Supplementary Report: Methods and evaluation for Washington State's toxic inhalation surveillance system, 2017 – 2020

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SHARP Safety & Health Assessment & Research for Prevention

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INTRODUCTION

The goal of Washington's toxic inhalation injury surveillance system is to identify exposure trends that when addressed with prevention activities, may lead to a reduction in inhalation injury burden. We initiated surveillance with the primary goal of tracking eight priority exposures: ammonia, beryllium, carbon monoxide, chlorine, chromium, methylene chloride, welding fume, and wildland smoke. Beyond these eight exposures, additional claims filed for toxic inhalation were captured using highly-inclusive search criteria and initially categorized as "other". The "other" cases were each manually reviewed to establish what chemical(s), product(s), or type of product that caused the toxic inhalation. By case count, "other" cases comprise the majority of the toxic inhalation exposures in our surveillance system.

Periodic evaluation of the surveillance program is necessary to ensure that the system is operating with maximum efficiency. Our surveillance process starts with the capture of potential cases from both State Fund and Self-Insurance workers' compensation claims administered by the Washington State Department of Labor and Industries (L&I). Establishing case-capture criteria is a balance between being too broad versus being too specific. When the case capture criteria are set too broadly, a high proportion of potential cases may not be valid, making the resources to review these cases inefficient. On the other hand, case capture criteria that is very narrow will return a high proportion of valid cases, but may leave other valid cases uncaptured, leading to an underestimate of the true burden. The case capture criteria used in our system is written to both include certain cases (such as by keyword) and exclude certain cases (such as traumatic injury). The results of our toxic inhalation surveillance system are in a complementary 2021 report which details the objectives, results, and future direction of the system (Washington State Department Labor and Industries, 2021, link).

The primary purpose of this supplementary report is to evaluate the system's case capture methods. A technical overview of the surveillance system's data source and chemical exposure case definitions is also given. We discuss the efficacy of the current case capture criteria in identifying valid cases and propose modifications that might improve the surveillance system.

METHODS

Data Source

The data source in this report is Washington State workers' compensation claims established from January 1, 2017 through December 31, 2020. In Washington State, 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 1.9 million (about two-thirds) of the workers in the state and 99.7% of all employers. Data from both the State Fund and self-insurance programs are entered into a centralized data warehouse at L&I which contains both medical diagnoses and administrative codes.

Surveillance Procedures

L&I's workers' compensation data warehouse is queried on a monthly basis to capture potential toxic inhalation injury cases. Potential cases are uploaded into SHARP's toxic inhalation injury database where they are reviewed, validated against the case definition, and classified for exposure. The case validation and exposure determination process uses information obtained from the claim initiation form, the medical records, and correspondence with L&I. Statements about the inhalation incident and the exposure come from the worker, their doctor, and their employer. In some cases product Safety Data Sheets (SDS), which list chemical ingredients by their Chemical Abstract System (CAS) number, are included in the medical record or are provided to L&I during claim adjudication.

Case Definition

A valid case has a known or suspected inhalation exposure to one or more of the eight specified priority substances or to an "other" substance. The eight priority substances are ammonia, beryllium, carbon monoxide, chlorine, chromium, metal fume, methylene chloride, and wildland smoke. Other substances can be chemical, metal, organic, or inorganic in the form of vapor, gas, dust or fume.

Among the eight priority substances, variation in chemical form are allowed. Variations in the form of ammonia include ammonia hydroxide, anhydrous ammonia, and ammonium chloride. Beryllium forms include pure beryllium metal as well as beryllium-containing alloys. The predominant forms of chlorine include chlorine gas and sodium hypochlorite. Chromium exposure includes hexavalent chromium (predominant), chromium metal and chromium compounds. Metal fume includes welding fume (predominant) as well as metal fume from non-welding exposures. Carbon monoxide, methylene chloride, and wildland smoke have no variation in the stated chemical form.

Other routes of exposure, such as dermal or ingestion may occur simultaneous with inhalation exposure, especially with splashes to the face or whole-body exposure to a gas. Our case capture criteria do not intend to capture non-inhalation cases but these other routes do occur among the potential cases being evaluated. A potential case will meet our surveillance case definition provided there is some measure of inhalation associated with the exposure. Potential cases that do not meet the case definition may be deemed either not valid, duplicate, or unknown (data not shown).

