforts, homemade saws are not in the scope of interest, and are excluded from the table saw blade-contact injury set. The results of this variable are not listed in this report, but the results are used in calculations throughout. (Format: Indicator)

### Values:

1 = yes, homemade (not manufactured table saw)

. = missing values indicate a manufactured (in-scope) table saw

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<sup>41</sup> <https://cpsc.gov/neiss/completemanual.pdf>

Table Saw Type (TableSawType): Captures the SME determination of the type of table saw involved in the incident. (Format: Categorical)

Categories:

Bench or jobsite saw  
Contractor saw<sup>42</sup>  
Cabinet saw  
Hybrid saw  
Other  
Unknown

Guard Type Manufactured with Saw (guard\_mfr): The SME determination of the type of blade guard the incident table saw was manufactured with, regardless to the guard's availability for use at the time of the incident and the circumstances of the incident. (Format: Categorical)

Categories:

Traditional  
Modular  
Other  
Unknown

Guard Type Received by Operator when Saw Acquired (guard\_received): Identifies the type of blade guard the user/owner received when s/he acquired the saw (*e.g.*, when the saw was bought (used or new), borrowed, rented, *etc.*). (Format: Categorical)

Categories:

Traditional  
Modular  
Other  
N/A-None received (*when the operator acquired the saw*)  
Unknown

Use frequency of the incident saw (use\_freq): This variable records the operator's use frequency of the incident table saw. (Format: Categorical). If additional information beyond these categories was provided, the information falls into these categories but was described differently than these categories, or if the use frequency description fit into the "other" category, the additional information is recorded in the "other\_use\_freq" variable.

Categories:

First time  
Daily to weekly  
Weekly to monthly  
Monthly to yearly  
Yearly  
Other  
Unknown

---

<sup>42</sup> The "contractor saw" and "hybrid saw" categories were collapsed for analysis purposes.

## Injury Variables

Was the injury related to blade contact? (blade\_contact): Captures if the injury was caused by the victim making contact with the table saw blade. (Format: Categorical)

Categories:

Yes

No

Unknown

Was the operator the injured person? (operator\_inj): Indicates if the operator was the injured party, and if not the operator, who was injured. (Format: Categorical). If the category is “No,” then the “not\_op\_who” variable provides information about who was injured.

Categories:

Yes<sup>43</sup>

No (*identified in the “not\_op\_who” variable*)

Unknown

Injury Description (injury\_dscrp): SME description of the injury (injuries). See (Goldsmith, 2018) for the discussion regarding injuries associated with table saw blade contact. (Format: Free text)

SME injury diagnosis (reviewed\_diag): The SME determination for the diagnosis. This variable is described further in the text in Section VII and IX with results compared to the NEISS diagnosis. (Format: Categorical)

Injured hand (injured\_hand): Identification of the injured hand. (Format: Categorical)

Categories:

Left

Right

Both

Unknown

Dominant hand (dominant\_hand): Identification of the victim’s dominant hand. (Format: Categorical)

Categories:

Left

Right

Both (*i.e., ambidextrous*)

Unknown

---

<sup>43</sup> Operators are not necessarily the owners or person responsible for the saw’s overall maintenance, but is the person responsible for the operation of the saw at the time of the incident.

## Incident Variables

Blade Guard Use (guard\_use): Indicates if the blade guard was in use (*i.e.*, attached and in the down position) at the time of the incident. (Format: Categorical)

Yes  
No  
N/A<sup>44</sup>  
Unknown

When the guard not in use, why was it not in use and when was it removed? (why\_noGuard\_categories and when\_guard\_removed): These two variables were created after all coding was completed, based on the information SME coded in the variable “why\_noGuard,” which is a free text variable where SME recorded all the information available for why a blade guard was not in use. The “why\_noGuard” variable contains more details that inform these two variables. This free text variable was reviewed after the IDI review process was completed, and these two variables and their categories were created, based on the patterns discovered. (Format: Categorical)

When was the guard removed?  
(when\_guard\_removed)

Categories:

Prior to [the saw’s] acquisition<sup>45</sup>  
Never installed  
After [the saw’s] acquisition  
[Guard in the] up position, not removed entirely  
Unknown

Why was the guard removed?  
(why\_guard\_removed)

Categories:

Did not receive a guard when saw acquired  
Inconvenient/visibility/cut type/stock size  
Broken  
Lost  
Difficulty installing  
Other  
Combination of these (each listed)  
Unknown

---

<sup>44</sup> Some variables have the category of “N/A” as an option. The “N/A” category is limited to situations where the variable cannot apply, like a person tripping over a saw that was not in use or cleaning underneath the table saw table top and accidentally turning the saw on. Even if a person is not actively cutting a piece of stock (*e.g.*, is between cuts, just finished a cut, or is retrieving a new piece of stock to cut), the existence of a safety feature, for example, is important to note. For an incident occurring in-between cuts, almost all variables are considered applicable, including unexpected stock movement, alignment devices, safety devices, stock type, *etc.*, and so all are coded without using the “N/A,” regardless of how the consumer or investigator answers in the IDI.

<sup>45</sup> *i.e.*, the operator did not receive a blade guard with the saw

How did the blade contact occur? (how\_blade\_contact): SME determination of the cause of blade contact (an attached, intact blade), whether the hand was pulled or not pulled into the blade, and additional information as available for the hand not being pulled into the blade. (Format: Categorical) If an “other” category is chosen, additional information is in the “other\_how\_BC” variable.

Categories:

Hand not pulled into blade/hand fed into blade (with workpiece)

Hand not pulled into blade/hand reached

Hand not pulled into blade/hand slipped or dropped off workpiece

Hand not pulled into blade/inadvertently moved hand into blade<sup>46</sup>

Hand not pulled into blade/other (*specified in the “other\_how\_bc” variable*)

Hand not pulled into blade/additional details unknown

Hand pulled into blade

Other (*specified in the “other\_how\_bc” variable*)

No blade contact/not kickback-related<sup>47</sup>

No blade contact/workpiece kickback with victim struck

No blade contact/other

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<sup>46</sup> The victim is not intentionally reaching for something or to do something.

<sup>47</sup> The “blade\_contact” variable, described earlier, contains the information about the injury being related to blade contact or not. The information is repeated here for incidents without blade contact to help any analyst recall the scope of the study accurately. No conclusions can be drawn for no-blade-contact incidents, because only blade contact or unknown blade contact incidents were assigned for follow-up investigation, with the goal to obtain information only for blade-contact injuries. These cases are the no-blade-contact cases within assigned and completed cases only, not the whole set of table saw injuries that are not related to blade contact. These categories are not reported in Sections VII or IIX, because they do not apply to the blade-contact set of injuries.



Circumstances leading to or at blade contact (circumstance): SME determinations answering: What happened immediately before blade contact (preceding action of “how did blade contact occur?”), or what is the most important circumstance before/at blade contact? This variable provides additional details for circumstances to the “How did blade contact occur?” variable; thus may sometimes be redundant information to “how did blade contact occur?” Also, it is not necessary that an incident with unexpected stock movement have the immediate or most significant circumstance to blade contact be the unexpected workpiece movement, though it certainly can be. (Format: Categorical). When an “other” category is chosen, additional information is in the “other\_circum” variable.

Categories:

Adjusting workpiece position  
Dislodging jam  
Distracted  
Nothing unusual/cutting workpiece  
Reaching around/over blade<sup>48</sup>  
Removing cutoff/workpiece<sup>49</sup>  
Switched off saw (blade slowing)  
Unexpected workpiece movement  
Other (*specified in the “other\_circum” variable*)  
No blade contact/other (*specified in the “other\_circum” variable*)  
No blade contact/unexpected workpiece movement  
Unknown

Unexpected stock movement (unexp\_stock\_move): Indicates if the stock moved in an unexpected way (this includes, but is not limited to, stock kickback), regardless of determination, if this led to the blade contact. (Format: Categorical)

Categories:

Yes  
No  
N/A  
Unknown

Alignment device in use (align\_device): Identifies the type of alignment device in use, if any, at the time of the incident. (Format: Categorical). When an “other” category is chosen, additional information is in the “other\_align\_device” variable.

Categories:

Rip fence  
Miter gauge  
Sled  
Jig  
Other (*specified in the “other\_align\_device” variable*)  
None (free hand)  
N/A  
Unknown

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<sup>48</sup> Reaching around/over blade: The person was reaching around or over the blade for some reason other than removing a cutoff or the workpiece.

<sup>49</sup> Removing cutoff/workpiece: The person was attempting to remove the cutoff or workpiece. It doesn't matter whether contact with the blade was during the reach or during the retraction.

How was the stock being pushed through the blade? (how\_pushed) Identifies how the victim was pushing the stock during the cut. (Format: Categorical). When an “other” category is chosen, additional information is in the “other\_pushed” variable.

Categories:

Hand(s)  
Miter Gauge  
Push block  
Push stick  
Sled  
Other (*specified in the “other\_pushed” variable*)  
N/A  
Unknown

Saw safety devices (saw\_safety\_all): Excluding the blade guard (see blade guard questions), this provides the use of other the safety devices with table saw guard assembly, not what the operator was wearing, at the time of the incident. This variable summarizes the detailed information available in the variable “saw\_safety1,” “saw\_safety2,” and “other\_saw\_safety.” (Format: Categorical)

Categories:

None  
Riving knife  
Spreader<sup>50</sup>  
Anti-kickback pawls  
Riving knife + Anti-kickback pawls  
Spreader + Anti-kickback pawls  
Other + Anti-kickback pawls  
N/A  
Unknown

Stock type (stock\_type): This describes the type of stock being cut in a general category (*e.g.*, wood laminate flooring is in the wood category). (Format: Categorical)

Categories:

Wood  
MDF  
Plastic  
Metal  
Other  
N/A  
Unknown

Stock Dimensions: length, width, thickness (stock\_length, stock\_width, stock\_thickness): Records the stock dimensions, in inches, in descending order of size for length, width, and thickness, respectively. Therefore, these variables record the stock dimension without considering the type of cut being made. If ranges were provided, the smallest measurement is recorded. (Format: Numerical, Continuous)

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<sup>50</sup> Includes splitters.

Type of Cut (cut\_type\_all): Indicates the type of cut, in relation to the stock (not the method of being cut), being made at the time of the incident. This variable summarizes the more detailed coding found in the “cut\_type” and “other\_cut\_type” variables. (Format: Categorical)

Categories:

Through/rip  
Through/cross  
Through/other  
Non-through/rip  
Non-through/cross  
Non-through/other  
Unknown/rip  
Other (*specified in “other\_cut\_type”*)  
N/A  
Unknown

Personal Protective Equipment (operator\_safety\_all): Identifies the type of safety clothing and other gear the victim wore at the time of the incident. This variable summarizes the more detailed coding found in the “operator\_safety1,” “operator\_safety2,” “operator\_safety3,” and “other\_op\_safety” variables. (Format: Categorical)

Categories:

None  
Eyeglasses<sup>51</sup>  
Safety glasses/goggles  
Other  
Multiple  
Unknown

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<sup>51</sup> Eyeglasses was an option to this category in the data record sheet of the IDIs. CPSC staff does not endorse eyeglasses as safety gear, but distinguishes between eyeglasses and safety glasses/goggles.

# Tab B



**UNITED STATES  
CONSUMER PRODUCT SAFETY COMMISSION  
4330 EAST WEST HIGHWAY  
BETHESDA, MD 20814**

Memorandum

Date: November 13, 2018

**TO :** Caroleene Paul, Table Saw Project Manager  
Division of Mechanical and Combustion Engineering  
Directorate for Engineering Sciences

**THROUGH:** Alice M. Thaler, DVM, Associate Executive Director  
Directorate for Health Sciences  
Jacque Ferrante, Ph.D., Director  
Division of Pharmacology and Physiology Assessment  
Directorate for Health Sciences

**FROM :** Jason R. Goldsmith, Ph.D., Physiologist  
Division of Pharmacology and Physiology Assessment  
Directorate for Health Sciences

**SUBJECT :** Table saw blade-contact injuries

In support of the notice of proposed rulemaking to develop a mandatory standard for safeguards against severe injuries from table saw blade contact, CPSC staff conducted a follow-up special study on table saw blade-contact injuries that occurred during calendar year 2017. The purpose of the special study was to gather more accurate estimates of the hazard patterns, including the types of saws involved and the blade-contact injuries that were received. The special study consisted of follow-up in-depth investigations (IDIs) of the incidents involving consumers who suffered emergency room-treated table saw blade-contact injuries between January 1, 2017, and December 31, 2017, that were reported through the National Electronic Injury Surveillance System (NEISS).

