Surveillance of Amputations among Washington State workers, 2016-2021

Technical Report of Expanded Surveillance System Methods and Results

Danièle Todorov, MS

Sara Wuellner, PhD MPH

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SHARP
Safety & Health Assessment & Research for Prevention

Washington State Department of Labor & Industries

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DEFINITIONS

DOSH	WA Dept. of Labor & Industries Division of Occupational Safety & Health
FTE	Full Time Equivalent employees
KOS	Kept on Salary
L&I	Washington State Department of Labor and Industries
NAICS	North American Industry Classification System
OIICS	Occupational Injury and Illness Classification System
OSHA	Occupational Safety and Health Administration
SF	Washington Industrial Insurance State Fund
SHARP	Safety and Health Assessment and Research for Prevention
SI	Self-Insured
WC	Workers' Compensation

KEYWORDS

SHARP; amputations; surveillance; Washington workers compensation;

EXECUTIVE SUMMARY

Amputations are a serious workplace injury that continue to happen in Washington workplaces. Public health surveillance provides data necessary to inform policies and programs designed to prevent work-related amputations. Data sources typically used for occupational injury surveillance, like the Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses, often provide limited information on specific injuries. Workers' compensation claims data offer a more extensive understanding of work-related amputations than most other data sources for three reasons. First, the data are independent of employer reporting, as claims are initiated by injured workers. Second, transactional administrative data allow for the capture of amputations that occur not at the time of injury but days, weeks, or months after, as part of medical care. Third, incident, injury, worker, and employer characteristics captured in workers' compensation data exceed the detail available in most other data sources.

This technical report describes a surveillance system for work-related amputations using Washington State workers compensation data, and summarizes the worker, injury, and employer characteristics of amputations occurring between 2016 and 2021. These data can augment employer-reported data to better target, develop, and evaluate effective prevention efforts.

Key Findings:

- Among all accepted claims with injury dates between 2016 and 2021, we identified 3,069 amputation cases (0.4% of all claims).
- 95% of amputations were to parts of the upper body. Finger and fingertip amputations in particular made up 78% of all amputations. Amputations of parts of the lower body and head (ears, nose, or decapitation) made up a total of 5% of amputations.
- Between 2016 and 2021, there were 19 amputations per 100,000 full-time equivalents (FTE). The industry sectors with the highest rate of amputations were Construction, Agriculture/Forestry/Fishing and Hunting, Manufacturing, and Accommodation/Food Services.
- A third of amputations were caused by machinery, and a fifth of amputations were caused by hand tools such as knives and saws.

INTRODUCTION

Workers continue to be at risk of work-related amputations. Between 2011 and 2020, an average of 5,220 work-related amputations occurred among private industry employers in the US each year, with 2019 experiencing the second-highest number of cases during the ten-year span with an estimated 6,020 amputations [1].

For Washington State, the results of the Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses suggests little change in the annual rate of amputations over the past decade [2].The BLS statistics are based upon private and public employer reports of non-fatal injuries. Previous research using Washington workers' compensation claims data from 1997 to 2005 identified a total of 6,440 amputations (using ANSI and ICD-9 codes) [3].

Workplace injuries that result in amputations are preventable, and OSHA has prioritized these injuries through two programs. OSHA's National Emphasis Program on amputations, initiated in 2002 and last updated in 2019, directs the agency's workplace inspection resources toward amputation hazards [4, 5]. As of 2015, OSHA's severe injury reporting requirement mandates that employers report to OSHA amputations within 24 hours of the injury, providing the agency with additional information to facilitate targeting worksite inspections [6].

Employer-reported data, the basis for both the BLS estimates of work-related injuries and the OSHA data on severe injuries reported by employers, are generally considered an incomplete assessment of work-related injuries [7], both because employers report only a portion of required cases [8], and because injuries tend to be characterized based on limited information available at the time of injury [9]. Other data sources, namely workers' compensation claims data can contribute to a better understanding the epidemiology of work-related amputations. In addition to being independent of employer reporting (in Washington, claims are initiated by an injured worker and the health care provider), workers' compensation claim data can be used to identify injuries where the limb is amputated at some time after the initial injury, as part of the medical care. This allows us to capture cases that do not present as amputations at the time of injury, but indeed involve the loss of a limb as the result of a work-related injury.

The aim of this study is to characterize work-related amputations in Washington that occurred between 2016 and 2021, using workers' compensation data to summarize worker, injury, and employer characteristics. These data can augment employer-reported data to better target, develop, and evaluate effective prevention efforts.

METHODS

Data Source

We used administrative data generated by the Washington State workers compensation system. In Washington State, nearly all nonfederal employers are required to obtain workers' compensation insurance through the Department of Labor and Industries (L&I), unless they meet specific requirements to self-insure or are covered under an alternative workers' compensation program. L&I's State Fund insurance program provides coverage for approximately 2.6 million (about 74%) of the workers in the state and 99.7% of all employers. L&I administers the state funded program and oversees the self-insured program. Because self-insured employers are only required to report to L&I select claim information, the data available for self-insured claims is limited compared to the data available for State Fund claims. Data from both the State Fund insurance program and the Self-Insurance program are entered into L&I's Industrial Insurance Data Warehouse.

The sole data source for the analyses in this report is L&I administrative data on the worker, employer, and claim process. We did not systematically review all amputation cases to garner more details from the medical records due to limited staff resources.

We calculated rates of amputation injuries by year, industry following the North American Industrial Classification System (NAICS), and industry following the L&I risk classifications. The denominator was calculated using the employers' quarterly reports of payroll hours. We defined one full time equivalent (FTE) as 2,000 hours worked.

The amputated body part was determined using information from ICD-9/10 codes, OIICS codes, and disability ratings. We systematized the body part descriptions across these three systems, so that each code was classified into an area (upper body, lower body, other amputation), a subarea (ex. lower arm), and part (ex. wrist or finger). We used the source that head the most complete information; i.e. could be coded down to the part level. Some ICD-9/10 codes such as "997* Complications of amputation stump" or OIICS body part "310 Arm(s), unspecified" could be coded as upper body or lower body. We used whichever source had the greatest level of specificity in the amputated body part for that claim. Ties are broken in the next steps.

A worker can have multiple amputated body parts from a single injury event, demonstrated by multiple ICD-9/10 codes, and an amputation injury can increase in level over time. For example, the injury starts with the loss of a finger and results in the amputation of the entire hand. We decided to report the highest level amputated per extremity (arm, leg, or head), regardless of body side. Ex. a worker who loses a toe on the right foot and the entire left foot will be reported solely as a foot amputation. We did not find any true amputation injuries of both upper and lower extremity body parts.