Case Capture Criteria

Potential cases are captured using three types of data:

a) Text search for keyword terms on the Report of Industrial Injury or Occupational exposure (ROIID) form. The ROIID form initiates the claim and among other things describes the initial treatment reason and the initial work-related diagnosis. It is completed by the injured worker, their physician, and their employer.
b) International Classification of Disease codes, revision 10 with clinical modification (ICD-10-CM). Diagnosis codes are assigned by health care providers and are pulled from the ROIID form, the claim adjudication process, and from medical and hospital bills.
c) Occupational Injury and Illness Classification System (OIICS) codes. OIICS codifies the characteristics of the injury or illness and are assigned by L&I's insurance division.

As cases can be captured by one or more data types, we use a Venn diagram to group cases together and evaluate the efficacy of each data type alone or in combination (Figure 1). Table 1 shows case capture criteria in detail.

Figure 1. Venn diagram showing combination of case-capture criteria

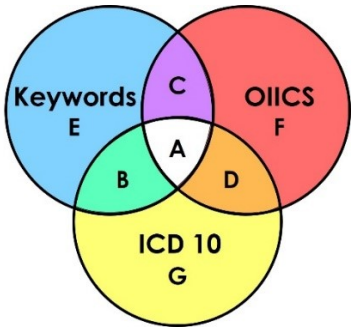

Table 1. Case capture criteria for eight priority exposures and "other" exposures under respiratory surveillance

Exposure	Keywords	OIICS[1] Source/Event/Nature	ICD-10-CM[2]
Ammonia	Ammonia; Amonia; NH3; Ammonium	091; 0981	no specific codes
Beryllium	Beryllium; Berilio	052	T56.7*
Carbon Monoxide	CO2; CO; Carbon dioxide/monoxide; CO(2); Carbox; Carb Exp; Exhaust Fumes; COHB	0941	T58
Chlorine	Chlorine	0422; 0429	T59.4*
Chromium	Chromium; Hex Chrome; Chrome VI; Hexavalent; CR6; CR 6	0563	T56.2*
Metal Fume	Metal Fume, Welding	050, 057, 059	no specific codes
Methylene Chloride	Methylene Chloride; Dichloromethane; DMC	0423	T53.4*
Wildland Smoke	Wildfire; Forest Fire; Wildland; wild fire;	512 (Event Code)	X01.1*; X03.1*
Other Toxic Inhalations	Inhale; inhl; inhil; toxic inhal; toxin inhal; chemical inhal	06; 07/340, 341/959	T51-T65; Z77

[1] Occupational Injury and Illness Classification System, Event, Nature and Source codes, v1.01
[2] International Classification of Disease Codes, Tenth Revision
* Select sub-codes within the umbrella code are excluded

Case Disposition and Validation

The surveillance process evaluates potential cases in two steps. Step 1 excludes potential cases that are overtly non-inhalation or non-respiratory in nature. The case-capture criteria outlined in Table 1 are purposefully broad and over-inclusive, so as not to lose any potential cases. The OIICS and ICD codes inadvertently capture other injuries related to chemical exposures, such as chemical burns, eye irritation, ingestion, and contact dermatitis. Traumatic injuries can be inadvertently captured when exposure keywords are used to describe the context for the traumatic injury (e.g. "fell from scaffold when 'welding' under bridge"). If the injured worker or their medical record does not describe inhalation or respiratory symptoms, then the potential case is excluded.

Cases that are not excluded from Step 1 move to Step 2 for case validation (Table 2). Case validation involves in-depth review of the medical records and if applicable, workplace safety investigation reports. An injured worker (case) can be exposed to more than one of the eight priority chemicals, or to one of the eight priority chemicals as well as to additional specified chemicals (other). Upon case review, we may learn of exposures different from or in addition to the exposure category a case was captured under. For example, Table 2 shows that seven cases were captured for beryllium, yet we dispositioned nine cases as valid beryllium exposure. This is because beryllium was mentioned as an exposure in the case records for two workers whose case was not initially captured for beryllium.