During the review of the completed IDIs, the CPSC staff subject matter experts review team (“review team”) observed that the NEISS injury diagnosis code did not always accurately reflect the type, extent, and/or severity of the blade-contact injuries incurred (in part, because diagnosis codes do not exist for all types of injury); in some cases the diagnosis code was entirely incorrect. Medical records were available for only 6 percent of the 161 incidents, and photographic evidence of the injuries was available for only 31 percent of the 161 incidents. However, in some cases, the review team determined that the diagnosis recorded in NEISS was inaccurate or inappropriate and that a different injury diagnosis better characterized the injuries. This determination was based on review of medical records, when available; written narratives; survey responses; NEISS final disposition codes; and photographic evidence, when available.

In this memorandum, Health Sciences (HS) staff discusses the findings of the analysis of the 2017 NEISS data in terms of the injury diagnoses and provides the reasoning for the review team’s decision to change injury diagnoses in some cases to more accurately characterize the injuries.

The memorandum is divided into three sections. The first section provides an introduction to the anatomy and physiology of the digits, which is the anatomical location of the vast majority of the table saw blade-contact injuries. This section provides a detailed description of the various constituent tissues found in the digits and serves as the foundation for the discussion in the second section of the blade-contact injury potential to these tissues. Organized by the depth of cut, the second section outlines how each tissue type is likely to be injured and discusses what treatment, if any, is required for healing to occur. Building on the first two sections, the third section discusses the findings of the review team's analysis with regard to the injury diagnoses. The various classes of incidents, for which a change in the diagnosis code was necessary, are described and the reasoning behind making these changes is explained.

## 1. Anatomy and Physiology of the Digits

The five digits, colloquially referred to as the thumb, index, middle, ring, and little fingers, respectively, are articulating appendages of the hand that allow one to grasp, touch, and sense objects in the environment. The thumb and index finger are uniquely positioned to perform independent movements that exceed those of the other three digits, and can also work in concert to perform fine motor motions, including prehensile movements, which require the opposition of thumb to index finger, such as grasping or picking motions. (As will be seen in the third section, these are also the two digits that are most often injured in table saw blade-contact injuries.) The essential structures that support these functions include bones, tendons, nerves, a hard nail, a spongy pad, and a generous vascular system. The anatomical and physiological overview provided in this section is intended to highlight the complexity of these structures and their close proximity to one another, and to provide an understanding of how and why the digits are highly vulnerable to blade-contact injury that can result in serious, permanent impairment.

This section will begin with an overview of skin characteristics. It will be followed by tissue-specific descriptions that begin at the volar (palm side) surface of the digit and move upwards through the digit to the dorsal surface (top side); this track will start with the most superficial tissues and progress toward the deepest tissue, the bone, and then proceed toward the more superficial tissues on the dorsal side of the digit. Where applicable, notable age and sex differences are discussed.

### *General properties of the skin*

The skin is a dynamic tissue that is tough, but also soft and pliable (Marble, 1960). It represents the interface between the body's external and internal environment. When intact, it provides protection against mechanical trauma, dehydration, noxious chemicals, thermal injury, bacteria, viruses, liquids, and ultraviolet radiation (Marble, 1960; Wysocki, 1999; Trott, 2005; Rayan and Akelman, 2011). Via its rich vascular supply and many sweat glands, the skin helps regulate body temperature. The skin also possesses the sensory receptors of the nervous system that allow us to perceive pain, pressure, temperature, touch, and vibration. The skin produces protein in the form of hair and nails, oils, water in the form of sweat, and vitamin D (Marble, 1960).

The skin is composed of two distinct layers: the epidermis, the outer layer, which we see, and the underlying dermis. The thickness of the skin and its component layers are the subject of considerable ambiguity in the medical literature, with some authors providing values that vary

greatly from those cited by others. In part, this appears to be due to differences in the areas sampled and/or the tissues that are considered to be part of the skin, but also appears to be due to the methodology employed to make such measurements. Measurement techniques have included measuring the thickness of skin folds, microscopically examining sectioned skin, radiography, and, more recently, ultrasound. The ultrasound technique has been continuously refined and appears to have allowed for the most precise measurements.

In general, the thickness of the skin has been found to vary throughout the body (Southwood, 1955; Goldsmith, 1983; Fornage and Deshayes, 1986; Wysocki, 1999; Rayan and Akelman, 2011). Recent sonographic analyses of the skin have concluded that skin thickness increases at puberty and starts to become thinner again after the second decade (Tan et al., 1982; de Rigal et al., 1989; Seidenari et al., 1994). Skin thickness is also known to increase as a result of exposure to the sun (Richard et al., 1994). In general, the skin of men is thicker than that of women (Southwood, 1955; Alexander and Miller, 1979; Tan et al., 1982; Fornage and Deshayes, 1986; Seidenari et al., 1994).

Aged skin (the skin of someone in at least their sixth decade) is atrophic (in a state of deterioration), making it transparent and less elastic, and allowing the vasculature to become more apparent (Montagna and Carlisle, 1979; de Rigal et al., 1989; Gilchrest, 1996). In addition to a thinning of both the epidermal and dermal layers with aging, the junction between the layers flattens, making the skin more fragile (Gilchrest, 1996; Baumann, 2007). A decrease in the vascularity of the dermis with aging and a reduction in the activity of fibroblasts (see below) results in prolonged wound healing (Gilchrest, 1996).

The thinner and more superficial of the two skin layers, the epidermis (also called the cutaneous layer), serves as the body's first line of defense against injury. It is avascular (lacking blood vessels) and contains no nerve endings; it is dependent on the underlying dermis for both nutrition and oxygen (Marble, 1960; Wysocki, 1999; Trott, 2005). The epidermis is a stratified epithelium that is made up of four or five layers (depending on its location in the body). In a constant state of turn-over, cell division occurring at the deepest level results in the migration of cells outward, eventually reaching the outermost layer over a period of weeks, where they are ultimately shed to the environment (Goldsmith, 1983). The majority of the cells that make up the epidermis produce the protein keratin. When cells reach the surface, engorged with keratin, they eventually die.

Between the epidermis and dermis is a thin basement membrane, essentially a firm mesh of fibers (Marble, 1960). Directly below, and attached firmly to the basement membrane, is the dermis, which is also called the cutis. The dermis represents the next line of defense against injury to the skin. It is both vascularized and innervated, providing both the blood vessels and nerves that supply the epidermis; the red or blue hue of the skin arises from this layer and the amount of oxygenated, versus deoxygenated, hemoglobin within the vascular network (Marble, 1960; Wysocki, 1999). In addition to sensory nerve endings, the dermis contains hair follicles, sweat glands, sebaceous glands, and lymphatics.

The dermis is many times thicker than the epidermis and represents the majority of the thickness of the skin. Unlike the epidermis, the dermis contains few cells; its thickness is due to connective tissue rather than cells. The main cell type found in the dermis is the fibroblast, which produces both collagen and elastin (Wysocki, 1999). Collagen is the principal structural component of skin

and provides the skin with both tensile strength and elasticity, whereas elastin is responsible for returning the skin to its normal configuration after it is stretched or pinched (Wysocki, 1999; Haake et al., 2004). The dermis is essential for proper wound repair; the fibroblast cells, and other cell types found in the dermis, such as macrophages, mast cells, and lymphocytes, are active during wound healing (Trott, 2005).

The aged dermis is relatively acellular and avascular, and is also characterized by both altered collagen production and the development of fragmented elastic fibers that results in a large decrease in its overall thickness (Baumann, 2007). The decreased tensile strength of the dermis diminishes its ability to resist injury and also makes sutures placed in this tissue less effective; in people over approximately age 50, sutures placed in the dermis tend to tear the tissue (Trott, 2005).

#### *Skin – volar surface*

The skin covering the digits is adaptively different than that of other areas of the body. The skin found on the volar surface of the digits is thickened, lacks hair, and possesses both whorls (fingerprints) and flexion creases. This specialized skin is termed glabrous skin. In the digits, the thickness of the skin varies from one surface to another; this is due to differences in the thickness of the epidermis and dermis (Southwood, 1955; Goldsmith, 1983; Fornage and Deshayes, 1986; Wysocki, 1999; Rayan and Akelman, 2011).

The epidermis in the digits ranges from 0.3 mm to greater than 1.0 mm in thickness (Southwood, 1955). On the volar surface of the digits, the epidermis is approximately 0.5 - 0.7 mm thick; whereas, on the dorsal surface of the digits, the epidermis is only 0.3 mm thick (Moore et al., 2003; Rayan and Akelman, 2011). Southwood (1955) found age- and sex-related differences in thickness of the epidermis in samples taken from the digits; the thickness grew from approximately 0.4 mm in infancy to 0.7 mm in the teenage years of puberty, followed by a decline after approximately age 40, achieving a thickness of approximately 0.5 mm nearing age 70. Additionally, the thickness of the male epidermis was overall found to be greater than that of the female by as much as 0.1 mm up to at least the fourth decade, after which differences diminish to only hundredths of a millimeter (Southwood, 1955).

In the digits, the dermis is approximately 1.4 mm thick on the volar surface (Southwood, 1995) and 1.5 mm thick on the dorsal surface (Moore et al., 2003). The relative age-related changes in dermal thickness and overall thicker dermis in men were found to be similar to those for the epidermis.

#### *Subdermal Fascia – volar surface*

Below the dermis are two layers of fascia (connective tissue), the superficial fascia and the deep fascia. Some medical experts consider these fascia layers as part of the skin, and this may, in part, account for the disparity in the values reported for skin thickness. The superficial fascia, which is also known as the subdermis or hypodermis, lies directly below the dermis. It is comprised of loose connective tissue that provides a supportive base to the skin, attaching it to underlying structures, and enclosing varying amounts of fat (Wysocki, 1999; Agache and Humbert, 2004; Trott, 2005; Rayan and Akelman, 2011). This tissue insulates the body against heat loss, provides a minimal amount of protection against trauma, and is responsible for an individual's particular body shape (Wysocki, 1999). Although structurally similar to the dermis, the connective tissue of



the superficial fascia is looser (Agache and Humbert, 2004; Trott, 2005). The blood vessels and sensory nerve branches that innervate the skin course through this fascia, just below the surface of the dermis. Pacinian corpuscles (mechanical pressure transducers) are also located within this tissue (Agache and Humbert, 2004).

In the digits, the superficial fascia of the volar surface is a specialized structure that plays a significant role; it is a thick tissue layer that is highly developed and is referred to as the digital pulp. The pulp space of the digital tip (fingertip) is composed of collagen fiber cords and a branching vasculature. Collagen fibers, called septa, that radiate out from the skin in spoke-like fashion, attach the dermis to the tissue surrounding the fibrous tendon sheath (sheath that surrounds the tendon) and periosteum (the connective tissue that envelopes the bone), providing a firm attachment of the skin of the digit and digital tip to the bone (Rayan and Akelman, 2011). These structures also anchor the fat and prevent the skin from sliding during movements of the digits. The lobules of fat found between the radiating collagen fibers within the pulp space provides elasticity to the digital tip.

Both the bone and the fingernail provide support to the pulp space. The digital pulp acts like a compression pad, similar to the fatty pad found in the palm of the hand or in the heel of the foot (Murai et al., 1997); it distributes the loads when pressure is applied to the tip and allows for pinching and grasping maneuvers, as well as for tactile sensation. The septa are also important in injury or infection, because they act to restrict both the amount of swelling and spread of infection that can take place in the digital tip (Rayan and Akelman, 2011). Injuries to the pulp space can lead to loss of function and sensitivity, and to persistent pain (Murai et al., 1997).

As described by Doyle (2006), the digital tip

“...represents a complex functional unit that consists of bone and soft tissue in the form of thick skin that covers a fat pad with fibrous tissue elements that separate the fat into compartments. This complex structure includes nerves and specialized end organs that provide sensibility to the digital tip in the form of pressure, pain, temperature, and identification of form and texture.”

Together with the skin and other soft tissue, including the flexor tendon (see *Flexor tendons* below) and its sheath, the pulp underlying the volar surface represents approximately 56 percent of the volume of the digital tip. The remaining volume consists of the dorsal soft tissue (approximately 26 percent) and bone (approximately 18 percent; Murai, et al, 1997).

The deep fascia is a thick and dense fibrous tissue layer that acts as a base for the superficial fascia; it also protects the underlying soft tissue structures, providing a barrier against the spread of infection from the skin and superficial fascia into the underlying soft tissues (Trott, 2005).

