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Descriptive Analysis of Acute Pesticide Illness and Injury Cases in Oregon, 2011-2020

Final report

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Oregon Health Authority
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Contents

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Executive summary

Understanding what led to acute pesticide-related illnesses (API) is essential to make informed decisions about pesticide policies. Oregon Health Authority (OHA) released the 2009–2011 descriptive analysis of pesticide exposure cases in 2014. This is the first time since then that OHA has done this analysis.

The OHA Pesticide Exposure, Safety, and Tracking (PEST) Program seeks to determine the burden of human pesticide-related illness on people in Oregon. There were 1,439 exposures reported to OHA from 2011 to 2020. From those, the program described 992 cases of API in Oregon for this analysis. OHA performed this analysis using the standardized case definition where a case is any exposure coded as "definite", "probable", or "possible". The variables OHA assessed were:

- Sex
- Age group
- Race and ethnicity
- Geographic distribution of illness
- Intended application targets
- Work-related and non-work-related cases
- Activities engaged in when exposed
- Cases by year of exposure
- Cases by month of the event
- Severity
- Intent
- Contributing factors
- Routes of exposure
- Types of exposure
- Categories of signs and symptoms
- The initial source of the report, and
- Functional class of pesticide products involved.

OHA has six key findings from the analysis of the 992 cases:

- The number of reported APIs in Oregon started to increase in 2019. There were increases in higher severity cases and fatalities in 2019 and 2020 when compared to other years. All fatal cases in this report were the result of self-harm or apparent self-harm. Some of the increase may be due to enhanced staffing during this period. This improved the certainty of case classification. Also, some increase may be due to the addition of emergency department and urgent care clinic surveillance data as a PEST data resource.
- The Hispanic population is overrepresented in pesticide exposures in Oregon.

- Those in rural counties in Oregon continue to be disproportionately burdened by cases of APIs.
- Residences continue to be where most pesticide exposures occur.
- Most APIs are not the result of workplace exposures.
- Drift is a leading contributor to pesticide exposures that lead to APIs.

Background

The Oregon Health Authority's (OHA) Pesticide Exposure Safety and Tracking (PEST) Program seeks to determine the burden of human API on people in Oregon. PEST is focused on the human health implications of pesticide incidents reported to the Pesticide Analytical and Response Center (PARC). PARC is a board of eight state agencies established in state law [Oregon Revised Statute (ORS) 634.550]. PARC tracks and identifies trends in pesticide-related incidents in Oregon. OHA is a charter member of PARC. Under state public health law (ORS 413.042, 433.004, 433.006), health care providers who diagnose or suspect human pesticide poisoning are required to make a report to their local public health authority or OHA within 24 hours. OHA performs a data-driven assessment of human API in Oregon on which policy can be based. This identification of trends in reported exposures keeps with PARC's statutory mandate (ORS 634.550). The most recent data on the distribution of APIs in Oregon on OHA's website are Cases of Acute Pesticide Poisoning Reported to the Oregon Health Authority 2009–2011. OHA's previous descriptive analysis of PEST data covered five years (Descriptive Analysis of PEST Cases 2002–2007).

Methodology

Connecting a specific pesticide event with a person's signs and symptoms

To aid in classifying a reported case of API, PEST assesses the likelihood of a causal pathway between:

- A person's symptoms, the toxicology of a formulated product, and
- The person's reported exposure to the pesticide.

OHA uses information from the reporting source combined with data gathered during investigations conducted by PEST.

Information on the specific pesticide product implicated in the exposure as well as the signs and symptoms of the exposed person is critical. The signs and symptoms of pesticide exposure are general. They can mimic other health problems, such as a cold or flu. Evidence of a causal pathway between signs and symptoms and pesticide exposures can prove the illness is pesticide-related. It also can help rule out other health conditions.

The term "pesticide" is a generic term for a broad range of categories of products (for example, herbicides, rodenticides and disinfectants) used to control or kill "pests." Pests are typically unwanted plants, insects, rodents, or other forms of life like algae or bacteria. Pesticide applicators choose active ingredients (AIs) to mitigate specific pests. Each AI can produce specific symptoms in people acutely exposed to them. "Acute" means a single exposure that occurs over a brief period (less than a day) to a substance that has human health effects. Thus, a public health investigator needs to know:

- The specific product, and
- Its active ingredients.

These help to show whether the signs and symptoms are truly the results of acute pesticide exposures.

The only reliable source of information that allows access to the names of active ingredients and concentrations is a product's Environmental Protection Agency (EPA) registration number. This "EPA Reg. No." is the official identifier assigned to pesticides regulated by the EPA and the Oregon Department of Agriculture (ODA). State and federal law requires EPA registration numbers to be located on the label of pesticide products.

A correct assessment of the burden of acute pesticide exposure on people in Oregon requires showing a causal pathway that links the exposure to signs and symptoms. Signs are objective findings a health care professional observes and describes (for example, rash). Symptoms are personal evidence reported by the patient (for example, pain). Specific variables needed to construct a causal pathway include:

- Toxicity of the pesticide product or products
- Length of time a person spent near the product or products during the application
- Distance from the application
- The use of personal protective equipment (for example, goggles, respirator, gloves and pants)
- The reported route of a person's exposure (for example, through the skin, inhaled or ingested)
- Weather patterns, if available
- The period between exposure and onset of symptoms, and
- Duration of symptoms.

PEST investigation and classification of cases

PEST gathers information on exposures in a variety of ways. This includes:

- Interviews with those who report exposures
- Interviews with bystanders to exposures
- Review of investigative reports from other agencies, and
- Review of medical records.

PEST uses this information to classify the likelihood of exposure with Sentinel Event Notification System for Occupational Risk (SENSOR) case classification criteria (1) created by the federal National Institute for Occupational Safety and Health (NIOSH) at the Centers for Disease Control & Prevention (CDC). An "exposure" is a sudden onset of symptoms attributed to a pesticide "event." A "pesticide event" is a single, specific release of a pesticide product. A pesticide event can result in multiple cases. PEST classified 992 of 1,439 reports as cases. Data in this report are subject to change based on new or corrected information given to OHA.

This analysis includes PEST cases from 2011 through 2020 that meet specific case criteria. Cases involve one or more of the following:

- Systemic signs or symptoms (including respiratory, gastrointestinal, allergic and neurological signs or symptoms)
- Skin damage, and
- Eye damage.

Cases must also have information in the following three categories:

- Documentation of exposure
- Documentation of health effects, and
- Evaluation of the causal relationship.

OHA adapted these categories from the CDC NIOSH Case Definition for Acute Pesticide-Related Illnesses and Injury Cases Reportable to the National Public Health Surveillance System (1). Details of these categories are below:

A. Documentation of exposure

1. Confirmed by:
    a. Positive environmental sample
    b. Residue or damage professionally observed
    c. Biologic exposure evidence
    d. Clinical evidence of injury at the contact site, or
    e. Two or more findings (where at least one is a sign of exposure) by medical staff.
2. Reported by:
    a. Case
    b. Witness
    c. Written application records
    d. Residue or damage observed by someone who is not a trained professional, or
    e. Other evidence.
3. Strong evidence that no pesticide exposure occurred, or
4. Insufficient data.