RESULTS AND EVALUATION

During the four-year period 2017 – 2020, a total of 4104 potential cases were captured for all exposures. Of the potential exposures, 1028 (25%) were excluded for being non-respiratory in nature leaving 3076 potential respiratory cases for review. Of the 3076 reviewed cases, 2604 (63%) were deemed valid for one or more of the eight specified exposures or for "other" inhalation exposures. The most common non-respiratory injures were chemical burns (N=96), eye irritation (N=94), musculoskeletal injuries (N=85) and ingestion (N=67, data not shown).

Table 2. Surveillance summary of toxic inhalation injuries in WA, 2017-2020

Exposure	Captured	Excluded[1]	Reviewed	Valid (% of Reviewed)
Ammonia	117	11	113	99 (88%)
Beryllium	7	0	9	9 (100%)
Carbon monoxide	725	220	523	389 (74%)
Chlorine	279	60	312	298 (96%)
Chromium	25	5	21	15 (71%)
Metal fume	302	207	107	80 (75%)
Methylene Chloride	44	43	4	2 (50%)
Other	2989	446	1804	1706 (95%)
Wildland Smoke	78	44	42	32 (76%)
Total	4104	1028	2848	2604 (91%)

[1]Excluded in Step 1 because the potential case was non-respiratory in nature.

Ammonia Case Capture Performance

Overall, the case-capture criteria for ammonia exposures perform well. The OIICS source code for ammonia (091* Ammonia and ammonium compounds) is highly specific and accurate when assigned. A quarter of valid cases had non-specific OIICS source codes (00 and 09 chemicals and chemical products unspecified); these cases were successfully captured using keywords. However, keywords alone also capture the most non-respiratory cases, commonly for eye irritation and chemical burns.

Table 3. Ammonia Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Keyword and OIICS	62	0	62	60 (97%)
Keyword	48	10	32	25 (78%)
OIICS	7	1	6	4 (67%)
Captured as Diff. Exposure	0	0	13	10 (77%)
Total	117	11	113	99 (88%)

Beryllium Case Capture Performance

Workers' compensation claims for beryllium exposure are rare and are best captured using keywords. A single claim utilized the OIICS source code "052: Beryllium and beryllium compounds" and the ICD code "T56.7* Toxic effects of beryllium and its compounds". Reliance alone upon this OIICS code and ICD code would result in an undercount. Two of the nine valid cases were captured exclusively through the "other" criteria. On one hand, the established capture criteria failed to find two (22%) of valid cases, on the other hand, it took review of 1804 "other" cases to find these two cases.

An accurate and timely capture of beryllium cases is critical for disease prevention. One health effect of beryllium exposure is chronic beryllium disease or berylliosis. Berylliosis can progress to a serious and life-threatening lung disease if left undiagnosed with continued exposure. Because there is an OSHA standard specifically for beryllium which includes medical surveillance for exposed workers, referral to DOSH can help ensure this metal is controlled for similarly-exposed workers in the workplace.

Table 4. Beryllium Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Keyword, ICD, and OIICS	1	0	1	1 (100%)
Keyword	6	0	6	6 (100%)
Captured as Diff. Exposure	0	0	2	2 (100%)
Total	7	0	9	9 (100%)

Carbon Monoxide Case Capture Performance

The best data types for capturing valid carbon monoxide cases were the OIICS and ICD codes. Keywords alone brought in 97% of non-respiratory cases for carbon monoxide, due to difficulty of accurately matching the abbreviation "CO". The letter combination "CO" is frequently used to describe co-workers, companies, or cardiac output, and can occur as a typo or text spacing error. This results in a high rate of false case-capture. However, keywords in conjunction with ICD codes or OIICS codes performed well.

Carbon monoxide has the lowest proportion of valid cases of all the exposures because it is difficult to determine the likelihood that an exposure occurred. Cases are often part of large clusters of cases, resulting from large facility-wide evacuations. These evacuations are triggered by carbon monoxide alarms or concerns about a gas leak. CO is a by-product of combustion. It is present in exhaust from most combustion engines including vehicle and airplanes. For workers exposed to exhaust fumes, such as airline workers, it is difficult to determine the severity of carbon monoxide exposure.