#### *Flexor tendons*

Tendons are cords of tough, inelastic connective tissue composed of collagen, through which the power of muscle contractions are transmitted to the digits. The tendons that are responsible for flexion of the digits (*e.g.*, when grasping items or making a fist) are located in the superficial fascia. The thumb has one flexor tendon, whereas the remaining digits have two main flexor tendons, the

flexor digitorum profundus and flexor digitorum superficialis, each occurring in a pair (Trott, 2005). The profundus provides the power needed for gripping and runs deep to the superficialis on its way to the fingertip, but at the level of the middle phalanx (middle bone segment) in digits 2 through 5, it passes through the superficialis and attaches to the distal (further away from the body) phalanx. The superficialis tendons are responsible for the positioning of the digits that is necessary for flexion. They are located superficially, just superficial to the dermal layer, until they are split by the profundus at the location of the middle phalanx at which point they course deeper and attach to the proximal (closer to the body) portion of the middle phalanx (Trott, 2005). The muscles to which these tendons are attached are located in the forearm; the digits themselves are devoid of muscle tissue.

The tendons are enveloped within a double-walled, synovial fluid-filled sheath that both lubricates and nourishes them (Marble, 1960; Rayan and Akelman, 2011). The inner layer is highly vascularized, has many tendon cells, and is rich in collagen. It closely adheres to the flexor tendon and is essential for the gliding, nutrition, and healing of the tendon. The outer layer of the sheath is surrounded by fibrous thickenings that are referred to as pulleys. The pulleys allow the muscles in the forearm to transform small movements of the tendons into a large amount of torque at the joints, which is necessary for pinching and grasping (Rayan and Akelman, 2011).

#### *Digital nerves*

There are two digital nerves that innervate each digit. The digital nerves travel along the radial (toward the thumb) and ulnar aspect (toward the little finger) of the volar surface of the digit within a neurovascular bundle (containing both nerves and blood vessels), and move ventral and lateral to the flexor tendons (Trott, 2005). The nerves arborize at the base of the nail, forming a network of sensitive nerve endings with branching occurring both upwards and downwards within the digit and providing sensation to both the nail bed area and volar surface of the digit and digital tip (Marble, 1960; Trott, 2005; Rayan and Akelman, 2011). The digital tip also possesses glomulus bodies, which are neurovascular structures composed of intertwined nerves and blood vessels that regulate blood flow at the perionychium (the nail unit; see *Nail* below); they are found within the nail bed and throughout the digital tip (Rayan and Akelman, 2011).

#### *Blood Vessels – volar surface*

Each digit has two digital arteries, radial and ulnar, that travel alongside the digital nerve on the volar side within the neurovascular bundle, just slightly deep to it within the superficial fascia (Rayan and Akelman, 2011). Proximal to the proximal interphalangeal joint (see *Bone* below), the digital arteries bifurcate, sending a dorsal branch to the skin on the dorsal side of the digit. Similar to the branching of the nerves that occurs at the base of the nail, the blood vessels also branch out just proximal to the nail root, toward both the dorsal and volar sides of the digit. The tip of the digit is richly vascularized with end loops formed by capillaries in the digital pulp (Rayan and Akelman, 2011). The venous return in the digits consists of a superficial and deep set of veins. Deep veins run alongside the digital arteries.

As stated by Trott (2005), the hand possesses a circulation that is both rich and redundant. Relative to other parts of the body, the hand receives a relatively greater blood supply, and the supply to the distal phalanges (bone segments) is greater than that to the other phalanges (Marble, 1960).

Based on that, and the fact that the circulation to the bone is relatively small, Marble reasons that the majority of the blood going to the digit supplies the skin.

### *Bone*

The thumb is composed of two phalanges, the proximal and distal phalanx, which are separated by one joint, the interphalangeal joint. The remaining four digits are each composed of three phalanges; the proximal, middle, and distal phalanx. Between the proximal and middle, and middle and distal phalanx of these four digits are the proximal interphalangeal joint and the distal interphalangeal joint, respectively. Each segment of a given digit is named for the underlying bony phalanx (*e.g.*, the terminal segment of the middle finger is referred to as the distal phalanx).

### *Retaining Ligaments*

Ligaments are tough tissues that act to hold together the bones of a joint. Like tendons, ligaments are also formed from collagen, but their bundles are less regular (Marble, 1960). At the interphalangeal joints, two ligaments attach the skin to the underlying tissues. Both of these fibrous tethers extend from the one side of the digit to the other, one traveling dorsal to the neurovascular bundle and one traveling beneath it, closer to the volar surface. These ligaments stabilize the joint, positioning both the skin and neurovascular bundle during movement of the joints (Rayan and Akelman, 2011).

### *Blood Vessels – dorsal surface*

The digital arteries that run along the dorsal side of the digit travel in the superficial fascia and branch at the distal interphalangeal joint. The dorsal veins, which are also found in the superficial fascia, superficial to the extensor tendons, are part of a larger system than the deeper venous system (Rayan and Akelman, 2011).

### *Subdermal Fascia – dorsal surface*

The deep fascia of the dorsal aspect of the digits is a layer of tissue that both incorporates and binds the extensor tendons. This layer contains sensory nerves as well as the venous return from the skin (Rayan and Akelman, 2011). The superficial fascia on the dorsal surface is a very narrow layer of loose connective tissue and a small amount of adipose tissue. It is loosely attached to the dermis, permitting the skin on the dorsal surface to move freely as the digits are flexed. Coursing through this fascia are the veins of the superficial venous system (Rayan and Akelman, 2011).

### *Nail*

The most prominent feature on the dorsal surface of the digits, the nail plate (fingernail) is part of a complex structure, called the perionychium (or nail unit), which is composed of the nail bed and the paronychium, the surrounding soft tissue that envelopes the nail along its lateral margins (Zook, 1990). The integrity of the perionychium is essential for the proper growth, tactile touch, regulation of peripheral circulation, as well as protection of the digital tip (Zook, 1990; Rayan and Akelman, 2011). Due to its location at the tip of the digit, the nail unit is particularly vulnerable; per Rayan and Akelman (2011), it is the part of the hand that is most frequently injured.

The nail plate is the hard, visible portion of the nail and is composed of a keratinous material that remains after the death of the cells from which it is initially formed (Rayan and Akelman, 2011). The nail plate varies in thickness from about 0.6 to 1.0 mm and grows at a rate of 0.1 mm per day

(Levit and Scher, 2004). The nail plate is devoid of cells in all but the area of the lunula, the white hemispherical (crescent moon) shape at the base of each nail; the absence of nuclei in these cells allows for the transparency of the nail plate. The normally pink coloration of the nail plate distal to the lunula is due to the underlying vascular system, which is seen through the nail plate (Zook, 1990).

The nail plate increases sensitivity of the digital tip by allowing the digital pulp to be compressed between it and what is being touched; consequently, the sensory nerve endings within the pulp are better able to discern what is being touched (Zook 1990; Rayan and Akelman, 2011). Removal of the nail results in reduced touch sensation, due to a significant increase in the two-point discrimination distance (Zook, 1990), *i.e.*, the minimum distance between two objects that is necessary to discern them as distinct from one another.

The nail bed, which the nail plate sits upon and adheres to, is a soft tissue consisting of the germinal matrix and the sterile matrix. The germinal matrix lies under the base of the nail (nail root) and is where new nail is generated; the cells forming this matrix are the source of the majority of the cells that make up the nail plate. The germinal matrix begins proximal to the visible portion of the nail and extends to the lunula (Zook, 1990; Rayan and Akelman, 2011). The deepest layer of cells making up the germinal matrix rests directly on the periosteum of the distal phalanx; consequently, fractures of the distal phalanx may disrupt this delicate tissue and, ultimately, the proper growth of the nail plate (Zook, 1990; Rayan and Akelman, 2011).

The sterile matrix adheres to the periosteum of the distal phalanx and is located distal to the germinal matrix. This matrix contributes a thin layer of cells to the deepest portion of the nail plate and increases its adherence to the nail bed; the actual amount varies by the individual, and, in some, can be so little that the nail is less tightly adhered (Zook, 1990). This matrix is the tissue that the nail plate passes over as it grows from the base of the nail toward the tip of the digit. As the nail plate moves forward, so too do the cells of the nail bed (Wood and Bladen, 1985). Deformities of the nail bed, such as ridging, can result when this tissue is injured or deformed (Zook, 1990; Rayan and Akelman, 2011).

The nail fold is the socket of tissue that anchors the proximal portion of the nail plate in place; its floor is comprised of the germinal matrix and its roof is comprised of the terminal portion of the eponychium, a specialized soft tissue that is located proximally to the nail, a portion of which (the cuticle) overlays the nail (Wood and Bladen, 1985; Zook, 1990; Rayan and Akelman, 2011). The skin that frames the nail plate along its sides (paronychia) functions to both stabilize the nail and prevent infection from developing under the nail (Rayan and Akelman, 2011). The hyponychium is the keratinous skin under the tip of the nail where the digital pulp meets the sterile matrix; this thickened epidermis is both highly vascularized and innervated (Wood and Bladen, 1985; Rayan and Akelman, 2011).

### *Extensor Tendons*

The thumb has two extensor tendons. The remaining digits each have a main extensor tendon that powerfully extends the digits and a small accessory tendon that can extend the digit in a weak fashion when the main extensor tendon is compromised (Trott, 2005). The extensor tendon inserts

into the distal phalanx just proximal to where the germinal matrix is located. All the extensor tendons are very superficial and may be apparent when one extends the digits.

### *Skin – dorsal surface*

As already noted, the skin on the dorsal surface is thinner than the volar surface. Unlike the glabrous skin of the volar surface, the skin on the dorsal surface bears hair follicles, is relatively sparsely populated with sensory nerve endings, is found in excess over joints, and is more mobile than the skin on the volar surface (Rayan and Akelman, 2011).

With an appreciation of the many tissues that make up the complex structure of the digits, it is now possible to discuss how these tissues may become injured as a result of contact with a table saw blade.

## 2. Table Saw Blade-Contact Injuries

Given the operating characteristics of a table saw and the attributes of a typical table saw blade, it is exceedingly likely that someone who contacts the spinning blade will suffer, at a minimum, a disruption of the skin (*i.e.*, receive at least a minor laceration injury). This is borne out by the 161 incidents in the 2017 NEISS dataset that were reviewed, all of which resulted in some form of laceration injury; there was an absence of (less severe) abrasion or contusion injuries (such injuries could occur, particularly if contact was made with only the plate of the blade rather than its teeth). Unfortunately, many who are injured by a table saw blade will suffer far worse than just a break in the skin. Such more severe wounds can involve all layers of the skin and damage to the underlying structures, and require extensive, long-term, complicated wound management, including multiple surgeries, long recuperation times, and the need for physical rehabilitation. Furthermore, these wounds and their treatment may be extremely painful, and may leave the victim badly scarred, disfigured, functionally impaired, and psychologically traumatized (Mason et al., 2002).

Practically speaking, all table saw blade-contact injuries are some form of a laceration injury, the depth, width, length, and severity of which can fall anywhere along a very wide spectrum, depending on a host of factors that include: (1) the angle and speed of approach of the hand/digits (*i.e.*, movement of the hand across the blade vs. directly into the blade; rate of approach/feed rate), (2) the height and angle of the saw blade, (3) the rotation rate of the blade, (4) the thickness of the blade, (5) the condition of the blade, (6) the number, type, and configuration of the teeth, (7) the angle at which the teeth are set relative to the center of the blade, (8) the metal composition of the teeth and their condition, (9) the condition of the bearings, (10) the number of digits affected, (11) the location along the length of the digit(s) where contact is made, and (12) the underlying structures that are ultimately contacted by or affected by the teeth of the blade.

At one extreme, blade contact can produce shallow, minor lacerations that disrupt only the skin. Injuries such as these may require little to no medical attention, are relatively inexpensive to treat, and likely will have no lasting repercussions. The width of the swath and/or the length of the laceration may necessitate the application of sutures to aid wound closure and healing. An exception to the injury potential of such shallow wounds is a laceration that involves the nail plate; such injuries can require extensive surgical repair, and even in the best of circumstances, result in

deformities of the nail plate and/or a compromised ability to touch and grasp due to a deformed nail plate (see *Severe lacerations* below for discussion of nail plate injury).