B. Documentation of health effects

1. Two or more signs of exposure, lab findings by medical staff or both
2. Either:
    - Two or more abnormal systemic symptoms, or
    - Any new illness or worsening of a pre-existing illness diagnosed by a licensed physician.
3. No signs or symptoms of exposure, no lab findings reported, or
4. Insufficient data (including only having one new sign, symptom or lab finding).

C. Evaluation of causal relationship

1a. Consistent with NIOSH SENSOR Appendix 2 (2)

1b. Consistent with literature

1. Evidence of relationship not present
2. Definite evidence of a non-pesticide causal agent, or
3. Insufficient toxicological information available to inform a decision.

To qualify as a case, the exposure must meet at least one of the outlined subcategories within each category above. PEST investigators classify pesticide exposures as:

- Definite
- Probable
- Possible
- Suspicious
- Unlikely
- Insufficient information
- Asymptomatic
- Unrelated
- Unknown, or
- Uncoded.

The following table (from the CDC NIOSH Case Definition for Acute Pesticide-Related Illnesses and Injury Cases Reportable to the National Public Health Surveillance System (1)) describes how the types of documentation (see A and B above) and results of evaluation (see C above) determine the classification of pesticide exposures.

Table 1: Case classification table.

Classification categories[1]											
Classification criteria	Definite case	Probable case		Possible case	Suspicious case	Unlikely case	Insufficient information		Not a case		
									Asymptomatic[2]	Unrelated[3]	
A. Exposure	1	1	2	2	1 of 2	1 of 2	4	–	–	3	
B. Health effects	1	2	1	2	1 of 2	1 of 2	–	4	3	–	
C. Causual relationship	1	1	1	1	4	2	–	–	–	–	3

PEST defines a case as an exposure with the classification of a definite, probable or possible rating. After a case is classified this way, PEST uses NIOSH SENSOR's Severity Index as a simple, standardized way to assign illness severity.

PEST defines aspects of each reported case using variables in NIOSH-SENSOR's Standardized Variables for State Surveillance of Pesticide-Related Illness and Injury (3).

Analytical method

Using the statistical computing program R (version 3.6.3), PEST assessed select variables by developing:

- Frequencies
- Cross-tabulations, and
- Data visualizations.

PEST created geographic data visualizations of acute pesticide-related illnesses per 100,000 population using ArcGIS Pro (version 2.6.3). The 2015 census for per capita rates per county and race and ethnicity estimates is what PEST used for population counts.

1 Only reports meeting case classifications of Definite, Probable, Possible and Suspicious are reportable to the National Public Health Surveillance system. Assitional classification categories are provided for states that choose to track the reports that do not fit the national reporting criteria.

2 The matrix does not indicate whether asymptomatic individuals were exposed to pesticides although some states may choose to track the level of evidence of exposure for asymptomatic individuals.

3 Unrelated = illness determined to be caused by a condition other than pesticide exposure, as indicated by a >3” in the evidence of >Exposure- or >Causal Relationship- classification criteria.

Limitations

Reporting sources of data

The data available to PEST are not always complete due to the nature of the reporting sources. During emergencies, sources may fail to provide county of exposure or exact pesticide product. In other conditions, exposed persons may not have sought medical care, so medical records are not available.

Data collection methods

This study period included a transition in case management databases from the CDC data collection system, SENSOR-Pesticide Incident Data Entry Reporting Software (SPIDER), to Oregon Public Health Epidemiologists' User System (Orpheus). OHA re-entered data from SPIDER into Orpheus. However, differences in data collection standards may have led to errors carried over into Orpheus. CDC also revised the NIOSH SENSOR Standardized Variables in 2015. This caused differences in how PEST entered data in different years.

An added limitation is the lack of data on race, ethnicity and gender. These data could be valuable to show further trends in pesticide exposure cases and disproportionately affected populations. In 2013, the Oregon Legislature enacted House Bill (HB) 2134. This bill established a standardized list of categories and questions on race, ethnicity, language and disability (REALD) that OHA must collect to the greatest extent possible. OHA adopted these requirements in rule in 2014. In 2021, HB 3159 added requirements that health care providers collect information on REALD plus sexual orientation and gender identity (SOGI), effective September 25, 2021. The inclusion of REALD data within PEST cases depends on the source of data; the proportion of cases including REALD data is small. PEST did not include SOGI data in this descriptive analysis since OHA did not have this collection requirement during the period of analysis. The collection of REALD and SOGI data will supply greater detail to future PEST analyses. It will also allow for the development of policies and interventions that aptly address disproportionately affected populations.

Pesticide's EPA registration number

Another limitation of these data is possible inaccuracies in the cited EPA registration number. Past data collection may have led to incorrect EPA registration numbers. What OHA gets as first reported is based on suspected pesticide. It may turn out it is not the actual pesticide involved. This could lead to inaccuracies about active ingredients and known toxicity of a product. PEST investigators can glean information from the brand name or class of product if given. However, these data are insufficient to reliably determine a complete exposure pathway from event to symptoms. Brand names are not a reliable source of data to track pesticides. This is because manufacturers change active ingredients often. They may sell multiple products with the same brand name but different active ingredients or their concentrations. Also, the same EPA registration number may be assigned to a pesticide product that manufacturers and retailers market under several brand names.

Inert or "other" ingredients

Inert ingredients continue to be a concern for people exposed to pesticides. Information on inert ingredients is on the National Pesticide Information Center website. Inert ingredients are substances other than the active ingredients in pesticide formulations. These ingredients range from non-toxic to extremely toxic and many can cause acute injury or illness, particularly if incorrectly applied. Active ingredients are the ingredients that have pesticidal properties. Inactive ingredients do not have specific pesticidal properties. They can also have other functions such as they can ensure adherence to a surface or extending the shelf life. Inert ingredients can make up to 99 percent or more, by volume, of a pesticide formulation.

EPA requires, by law, that manufacturers list active ingredients on the label. However, EPA does not require manufacturers to list inert ingredients. Manufacturers often consider inert ingredients as confidential or trade secrets. However, EPA requires manufacturers to list inert ingredients of toxicological concern based on their relative toxicity. The toxicity categories of inert ingredients are:

- Category 1: Toxicological concern
- Category 2: Potentially toxic inert ingredients or high priority for testing
- Category 3: Unknown toxicity, and
- Category 4: Minimal concern. (4)

It is quite possible for somebody exposed to a pesticide to react to inert ingredients. If their response is different than an expected active ingredients response, then it is hard for an investigator to find a causal relationship; that exposure might not qualify as a case.

Chronic diseases reported after pesticide exposures

Research has linked pesticide exposures, especially exposures over a long time, to chronic diseases. (5) However, many other factors play into the development of chronic disease, making it difficult to determine causation. Since it is difficult to link pesticide exposure to the development of chronic disease, PEST focuses on acute cases. In acute cases, signs and symptoms appear at once or soon after exposure.