Table 5. Carbon Monoxide Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Key, ICD, and OIICS	214	0	214	197 (92%)
Key and ICD	53	0	53	45 (85%)
Key and OIICS	51	0	50	42 (84%)
ICD and OIICS	9	0	9	9 (100%)
Key Only	336	215	117	50 (43%)
OIICS Only	27	0	26	12 (46%)
ICD Only	35	5	30	19 (63%)
Captured as Diff. Disease	0	0	24	15 (63%)
Total	725	220	523	389 (74%)

Chlorine Case Capture Performance

Keywords and OIICS codes for chlorine brought in many non-respiratory injuries. Cases for eye irritation and chemical burns from chlorine were very common. In the future, excluding eyes as an OIICS body part or excluding cases with the keyword "eyes" would reduce the number of false captures. At the outset, "bleach" was not a keyword for chlorine and such cases were initially captured as "other". This lead to the identification of 93 additional cases that were ultimately dispositioned as valid for chlorine (30% of valid chlorine cases). Developing a strategy to capture bleach cases, in conjunction with a strategy around capturing cleaning chemicals, will clarify and improve our surveillance for 'chlorine'.

Table 6. Chlorine Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Key, ICD, and OIICS	13	1	12	12 (100%)
Key and ICD	36	2	34	34 (100%)
Key and OIICS	14	0	13	13 (100%)
ICD and OIICS	1	0	1	0 (0%)
Key	60	11	50	45 (90%)
OIICS	128	41	87	81 (93%)
ICD	27	5	22	21 (95%)
Captured as Diff. Exposure	0	0	93	92 (99%)
Total	279	60	312	298 (96%)

Chromium Case Capture Performance

Chromium has one of the lowest proportion (71%) of valid cases compared to other chemicals in the surveillance system. Cases of chromium exposure often involve multiple chemical exposures. This resulted in several difficulties identifying valid cases. A single case used the specific OIICS source code for chromium; the other valid cases used OIICS source codes for "Chemical and Chemical Products Unspecified/NEC" or other chemical mixtures. Therefore the case-capture criteria had to rely predominantly on keywords and ICD codes. Out of six cases found to be not valid during manual review, three cases had medical workup for metal-fume exposure with suspected chromium exposure but chromium per se could not be definitively confirmed during the manual case review.

Table 7. Chromium Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Key and ICD	2	0	2	1 (50%)
Key and OIICS	1	0	1	1 (100%)
Key	21	5	15	11 (73%)
ICD	1	0	1	1 (100%)
Captured as Diff. Exposure	0	0	2	1 (50%)
Total	25	5	21	15 (71%)

Metal Fume Case Capture Performance

The case-capture criteria for metal fume need significant revision from what was initially established. Thirty percent of keyword-only cases were excluded. The "welding" keyword in particular brought in many welding-related musculoskeletal injuries and welding flash burns to the eye. Yet with the current set of criteria, keywords proved the best way to capture metal fume exposures. The OIICS source code "057 : Welding or soldering fumes" returned only 7 valid cases, while source codes "050/059 : Metallic particulates, trace elements, dusts, powders, fumes" returned none. The most commonly assigned OIICS code for valid metal fume exposure cases was non-specific, "099: Chemical and Chemical Products Unspecified/NEC". Several additions should be made to the criteria: the ICD code "T59.9: Toxic effect of unspecified gases, fumes and vapors", the OIICS nature code "1462, Metal Fume Fever", and the OIICS source "0929, Cryogenic Gases".

Table 8. Metal Fume Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Key and OIICS	6	0	6	6 (100%)
Key	289	203	84	59 (70%)
OIICS	7	4	3	1 (33%)
Captured as Diff. Exposure	0	0	14	14 (100%)
Total	302	207	107	80 (75%)

Methylene Chloride Case Capture Performance

Our surveillance system captured only two valid methylene chloride cases. Out of the 44 cases captured through the methylene chloride criteria, only one was valid. An additional two potential cases were captured as "other"; of these, one was valid. The chemical methylene chloride is difficult to capture for multiple reasons. It has two widely used synonyms (DMC and dichloromethane) which are part of our case capture. However, the keyword "DMC" often appears in the physician's notes in the context of "NSAIDS PT DMC", possibly for "decision-making capacity". This keyword should be kept and the OIICS exclusion rules improved to better exclude traumatic injuries.