Case Capture Criteria

In December 2022, we searched for amputation claims among all accepted State Fund and self-insured claims with injury dates between January 1st, 2016 and December 31st, 2021. Any claims meeting one or more of the case capture criteria described below (keywords, OIICS codes, or ICD-9/10 codes) were classified as an amputation case.

The text on claim initiation forms describing the injury and the treatment plan were searched for amputation keywords (Appendix A). These forms are submitted by the worker, health care provider, or employer. The amputation keyword had to occur in a context where it was clearly not used as a unit of measurement ("50 amp"), as a descriptor of a third party to the injury ("back injury while assisting amputated patient"), or as the surgical procedure during which the medical care provider was injured. These false-positives were common without the extensive context requirements.

The ICD-9-CM and ICD-10-CM codes for amputations (Appendix A) are identified in the injured worker's medical and hospital bills, and from the allowed diagnoses assigned in the claim adjudication process. Bills that were rejected or unpaid for by L&I were included in this search. We encountered problems with the quality of ICD-9/10 coding. Muscle strain injuries were sometimes miscoded as amputations, as the codes have a one digit separation. To counteract this, we dropped claims captured solely through ICD-9/10 codes (no keywords or OIICS codes related to amputation) and who had a single ICD-9/10 code for amputation entered on a single bill (N = 313).

The last case capture criteria, OIICS codes, are assigned by L&I staff to characterize the injury by nature, source, and body part. We use OIICS nature codes "0311-Amputations, Fingertip" and "0319-Amputations, Except Fingertip". We did not rely solely upon OIICS nature codes because there tends to be a delay in claim coding, especially among self-insured claims, and complex injuries involving amputations may be coded as a different, more severe injury.

Development of Case Capture Criteria

The case capture criteria used in this surveillance system were derived in part from previous work done at SHARP, with several large updates [3]. Since 2010 when the previous report was published, Washington's workers compensation system has transitioned over to ICD-10 coding and ceased using the ANSI injury coding system. Additionally, we wanted to improve the speed of case-capture for future real-time communication of amputation cases with OSHA. Standardized injury coding systems such as ANSI and OIICS are very efficient at capturing amputation cases but they are assigned several months to a year after the claim is established.

We found the notes entered in by the claims managers to be a useful guide in this process. The claim managers often record details on upcoming surgical procedures and disability ratings. We queried these for amputation keywords as well, and used those results as additional proof that the captured case was an amputation. It proved instrumental for testing the efficacy of our methods for lower limb

amputations, which tend to be less well characterized by the OIICS nature codes. As our methods were refined, this data source ceased to be as necessary.

As we developed these new methods, we reviewed the medical records for subsets of claims to determine the efficacy of our methods. This process was incremental and targeted cases captured by more ambiguous criteria. A total of 325 potential amputation claims were reviewed, 74% of which were not true amputations. The following is a summary of some of the methods that were tested through this process and ultimately dropped due to excessive false-positives:

- ICD-9/10 codes for open wounds or lacerations (873, 878, S11.82, S01) were found to be rarely used and never true amputations when used in isolation. The same occurred for ICD-9/10 codes for late effect of traumatic amputation (905.9, Y83).
- ICD-9/10 or OIICS codes for the primary cause of a later amputation – ex. gangrene, frostbite, or chronic skin ulcers.
- Keywords for cuts and lacerations in combination with mentions of power tools or other common sources of injury. This was to capture claims who describe their initial injury but not the amputation that may have followed.

RESULTS

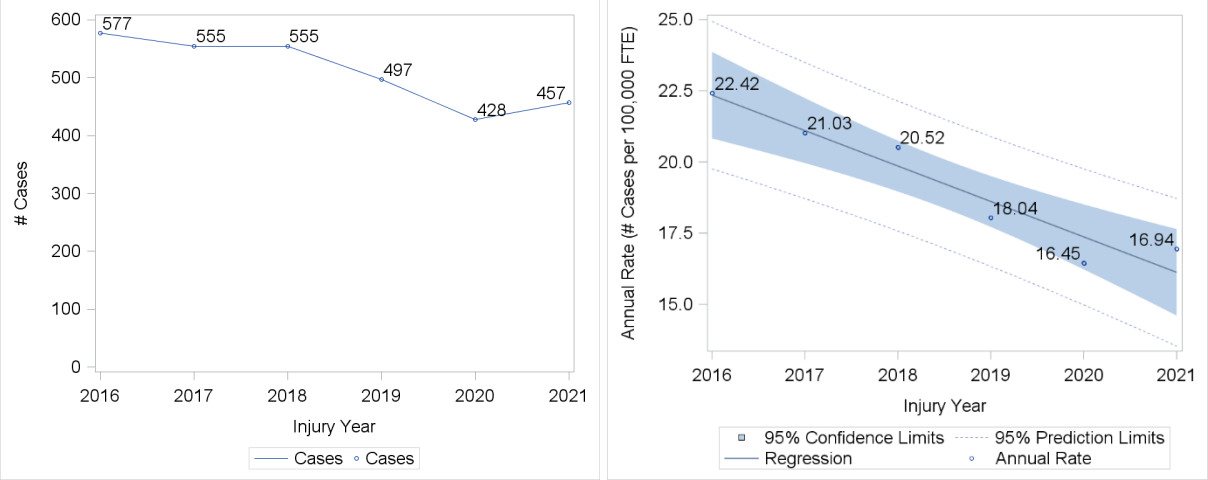
Case Capture

Among the 739,241 accepted State Fund and self-insured claims with injury dates between 2016 and 2021, we identified 3,069 amputation cases (Table 1). The captured claims were overwhelmingly from the State Fund (97%), due to the inclusion of medical billing data and greater number of ROA text fields available for these claims. The number of claims per injury year has decreased steadily, with a net change of -22% between 2016 and 2021 (Figure 1).

Table 1. Number of captured amputation cases by injury year and claim liability

Injury Year	State Fund	Self-Insured	Total
2016	563	14	577
2017	531	24	555
2018	538	17	555
2019	470	27	497
2020	417	11	428
2021	444	13	457
Total	**2,963**	**106**	**3,069**

Figure 1. Number of amputation cases and amputation rate by injury year



Among the 3,069 captured cases, 89% have an amputation ICD code, 69% have amputation keywords in the ROA text, and 54% have the amputation OIICS nature code (Table 2). As expected, very few self-insured cases had ICD-9/10 codes available, as self-insurers are not required to submit medical billing data to L&I in all cases.