Findings

Basic information about all cases reported to PEST, 2011–2020

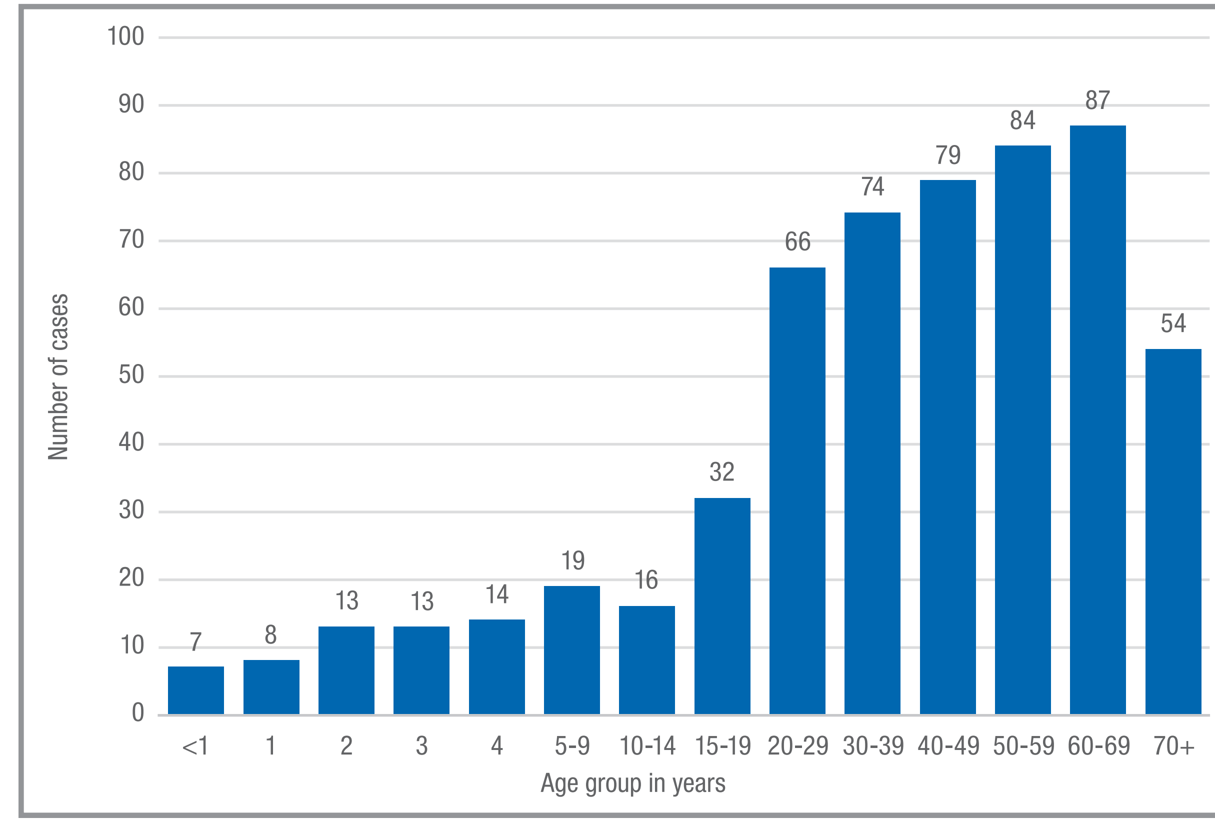
From 2011–2020, there were 1,439 reports of acute pesticide-related illnesses to PEST determined to be valid. Of these reports, 992 met the definite (138), probable (103) or possible (751) criteria PEST defined as a case. The rest of the findings in this report are only on these 992 cases.

Table 2: Reports of acute pesticide-related illnesses by case status, 2011–2020.

Status	Number	Percent
Definite	138	9.6%
Probable	103	7.2%
Possible	751	52.2%
Suspicious	18	1.3%
Unlikely	98	6.8%
Insufficient information	233	16.2%
Exposed and asymptomatic	63	4.4%
Unrelated	35	2.4%
Total	**1,439**	**100.0%**

Of the 992 cases, there were 486 females (49.0%), 476 males (48.0%), and 30 cases (3.0%) where sex was unknown or not entered. For this analysis, sex refers to the sex assigned at birth. PEST did not analyze data on gender.

Figure 1: Age distribution of cases of acute pesticide-related illnesses reported to OHA, 2011–2020 (n = 566*).



* Ages not known for 426 (42.9%) of cases.

Age was available for 566 of the API cases reported to OHA. Most cases of API reported in the study period occurred among adults aged 60–69 years. Starting at the 15–19-year age category, API cases began to increase with age. For pediatric cases (ages 1–4 years), PEST broke the age groups down further to reflect the specific psychological and behavioral stages of children. In the 2011–2020 period, 8.5% (using n = 566) of cases occurred in children ages 1–4 years. (Figure 1)

In contrast to previous years, PEST collected race and ethnicity data, when available, during the 2011–2020 study period. However, the data were extremely sparse. See the Limitations section above for more details. There were 137 cases where race was known. Table 3 shows the distribution of these races. Ethnicity data were lacking, except for the question that asked whether the case was Hispanic or not (n = 130). 78.5% of respondents reported they were not Hispanic, while 21.5% said they were Hispanic. Comparing these numbers to the 2015 estimated population (6) of Hispanic people in Oregon, 87.7% and 12.3% respectively, it shows that Hispanics are overrepresented among acute pesticide exposure cases in Oregon for which race data are available. This overrepresentation is particularly concerning given that Hispanic populations (7) often underreported pesticide exposures.

Table 3: Race distribution of human acute pesticide-related illnesses reported to OHA, 2011–2020, where race was known (n = 137).

Race	Number	Percent	2015 population estimate in Oregon (%)
White	118	86.1%	85.1%
Black	5	3.6%	1.8%
Other	5	3.6%	3.4%
American Indian or Alaskan Native	2	1.5%	1.2%
Pacific Islander	2	1.5%	0.4%
Asian	1	0.7%	4.0%
Two or more races	4	2.9%	4.1%
Total	**137**	**99.9%***	**100.0%**

Total is not equal to 100.0% due to rounding.

Signs, symptoms and severity

The person or a health care provider may report symptoms. However, only a health care provider may report signs. The most commonly reported signs and symptoms involved the respiratory system. The second most commonly reported health effects were neurological. (Table 4)

Table 4: Reported cases of acute pesticide-related illness and associated signs and symptoms, 2011–2020 (n = 2,085*).

Sign and symptoms categories	Number
Respiratory: health effects that involve the lungs or upper respiratory system	497
Neurological: health effects that involve the nervous or sensory systems	456
Gastrointestinal: health effects that involve the gastrointestinal tract	326
Ocular: health effects that involve the eye	320
Dermatological: health effects that involve irritation or sensitization of the skin	278
General: health effects not captured by other health effects categories	123
Cardiovascular: health effects that involve the heart or circulatory system	73
Renal: health effects that involve renal or genitourinary systems	12
Total	**2,085**

* The total is greater than 992 because a case can have multiple signs and symptoms in multiple categories.

Table 5: Severity of adverse health effects of acute pesticide-related illnesses, 2011–2020 (n = 986*).

Severity of adverse health effects	Number	Percent
Fatal	14	1.4%
High	8	0.8%
Moderate	84	8.5%
Low	880	89.2%
Total	**986**	**99.9%***

* Severity was not assessed for six cases; the total was not equal to 100.0% due to rounding.

The severity of cases remained mostly in the "low" category. However, compared to past analyses, there is a noticeable increase in fatal and high-severity cases. In the 2002–2007 report, the severity percentages for fatal and high-severity cases were 0.1% and 0.6%, respectively.