Table saw blade teeth that penetrate only slightly deeper (*i.e.*, greater than approximately 4 mm from the skin surface) than those producing minor lacerations, have the potential to produce injuries that can be far more severe and both complex and expensive to treat. This is owing to the many tissue types found in the digits (as described in first section), their close association to one another, and their close approximation to the skin layers under which they lie. Saw blade teeth that penetrate to such depths can easily lacerate the subdermal fascia, tendons, and the bilateral neurovascular bundles that traverse the length of the digits and house both the nerve and vascular supply of the digits. Still deeper penetration of the blade can injure ligaments and bone. The complex laceration of nerves, blood vessels, tendons, ligaments, and bone are severe lacerations that will require extensive and complicated surgical treatment, including microsurgery to reestablish nerve connections and restore blood flow to the injured digit, surgery to reconnect tendons and repair ligaments, and the resetting of bone.

Amputation injuries are an extension of the most severe lacerations – differing only by the fact that the laceration proceeds all the way through the thickness of the digit, separating the digit from the hand, or segment of the digit from the remainder of the digit. Depending on the location and condition of the amputated digit/segment, the treatment may be very similar to that required for a severe laceration, but may also necessitate the surgical shortening of the digit, the replanting (reattachment) of the amputated segment, the application of skin grafts, or the complete removal of the digit.

In general, the injury severity will determine whether the wound from a table saw blade can be allowed to heal on its own (healing by secondary intention) or will require medical treatment that may include surgical closure of the wound (healing by primary intention). Given the complexity of the digits and the unique attributes of the component tissues, the likely table saw blade-contact injuries that may occur will be discussed in greater detail below; discussion will start with the most superficial of injuries and proceed to those involving the deepest structures. Special emphasis will be placed on the unique properties of the tissues affected, the required wound treatment, and the long-term consequences of such injuries.

#### *Simple laceration injuries and avulsions, not involving deeper structures*

As mentioned above, laceration injuries can be divided into simple lacerations, complex lacerations, and those that completely sever the digit, *i.e.* amputations. Simple lacerations are, for the most part, minor injuries, which involve only the skin layers. These injuries may heal without any intervention, or require only minor care, such as cleaning and applying dressing to the wound, thereby allowing it to heal spontaneously, or may require primary surgical closure (healing by primary intention) in the emergency department in order for healing to occur.

The shallowest of cuts will penetrate only the epidermis. Given that the epidermis does not possess any blood vessels, there is no bleeding in such wounds; a paper cut that does not bleed is an example of such an injury. Such wounds only require a few days to heal. New cells are formed and they migrate to fill in the wound. Because the epidermis is so thin, when examining a wound

it cannot be easily differentiated from the dermis with the naked eye alone; however, the absence of blood will confirm that only the epidermis has been affected.

Slightly deeper lacerations will also injure the dermis. Wounds of this depth will take several days or weeks to heal completely. In general, there are several phases to healing from this type of injury. The immediate response is one of rapid hemostasis. Severed blood vessels will initially flood the wound with blood, which will clean the wound of microbes and other contaminants. However, such bleeding will be limited due to wound-edge retraction and tissue contraction, which compresses the small vasculature, and reflex vasoconstriction. The exposed wound surfaces will begin to amass platelets, which will fill the wound with clotting material, the top of which will harden into a scab (Falabella and Falanga, 2004; Trott, 2005). Other compounds released into the wound will result in the dilation of uninjured capillaries, which will initiate the flushing of the wound of bacteria and contaminants (Wysoki, 1999; Trott, 2005).

The next phase is the inflammatory response, wherein granulocytes and lymphocytes (both forms of white blood cells) are attracted to the wound to mitigate bacterial infection. Within a day or two, macrophages (also a form of white blood cell) appear in great numbers and digest debris in the wound and also stimulate fibroblast reproduction and the growth of new blood vessels (Trott, 2005). Simultaneously, intact cells of the basal layer of the epidermis begin to form foot-like structures and combined with their accelerated replication, will begin to fill in the wound over the damaged dermis and under the scab, and reestablish the normal layering of the epidermis (Trott, 2005).

Within a few days, new blood vessels will replace damaged vasculature, which sustains the wound healing process. This, in turn, promotes the proliferation of fibroblasts and the production of new collagen fibrils, which are laid down in a random pattern, having little tensile strength (Wysoki 1999; Trott, 2005).

Over weeks and months, the collagen is continually broken down and replaced, forming a stronger tissue as time progresses. As new tissue and blood vessels grow beneath the scab, filling in the damaged area, the initial blood clot is replaced. The scab falls off once cells in the epidermis have regenerated. A scar, which is composed mainly of collagen, usually remains. The scar tissue has little or no blood supply and has less flexibility than normal skin.

Over many months, the scar will undergo remodeling, contracting toward the center point of the wound as it does so, which pulls the surrounding normal skin into the wound area. Wide wounds and those involving significant surface area will eventuate in noticeable scarring; whereas, deep wounds that cause injury to underlying structures will be depressed or otherwise irregular (Trott, 2005).

Some wounds will require intervention for proper healing to occur. To make the determination whether it is necessary to repair the tissues and close the skin with the placement of sutures, to close the wound without repairing it, or to leave it open, debris must be removed from the wound and it should be cleaned and debrided (all contaminated and dead tissue removed) before attempting to match up the sides of the wound (Marble, 1960). Sutures may be required if the tissues do not lie closely opposed or if the laceration is lengthy. Per Wittstadt (2005), primary

closure is straightforward and will result in good sensation, rapid healing and early mobilization. Closure of this type is appropriate for lacerations that are relatively clean and with minimal tissue loss (Trott, 2005).

Given the critical function that the skin plays in the digits, the only skin edge that should be excised during treatment of laceration injuries is that skin which is clearly mechanically damaged. Excessive loss and/or removal of skin is problematic, and can lead to inadequate coverage or wound contraction (Marble, 1960; Trott, 2005). Excision of dermal tissue should be done sparingly and limited to only that tissue that is compromised, as any defects in the dermis are replaced by scar tissue (Marble, 1960; Trott, 2005). The edges of the injured skin should be cleaned down to the pink tissue. Marble cautions that in a simple laceration, the damage to the skin is slight and excision of the edge is unlikely to be necessary and should rarely be done, as there is no excess skin on the hand and that any loss, no matter how small, must be replaced with skin grafts from other parts of the body. The laceration created by a table saw blade is likely to require a greater amount of excision. If grafting is necessary to close the skin, there should be no tension, because tension will affect healing. Open treatment (healing by secondary intention) is often reserved for children and for injuries of moderate size (1 cm squared or less; Wittstadt, 2005).

Avulsion (forceful tearing away) injuries of the skin can also occur under certain circumstances after contact with a table saw blade and can be minor or severe, depending on the size or volume of the tissue that is torn away. There is agreement that fingertip avulsions that are less than 1-cm square in area and with no bone exposed can be left to heal spontaneously (Trott, 2005). Individuals with older, thinner skin are more likely to suffer partial avulsions of skin to forces that would not disrupt younger, thicker skin. In such cases, the skin separates at the boundary between the dermis and superficial fascia. Unfortunately, slower wound healing also occurs in those of advanced age (Trott, 2005). When the protective skin layers are stripped from any part of the hand, fascia, tendons, blood vessels, nerves, ligaments, bones and joints can be revealed. If not promptly covered, these tissues can become dry, infected, and die; thus, any loss of skin must be promptly replaced (Marble, 1960).

Avulsions of the nail plate can also occur. If cleanly avulsed from the nail bed, very little treatment is necessary. However, when greater injury of the nail unit is produced, or the avulsion occurs along with laceration of the underlying or supportive tissues, then the injury may be more severe and require more complicated treatment (see *Severe lacerations, fractures, and avulsions, involving deeper structures* below for discussion of nail plate injury).

#### *Severe lacerations, fractures, and avulsions, involving deeper structures*

What outwardly may appear to be a minor laceration injury can actually be much more serious when underlying structures have been compromised; however, the detection of these more extensive injuries may not occur until the wound is opened further and an elaborate inspection is performed. Thus, treatment of anything but the most minor laceration wound from table saw blade contact should involve inspecting the deeper tissues to determine the true extent of the injury.

As described by Loda (1999), injuries of the digit, and the tip in particular, can be totally disabling. This is because of the very precious digital sensitivity of the digits. Recognition of the extent of the injury and receiving the proper treatment are of critical importance in regaining sensitivity.



Loda cautions that recovery from an injury to a digit can be thought of in either terms of basic recovery or functional recovery. Basic recovery consists of the restoration of nerve pathways and simple reception of touch, cold, heat and pain, whereas functional recovery describes the ability to recognize an object, assess it, and intellectually interpret what it is. Any modification to the sensitivity of the digits will also affect their functional ability. Thus, it is essential that the true extent of a blade-contact injury be carefully assessed.

The action of the table saw blade is one that both crushes and compresses the tissue as it lacerates through the tissue; consequently, the tissues that are affected may lie deeper than the actual penetration depth of the teeth of the table saw blade. If it is apparent that the deeper structures have been involved, Furlong (1957) advises that the patient should be admitted to the hospital, so that the required exploration of the wound is not rushed and any complications can be addressed. Table saw blade wounds are marked by ragged or shredded edges, with skin and superficial fascia that are devitalized in the process; these wounds are more susceptible to infection than a more sharp shearing injury (Trott, 2005). In contrast to the wounds made by a surgeon's scalpel (incised wounds), which require little debridement, laceration wounds in general require relatively more excision of tissue, but those that also involve crushing of the tissue, as occurs with a table saw blade, require even more (Marble, 1960). Although seemingly obvious, Marble remarks that when such injuries take place, it should be the surgeons' goal to ensure that the tendons move, the nerves transmit, and the bones heal, and describes the necessary techniques as akin to those of the finest instrument maker. This statement reflects the fact that the digits are complex specialized structures, where the repair of which must go beyond cosmetic appearance.

Treatment decisions are often based on a combination of the affected anatomy, the orientation of the laceration, and the location and geometry of the skin and soft tissue that has been lost, as well as factors such as the patient's age, occupation, functional needs, and the surgeon's experience with the required techniques (Wittstadt, 2005; Doyle, 2006). However, the more severe laceration injuries that involve damage to the tendons, nerves, and vascular system, are not injuries that the body can recover from on its own and will require complex and complicated surgery that is best performed by a specialist.

The fat in the superficial fascia makes this layer of fascia readily recognizable after a laceration injury. Fascia tissue that is torn or shredded must be removed, and if not shredded can be repaired with sutures or left open (Marble, 1960). Trott (2005) advises that the fat of this layer can be removed as necessary because it is a good substrate for bacterial growth, and failure to remove devitalized tissue, blood clots, and other debris can result in infection. However, there are a couple of caveats. The septa of the volar surface should be left intact whenever possible because injury to this tissue can result in the creation of dead space within the digit, and because injured fat does not regenerate, fat that is lost from the digital pulp can affect the padding that the tissue provides (Trott, 2005). Laceration injuries of the deep fascia are easily recognizable by the off-white color of the sheath-like material. Closure of the deep fascia is necessary after injury to reestablish both the protective and supportive functions of this layer (Trott, 2005).

Careful exploration must be performed whenever the function of the tendons is in question. Although function may be maintained, after their direct visualization subsequent to exploration, the tendons may be found to be partially severed (Trott, 2005). If they are crushed or severed, they

may be retracted and found encased in a mesh of blood clots. When they are cut, the proximal half will retract due to the pull of the muscle, and can be difficult to find, whereas the distal segment is usually easy to locate. Similarly, if during examination, the hand is in an orientation that differs from the orientation during the injury, the lacerated tendon may not be visible in the wound opening, but rather some distance away from the laceration through the skin (Marble, 1960; Trott, 2005). In these cases, it may be necessary to actively flex and extend the digits and/or enlarge the wound in order to locate them. As mentioned above, in general, debriding with a scalpel is necessary to remove all contaminated and dead tissue, including fascia, torn tendons, and skin. This is of particular importance with regard to the proper movement of the tendons, because any trace of foreign material that is left in the wound could cause inflammation, which could disrupt normal function, such as the smooth gliding of tendons (Trott, 2005). Once located, the tendons must be washed and the wounded ends trimmed, before the ends can be sutured together (Marble, 1960).

In many cases, lacerated flexor tendons may be repaired as late as 3 weeks after injury, but in those cases where there is extensive tissue destruction or skin loss, injured bone, or excessive contamination, repair is best performed immediately. Lacerations of the flexor tendons are routinely referred to a specialist for attention. Trott (2005) cautions that repair of these tendons is a delicate matter that is fraught with complications; that even under ideal circumstances, including treatment by a specialist in tendon injuries, the full range of motion is never realized after such injuries. Splinting of the digits and forearm for a period of four weeks is necessary after repair of the flexor tendons.