Table 2. Case-capture criteria used to identify amputation cases by claim liability

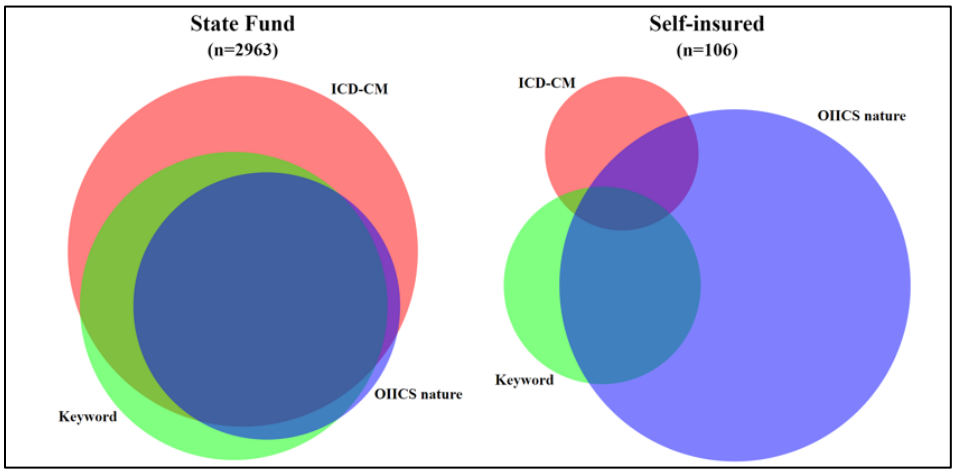
Case capture criteria	State Funded	Self-insured	Total
ICD-9/10 Codes	2,704 (91%)	17 (16%)	2,721 (89%)
Keyword	2,102 (71%)	28 (26%)	2,130 (69%)
OIICS Nature Code	1,574 (53%)	89 (84%)	1,663 (54%)
Total	**2,963 (100%)**	**106 (100%)**	**3,069 (100%)**

Claims were captured using a single case-capture criteria 36% of the time. Overall, 28% of claims were captured using exclusively ICD codes; 6% were captured using exclusively keywords; and only 2% were captured using exclusively OIICS codes (Table 3, Figure 2). However, among self-insured claims, a greater percentage were captured exclusively through OIICS (61%).

Table 3. Co-occurrence of case capture criteria used to identify amputation cases by claim liability

Co-occurrence of case capture criteria	State Funded	Self-insured	Total
ICD-9/10 codes	812 (27%)	9 (8%)	821 (27%)
ICD-9/10 codes and Keywords	399 (13%)	0 (0%)	399 (13%)
ICD-9/10 codes, Keywords, and OIICS	1457 (49%)	3 (3%)	1460 (48%)
ICD-9/10 codes and OIICS	36 (1%)	5 (5%)	41 (1%)
Keywords	178 (6%)	8 (8%)	186 (6%)
Keywords and OIICS	68 (2%)	17 (16%)	85 (3%)
OIICS	13 (0%)	64 (60%)	77 (3%)
Total	**2,963 (100%)**	**106 (100%)**	**3069 (100%)**

Figure 2. Venn diagram of co-occurrence of case capture criteria by claim liability group



The most common ICD code was S68* Traumatic amputation of wrist, hand and fingers, which includes fingertips in the ICD-10 version; this code makes up 94% of all claims captured with ICDs (Table 4). For the full list of included sub-codes, see Appendix A.

Table 4. Frequency of ICD-9 and ICD-10 major group codes used to capture amputation cases

ICD-9/10 Major Group, with sub-code exceptions	# Cases (% of total cases with amputation codes)
S68 - Traumatic amputation of wrist, hand and fingers	2,534 (94%)
S98 - Traumatic amputation of ankle and foot	95 (4%)
S48 - Traumatic amputation of shoulder and upper arm	55 (2%)
S88 - Traumatic amputation of lower leg	48 (2%)
S58 - Traumatic amputation of elbow and forearm	24 (1%)
S78 - Traumatic amputation of hip and thigh	18 (1%)
T87 - Complications of amputation stump	17 (1%)
886 - Finger amputation	6 (<1%)
885 - Thumb amputation	6 (<1%)
887 - Hand/arm amputation	2 (<1%)
997 - Complications of amputation stump	1 (<1%)
895 - Toe amputation	1 (<1%)
897 - Leg amputation	1 (<1%)
997 - Amputation stump complication	0 (0%)
896 - Foot amputation	0 (0%)
V49 - Upper limb amputation status (acquired absence)	0 (0%)
Total claims with amputation ICD-CM code	**2,721 (100%)**

Number of claims with one or more codes by major group. Sum of claims exceeds total because a claim may be associated with more than one major group code

Speed of Case Capture

Our ultimate goal is to develop a real-time surveillance system for amputation cases. The speed at which pieces of information are received by L&I and accessible in the data warehouse is critical for our future system. Claims are established within a median of 3 days from the injury date. Amputation cases in this cohort could have been captured within a median of 7 days from the injury date, and 76% of cases can be captured within 14 days. There is a slight slow-down with claims in 2021 compared to the previous years; the median days between injury and case capture increases to 8 days and 75% of cases can be captured within 14 days.

The earliest source of case-capture data for the amputation case is most often the ICD-9/10 codes; it is the fastest for 77% of claims, with a median of 7 days between the injury date and when the ICD code is available in the data warehouse (Table 5). Keywords are fastest for 19% of cases and take a median of 11 days to be available. The amputation OIICS nature code is the slowest; taking a median of 36 days and is fastest for only 4% of cases. Of these, the OIICS codes were the only variable captured 60% of the time. Self-insured cases take a median of 221 days to be captured (Table 6).

Table 5. Speed of amputation case capture by case capture criteria

Case capture criteria	Median delay between injury date and when the data was accessible (days)	% Claims with <= 14 days delay
ICD-9/10 codes	7	77%
ROA text fields	11	68%
OIICS nature code	36	15%

Table 6. Speed of amputation case capture by claim liability

Claim liability group	Median delay between injury date and when the data was accessible (days)	% Claims with <= 14 days delay
State Fund	7	79%
Self-Insured	221	4%

Claim Characteristics

Compensable claims make up 70% of the cohort. Around 5% (N=166) claims remain open at the time of reporting. Total permanent disability was awarded to less than 1% of cases (N = 14, Table 7) while partial permanent disability was awarded to 50% of cases (N = 1,545; reported under a different variable than claim status). There were two fatalities in the cohort. One was a case of decapitation from a fall into a hay processing machine in 2018. The second was a case in 2020 where the worker's hand was caught in a conveyor belt and was pulled into a machine, resulting in a fatal asphyxiation.