Event and illness geography

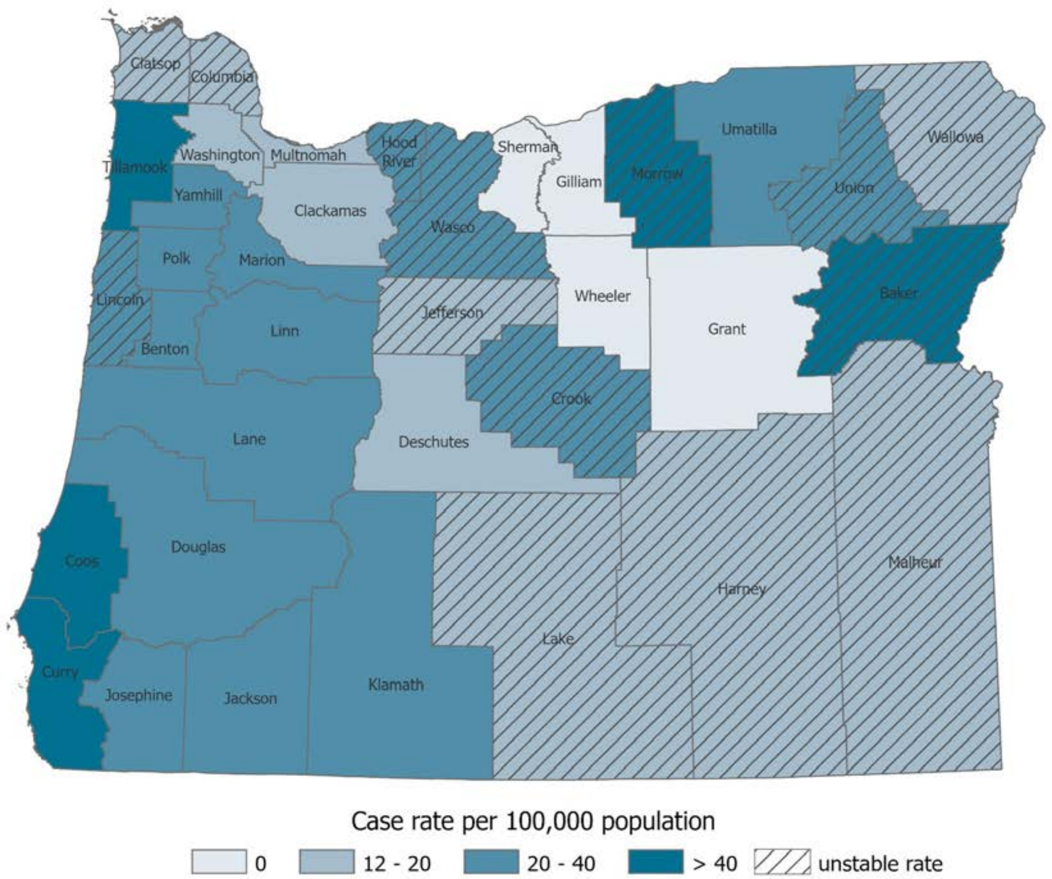
PEST explored geographic variation of pesticide exposure cases. (Figure 2) There is a large geographic variation in illness rates. Take caution in interpreting these data. Illness is reported by county of exposure. However, there could be misreporting (for example, accidentally entered as the county of residence, or the person didn't know what county they were exposed in to and didn't guess correctly). Drift is defined as exposure via the movement of pesticide away from the treatment site. (8) Pesticide exposures are not bound by county lines, so drift could lead to dual county exposure.

Additionally, event rates can differ from illness rates because a pesticide poisoning event can affect more than one person. There were 796 unique pesticide events in Oregon from 2011 to 2020, leading to an event rate of 19.8 per 100,000 population based on the 2015 estimated Oregon population. (9) The overall rate of acute pesticide-related illness in Oregon was 24.7 per 100,000 population. Notable events impacting these rates are:

- Highway 36 Corridor Exposure Investigation
- Curry County PARC incident, and
- Coos Bay Children's Academy Exposure.

The PARC biennial reports discuss these events and others in greater detail. In counties with fewer than sixteen cases, rates were unstable. Unstable rates also occurred because of small population sizes in rural counties. For example, Wallowa County has one case, but the small population size misleadingly inflates the rate.

Figure 2: Reported illness case rate by Oregon county, 2011–2020 (n = 932*).



* Rate calculated using 2015 Census county population data; figure does not include 60 cases where the county of exposure was unknown.

Location of pesticide events and exposures

Table 6: Intended and unintended pesticide releases and cases of acute pesticide-related illness by site category, 2011–2020.

Site category	Number of pesticide releases by site	Cases of acute pesticide-related illnesses by site	Percent of pesticide releases by site	Percent of acute pesticide-related illnesses by site
Private residence	511	682	64.2%	68.8%
Agricultural (farms, nurseries, forests, etc.)	131	77	16.5%	7.8%
Unknown	57	45	7.2%	4.5%
Other	38	42	4.8%	4.2%
Non-manufacturing commercial facilities	31	54	3.9%	5.4%
Institutions (residential institutions, schools, day cares, prisons, hospitals, etc.)	16	70	2.0%	7.1%
Manufacturing	10	19	1.3%	1.9%
More than one site	2	1	0.3%	0.1%
Not applicable	0	2	0.0%	0.2%
Total	**796**	**992**	**100.0%**	**100.0%**

A single pesticide release can result in acute pesticide-related illnesses in multiple people. A considerable proportion of both pesticide releases (64.2%) and exposures (68.8%) occurred in residences. This is similar to the percentages reported in 2009–2011, which were 61.8% and 68.5% respectively. For this table, residences include:

- Single-family homes
- Manufactured homes and trailers
- Multi-unit housing (apartments, multiplexes, residential hotels that rent monthly)
- Labor housing, and
- Other private residences.

PEST adopted site categories from the NIOSH Standardized Variables for State Surveillance of Pesticide-Related Illness and Injury (3) aggregation categories.

Activities when exposed

The most common activity during non-work pesticide exposures was outdoor activities that did not involve pesticide application. This typically involves the chance exposure of bystanders (for example, working in the yard while a neighbor sprays pesticides or sitting on the porch with potential exposure to aerial application drift). This shows the need for people to be aware of pesticide applications nearby. Also, the need for pesticide applicators to ensure they:

- Tell people in the area
- Follow best practices, and
- Follow what it states on labels and instructions.

Please note that some of the non-work activities have codes that imply work exposure, such as routine work activity. This may be the result of exposures at workplaces. However, they do not fit the criteria of work-related per Appendix A of the NIOSH SENSOR Standardized Variables (3).

Table 7: Non-work acute pesticide-related illnesses activities accompanying exposure, 2011–2020 (n = 797).

Reported activity accompanying exposure	Number	Percent
Routine outdoor activities that do not involve pesticide application	259	32.5%
Applying pesticide	239	30.0%
Routine indoor activities that do not involve pesticide application	200	25.1%
Unknown	55	6.9%
Routine work activities that do not involve pesticide application (includes exposure to field residue)	19	2.4%
Application to self or another human of a pesticide intended for use on human skin, hair, or clothing	11	1.4%
Mixing or loading pesticide	6	0.8%
Transport or disposal of pesticide	3	0.4%
Combination of activities	3	0.4%
Repair or maintenance of pesticide application equipment	1	0.1%
Emergency response	1	0.1%
Total	**797**	**100.1%***

* Total not equal to 100.0% due to rounding.

Table 8: Work-related acute pesticide-related illnesses activities accompanying exposure, 2011–2020 (n = 164).