Severed extensor tendons will require a longer period of splinting than that required for flexor tendons (6 weeks vs. 4 weeks, respectively; Marble, 1960). Per Wittstadt (2005), even after the best possible repair and cooperation from the patient, the tendons may become adherent to the tendon sheath and fail to glide smoothly enough to return adequate digital function. Providing that the adjacent pulleys are intact, the loss of one tendon pulley can be tolerated; however, loss of more than one pulley results in ineffective operation of the tendon and loss of motion of the joint (Rayan and Akelman, 2011).

The colocalization of the arteries and nerves in neurovascular bundles is useful in injury assessment because cases of arterial bleeding will usually indicate that there has been nerve injury as well, and vice versa (Trott, 2005). When arteries are completely transected, the vessels will contract and bleeding will stop; however, when only partially lacerated, the vessels cannot close and bleeding will continue (Marble, 1960). Veins will bleed vigorously until thrombosis occurs (Marble, 1960). Severed blood vessels should be sutured closed (Marble, 1960). Through the process of angiogenesis, new vessels grow, migrating toward the wound (Falabella and Falanga, 2004).

A digit with compromised sensation is a serious disability; therefore, all severed nerves must be repaired. The best recovery of nerve function is associated with treatment by individuals skilled in the proper repair of nerve injuries. The nerves may be lacerated, but are rarely crushed or injured so severely that they cannot be repaired (Marble, 1960). Once the severed ends are located, they are washed, their ends are recut, and they are brought together; the sheath that contains them is then sutured together (Marble, 1960; Trott, 2005). Sutured nerves require four weeks of

immobilization. Marble (1960) states that the nerves within the sheath will regenerate at a rate of 1 mm per day if the suturing is done properly. The number of millimeters from the injury location to the tip of the digit will approximate the number of days before sensation will be restored to the tip of the digit. During healing, for approximately 3 weeks, sensory nerves will sprout extensively, after which autonomic nerve fibers will appear (Metze and Luger, 2004).

A fracture of one of the phalanges is often associated with injury of the tendons, ligaments, nail plate, or other soft tissue. Lacerated, or otherwise injured bone, should be cleaned, all contaminants removed using a small chisel or rongeur (a surgical instrument with a sharp-edged, scoop-shaped cutting tip), and any small bone fragments removed (Marble, 1960). Whenever the bone is exposed, shortening of the bone may be required in order to close the wound, but the preservation of the length of the digit should always be strived for; in particular, this is the case for the thumb (Rayan and Akelman, 2011). The realignment (reduction) of broken or dislocated bones can usually be accomplished under local anesthesia in the emergency department; however, some fractures or dislocations may require surgical repair in an operating room. Splinting of the bone for several weeks, when required, will stabilize the realigned bone and permit faster healing. Fractures that are nearer to the joint may require splinting or the placement of pins or wires to properly align the bone.

Displaced closed fractures of the distal phalanx have to be given special attention; they must be reduced (either with closed reduction and splinting or placement of wires) and stabilized to prevent injury of the overlying sterile matrix, which, if injured, could result in deformation of the nail plate. Fractures from table saw blade contact usually result from direct contact with the bone; however, fractures of the fragile tuft (end) of the distal phalanx may occur due to the forces involved in the disruption of surrounding tissue. Small fractures of the tuft generally do not affect the strength of the bone and require little, if any, treatment. Fractures of the phalanges heal quickly, but the deposition of calcium occurs after the bone is considered solid (Marble, 1960).

Injury of the nail plate or nail bed can be of significant consequence. Injuries to the nail bed may result in deformity of the nail plate as well as functional disability. Lacerations can be repaired only after complete removal of the nail plate and the placement of sutures, followed by placement of the plate back into the nail fold (Fassler, 1996). When the nail has been injured, it is critical to ensure that the eponychium is not allowed to adhere to the germinal matrix (directly, or by the build up of scar tissue), because this will impair nail regeneration. If the nail bed has been exposed (*i.e.*, in cases of nail avulsion), such adherence can be prevented by suturing the detached nail or some other material in place until new nail growth pushes it out (Zook, 1990; Trott, 2005). It is also essential that the nail bed is smooth (*i.e.*, it is necessary to close wounds in this area with fine sutures), or scar tissue will develop and its presence will not allow for the nail to adhere to the nail bed (Zook, 1990). When there is loss of the nail matrix tissue, treatment is often difficult and is likely to result in a deformity of the nail plate (Fassler, 1996).

After repair to the deep tissues has been effected, proper skin closure, whether through suturing, or grafting, is necessary to save exposed tendons, nerves, joints and bone; not doing so will lead to their necrosing (Marble, 1960).

Severe avulsions of soft tissues and/or the nail plate can also occur under certain circumstances and can disrupt the soft tissues in a manner not unlike the above-described severe laceration injuries. For larger areas, but with intact nail and no exposed bone, conservative treatment can be attempted, but skin grafts may be necessary (Marble, 1960; Trott, 2005). Larger wounds that are allowed to heal spontaneously will have a thin layer of epithelium that may prove not to be very durable (Fassler, 1996). Granulation tissue will form wherever skin has been removed; it provides the bed for the development of scar tissue, which can both severely constrain movement about joints and impair sensitivity (Furlong, 1957). For avulsions with involvement of the nail, repair of the matrix is necessary.

As articulated by Wittstadt (2005), complications of digital injuries are many and include infection, hook nail deformity, flexion contracture, cold intolerance, altered sensibility, and graft or flap failure. Although infection may be minimized by adequate debridement of the wound, antibiotics beyond the usual course are not generally believed to be helpful in the prevention of infection. Failure to trim the nail bed back to the level of the bone can result in the nail hooking over; the nail requires the support of the underlying bone. Use of various flaps can result in the inability to fully extend the digits, owing, at least in part, to the positioning of the digits during the procedure. Finally, cold tolerance is a particularly common problem, occurring in 30 to 70 percent of digital injuries; those who suffer loss of the digital pulp have both a 30 to 50 percent chance of cold intolerance and a 30 percent chance of having altered sensibility.

For many who receive such severe lacerations, the treatment will extend far beyond the initial hospitalization. Sutures, wires, fixation points for tendon repair, splints, and casts will have to be removed, x-rays taken, examinations performed, and, in some cases follow-up surgeries performed. For many, physical therapy will have to be initiated toward the goal of regaining a useful range of motion.

#### *Amputation injuries*

Amputations are severe laceration injuries that have completely severed the digit from the hand or a portion of the digit from the remainder of the digit (partial amputation). It is important to realize the subtle difference between a severe laceration injury that severs the skin and all internal tissues, but leaves intact the skin on the opposite side of the digit from where the blade entered, and the amputation injury that completely transects the digit. In terms of the NEISS injury diagnosis code that may be used, only the slightest difference in the depth of laceration – on the order of 0.5 mm – separates an injury that will be termed a laceration from an amputation.

Although there is much in common between the treatment of amputations and the treatment of the severe laceration injuries to soft tissues, as discussed above, amputations present both the treating physicians and patient with a number of difficult challenges, such as the decision whether to replant an amputated segment, to surgically shorten an amputated digit, or which digit to salvage when more than one has been amputated. Tissue that has been separated for too long, small pieces of tissue, or severely damaged tissue may not be salvageable – an unfortunate reality. In some cases, the best treatment may consist of leaving the amputated digit/segment off, because reattaching it may impair the function of the hand. Unlike a severe laceration that may involve one or more tissues, and require some level of expertise to treat, amputations are likely to require the expertise of one or more specialists, depending on the tissues affected and the decision to replant or not.

Replantation of digits can occur up to a day after the amputation, if the amputated segments were properly chilled (Doyle, 2006). After the bleeding is stopped, and the wounded tissue, including the separated segment(s), are cleaned and debrided, the tissues can then be carefully examined, and the decision to replant made. Amputations that are relatively clean (not jagged) and which occur at or proximal to the distal interphalangeal joint are considered candidates for replantation (Wittstadt, 2005). For such amputations, the main objectives are to preserve the digit length, nail growth capacity, and the fingertip padding, while retaining sensibility and function, and minimizing pain and recovery time; the maintenance of length must be balanced against a tension free closure that is well padded, is not painful, and that will provide for pinch and fine motor skills (Trott, 2005; Doyle, 2006; Rayan and Akelman, 2011). If the portion of the distal phalanx where the flexor and extensor tendons insert is lost or cannot be preserved, then the distal phalanx is generally removed because there is no advantage to preserving a small stump of the distal phalanx if it cannot be manipulated (Fassler, 1996).

Replantation normally consists of shortening and/or fixation of the bone, repairing tendons, anastomosis of arteries and veins, repairing digital nerves, and ensuring adequate skin coverage (Doyle, 2006). Urbaniak (1979) describes the order of the many steps involved in replantation as follows: (1) locate and tag the vessels and nerves, (2) shorten and fix the bone, (3) repair extensor tendons, (4) repair the arteries, (5) repair the nerves, (6) repair the flexor tendons, (7) repair the veins, and (8) complete with skin coverage. In some cases, to preserve the length of the digit, a joint may be fused; this will no longer permit movement about the fused joint. Replantation of a single digit can take a microsurgeon or team of specialists 3 hours to perform; whereas, multiple digits can require as many as 20 hours (Urbaniak, 1979).

Survival of a replanted digit/segment is typically over 95 percent (Godfrey et al., 1984). In some cases, the replanted digit will not have reperfused (have normal blood flow) over a period of a couple of weeks, and will have to be surgically amputated. Even amongst the best recoveries, replanted parts are rarely 100 percent functional and many with a replanted digit/segment will complain of scar tenderness, pain, and discomfort in cold weather, and may have nail deformities and reduced range of motion.

When replantation does not occur after a partial amputation, the most must be made of the digit that remains. If bone is protruding from the wound, it will have to be trimmed back with a rongeur until there is sufficient skin to close over the wound (to minimize tension on the tissues) or a skin graft will have to be applied (Marble, 1960). Fassler (1996) remarks that there is rarely sufficient tissue to surgically close such wounds, and when it is attempted, a painful digital tip or death of the tissue may result. If bone, tendon, or a joint is exposed, then one of several varieties of local skin flap will be required to cover the area, some of which can preserve sensation and length of the digit (Burke, 1984). Split-thickness skin grafts are used to promote rapid healing of digital tip amputations (Doyle, 2006). When full-thickness skin grafting is required, as in larger wounds or distal tip amputations, the loss of digital pulp is likely to result in a loss of sensory function and sensitivity to the cold. Exposed nerves will need to be resected (surgically lacerated) about 1 cm back from the wound; if this is not done, the normal healing process of the nerve will cause innervation of the scar tissue, which can be chronically painful (Marble, 1960; Doyle, 2006).

Table saw blade-contact injuries often produce amputations of the tip of the distal phalanx. Such injuries can be divided into three types. In the first, the amputation is oblique and there is greater length preserved across the volar surface than the dorsal surface. This type of amputation is the most straightforward to treat. After shortening of the exposed bone, the wound can be closed by suturing the volar skin to the nail plate. In the second type, the damage is the opposite of the first type – the volar surface is more extensively damaged than the dorsal surface; consequently, this is the most severe type. To close this wound, almost all of the length of the segment will have to be sacrificed or a flap from the palm will have to be utilized. The third type is an amputation that is relatively straight across – perpendicular to the length of the digit – causing an equal amount of tissue loss on the volar and dorsal surfaces. This is a more complicated wound than the first type, but is not as severe as the second type. If the surface area is greater than 1 cm squared, then a full thickness skin graft will likely be required. Alternatively, the bone can be shortened and the wound closed by primary intention, but this will result in a shorter digit; Burke (1984) states that this is one of the most common procedures performed.

The one exception to the severe nature of amputation injuries is an amputation that results in the loss of only the distal portion of the distal phalanx (*i.e.*, most similar to the third type mentioned in the previous paragraph). Although it may appear to be a devastating wound, if there is minimal tissue loss and no exposed bone, after cleaning and bandaging, the injury may be left to heal spontaneously (heal by secondary intention); such treatment is often reserved for those wounds that are no larger than 1 cm squared (Burke, 1984; Rayan and Akelman, 2011). Remarkably, when fully healed, such injuries often achieve their previous appearance and level of sensitivity.