Table 7. Claim status for amputation cases

Claim Status	# Cases	Percent of All Cases
Time loss	1287	42%
Medical-aid only	920	30%
Kept on salary (KOS)	828	27%
Loss of earning power (LEP)	18	1%
Total permanent disability	14	<1%
Fatality	2	<1%
Total	**3,069**	**100%**

Among claims with at least 1 day of paid time loss, the median number of paid days was 61 (range of 1-2,441 days). The claim with the highest number of time loss days (over 6 years) was a complex case of traumatic foot injury complicated by uncontrolled diabetes, resulting in additional amputations of the toe and foot. The median total claim cost was $9,418 (range of $12 – $1,145,489). The median medical expenditure was $5,672. State Fund and self-insured cases have equivalent total claim costs, with a slight difference in the median medical cost ($5,905 SF vs. $3,963 SI).

Claimants in the amputation claims were 86% male; 14% female. The claimant's preferred language was English for 80% of cases, Spanish for 18% of cases, and 2% other languages. The median age at time of injury was 38 years. Injured workers had a median tenure of 1 year at the job of injury (mean of 3.8).

Amputated Body Part

Upper body amputations were 18 times more common than lower body amputations (Table 8). There were only 6 cases of amputations to parts of the head, which includes ears, noses, and decapitation. The rate of upper body amputations is 18 per 100,000 FTE.

Table 8. Area of amputated body part per claim

Amputated Body Part(s)	# Cases	% of Cohort	Amp Cases per 100,000 FTE
Upper extremities	2,907	95%	18.20
Lower extremities	156	5%	0.98
Parts of the head	6	>1%	0.04
Total	**3,069**	**100%**	**19.22**

As show in Table 9, lower extremity amputations are associated with a greater claim cost, higher rate of hospitalization, and higher median time loss days compared to upper extremity amputations. This trend persists even when finger and toe amputations are excluded. We identified hospitalized claims using the non-missing admission date associated with the medical bill; out-patient services which occurred in hospitals would not be counted.

Table 9. Characteristics of amputation cases by amputated body part

Amputated Body Part	Cases	Median Cost	% Hospitalized[1]	% Disability[2]	% Has Any Time Loss	Median time loss days[3]
Upper extremities	2,907	$9,794	7%	51%	34%	54
Parts of the arm	75	$34,206	31%	29%	59%	554
Upper arm	53	$28,257	26%	26%	60%	439
Elbow	9	$69,266	44%	56%	56%	688
Forearm	13	$149,046	38%	23%	54%	706
Wrist, hand, or fingers	2,831	$9,620	7%	52%	33%	50
Wrist	20	$48,395	35%	60%	60%	123
Hand	113	$38,800	35%	58%	50%	164
Finger	2,697	$9,035	5%	51%	32%	47
Unknown	1	$2,516	0%	0%	0%	-
Lower extremities	156	$58,255	52%	47%	62%	300
Parts of the leg	56	$173,942	61%	34%	64%	847
Upper leg	19	$275,724	74%	16%	84%	864
Knee	12	$93,472	58%	42%	67%	326
Lower leg	25	$157,510	52%	44%	48%	965
Ankle or foot	100	$37,778	46%	55%	60%	223
Ankle	9	$24,004	11%	11%	44%	446
Foot	38	$62,028	63%	61%	76%	287
Midfoot/heel/sole	3	$70,605	67%	33%	100%	455
Toe	50	$27,122	38%	60%	48%	111
Parts of the head	6	$5,993	0%	33%	17%	227
Decapitation	1	$9,826	-	0%	0%	-
Ears	4	$2,066	0%	25%	0%	-
Nose	1	$74,417	0%	100%	100%	227
Total	**3,069**	**$10,566**	**10%**	**51%**	**35%**	**300**

1. # amputation cases with non-missing admission date in medical billing data / amputation cases with billing data
2. Claim was awarded permanent partial disability or total permeant disability.
3. Median paid time loss days among claims with at least 1 day of paid time loss. Excludes non-compensable claims.

Medical Treatment among Amputated Cases

As discussed above, amputations can occur at the same date of the traumatic injury or as part of follow-up care. To estimate when the amputation occurred relative to the initial injury, we make two assumptions. Firstly, that the amputation occurred on the earliest medical service date listed on bills with an amputation ICD-9/10 code. Secondly, that that the claim's injury date was the date of the initial injury and not when major treatment was sought.

Out of 3,069 amputation cases, 83% have one or more medical bills with an amputation ICD-9/10 code. Note that this is lower than the total number of cases that have ICD-9/10 codes (89% of cohort) because in the case capture process, ICD-9/10 codes were also queried from an administrative dataset of allowed diagnoses for the claim. The estimated amputation date occurred on the same day as the claim's injury date in 77% of cases with an amputation ICD-9/10 code (N = 1,965), within the same week in an additional 10% of instances (N = 264, Table 9). Around half of lower body amputations occurred more than a month after the injury date, compared to only 5% of upper body amputations.

Table 9. Estimated amputation date relative to the claim injury date

Difference between first amputation and injury	Upper body amputation	Lower body amputation	Total
Amp. date before injury date	24 (1%)	2 (2%)	26 (1%)
Amp. date same as injury date	1,931 (79%)	34 (30%)	1,965 (77%)
Amp. date within 1 to 7 days of injury date	262 (11%)	2 (2%)	264 (10%)
Amp. date within 8 to 30 days of injury date	96 (4%)	16 (14%)	112 (4%)
Amp. date > 31 days from injury date	122 (5%)	58 (52%)	180 (7%)
Total with amp. ICD-9/10 codes	**2,435 (100%)**	**112 (100%)**	**2,547 (100%)**

Among amputation cases with *any* medical billing data regardless of the use of amputation ICD-9/10 codes (97% of cases), 10% were hospitalized (Table 10). In the recovery period, 42% had one or more medical bill for physical or occupational therapy, and 41% of cases with medical billing data had an IME exam. Rarer follow-up care includes visits to chiropractors and pain clinics.

Table 10. Characteristics of medical services billed by amputated body part

Amputated Body Part(s)	# Cases with Medical Bills	Bill for Physical or Occ. Therapy	Bill for IME Exam	Bill for Chiropractor	Bill for Pain Clinic
Upper extremities	2826	1,175 (42%)	1,138 (40%)	35 (1%)	24 (1%)
Lower extremities	151	83 (55%)	96 (64%)	14 (9%)	6 (4%)
Parts of the head	5	1 (20%)	2 (40%)	0 (0%)	0 (0%)
Total	**2,982**	**1,259 (42%)**	**1,236 (41%)**	**49 (2%)**	**30 (1%)**

Rarely do cases have OIICS nature codes that indicate the amputation was caused by an external, non-traumatic condition. These tend to be lower body amputations resulting from gangrene (N = 4) or skin ulcers (N =1). The ICD-9/10 diagnosis codes associated with the claim are a richer source of information for these comorbidities. As shown in Table 11, lower body amputation cases were diagnosed with osteopathies 34% of the time, gangrene 31% of the time, and skin ulcers 29% of the time.