Reported activity at work	Number	Percent
Routine work activities that do not involve pesticide application (includes exposure to field residue)	75	45.7%
Applying pesticide	49	29.9%
Mixing or loading pesticide	12	7.3%
Routine indoor activities that do not involve pesticide application	9	5.5%
Transport or disposal of pesticide	6	3.7%
Routine outdoor activities that do not involve pesticide application	5	3.0%
Combination of activities	3	1.8%
Unknown	3	1.8%
Repair or maintenance of pesticide application equipment	1	0.6%
Application to self or another person of a pesticide intended for use on human skin, hair, or clothing	1	0.6%
Total	**164**	**100.0%**

The activity with the highest portion of work-related pesticide exposures is routine work not involved with pesticide activity. This includes exposure to field residue (residual pesticide on crop surfaces). This data shows that bystander exposure continues to be an issue in the workplace. Likewise, exposures may be due to a lack of communication about when and where pesticides are applied. Applying pesticides accounts for the second-highest number of reported activities at work during the time of exposure.

Target of application events

Table 9: Reported intended application targets for 2011–2020 unique events (n = 796).

Intended application target	Number	Percent
Building treatment (space, structure, surface)	208	26.1%
Unknown	139	17.5%
Landscape or ornamental	80	10.1%
Undesired plant	79	9.9%
Crops	78	9.8%
Not applicable (no intended target, accidental release)	60	7.5%
Forest	42	5.3%
Other	29	3.6%
Human (skin, hair or clothing)	26	3.3%
Veterinary - domestic	24	3.0%
Bait for rodent, bird, or predator	12	1.5%
Pools (swimming pools, spas, jetted bathtubs, hot tubs, fountains)	6	0.8%
Veterinary - livestock	5	0.6%
Community-wide application target	4	0.5%
Wood product	4	0.5%
Total	**796**	**100.0%**

The most common intended application target was building treatments. This shows there is ample room to:

- Improve communication between applicators and building occupants,
- Assure applicators follow best practices, and
- Assure applicators follow labels and instructions.

The second most common intended application target was unknown.

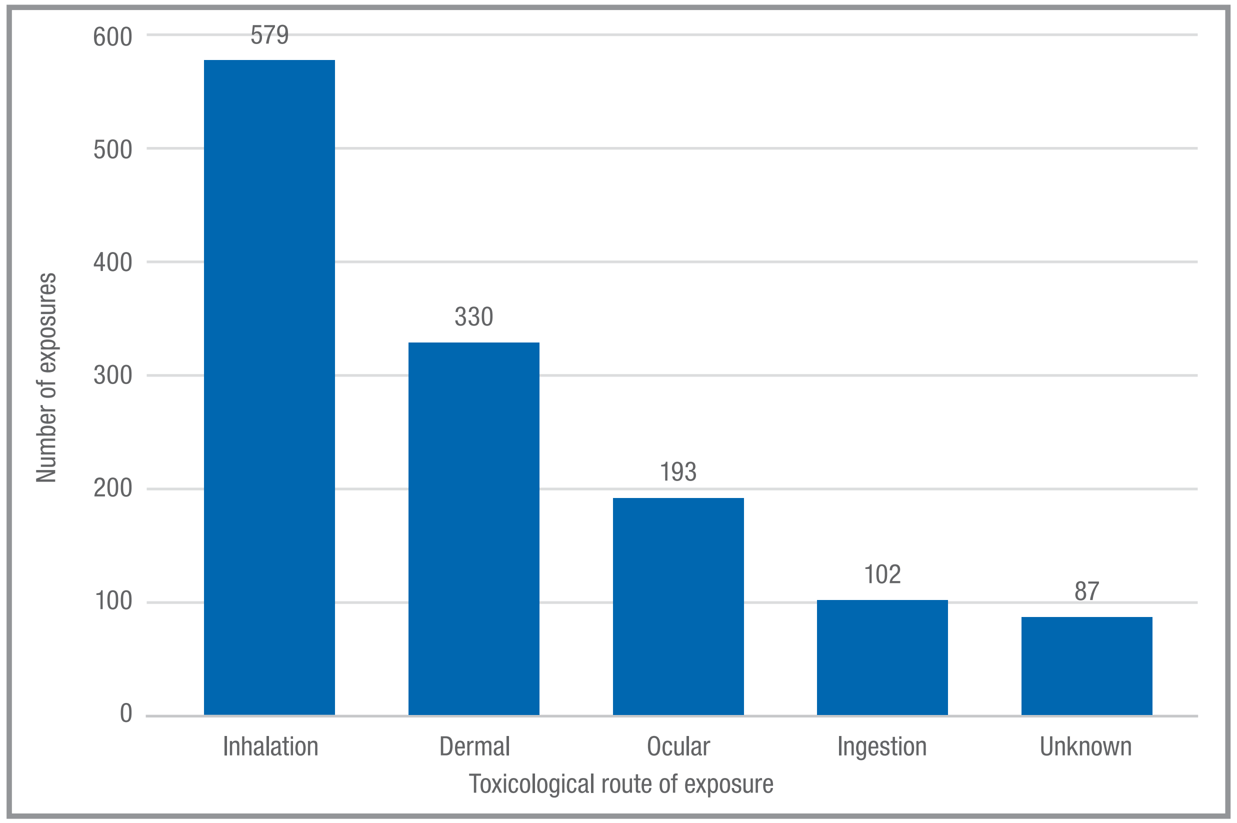
Routes of exposure

Knowing the route or routes of exposure is important to:

- Connect the toxicity of an active ingredient to the symptoms experienced, and
- Medical treatment, since symptoms may be delayed, or missed during a clinical examination, or both, if the pesticide is absorbed through the skin or ingested.

Figure 3 describes the reported routes of exposure. The total number exceeds the number of cases as a person can become exposed to a pesticide through more than one route of exposure.

Figure 3: Reported toxicological routes of exposure to acute pesticide-related illnesses, 2011–2020 (n = 1,291*).



* A person can be exposed through more than one route into their body.

The most common route of exposure was through inhalation, as in the 2002–2007 descriptive report.