An amputation injury can have a profound effect on one's life, affecting not only their physiologic state, but their mental state as well. The loss or disfigurement that results can produce feelings of helplessness and may leave the individual feeling incomplete. Some will proceed through the various stages of grieving as they try to cope with their loss. Others may be affected for some period of time with phantom pain, which is pain that is perceived to originate from the digit or segment of the digit that has been lost.

Having discussed the relevant anatomy and physiology and the ways the tissues of the digits are likely to be injured subsequent to making contact with the blade of an operational table saw, it is now possible to discuss the review team's analysis of the 2017 NEISS table saw blade-contact injuries and the extent to which the reported injuries fell into the above categories, as well as the changes in injury diagnoses that were made.

### 3. Findings of Review Team's Analysis of Table Saw Blade-Contact Injuries Treated in NEISS System Emergency Rooms and Changes Made to Injury Diagnoses

Early on in the review of incidents, it became clear to the review team that, due to the complexity and degree of the injuries that can occur, it was likely a difficult task for the NEISS coders to assign an appropriate diagnosis code for certain table saw blade-contact injuries (the review team faced the same difficulty). In large part, this is because NEISS coders are tasked with coding only one injury diagnosis code for an incident. It is likely that this usually meant adopting the attending physician's primary diagnosis code, which in many cases can be very straightforward (providing that the physician's diagnosis is accurate). However, in other cases, it appears that the diagnosis

code may have been derived by other means, including choosing the injury that may have seemed the worst.

In 55 incidents, the review team concluded that the diagnosis code was entirely incorrect, or inaccurately conveyed the true extent of the injuries received. This easily can be illustrated with a few examples. In an incident where a laceration from the table saw blade caused both a fracture of bone and nerve damage, the coder would have been faced with having to choose from one of three available diagnosis codes: laceration, fracture, or nerve damage. Only one code can be assigned, but, in this case, none would do a particularly good job of conveying the true extent and severity of the injuries. If in another incident, reported injuries from a table saw blade laceration included a fracture and tendon damage, the coder would be forced to disregard the tendon damage and choose from either laceration or fracture, as no diagnosis code exists for tendon damage. Unfortunately, fracture would likely have been chosen, even if the fracture was so inconsequential that no treatment for it was received, yet hours may have been required to repair the severed tendons. Finally, if both tendon damage and injury to the vascular system are reported as a result of a laceration from the table saw blade, the coder has no choice but to default to laceration injury, because there is not a code for either tendon damage or vascular injury. This last example highlights the deficiencies of the present system; such a laceration, which is obviously severe, could end up in the same category with lacerations that are so minor that little or no blood was shed.

Given the limitations of the available NEISS injury diagnosis codes, and the challenges presented by injuries like those discussed above, the review team was forced to deliberate over these issues and formulate a workable solution that would allow for a more comprehensive, accurate, and repeatable way to characterize certain blade-contact injuries. Following a brief general overview of the injuries reported in the 2017 NEISS incidents, the classification system that was ultimately used by the review team will be discussed.

For all 161 of the 2017 completed table saw blade-contact IDIs that were analyzed, the injuries were confined to the digit(s) and/or palm, or forearm, of one arm (*i.e.*, either the left or right). Specifically, 158 incidents involved either injuries to one or more digits (153), or to one or more digits and the palm (5). The remaining three incidents involved injuries that were exclusively to anatomical areas other than the digits; two incidents involved only the palm and one only the forearm. The digits and palms involved in these incidents are illustrated in Figure 1; the one forearm injury (of the right arm) is not illustrated. For both the left and right hand, the thumb and index finger sustained the greatest number of digital injuries and the little finger the least.

Although injuries to the digits can occur anywhere along their length, the placement of the digits on the workpiece and/or the course of movement one takes toward the blade means that the distal portions of the digit are frequently involved. Of those incidents where handedness was known, a slightly greater number of injuries involved the nondominant hand for both left-handed (60 percent) and right-handed (67 percent) individuals (See Table 1).

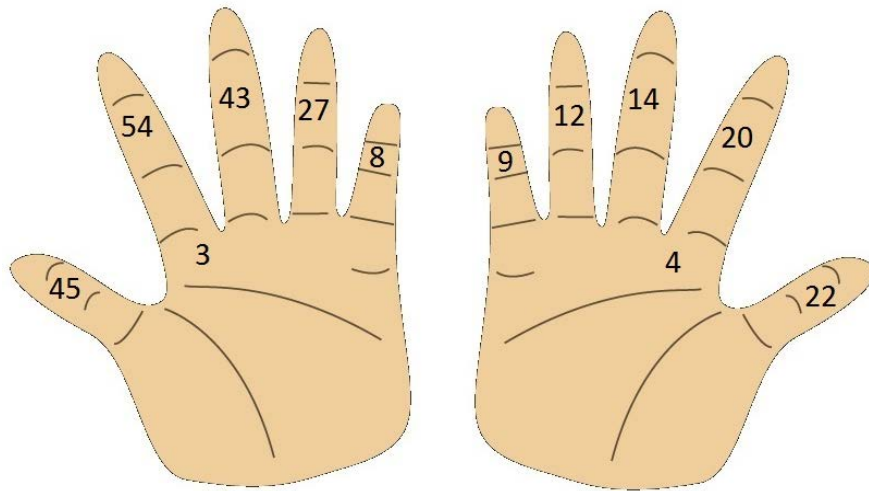


Figure 4. Left and right digits and palms involved in 160 of the 161 2017 NEISS reported table saw blade-contact injuries; one injury, to the right forearm, is not illustrated. Due to multiple injured digits or a combination of injured digit(s) and a palm in many incidents, the total number of injuries depicted greatly exceeds the number of incidents (*i.e.*, 261 injured digits and palms were reported in 160 incidents).

Table 1. Hand dominance vs. side injured

Dominant Hand	Side Injured			Total
	Left	Right	Unknown	
Left	4 (40%)	6 (60%)	0	10
Right	85 (67%)	42 (33%)	0	127
Ambidextrous	9	0	0	9
Unknown	8	2	5	15
Total	106	50	5	161

During its review of the 161 IDIs, the review team determined in just over one third of the incidents (55; 34 percent) that it was necessary to augment the injury diagnosis that was assigned to the incidents by the NEISS coders (See Table 2). This was necessary either because the diagnosis code was determined to be inappropriate or incorrect, or it failed to adequately capture the nature, extent, or severity of the injuries and/or the necessary treatment (see below). Additionally, for 29 of the incidents (18 percent), the team determined that it was necessary to create a new injury diagnosis, severe laceration, to better characterize those laceration injuries that were more severe than simple lacerations, and for which no other injury diagnosis was entirely adequate. Most of the severe lacerations involved injury to one or more of the deeper tissues. In a subset of these



severe lacerations, the wounds appear to have been just shy of an amputation injury; these were often -coded by NEISS coders as amputations.

Table 2. Changes made to injury diagnoses

NEISS Reported Injury Diagnosis (Total)	Review Team Injury Diagnosis					Total
	Laceration	Severe Laceration	Amputation	Fracture	Avulsion	
Laceration (94)	71	19		2	2	94
Fracture (32)	10	6	5	11		32
Amputation (27)	3	3	19	2		27
Avulsion (7)	2				5	7
Nerve Damage (1)		1				1
Total	86	29	24	15	7	161

The justifications for the various changes to the injury diagnosis are as follows:

*1. The NEISS diagnosis code was inappropriate or incorrect*

From the evidence available to the review team, in 15 incidents the NEISS diagnosis code appeared to be in error. In these cases, the diagnosis code was changed for one of three reasons:

- a. In one incident, the correct diagnosis was provided in the NEISS narrative, but the NEISS diagnosis code (mistakenly) provided a different injury diagnosis:

IDI 170921HEP9015 - the NEISS narrative states "...DX FINGERTIP AVULSION"; the NEISS diagnosis code is Laceration; the review team diagnosis is Avulsion, based on the evidence of an avulsion injury.

- b. In seven incidents, the diagnosis code that was used was inappropriate. This occurred most often when a laceration was mischaracterized as a partial amputation (*i.e.*, coded in NEISS as an amputation injury) when it really was a severe laceration or an incomplete amputation, and/or was later surgically amputated.

Example: IDI 170228HEP9012 - the NEISS narrative states "...DX: PARTIAL TRANSPHALANGEAL AMPUTATION, FINGER."; the NEISS diagnosis code is Amputation; the review team diagnosis is Fracture, based on multiple digits having been fractured for which pins were placed, but none actually having been amputated.

Example: IDI 170331HEP9012 - the NEISS narrative states "...DX: AMPUTATION L THUMB."; the NEISS diagnosis code is Amputation; the review team diagnosis is

Severe Laceration, based on evidence that suggests that the severely injured digit was surgically amputated.

- c. In seven incidents, there was no evidence provided by the investigation to suggest that the patient suffered an injury that was consistent with the NEISS diagnosis code.

Example: IDI 170427HEP9005 - the NEISS narrative states "...DX FINGERTIP AMPUTATION..."; the NEISS diagnosis code is Amputation; the review team diagnosis is Laceration, based on the described laceration injuries and the consumer's statement to the investigator that his digit "... was NOT amputated. The injury was only cosmetic."

Example: IDI 170927HEP9011 - the NEISS narrative states "...NAIL AVULSION LEFT 4<sup>TH</sup> FINGER...", the NEISS diagnosis code is Avulsion; the review team diagnosis is Laceration based on the evidence of only laceration injuries, and the absence of any mention by the consumer of the loss of a nail.

## 2. *NEISS diagnosis codes that failed to capture the complete extent or severity of the injuries*

In 40 cases, the evidence available to the review team suggested that a different diagnosis code would better capture the injuries that were received. In these cases, the diagnosis code was changed for one of two reasons:

- a. In 34 incidents, the evidence available to the review team suggested that a more severe diagnosis would more accurately characterize the injuries and/or a different diagnosis would more accurately characterize the complexity/cost of the necessary treatment.

Example: IDI 170202HEP9002 - the NEISS narrative states "...DX:..(R) HAND WITH FLEXOR TENDON & DIGITAL NERVE DAMAGE."; the NEISS diagnosis code is Nerve Damage; the review team diagnosis is Severe Laceration, which captures not only the nerve damage, but injuries to the flexor tendons, and nail plate (and presumably also the blood vessels) that were treated with reconstructive surgery.

Example: IDI 170223HEP9008 - the NEISS narrative states "...DX: L THIRD FINGER OPEN FX."; the NEISS diagnosis code is Fracture; the review team diagnosis is Severe Laceration, which better characterizes the scope and severity of injuries, which included not only injury of the bone, but injuries to the nail bed and tendons that required surgery and two nights in the hospital.

Example: IDI 170630HEP9006 - the NEISS narrative states "...FRACTURED FINGER..."; the NEISS diagnosis code is Fracture; the review team diagnosis is Amputation, based on evidence of the existence of an amputation (an injury that likely included a fracture of bone).

Example: IDI 171108HEP9003 - the NEISS narrative states "...DX TENDON LAC OF R HAND WITH OPEN FX"; the NEISS diagnosis code is Laceration; the review team diagnosis is Severe Laceration, which better characterizes the scope and severity

of injuries, which included multiple fractures, laceration of tendons, and the need to place multiple pins to reset bones.

- b. In six incidents, the evidence available to the review team suggested that either a less severe diagnosis would more accurately characterize the injuries and/or a different diagnosis would more accurately characterize the complexity/cost of the necessary treatment.

Example: IDI 170921HEP9006 - the NEISS narrative states “DX; OPEN FX...”; the NEISS diagnosis code is Fracture; the review team diagnosis is Laceration, which better characterizes the scope and severity of injuries, the treatment of which included only stitches and bandaging, suggesting that the fracture was likely insignificant and did not require any treatment to reset the bone.

The above changes resulted in the team avoiding usage of only one injury diagnosis code, Nerve Damage, and adding another, Severe Laceration. Although the same number of injury diagnosis codes was used by the NEISS coders and the review team, those used by the latter allowed a much improved system for classifying the injuries.

For the most part, the injuries that were coded as Lacerations by the review team consisted of those injuries that were simple lacerations; lacerations that did not affect deeper tissues. An exception was for a subset of lacerations that also had open fractures that did not require any treatment; such relatively insignificant fractures likely involved only the tuft of the terminal phalanx and it is appropriate that they not be included with fractures requiring specialized reduction treatment to reset the bone.