In a laboratory setting, methylene chloride is likely known to chemists by name and label. In construction and manufacturing, the chemical is an ingredient found in strippers and adhesives, and is likely known to users by product name and not as a single ingredient name. One possible way to find more cases involving methylene chloride is to investigate inhalation injuries involving strippers and adhesives where the product name is given (not a common occurrence), obtain the product SDS, and review the chemical ingredients therein. Among the 1804 "other" cases that were reviewed, two mentioned chemical products containing methylene chloride and one resulted in a valid case. A significant amount of labor was required to identify additional cases. Overall, from the "other" cases, we found 13 cases for adhesives and 29 cases for strippers. Keywords such as "adhesive" and "strippers" could potentially be added to the methylene chloride query to more quickly find these additional cases.

Table 9. Methylene Chloride Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Key and ICD	1	1	1	0 (0%)
Key	43	42	1	1 (100%)
Captured as Diff. Exposure	0	0	2	1 (50%)
Total	44	43	4	2 (50%)

Wildland Smoke Case Capture Performance

Several barriers to effective wildland smoke inhalation case-capture were found. Keywords for wildland smoke capture a large number of traumatic injuries sustained by firefighters during wildfire response; 60% of keyword-only cases were excluded. Better exclusion criteria by traumatic OIICS injury codes would be beneficial. Additionally, if the injured worker describes the fire by name, typically the geographical location where it started, these case-capture methods will not capture the case. Temporally relevant keywords for on-going or recent fires could be added to the query each month to improve wildland smoke surveillance.

Table 10. Wildland smoke Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Key	72	43	28	23 (82%)
ICD	6	1	4	2 (50%)
Captured as Diff. Exposure	0	0	10	7 (70%)
Total	78	44	42	32 (76%)

Other Toxic Inhalation Case-Capture Capture Performance

The case-capture criteria for the "other" category were purposefully broad. Cases captured through keywords (variations of the word "inhalation") or ICD codes alone where non-inhalation injuries over 20% of the time. The keywords and ICD codes should be refined.

The "other" category allowed us to capture 133 additional cases for the eight target conditions. In these instances, the case did not have any keywords, ICD codes, or OIICS codes that related to the target exposure. However, upon review of the medical records, we found information on valid exposure to a target exposure. Within the "other" category we found valid chlorine cases (30% of all chlorine cases), beryllium cases (2 out of 9 valid beryllium cases), and a methylene chloride case (1 out of 2 valid methylene chloride cases). Reviewing the "other" cases allowed us to find new case-capture criteria for the target conditions and identify potential biases in the current criteria.

Table 11. Other Toxic Inhalations Case Capture Criteria Performance

Case Capture Criteria	Captured	Excluded	Reviewed	Valid (% of Reviewed)
Key, ICD, and OIICS	559	7	388	377 (97%)
Key and ICD	155	10	101	99 (97%)
Key and OIICS	632	31	340	319 (94%)
ICD and OIICS	760	159	468	453 (97%)
Key	463	103	245	223 (91%)
ICD	420	136	235	214 (91%)
Captured as Diff. Exposure	0	0	27	24 (89%)
Total	2989	446	1804	1706 (95%)

Result Summary and Recommendations

Table 12 summarizes the case capture performance for the eight target conditions, along with recommendations to improve the surveillance system's case capture.