Type of exposure

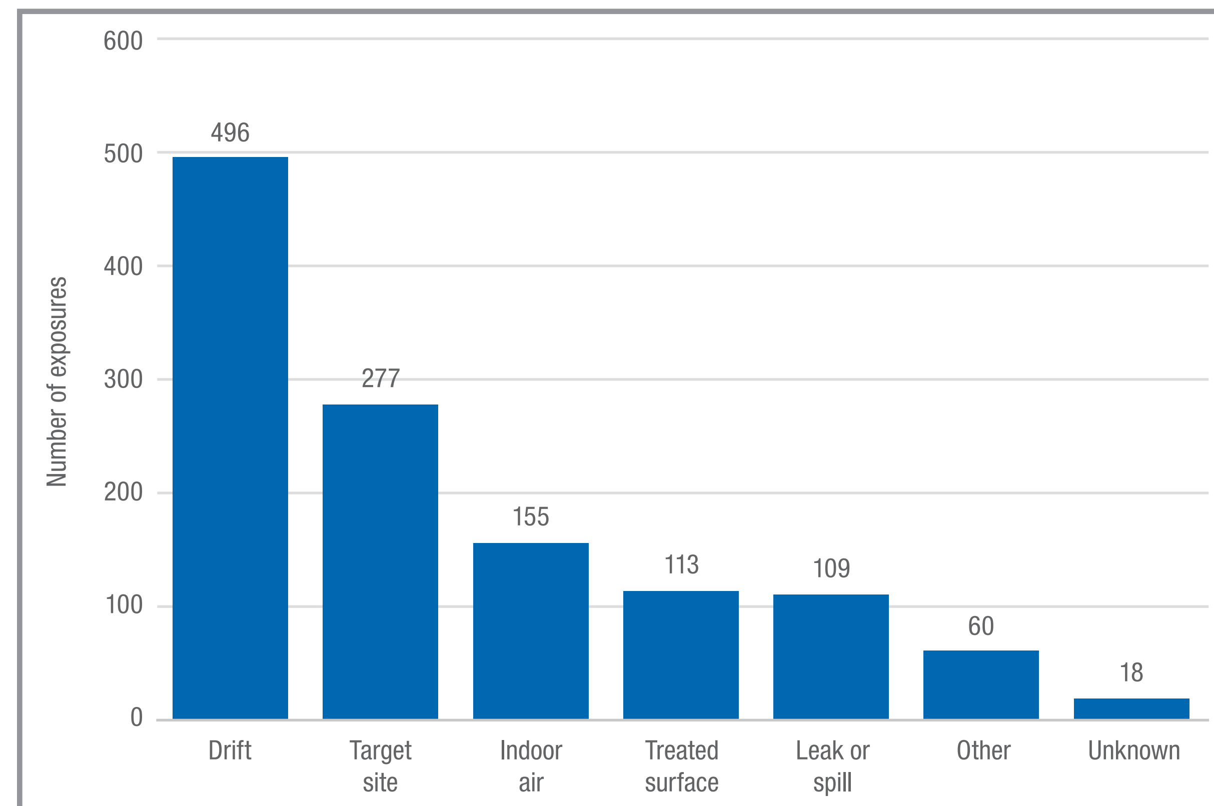
For each case, PEST attempts to track and classify the type of exposure that accompanies reported symptoms. (Figure 4) Understanding the type of exposure is important for:

- Finding trends, and
- Assessing the pathway of association between the pesticide event and the person's reported symptoms.

PEST categorizes these types of exposure according to NIOSH's exposure descriptions (3):

- Drift
- Target site
- Indoor air
- Treated surface
- Leak or spill
- Other exposure methods, or
- Unknown.

Figure 4: Reported types of exposure, 2011–2020 (n = 1,228*).



* A person can have more than one exposure type.

Drift was the most common exposure type, then the target site and then indoor air. As shown by this graph and other data previously in this report, drift is a large issue for acute pesticide-related illnesses.

Contributing factors of exposure

The 2002–2007 descriptive analysis noted that a limitation of the analysis was the inability to assess data on what human factors led to exposures. This led OHA, in consultation with PARC, to define "contributing factors" for use by OHA and partner state agencies that investigate pesticide exposures:

- Oregon Department of Agriculture
- Oregon Occupational Safety and Health Administration
- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife

The creation of the contributing factors field has aided in removing this limitation for analyses. This field allows agencies to track information on factors that may:

- Contribute to exposure, and
- Be useful for developing intervention strategies.

Contributing factor data were sparse from 2011 to 2013, so PEST included only data from 2014 to 2020 in this table.

Table 10: Contributing factors for acute pesticide-related illnesses, 2014–2020 (n = 1,141*).

Contributing factor	Number
Drift	184
People were in the treated area during application	114
Notification or posting lacking or ineffective	107
Unknown	103
Decontamination not adequate or timely	86
Early re-entry	75
Spill or splash of liquid or dust (that does not involve application equipment failure)	72
Required respirator not worn or was inadequate	62
Inadequate ventilation of treated area before re-entry	59
Required eye protection not worn or was inadequate	42
Other required personal protective equipment not worn or was inadequate	35
Intentional harm	35
Applicator not properly trained or supervised	34
Excessive application of pesticide	32
Application equipment failure	30
Pesticide stored within reach of child or other improper storage	25
Required gloves not worn or were inadequate	21
Label violations not otherwise specified	10
No label violation identified but person still ill or exposed	7
Use of illegal pesticide or illegal dumping of any pesticide	4
Mixing of incompatible products	4
Total	**1,141**

* Total number more than the number of cases because each case can be coded for up to five contributing factors.

The top three most common contributing factors, in order, were:

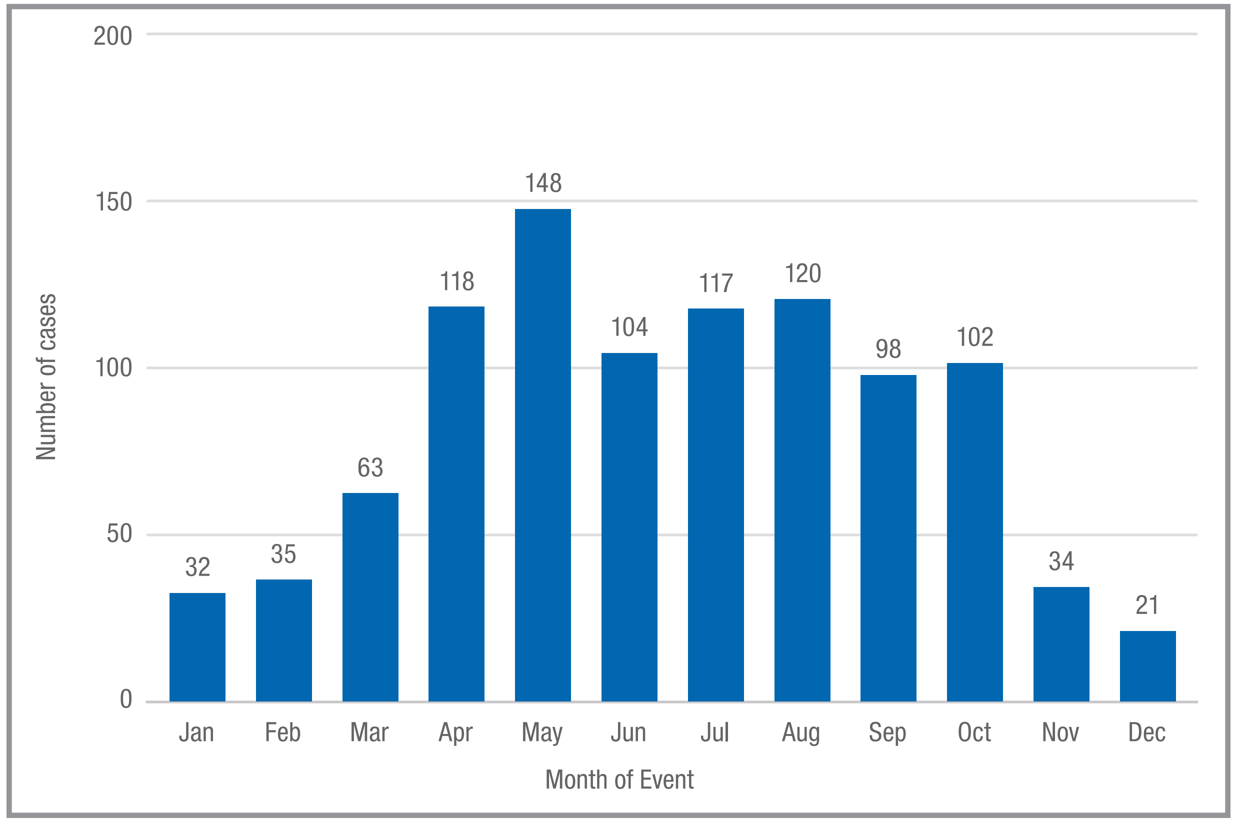
1. Drift
2. People in the treated area during application, and
3. Notification or posting was lacking or ineffective.