Table 11. Potential causes leading to amputation, among cases with medical billing data

Amputated Body Part(s)	# Cases with Medical Bills	Osteopathies (% cases with med bills)	Gangrene (% cases with med bills)	Skin Ulcers (% cases with med bills)
Upper extremities	2826	80 (3%)	74 (3%)	10 (0%)
Lower extremities	151	52 (34%)	47 (31%)	44 (29%)
Parts of the head	5	0 (0%)	0 (0%)	0 (0%)
Total	**2982**	**132 (4%)**	**121 (4%)**	**54 (2%)**

Other risk factors for wound healing complications are more common among cases of lower body amputations compared to upper body (Table 12).

Table 12. Risk factors for wound healing, among cases with medical billing data

Amputated Body Part(s)	# Cases with Medical Bills	Hypertension (% cases with med bills)	Diabetes (% cases with med bills)	Peripheral vascular disease (% cases with med bills)	Renal failure (% cases with med bills)
Upper extremities	2826	359 (13%)	123 (4%)	9 (0%)	14 (0%)
Lower extremities	151	56 (37%)	45 (30%)	26 (17%)	18 (12%)
Parts of the head	5	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	**2982**	**415 (14%)**	**168 (6%)**	**35 (1%)**	**32 (1%)**

Amputation Rates by NAICS Industry

The overall rate of amputation between 2016 and 2021 is 19.22 amputations per 100,000 full-time equivalents. The three NAICS industry sectors with the highest rate of amputations were Construction, Agriculture, Forestry, Fishing and Hunting, and Manufacturing (Table 13).

Table 13. Amputation rate by NAICS industry sector

NAICS Industry Sector	Amp Cases	100,000 FTE	Amp Cases per 100,000 FTE
Construction	717 (23%)	10.5 (7%)	68.37
Agriculture, Forestry, Fishing and Hunting	285 (9%)	5.7 (4%)	50.19
Manufacturing	582 (19%)	14.5 (9%)	40.04
Accommodation and Food Services	363 (12%)	10.4 (6%)	35.04
Wholesale Trade	204 (7%)	7.4 (5%)	27.50
Transportation and Warehousing	116 (4%)	5.0 (3%)	23.26
Arts, Entertainment, and Recreation	29 (1%)	1.4 (1%)	20.77
Administrative/Waste Management/Remediation	203 (7%)	11.1 (7%)	18.28
Other Services (except Public Administration)	92 (3%)	5.6 (4%)	16.39
Retail Trade	225 (7%)	17.7 (11%)	12.68
Real Estate and Rental and Leasing	45 (1%)	3.7 (2%)	12.06
Public Administration	52 (2%)	8.0 (5%)	6.49
Professional, Scientific, and Technical Services	40 (1%)	11.8 (7%)	3.39
Educational Services	32 (1%)	9.6 (6%)	3.33
Health Care and Social Assistance	57 (2%)	22.9 (14%)	2.49
All Other NAICS Sectors with < 10 amputations	27 (1%)	14.4 (9%)	1.88
Total	**3069 (100%)**	**159.7 (100%)**	**19.22**

The same three sectors have the highest rate of finger or fingertip amputations, and all other upper body amputations (not shown). However, the highest rates of lower body amputations is in the Transportation and Warehousing sector.

While most NAICS sectors saw a general decline in amputation rate from 2016 to 2021, the only statistically significant change was found in the “Administrative and Support and Waste Management and Remediation Services” sector, which decreased by at least 2.7 amputations per 100,000 FTE (estimated decline between 2.7 – 3.9 amputations per 100,000 FTE, p-value < 0.001).

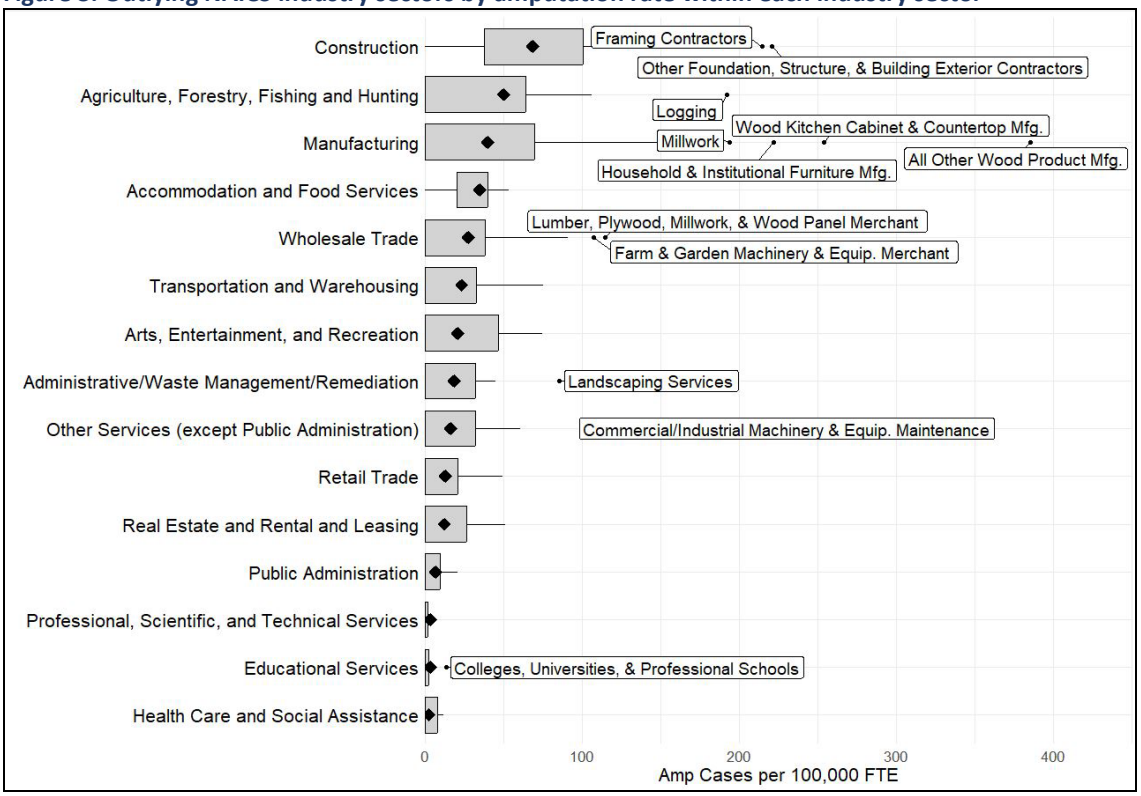
The ten NAICS industry subsectors with the highest amputation rates are shown in Table 14. These ten subsectors account for 37% of the 3,069 identified cases.