The addition of the Severe Laceration diagnosis allowed for a more accurate characterization of those complex lacerations that affected one or more deeper tissues, including the digital nerves and arteries, tendons, ligaments, and bone, and for which hospitalization and specialized treatment was necessary, including microsurgical procedures, skin grafting, bone resetting, and other surgeries. Use of this diagnosis alleviated the problem of there being no diagnosis code for some injuries, including those to the vascular system, tendons, and ligaments. Some of the injuries that were assigned the diagnosis of Severe Laceration were just short of being amputation injuries, and some were so severe that, out of necessity, were surgically amputated by the physician who treated the injuries.

Without the Severe Laceration diagnosis, a laceration that almost penetrated all the way through the digit would have been relegated to either a laceration injury diagnosis or (usually) to a code that only partially characterized the injuries (*e.g.*, fracture); in such cases as the latter, although the bone may be fractured, tendons cut, vascular system lacerated cleanly through, and nerve bundle severed, it would have been characterized as only a fracture. This is misleading, as the treatment and prognosis associated with an injury of this severity is dramatically different than a less severe injury, such as a minor laceration with a tuft fracture; both may be coded as a fracture, but the former may require hospitalization, surgical repair of nerves, blood vessels and tendons, and setting of bones, whereas the latter may require only cleaning of the wound and bandaging. The

ability to classify it as a Severe Laceration is far more accurate and conveys the understanding that one or more deeper tissues were likely to have been injured.

The Amputation diagnosis was reserved for only those injuries where the laceration resulted in the complete transection of the digit, with separation of a part from the whole. In the present analysis, all the amputations were partial amputations in that no digit in its entirety was amputated; instead, only a portion of the digit was amputated. Incomplete amputations (*i.e.*, those injuries where the digit was not completely transected) were not considered amputations, and were, more appropriately, categorized as Severe Lacerations. An exception to the use of this diagnosis code was those amputations of the very tip of a digit, an injury that may heal spontaneously and require no medical treatment beyond cleaning and bandaging of the wound — these injuries were classified as laceration injuries.

Fracture as a diagnosis code is entirely appropriate and was used by the review team, even though the bone is a deeper tissue. This is because fractures can occur in the absence of laceration injuries to other deeper tissues. Use of this diagnosis code was limited to those fractures that were not attended by injuries to other deeper tissues and were of significant severity that fusion of bone, placement of pins, and/or other resetting procedures were required as part of the treatment.

The Avulsion diagnosis code was reserved for those incidents where the action of the blade appeared to forcefully rip away a tissue or tissues from the digit. This is particularly appropriate for when large sections of skin are avulsed, the nail plate is avulsed, and when the blade, via a trenching action, removes a large volume of soft tissue.

Finally, it is important to at least touch on the additional complexity in the diagnostic picture that occurs when multiple digits have been injured, as quite often not all of the digits may demonstrate the same injury pattern. The review team applied similar logic in the assignment of an injury diagnosis to these cases. For example, one or more digits may receive minor lacerations, whereas, another may suffer an amputation at the distal interphalangeal joint. In this case, amputation may be entirely appropriate as an injury diagnosis code. However, in another case, several digits may suffer complex laceration injuries, whereas another may suffer a partial amputation very close to the tip of the digit that requires no complex treatments. In this case, it is the severe laceration injuries of the other digits that better captures the type and extent of the injuries received, the need for hospitalization, and the complex and specialized surgeries and associated expense that are necessary to treat these most serious injuries. Similarly, there may be multiple digits that have been deeply lacerated, with significant loss of soft tissue, and likely damage to the nerves, and another digit with a fracture of the tuft. In this case, the fracture is of little consequence — no splinting, setting or other orthopedic manipulations take place and the wound is left open to heal on its own; here a diagnosis of severe laceration is more appropriate.

## CONCLUSION:

In this memorandum, HS staff has provided a discussion of the anatomy and physiology of the digits of the human hand and the degree to which they may be injured subsequent to contact with a rotating table saw blade. Brief contact with the rapidly rotating saw blade of a table saw can inflict wounds that range from a minor laceration of the epidermis to the far more complicated amputation of a digit. Between these two extremes, the classification of injury type is more complicated. In its analysis of the 2017 NEISS incidents involving table saw blade-contact injuries, the review team was able to add clarity by the creation of a new diagnosis code, Severe Laceration, and by following logical criteria for the use of the other injury diagnosis codes of Laceration, Amputation, Fracture, and Avulsion, was able to classify all injuries in a comprehensive, accurate, and repeatable manner.

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# Tab C





UNITED STATES  
CONSUMER PRODUCT SAFETY COMMISSION  
4330 EAST WEST HIGHWAY  
BETHESDA, MD 20814

Memorandum

Date: November 13, 2018

TO : Caroleene Paul, Table Saw Project Manager  
Division of Mechanical and Combustion Engineering  
Directorate for Engineering Sciences

THROUGH : Gregory B. Rodgers, Ph.D., Associate Executive Director,  
Directorate for Economic Analysis

Robert Franklin, Senior Staff Coordinator,  
Directorate for Economic Analysis

FROM : Mark Bailey, Directorate for Economic Analysis

SUBJECT : Table Saw Population Estimates for 2017

## Background

The Directorate for Epidemiology conducted a special study of table saw blade-contact injuries treated in U.S. hospital emergency departments (ED) during 2017 (Garland and Tu, 2018). The special study was conducted in support of ongoing rulemaking activities to develop a mandatory standard to reduce blade-contact injuries and included IDIs of the table-saw injuries that involved contact with the blade.

The purpose of this memorandum is to estimate the number of table saws in use in 2017,<sup>52</sup> and the proportion of table saws in use that were equipped with the modular blade guards (MBG) required under the 7<sup>th</sup> edition of UL 987.<sup>53</sup> These estimates can then be compared to the results of the 2017 special study of blade contact injuries to determine table saw injury rates and evaluate the impact of MBGs on the risk of blade-contact injury.

This memorandum presents an overview of the methodology used to make the estimates, and describes the results. Additionally, an appendix presents an analysis evaluating the sensitivity of the risk of injury findings developed by the Directorate for Epidemiology to possible variations in the estimated proportion of table saws equipped with the MBG systems.

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<sup>52</sup> The estimate of the number of table saws in use represents the number available for use; it does not represent a measure of frequency of use.

<sup>53</sup> The 7<sup>th</sup> edition of UL 987 was published in 2007. The effective date for the MBG requirements was January 2010, though some producers equipped their saws with the MBGs as early as 2007.

## Data Sources

### Sales/Shipments

Aggregate annual table saw sales from 2002 through 2012 were provided by the Power Tool Institute (PTI).<sup>54,55</sup> Annual sales for 2013 through 2017 were from a table saw market research report published by Global Info Research (2018). (See Table 1). Global Info Research also provided estimates for bench, contractor, cabinet, sliding, and other saws for the 2013 to 2017 time period, as shown in Table 1. In the absence of any information on market shares by saw type prior to 2013, we assumed the proportional distribution of table saws *by type* prior to 2013 was equal to the 5-year average for the 2013-2017 time period. Based on the Global Info Research data, the 5-year average for bench, contractor, cabinet, sliding, and other saws accounted for 79 percent, 10 percent, 6 percent, 3 percent, and 2 percent of sales respectively. Table saw sales, by type, are shown in Table 1. For purposes of this analysis, and consistent with procedures used in the preliminary regulatory analysis for the table saw notice of proposed rulemaking (NPR) (Zamula, Rodgers, and Bailey, 2016), we combined sliding saws with cabinet saws and the saws categorized as “other” (which were probably hybrid saws) with contractor saws.

Year	Total	Bench Saws	Contractor Saws	Cabinet Saws	Sliding	Others
2002	725	573	73	44	22	15
2003	750	593	75	45	23	15
2004	775	612	78	47	23	16
2005	800	632	80	48	24	16
2006	825	652	83	50	25	17
2007	825	652	83	50	25	17
2008	650	514	65	39	20	13
2009	589	465	59	35	18	12
2010	429	339	43	26	13	9
2011	600	474	60	36	18	12
2012	625	494	63	38	19	13
2013	609	477	65	37	17	13
2014	625	494	63	37	18	13
2015	646	514	65	36	18	13
2016	625	496	63	36	17	13
2017	651	517	65	38	17	14

Source: Power Tool Institute, Global Info Research

<sup>54</sup> PTI annual estimates were reported on the PTI website or provided to the U.S. Consumer Product Safety Commission (CPSC) by means of personal communication with staff. For the years 2006 and 2007 PTI provided a range for the sales estimate rather than an exact number. We used a simple mean of that range for these two years. This data was used in the regulatory analysis contained in the CPSC’s 2017 notice of proposed rulemaking (NPR). See Table 4 Tab C of Commission Briefing package “Proposed Rule: Safety Standard Addressing Blade-Contact Injuries on Table Saws.”

<sup>55</sup> PTI provided total estimated sales for all table saws; PTI did not provide estimates by table saw type.

## **Expected Product Life by Saw Type**

The preliminary regulatory analysis for the 2017 NPR used an expected product life of 10 years for bench saws, 17 years for contractor saws (including hybrids), and 24 years for cabinet saws (including sliding). These estimates were based on information provided by PTI in a meeting with Commissioner Adler on March 2, 2011. However, in PTI's comment on the NPR, PTI asserted that bench saws have an average expected product life of about 7.5 years, rather than 10 years. Consequently, in estimating the population of table saws available for use, we used a 7.5 year expected product life for bench saws, as submitted by PTI in its formal comment on the proposed rule.

### **Sales of Saws Equipped with MBGs**

PTI also provided sales estimates on the number of table saws equipped with the modular blade guard systems required under the 7<sup>th</sup> edition of UL 987. These estimates were published by PTI on their webpage *PTI Facts at a Glance*, which is updated regularly. PTI estimated that:

- “Since 2007 [through 2010], PTI members have introduced over 800,000 saws with the newly designed guards which meet the requirements of UL 987 safety standard.”(PTI, 2011);
- “From 2007 through the end of 2014, PTI members have introduced over 2.6 million saws with the newly designed guards which meet the requirements of the newly revised UL 987 safety standard” (PTI, 2016); and finally,
- “From 2007 through the end of 2017, PTI members have introduced over 4.3 million saws in the U.S. with the newly designed modular guarding systems, including a riving knife, which meet the relevant requirements of the 7<sup>th</sup> and 8<sup>th</sup> editions of UL 987 and UL 62841-3-1 safety standards” (PTI, 2018).

Based on (1) PTI estimates of saws equipped with MBGs, (2) the sales estimates presented in Table 1, (3) the PTI estimate that their members account for approximately 80 percent of the sales of all table saws in the U.S. (PTI, 2012), and (4) the assumption that non-PTI members equipped their saws at roughly the same rate as PTI members, we project that saws equipped with the MBG systems accounted for about 30 percent of sales from 2007 through 2010, 90 percent of the saws sold from 2011 through 2014, and 100 percent of the saws sold from 2015 through 2017.

## **Methodology and Results**

### **Estimating the Table Saw Population in Use for 2017**

The annual number of table saws in use was estimated with the CPSC's Product Population Model (PPM), a statistical model that projects the number of products in use given estimates of annual product sales and information on product failure rates over time (Gordon and Lahr, 1980). For this analysis, we estimated the population of each type of table saw in 2017, based on the annual sales for each type (Table 1) in combination with information on the

expected product life provided by PTI. The failure rate for each type of saw was assumed to follow a gamma distribution (with a shape parameter of 3), which is a commonly used distribution for modeling product failure rates. Totals for 2017 were then aggregated as the summation of the estimated population for each saw type. Based on this analysis, there were an estimated 6.86 million table saws in use in 2017.

### **Estimating the Population of Saws in Use Equipped with the MBG system in 2017**

The annual number of table saws in use equipped with the MBG system was estimated using the share of saw sales estimated for the years 2007 through 2017 and determining what proportion of the saws equipped with MBGs remained in use in 2017. Based on this analysis, we estimate that 3.94 million, or 57.4 percent, of the table saws in use in 2017 were equipped with MBGs.

Attachment: Sensitivity Analysis

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## Appendix: Sensitivity of relative risk estimates to variations in exposure estimates

Using information from the 2017 special study of table saw blade-contact injuries treated in U.S. hospital emergency departments (Garland and Tu, 2018), in combination with estimates of the number of table saws in use and estimates of the proportion of table saws in use that were equipped with the modular blade guards (MBG required by the 7<sup>th</sup> edition of UL 987, the Directorate for Epidemiology estimated about 6,075 ED injuries per million table saws equipped with a traditional (pre-modular) blade guard system, compared to about 819 ED injuries per million table saws equipped with the MBG system. This yielded a relative risk of about 7.4 (*i.e.*, 6,075 injuries per million saws with traditional blade guards ÷ 819 injuries per million saws with MBGs), suggesting that the MBGs may have reduced the blade-contact injury risk by about 86.5 percent (*i.e.*,  $(6,075 - 819) \div 6,075$ ).