OHA also analyzed intent in this report. Most pesticide exposures were not intentional. However, some incident exposures were intentional. Of the 992 cases, PEST classified 36 cases (3.6%) as intentional, which include:

- Suicides and suicide attempts
- Self-harm
- Tampering, and
- Assault cases.

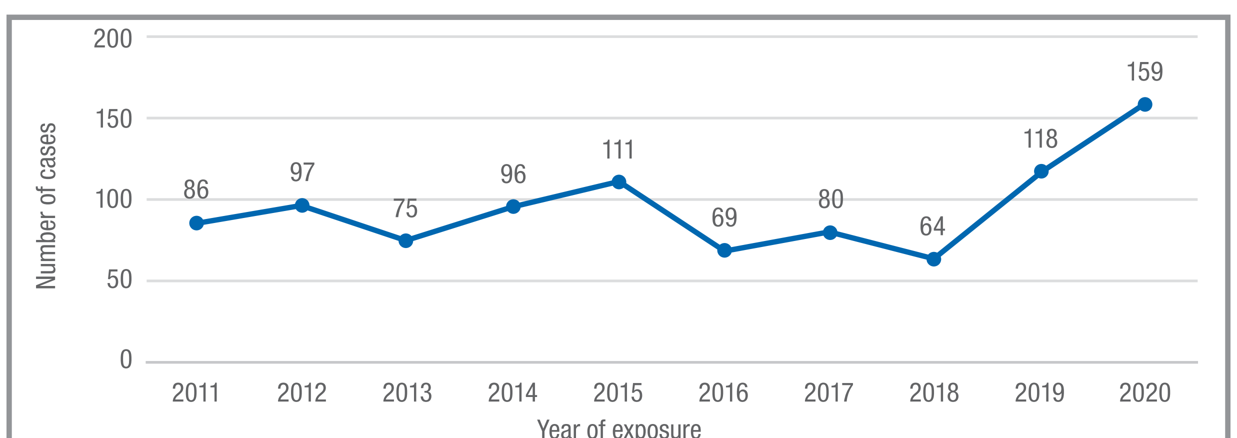
Months and years of exposure

Figure 5: Number of acute pesticide-related illness cases by month of the event, 2011–2020 (n = 992).



Pesticide illness cases increased seasonally on average, with higher numbers of cases in spring, peaking in May, and in summer. This may be the result of increased agricultural activity in those months. Additionally, many insects that can be pests are more active in warmer months.

Figure 6: Cases of acute pesticide-related illnesses by year of exposure, 2011–2020 (n = 992).

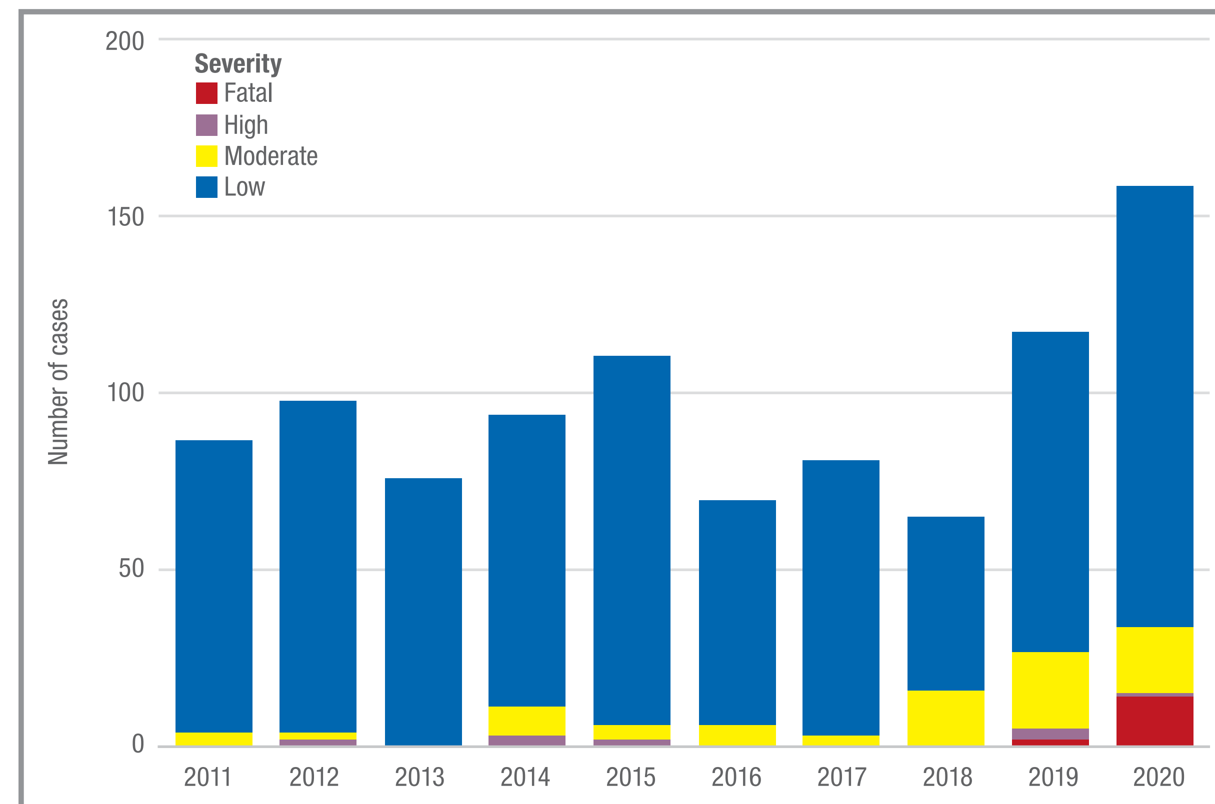


API cases increased in 2012, 2014, 2015, 2017, 2019 and 2020. Starting in 2019, cases of API show a sharply increasing trend. It is unclear what has driven this trend. PEST was able to complete more rigorous follow-ups on cases in 2019 and 2020. This may be due to an increase in investigative resources. In these years, PEST also started getting case reports from previously unutilized sources:

- Near-real-time emergency department, and
- Urgent care clinic records from the OHA ESSENCE system.

There was also an increase in self-harm and suicides in 2019 and 2020. Additionally, some disinfectants are pesticides. Therefore, items used to disinfect surfaces for COVID-19 may drive some of the 2020 numbers. An analysis of 2020 and 2021 disinfectant exposures compared to previous years may help prove or disprove this hypothesis. When controlling for new data sources, intentional exposures and disinfectants, 2019 and 2020 case numbers are closer to numbers reported in previous years. Please note, that this data may not capture all cases of API, as sometimes people report exposures years after they occurred, or agencies get contact information for those exposures later. This may be especially true for 2020 data since OHA expected more reports of 2020 exposures in 2021. Analysis of these data will be in a future report.