Table 14. Top 10 NAICS Industry subsectors, by amputation rate

NAICS Industry Subsector	# Amp Cases	100,000 FTE	Amp Cases per 100,000 FTE
337 - Furniture and Related Product Manufacturing	60	0.31	194.9
113 - Forestry and Logging	34	0.19	178.6
321 - Wood Product Manufacturing	106	0.66	159.5
332 - Fabricated Metal Product Manufacturing	104	1.06	98.17
236 - Construction of Buildings	226	2.49	90.94
326 - Plastics and Rubber Products Manufacturing	34	0.39	86.88
331 - Primary Metal Manufacturing	17	0.21	80.61
238 - Specialty Trade Contractors	436	6.85	63.69
212 - Mining (except Oil and Gas)	8	0.13	61.83
311 - Food Manufacturing	107	1.98	53.97

Figure 3 demonstrates the outlying NAICS industry subsectors by amputation rate for each sector, using the IQR method of outlier detection. Note that "Colleges, Universities, and Professional Schools" outlying subsector includes a large, university-affiliated hospital system.

Figure 3. Outlying NAICS industry sectors by amputation rate within each industry sector



Amputation Rates by Risk Class

The risk class industries with the highest rate of amputation cases per million hours worked were Forest Products (162.3), Building Construction (144.3) and Food Processing (64.1) (Table 15).

Table 15. Amputation rate by account risk class industry

Account Risk Class Industry	# Amp Cases	100,000 FTE	Amp Cases per 100,000 FTE
Forest Products	256 (8%)	1.6 (1%)	162.3
Building Construction	408 (13%)	2.8 (2%)	144.3
Food Processing and Manufacturing	220 (7%)	3.4 (2%)	64.12
Miscellaneous Construction	184 (6%)	3.1 (2%)	59.15
Miscellaneous Manufacturing	139 (5%)	2.5 (2%)	54.93
Trades	199 (6%)	4.3 (3%)	46.37
Agriculture	205 (7%)	4.7 (3%)	43.77
Metal and Machinery Manufacturing	245 (8%)	5.8 (4%)	42.53
Dealers and Wholesalers	142 (5%)	3.7 (2%)	38.74
Temporary Help	78 (3%)	2.6 (2%)	29.95
Miscellaneous Services	541 (18%)	20.1 (13%)	26.93
Transportation and Warehousing	138 (4%)	6.3 (4%)	22.00
Stores	127 (4%)	11.1 (7%)	11.48
Government	59 (2%)	8.2 (5%)	7.20
Schools	37 (1%)	13.9 (9%)	2.67
Health Care	26 (1%)	12.5 (8%)	2.09
Misc. Professional and Clerical	56 (2%)	48.2 (30%)	1.16
All other risk class industries with < 10 amputations	9 (0%)	5.2 (3%)	1.75
Total	**3069 (100%)**	**159.7 (100%)**	**19.22**

Most risk class industries saw a general decline in the rate of amputations between 2016 and 2021. However, the only statistically significantly declines were “Dealers and Wholesalers”, Miscellaneous Services, and Temporary Help.

The ten risk class sub-industries with the highest amputation rates are shown in Table 16. These ten sub-industries account for 12% of the 3,069 identified cases.

Table 16. Top 10 risk class sub-industries by amputation rate

Top 10 Account Risk Class Sub Industry	# Amp Cases	100,000 FTE	Amp Cases per 100,000 FTE
Woodenware Products Manufacturing	6	0.01	967.2
Cabinet and Countertop Manufacturing - Wood	79	0.24	324.5
Meat, Fish and Poultry Dealers - Retail	10	0.04	268.5
Furniture and Casket Manufacturing - Wood	7	0.03	268.0
Temporary Help - Machine Operation	24	0.10	251.3
Wood Frame Building Construction	125	0.50	248.3
Wood Products Manufacturing, N.O.C.	79	0.35	224.0
Tree services	15	0.07	210.4
Fence Erection, N.O.C.	12	0.06	209.6
Pile Driving with Water Hazard	5	0.02	204.9

Nature of Injury

Excepting finger or fingertip amputations, the OIICS nature codes for amputations (311 and 319) are rarely used for amputation cases. The codes are used for 59% of finger or fingertip amputations, 50% of amputations to parts of the head, 25% of amputations to other parts of the upper body, and 15% of lower body amputations. The alternate OIICS nature codes used in amputation injuries are described in Table 17.

Table 17. OIICS Nature of Injury by Amputated Body Part

OIICS Nature of Injury (Code)	# Cases
Finger or fingertip amputations	2697 (100%)
Amputations, fingertip (311)	1381 (51%)
Fractures (12)	421 (16%)
Cuts, lacerations (34)	277 (10%)
Avulsions (33)	210 (8%)
Amputations, except fingertip (319)	204 (8%)
Open wounds, unspecified (30)	48 (2%)
Crushing injuries (971)	27 (1%)
Punctures, except bites (37)	19 (1%)
Fractures and other injuries (84)	17 (1%)
Sprains, strains, tears (21)	13 (0%)
Missing / unclassifiable / unknown (999)	21 (1%)
All other natures with < 10 cases	59 (2%)
All other hand/arm amputations	210 (100%)
Fractures (12)	39 (19%)
Sprains, strains, tears (21)	29 (14%)
Amputations, fingertip (311)	29 (14%)
Cuts, lacerations (34)	28 (13%)
Amputations, except fingertip (319)	23 (11%)
Crushing injuries (971)	10 (5%)
All other natures with < 10 cases	52 (25%)
Lower body amputations	156 (100%)
Fractures (12)	31 (20%)
Sprains, strains, tears (21)	21 (13%)
Amputations, except fingertip (319)	17 (11%)
Punctures, except bites (37)	14 (9%)
Other combinations of traumatic injuries and disorders n.e.c. (89)	10 (6%)
All other natures with < 10 cases	63 (40%)
Parts of the head	6
Total	**3069**

Source of Injury

The injury source is taken from the OIICS code, grouped to the highest level that contains at least 20 cases in for fingertip/finger amputations (Table 18) and 10 cases for all other parts (Tables 19-21).