Table 12. Summary and recommendations

Exposure	Case capture performance	Recommendations/Notes
Ammonia	There is no AOEC code for ammonia, NOS	Create an AOEC code for ammonia, NOS
Beryllium	Two valid cases were found during review of the "other" category. Changes to keyword search terms would not have captured these missed cases.	No action. Our current system may under-capture beryllium cases, particularly if we decide to cease review of "other" cases.
Carbon Monoxide	Keyword search term 'CO' captures many false cases due to the ubiquity of this letter combination.	No action. Steps to reduce false case capture were taken in 2017 and 2020 in regards to the SAS code. There no further improvements we can make.
Chlorine	Capture criteria did not capture bleach-related claims	Modify the case capture criteria Add keywords for bleach.
Chromium	Capture criteria relies predominantly on existing keywords and ICD codes	No action.
Metal fume	"Welding" keyword returns many non-inhalation cases.	Add ICD code T59.9 Toxic effect of unspecified gases, fumes and vapors. Add OIICS nature 1462 Metal fume fever and OIICS source 0929 Cryogenic gases

Methylene Chloride	Workers typically know the name of chemical strippers and adhesive products they use, but not the individual chemicals (such as methylene chloride) inside the product. Therefore methylene chloride is unlikely to be named by the worker on the claim form.	No action.
Wildland Smoke	Keywords brought in a high number of traumatic injuries in workers fighting wildfires. Geographically-named fires are not captured.	Add OIICS nature codes "012 Fractures" and "021: Sprain, strain, tear" as negative criteria to exclude these injuries. Add relevant keywords for on-going fires in the region.
Other	Capture criteria were set intentionally broad so that these cases could be further reviewed.	Future system expansion could include the most frequent exposures: cleaning chemicals, agricultural chemicals, and pharmaceuticals.

DISCUSSION

Our approach for using three types of capture criteria—keywords, ICD codes, and injury (OIICS) codes— is a viable strategy for a toxic inhalation surveillance system. Each of the three types of capture criteria performed differently for the targeted exposures and in ways we could not have predicted. Extensive manual case review was necessary to evaluate the criteria. The insight gained from using these criteria for toxic inhalation injury can be modified for future surveillance applications, especially those where case review is not possible.

Case capture is a balance between setting capture criteria that are general enough to capture all possible cases, but not so general that false-positive cases are numerous. Codes that are likely to improve the capture of chlorine and metal fume were identified (see Table 12). We identified a need to establish case-exclusion criteria that could reduce the number of non-inhalation injuries we capture, especially for carbon monoxide, metal fume, and wildland smoke exposure (see Table 12).

During the manual review of the "other" category, we sometimes encountered cases rightfully belonging to the eight targeted exposures that the enhanced capture criteria had missed. Potential targeted cases were missed if the text word search, OIICS, or ICD-10 codes were not sufficient, or if the exposure was detailed in the medical record but not on the claim form. Case capture for chlorine was the poorest; 30% of valid chlorine cases were found during review of "other" cases. A small but significant number of other target exposures beryllium, chromium, and methylene chloride were identified from the "other" category. Common types of exposures within the "other" category include cleaning chemicals, agricultural chemicals, and pharmaceuticals. Because these exposures are so prolific, case-capture criteria that specifically capture these three exposures could be considered as an area of system expansion in the future.

CONCLUSION

A case-capture framework based on keywords, OIICS injury codes and ICD-10 diagnoses codes was a successful strategy upon which to build a surveillance system for toxic inhalation in Washington workers. This evaluation has identified several case-capture modifications that could improve the capture of true cases and also reduce the capture of false cases. These modifications should improve overall surveillance system efficiency.

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SUPPLEMENTARY MATERIALS

Washington State Department of Labor and Industries. **Surveillance of toxic inhalation for Washington workers,** 2017-2020. August 2021. SHARP Publication # 64-30-2021. Safety and Health Assessment and Research for Prevention Program, Olympia WA. https://lni.wa.gov/safety-health/safety-research/files/2021/64_30_2021_SurveillanceToxicInhal_2017-2020.pdf

Washington State Department of Labor and Industries. **Appendix Tables: Methods and evaluation for Washington State's toxic inhalation surveillance system**, 2017-2020. August 2021. SHARP Publication # 64-32-2021. Safety and Health Assessment and Research for Prevention Program, Olympia WA. https://lni.wa.gov/safety-health/safety-research/files/2021/64_32_2021_AppendixTablesSurveillanceToxicInhal_2017-2020.pdf