This appendix describes the results of an analysis designed to evaluate the sensitivity of the relative risk estimate to variations in the possible distribution of injuries where the presence of an MBG on the original equipment could not be determined, variations in the estimated number of table saws in use, and variations in the estimated proportion of saws in use that were equipped with the MBGs.

The estimate of table saws in use in 2017 and the proportion of those in use that were equipped with the MBGs required under the 7<sup>th</sup> edition of UL 987 (described in the body of this memorandum), were based on:

- annual total table saw sales estimates provided by PTI for 2002 through 2012;
- annual total sales estimates from Global Info Research (2018) for 2013 through 2017;
- table saw sales, by type, from Global Info Research (2018) for 2013 through 2017;
- an assumption that the percentage market share of sales by saw type for saws sold prior to 2013 was the same as the average market share during the 2013-2017 time period;
- estimates, based on information provided by PTI, that about 30 percent of table saws sold from 2007 through 2010 were equipped with the MBG systems, 90 percent of table saw sold from 2011 through 2014 were equipped with MBGs, and 100 percent of saws sold from 2015 through 2017 were equipped with MBGs; and
- PTI estimates of the expected average product life of bench, contractor, and cabinet saws, which were 7.5 years, 17 years, and 24 years, respectively.

Based on these estimates, the Directorate for Economic Analysis projected an estimated 6.86 million table saws in use in 2017, with about 57.4 percent equipped with the MBGs.

## First Sensitivity Evaluation

To conduct the initial sensitivity evaluation, we separated the ED injury estimates into three categories: those *not* equipped with MBGs,<sup>56</sup> those equipped *with* MBGs (*i.e.*, those conforming to the voluntary standard's MBG requirements), and those injuries for which it could not be determined whether the saws had been equipped with MBGs (*i.e.*, the "unknowns"). We then evaluated how the distribution of the unknowns could have affected the relative risk estimate, given the estimate of table saws in use and the proportion equipped with MBGs. More specifically, we looked at three alternative assumptions: (a) that the injuries involving blade guards categorized as unknown were distributed proportionally to the knowns; (b) that all of the "unknowns" involved saws not equipped with MBGs, and (c) that all of the "unknowns" involved saws equipped with MBGs. Note that while both alternatives (b) and (c) are unlikely, they nevertheless provide the outer bounds for alternative (a).

The results of this analysis are presented in Part 1 of Table 2, which appears later in this appendix. The base injury rate for our analysis assumed that the unknowns (5,200 ED injuries) were distributed proportionally to the knowns (column 3). This alternative resulted in a relative risk of 7.63 (*i.e.*, 7,707 injuries per million saws not equipped with MBGs ÷ 1,010 injuries per million equipped with MBGs), suggesting that MBGs reduced the risk by 86.9 percent (*i.e.*,  $(7,707 - 1,010) \div 7,707$ ).<sup>57</sup> This relative risk was bounded by a relative risk estimate of 9.82 under the assumption that all of the 5,200 unknowns had no MBGs (column 4) suggesting a risk reduction 89.9 percent, and a relative risk estimate of 2.91 under the assumption that all the unknowns had been equipped with the MBGs (column 5) and suggesting a risk reduction of 65.6 percent.

## Second Sensitivity Evaluation

Because the preliminary regulatory analysis assumed an expected product life of 10 years for bench saws (Zamula, Rodgers, and Bailey, 2016), rather than the 7.5-year estimate currently recommended by PTI,<sup>58</sup> we also conducted a sensitivity analysis based on the 10-year product life assumption to determine how the results would have varied given the assumptions used in the preliminary regulatory analysis contained in the 2017 notice of proposed rulemaking (NPR).

Given this longer hypothesized product life for bench saws, we projected an estimated 8.20 million table saws in use in 2017, with 51.9 percent having been equipped with the MBGs, compared to the 6.86 million and 57.4 percent estimates for the 7.5-year product life assumption. Using these revised estimates with a 10-year bench saw expect life, we again evaluated how the distribution of the injury unknowns could have affected the relative risk estimate, as we did in the first sensitivity evaluation. The results of this second analysis are presented in Part 2 of Table 2. The base injury rate for our sensitivity analysis assumed that the unknowns (5,200 ED

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<sup>56</sup> From Table 16 of Garland and Tu (2018), these included the 102 injury cases involving tables saws determined to have been originally equipped with "traditional" pre-modular blade guards and the single injury case which was categorized as not applicable or none because it was believed to have been too old to have been originally equipped with any blade guard at all, let alone the MBG.

<sup>57</sup> Because the unknowns are distributed proportionally to the knowns in column (3), the relative risks are necessarily identical to those calculated in column (2).

<sup>58</sup> The expected product life for contractor and cabinet saws in the preliminary regulatory analysis were 17 and 24 years, respectively, which were consistent with the current PTI recommendations.

injuries) were distributed proportionally to the knowns (column 3). This alternative resulted in a relative risk of 6.11, suggesting that the MBG system would have reduced the injury risk by about 83.6 percent. This relative risk was bounded by a relative risk estimate of 7.87, suggesting a risk reduction 87.3 percent (column 4), and a relative risk estimate of 2.33, suggesting a risk reduction of 57.1 percent (column 5).

### Third Sensitivity Evaluation

In 2007, UL published the seventh edition of UL 987, which expanded the table saw blade guard requirements to include the MBG design developed by the joint venture of the leading table saw manufacturers. The effective date for the MBG requirements was January 2010. As described above, PTI estimated that about 30 percent of table saws sold during 2007 through 2010 were equipped with the MBG. Because three of these four years were prior to the January 2010 effective date, we evaluated the impact of an assumption that no table saws during the entire 2007 through 2010 time period were equipped with the MBGs, contrary to PTI estimates.

These results are presented in Part 3 of Table 2. We again evaluated how the distribution of the injury unknowns could have affected the relative risk estimate, as we did in the first and second sensitivity evaluations. The base injury rate for this sensitivity analysis assumed that the unknowns (5,200 ED injuries) were distributed proportionally to the knowns (column 3). This alternative resulted in a relative risk 6.29, suggesting that the MBG system would have reduced the injury risk by about 84.1 percent. This relative risk was bounded by a relative risk estimate of 8.10, suggesting a risk reduction 87.7 percent (column 4), and a relative risk estimate of 2.40, suggesting a risk reduction of 58.3 percent (column 5).

### Fourth Sensitivity Evaluation

We conducted a fourth sensitivity evaluation based on relative risks derived from the approximate 95 percent confidence interval (CI) for injury rates presented by the Directorate for Epidemiology. Based on Garland and Tu (2018), an approximate 95 percent CI for table saws not equipped with the MGS ranged from 5,753 to 6,399 injuries per million, and the approximate 95 percent CI for table saws with modular blades ranged from 748 to 890 injuries per million. Using these estimates, relative risks could have ranged from 8.55 ( $6,399 \div 748$ ) to 6.46 ( $5,753 \div 890$ ). These two relative risks suggest an injury rate reduction associated with the MBG of 88.3 percent and 84.5 percent, respectively.

### Fifth Sensitivity Evaluation

By basing estimates of relative risk on the numbers of saws in use, the analyses above implicitly assumed that table saw usage was proportional to the numbers of table saws in use, and that the average usage time per table saw for those equipped with MBGs was about the same as for saws not equipped with MBGs. However, if the average usage time for saws *not* equipped with the MBGs were greater than the average usage time for saws equipped with MBGs, then the relative risk associated with the saws not equipped with the MBGs would have been overestimated. While we have no empirical basis for assuming that the average usage time per table saw for those equipped with MBGs was about the same as for saws not equipped with MBGs, we conducted a sensitivity evaluation to determine how sensitive our results would have



been to such an assumption. If saws not equipped with MBGs were, on average, used twice as much as those with MBGs, then relative risks could be approximated in Part 1 by doubling the estimate of table saws in use from 2.92 million to 5.84 million. The estimate of relative risk from part 1, column 3, would therefore decrease from 7.63 to 3.82 (*i.e.*,  $[22,519 \text{ injuries} \div (2 \times 2.92 \text{ million table saws in use})] \div 1,010 \text{ injuries/million saws}$ ), suggesting a risk reduction of about 73.8 percent relative to the risk on saws with MBGs.<sup>59,60</sup> Similarly, this risk reduction would be bounded by a relative risk of 4.91 (part 1, column 4), suggesting a risk reduction of about 79.6 percent, to a relative risk of 1.45 (part 1, column 5), suggesting a risk reduction of 31.2 percent.

### Summary of Results

Given the available data, the results of this sensitivity analysis appear to be quite strong with respect to the estimated numbers of table saws in use. The sensitivity analysis suggests that the risk reduction associated with the MBG system is largely driven by the relatively small proportion of injuries (about 15 percent) involving saws equipped with the MBGs, and not the various assumptions applied to obtain estimates of table saws in use. Substantial reductions in the estimate of the proportion of table saws equipped with the MBG system, as required by the current voluntary standard, would be needed to alter the statistically significant difference in the injury risks between non-modular and modular blade guard saws reported in table 12 of Garland and Tu (2018).

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<sup>59</sup> Based on the Part 1, column (3) assumptions, the usage of saws without MBGs would have to increase by a factor of about 7.6 for the risks on saws without MBGs to equal the risk on saws with MBGs (*i.e.*,  $[22,519 \text{ injuries/million saws} \div (7.6 \times 2.92 \text{ table saws in use})] \div 1,010 \text{ injuries/million saws} = 1$ )

<sup>60</sup> It is also possible that table saws equipped with MBGs are used, on average, more than saws not so equipped. However, because this would result in an even greater relative risk on saws without MBG, we have not explicitly included it in this analysis.

Table 2: Estimated Risks and Relative Risks associated with table saws modular blade guard (MBG) systems, 2017

		(1)	(2)		(3)*		(4)		(5)	
		Table Saws in Use (in millions)	Original distribution of ED Injuries	Risk**	Unknowns distributed proportionately ED Injuries	Risk**	Unknowns assumed to involve non-modular BG ED Injuries	Risk**	Unknowns assumed to involve modular BG ED Injuries	Risk**
Part 1	Total Table Saws***	6.86	26,500	3,861						
	Equipped with:									
	No MBG	2.92	18,100	6,195	22,519	7,707	23,300	7,974	18,100	6,195
	MBG	3.94	3,200	812	3,981	1,010	3,200	812	8,400	2,131
	Unknown		5,200	NA						
	Relative Risk			7.63		7.63		9.82		2.91
	Injury Rate Reduction			86.9%		86.9%		89.8%		65.6%
Part 2		Table Saws (in millions)	ED Injuries	Risk**	ED Injuries	Risk**	ED Injuries	Risk**	ED Injuries	Risk**
	Total Tables Saws****	8.20	26,500	3,231						
	Equipped with:									
	No MBG	3.94	18,100	4,591	22,519	5,712	23,300	5,910	18,100	4,591
	MBG	4.26	3,200	751	3,981	934	3,200	751	8,400	1,972
	Relative Risk			6.11		6.11		7.87		2.33
	Injury Rate Reduction			83.6%		83.6%		87.3%		57.1%
Part 3		Table Saws (in millions)	ED Injuries	Risk**	ED Injuries	Risk**	ED Injuries	Risk**	ED Injuries	Risk**
	Total Table Saws*****	6.86	26,500	3,861						
	Equipped with:									
	No MBG	3.25	18,100	5,572	22,519	6,932	23,300	7,173	18,100	5,572
	MBG	3.61	3,200	885	3,981	1,101	3,200	885	8,400	2,324
	Relative Risk			6.29		6.29		8.10		2.40
	Injury Rate Reduction			84.1%		84.1%		87.7%		58.3%

\* Because the unknowns are distributed proportionally to the knowns, the relative risks in column (3) are identical to those calculated in column (2).

\*\*ED Injuries per million table saws in use

\*\*\* Assumes an expected product life of 7.5 years for bench saws, 17 years for contractor saws, and 24 years for cabinet saws

\*\*\*\* Assumes an expected product life of 10 years for bench saws, 17 years for contractor saws, and 24 years for cabinet saws

\*\*\*\*\* Assumes no table saws were equipped with MGBs during 2007-2010