Table 18. Source of injury among finger and/or fingertip amputation cases

OIICS Source of Injury (Code Number)	# Cases
Machinery (3*)	1066 (40%)
Metal, Woodworking, and Special Material Machinery (35*)	375 (14%)
Table Saws (3573)	212 (8%)
Sawing Machinery (3570)	38 (1%)
Band Saws (3572)	24 (1%)
Brake Presses (3562)	20 (1%)
All Other Metal, Woodworking, and Special Material Machin.	81 (3%)
Special Process Machinery (37*)	186 (7%)
Food Slicers (3711)	137 (5%)
All Other Special Process Machinery	49 (2%)
Material Handling Machinery (34*)	84 (3%)
Conveyors (341*, 342*)	42 (2%)
All Other Material Handling Machinery	42 (2%)
Agricultural and Garden Machinery (31*)	41 (2%)
Construction, Logging, and Mining Machinery (32*)	35 (1%)
Heating, Cooling, and Cleaning Machinery and Appliances (33*)	24 (1%)
All Other Machinery	321 (12%)
Tools, Instruments, and Equipment (7*)	726 (27%)
Handtools (71*, 72*)	660 (24%)
Knives (7124)	253 (9%)
Saws (7125)	144 (5%)
Cutting Handtools (7129)	104 (4%)
Hand Grinders (7242)	28 (1%)
Routers and Molders (7214)	20 (1%)
Scissors, Snips, Shears (7126)	20 (1%)
Drills (7113)	20 (1%)
All Other Handtools	71 (3%)
All Other Tools, Instruments, and Equipment	66 (2%)
Parts and Materials (4*)	369 (14%)
Building Materials (41*)	183 (7%)
Fasteners, Connectors, Ropes, Ties (42*)	65 (2%)
Vehicle and Mobile Equipment Parts (48*)	48 (2%)
Machine, Tool, and Electric Parts (44*)	35 (1%)
All Other Parts and Materials	38 (1%)
Vehicles (8*)	144 (5%)
Structures and Surfaces (6*)	110 (4%)
All other exposures	176 (7%)
Missing OIICS injury source	106 (4%)
Total Finger/Fingertip amputation cases	**2697 (100%)**

Table 19. Source of injury among upper body amputation cases, excluding finger and/or fingertip

OIICS Source of Injury for upper body amputations excluding fingers	# Cases
Machinery (3*)	87 (41%)
Metal, Woodworking, And Special Material Machinery (35*)	26 (12%)
Table Saws (3573)	12 (6%)
All Other Metal, Woodworking, And Special Material Machinery	14 (7%)
Material Handling Machinery (34*)	15 (7%)
Conveyors (342*)	10 (5%)
All Other Material Handling Machinery	5 (2%)
All Other Machinery	46 (22%)
Structures And Surfaces (6*)	26 (12%)
Floors, Walkways, Ground Surfaces (62*)	18 (9%)
All Other Structures And Surfaces	8 (4%)
Tools, Instruments, And Equipment (7*)	26 (12%)
Handtools (71*, 72*)	24 (11%)
All Other Tools, Instruments, And Equipment	2 (1%)
Parts And Materials (4*)	21 (10%)
Building Materials (41*)	11 (5%)
All Other Parts And Materials	10 (5%)
Persons, Plants, Animals, And Minerals (5*)	12 (6%)
Containers (1*)	12 (6%)
Vehicles (8*)	10 (5%)
All other exposures	8 (4%)
Missing OIICS injury source	8 (4%)
All upper body amputation excluding fingertip/fingers	**210 (100%)**

Table 20. Source of injury among lower body amputation cases

OIICS Source of Injury	# Cases
Vehicles (8*)	33 (21%)
Highway Vehicle, Motorized (82*)	15 (10%)
Plant And Industrial Powered Vehicles, Tractors (85*)	13 (8%)
Forklift (851*)	13 (8%)
All Other Vehicles	5 (3%)
Parts And Materials (4*)	31 (20%)
Building Materials (41*)	15 (10%)
Fasteners, Connectors, Ropes, Ties (42*)	11 (7%)
All Other Parts And Materials	5 (3%)
Persons, Plants, Animals, And Minerals (5*)	25 (16%)
Person (56*, 57*)	21 (13%)
All Other Persons, Plants, Animals, And Minerals	4 (3%)
Structures And Surfaces (6*)	24 (15%)
Floors, Walkways, Ground Surfaces (62*)	21 (13%)
All Other Structures And Surfaces	3 (2%)
Machinery (3*)	13 (8%)
Tools, Instruments, And Equipment (7*)	10 (6%)
All other exposures	16 (10%)
Missing OIICS injury source	4 (3%)
Lower body amputation cases	**156 (100%)**

Table 21. Source of injury among cases of amputation to parts of the head

OIICS Source of Injury	# Cases
Unspecified Cases, Cabinets, Racks, Shelves (210)	1
Unspecified Agricultural and Garden Machinery (310)	1
Dogs (5153)	1
Windows (638)	1
Unspecified Floors, Walkways, Ground Surfaces (620)	1
Ramps, Runways, Loading Docks (6292)	1
Parts of the head amputation cases	**6**

Injury event

Contact with objects or equipment was the leading injury event, associated with nearly all finger or fingertip amputations (96%), and a majority of hand/arm and lower body amputations (75% and 57%, respectively). Falls and transportation accidents accounted for more than one in four lower body part amputations. Table 22 presents amputations by OIICS injury event and amputated body part.

Table 22. Injury event by amputated body part

OIICS Injury event	Finger or fingertip	Hand or Arm	Lower body	Head	Total cases
Contact with objects, equipment (0*)	2599 (96%)	157 (75%)	89 (57%)	4 (67%)	2849 (93%)
Bodily reaction, exertion (2*)	31 (1%)	21 (10%)	24 (15%)	0 (0%)	76 (2%)
Falls (1*)	19 (1%)	16 (8%)	22 (14%)	1 (17%)	58 (2%)
Transportation accidents (4*)	4 (<1%)	6 (3%)	18 (12%)	0 (0%)	28 (1%)
Assaults and violent acts (6*)	19 (1%)	5 (2%)	0 (0%)	1 (17%)	25 (1%)
Exposure to harmful substances or environments (3*)	11 (<1%)	4 (2%)	2 (1%)	0 (0%)	17 (1%)
Fires and explosions (5*)	2 (<1%)	0 (0%)	0 (0%)	0 (0%)	2 (0%)
Other events or exposures (9*)	3 (<1%)	1 (<1%)	0 (0%)	0 (0%)	4 (<1%)
Missing / Unclassifiable / Unknown	9 (<1%)	0 (0%)	1 (1%)	0 (0%)	10 (<1%)
Total	**2697 (100%)**	**210 (100%)**	**156 (100%)**	**6 (100%)**	**3069 (100%)**

DISCUSSION

This new surveillance system captured 3,069 amputations in Washington workers compensation system for injuries occurring between 2016 and 2021. We observed a decrease in the rate of amputations from 22.4 amputations per 100,000 FTE in 2016 to 16.9 amputations per 100,000 FTE in 2021. Likely due to economic changes during the COVID-19 pandemic, 2020 saw the lowest number of amputation cases and the lowest amputation rate.

The BLS estimates 720 amputations in Washington State between 2016 and 2020, far lower than the 2,612 amputations observed [10]. A key methodological difference is that BLS estimates are based on characteristics reported at the time of injury, while this study utilized transactional data to add amputations that occurred at some time after the initial injury (cases which presumably would have been classified by BLS as some other type of injury). The number of claims assigned OIICS amputation codes, based on the characteristics reported at the time of claim filing, approached the BLS estimate, although still exceeded it. Regardless, for state surveillance, the utility of BLS work injury data is limited. Annual BLS estimates of amputations among Washington workers vary widely from one year to the next, likely because of small sample sizes, making it difficult to identify a true trend over time. Additionally, the state estimates are too small to be published by industry or injury characteristic, hindering efforts to identify high risk industries or work processes and set priorities accordingly. Both the increase in case ascertainment and the detailed injury, worker, and employer data captured in the workers' compensation system underscore the value of the Washington workers' compensation data for public health surveillance of occupational injuries.

This study updates the methods first developed by Anderson et al. [3], who employed diagnosis and procedure codes to augment the number of amputations identified through injury classification codes alone. Using Washington state fund data from 1997-2005, they averaged 45% more amputations than this study (based on an annual average of 715 vs. 494 state fund claims in the current study), with 61% captured from diagnosis and procedure codes – a much larger portion than the 40% identified from similar codes in this study. The distribution of amputations by body part however, were similar; in both studies, fingers accounted for nearly 90% of cases, lower extremities made up 5%, and upper extremities other than fingers roughly 5%. While the industry-specific rates of amputation were higher in the previous study, both studies observed the highest rates among the same three industries: Agriculture, Forestry, Fishing, and Hunting, Construction, and Manufacturing. Agreement was also seen for injury source, where machinery was found to cause more amputations than any other single source, accounting for over 36% of amputations in both studies. Despite differences in the number and rate of amputations reported by each study, which could be due a difference in injury classification systems (ANSI vs. OIICS), versions of ICD-CM codes (9 vs. predominantly 10), or a true change over time, both studies suggest similar industries and injury sources to target for amputation prevention.

The injury classification system employed by this study (OIICS) proved to be an imperfect method of capturing amputation cases. Half of claims used other OIICS nature of injury codes, such as those for lacerations or other open wounds. Our use of alternative case capture criteria makes up for the slow

and incomplete OIICS coding. The long-term goal of this surveillance system is a near real-time capture and communication of amputation cases to DOSH partners.

A potential source of error in our methods is our reliance upon administrative data to determine which claims are amputations, without additional review of medical records or other claim documents. The case-capture criteria employed are liable to false-positives, especially the ICD-10 diagnoses codes and keywords. We found common shoulder strain injuries miscoded as amputations within the ICD-10 S48* major group, which may be the result of typos. Amputation keywords were used in many unexpected contexts, such as injuries sustained by medical staff while treating amputated clients. Short keywords such as "amp" are especially susceptible to false-positive matches, as it is both a unit of measurement, a form of electrical equipment, and can result from a space inserted into the common words "ramp" and "clamp".

Despite our extensive match filtering to remove invalid diagnosis codes and incorrect keyword hits, it is likely that some false-positives remain. In developing the case capture criteria, we manually reviewed the medical records of some amputation cases with less certain identification criteria. Of the reviewed claims that remain within the cohort (N = 63), 87% were found to be true amputations and 13% were undetermined due to insufficient medical records. This subset of reviewed claims makes up only 2% of total cases and are were more likely to be on the borderline of our case definition.

Similar to other states, we observe higher amputation rates in Food Manufacturing (54 cases per 100,000 FTE) than Manufacturing overall (40 cases per 100,000 FTE), and a higher amputation rate in Animal Production (51 cases per 100,000 FTE) than Agriculture, Forestry, Fishing and Hunting overall (50 per cases per 100,000 FTE). Amputations in Food Manufacturing and Animal Production are most often the loss of a fingertip while using knives. The magnitude of difference however is less than federal OSHA observed in Ohio and Illinois. Though the changes were statistically insignificant, there was an observed increase in the amputation rate between 2016 and 2021 for Food Manufacturing while manufacturing sub-sectors for Fabricated Metal, Wood Product, and Paper Manufacturing saw declines over the same period. It is concerning that Food Product Manufacturing is reversing the trend of amputation declines.

CONCLUSION

Over 450 amputation injuries occurred in Washington State workplaces in 2021, the majority resulting from the use of machinery or powered hand tools. While amputation rates declined across the study period, Construction, Agriculture, and Manufacturing still see excessively high injury rates. These occupational injuries are preventable through adequately safeguarded machinery and training. Our updated surveillance methods increases the speed and detail of amputation case reporting, and will be used to inform prevention policies and programs to prevent workplace amputations.

APPENDIX A

Keywords Used in Case Capture

- Text search for amputation keywords were done using regular expressions. We experienced a high rate of false-positives when claims were captured on keywords alone. To reduce this, we were liberal with the number of patterns that caused a claim to be dropped, expected that the rare true amputations with a match would be picked up through OIICS codes or ICD-9/10 codes. Other workers compensation systems more reliant upon text searching may use less conservative methods.
- Text matches patterns for amputations: “\bAMP\b” or “\bAMPUT”
- Text does not match any of these patterns:
    - Amputee used to describe the patient causing a fall injury or injury during amputation procedure:
        - "\b(PT|CLIENT|PATIENT|RESIDENT|SPECIMEN)\b"
        - "\b(LIFT.*|TRIP.*|FALL|SLIP|PICK UP|TRANSFER.*|BACK PAIN|POSITION.*|SCALPEL)\b"
    - Amp used as a unit of voltage or when describing a piece of machinery
        - “\b(VOLT(AGE)|ELECTRIC.*|POWER|ACOUSTIC|BASS|GUITAR|AC)\b"
        - “\b[0-9]{2,3} AMP\b”
    - Amp results from a space inserted into the common words “ramp” and “clamp”
        - “\b(R AMP|CL AMP|CR AMP)\b”
    - Amput* used in the context of a personal history of amputation or injury to an existing prosthetic
        - "\bPROSTHETIC\b”
        - "\b(HX|HISTORY) OF.{0,50}AMP\b”
    - UTF-8 encoding error causes the ampersand symbol to be coded as “&amp”

ICD-9/10 Codes Used in Case Capture

Complete list of amputation ICD-9 and ICD-10 codes used in this surveillance system, including those that had no hits in our workers compensation system:

Table 23. ICD-9/10 codes used in case capture

ICD Version	Code
9	885*
9	886*
9	887*
9	895*
9	896*
9	897*
9	997.6*
9	997.61*
9	V49.60*
9	V49.61*
9	V49.62*
9	V49.63*
9	V49.64*
9	V49.65*
9	V49.66*
9	V49.67*
9	V49.70*
10	S48*
10	S58*
10	S68*
10	S78*
10	S88*
10	S98*
10	T87.30*
10	T87.9*

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