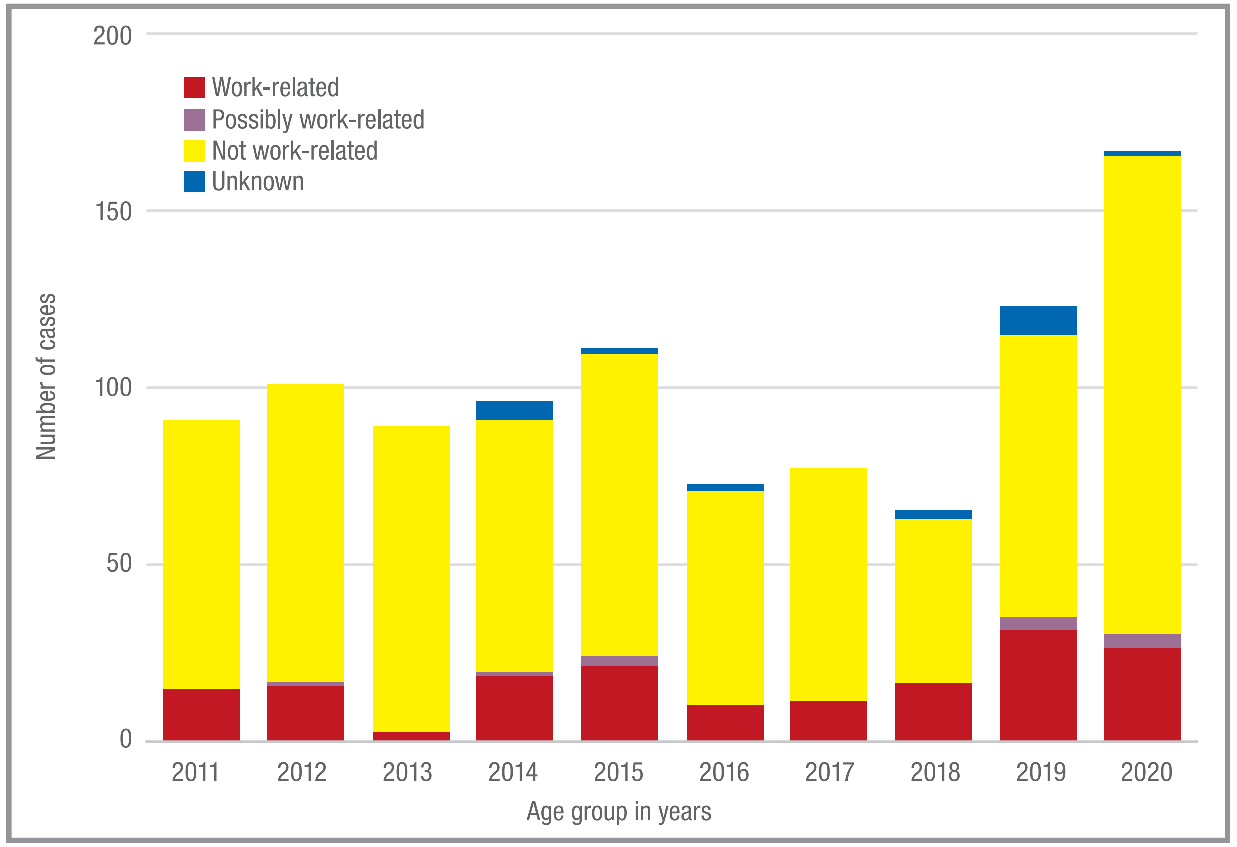
Figure 7: Acute pesticide-related illnesses by year ranked by severity, 2011–2020 (n = 986*).



* Severity was not assessed for six cases.

2019 and 2020 saw upticks in moderate severity, high severity, and fatal cases. 2020 had the highest number of fatal cases. All fatal cases in this report were the result of self-harm or apparent self-harm.

Figure 8: Cases of acute pesticide-related illness stratified by work-related and non-work status of exposure, 2011–2020 (n = 992).



In all years, non-work cases made up most pesticide exposures. Since most pesticide exposures are not work-related, there is a need to ensure the public is aware of:

- Proper pesticide storage
- Proper pesticide use and application
- Effects that pesticides can have on their health, and
- Who to contact when pesticide exposure occurs.

It is also important to be aware that improper use of pesticides can affect off-target organisms in the environment (that is, desirable plants, insects, fish, etc.). Reading and following the pesticide container label can:

- Help identify the relevant pest target, and
- Reduce the wider unnecessary spread of pesticides.

Initial source of the report

Table 11: Initial source of report for acute pesticide-related illnesses, 2011–2020 (n = 992).

Source	Number	Percent
Poison control center	499	50.3%
Report or referral from governmental agency	387	39.0%
ESSENCE	36	3.6%
Physician report	27	2.7%
Unknown	21	2.1%
State health department	13	1.3%
Self-report	4	0.4%
Other health care provider report (including emergency room or hospital report)	3	0.3%
Co-worker report	2	0.2%
Total	**992**	**100.0%**

Various sources report incidents of pesticide exposure to PEST. Table 11 shows the source that initially notified the PEST program of a case. Oregon state law (ORS 433.004 and 433.006) requires health care providers to report, within 24 hours, cases of suspected or confirmed acute pesticide-related illnesses directly to:

- The PEST program, or
- A local health authority (which they send to PEST).

Timely reporting of API cases is essential to prevent added injuries. Furthermore, prompt reporting of cases can have policy and regulatory implications. As a result of reporting, PEST can refer the case to the state interagency Pesticide Analytical and Response Center (PARC) with the permission of the affected person. Collaboration between PEST and PARC can lead to regulatory or policy changes about the purchase and use of pesticides.

OHA added Oregon's syndromic surveillance system, the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE), as a source of reports in 2019. There were 36 cases reported from ESSENCE. This added reporting system may have contributed to the increase in cases in 2019 and 2020 by capturing previously unknown information. However, when controlling for ESSENCE reports, 2019 and 2020 still show higher numbers of acute pesticide-related illnesses compared to previous years.

Table 12: Functional classes of pesticide products associated with API cases, 2011–2020.

Functional class of product	Number	Percent
Insecticide	419	42.2%
Herbicide or algaecide	306	30.8%
Disinfectant	65	6.6%
Fungicide	54	5.4%
Multiple	31	3.1%
Insect repellent	26	2.6%
Unknown (functional class undetermined)	26	2.6%
Other (plant growth regulators, etc.)	19	1.9%
Insecticide and fungicide	15	1.5%
Insecticide and herbicide	11	1.1%
Rodenticide	7	0.7%
Fumigant	4	0.4%
Herbicide and fungicide	4	0.4%
Insecticide and insect repellent	4	0.4%
Insecticide and other	1	0.1%
Total	**992**	**100.0%**

Table 12 shows functional classes of pesticide products involved in the 992 pesticide cases reported from 2011 to 2020. PEST classified products according to their intended functional class, not how the product was being used or misused. PEST classified most products involved in pesticide exposures as insecticides. When the product did not have an associated product type entered, PEST used the active ingredients to find the most likely product type.

Findings

A. Acute pesticide-related illnesses started to increase steeply since 2019, with increasing severity and fatalities.

This increase in cases may be due to an increase in reporting, as PEST began getting cases from ESSENCE in 2019. The increase in high severity and fatal exposures, especially in 2020, is the result of more self-harm and suicide cases. All fatal cases in this report were the result of self-harm or apparent self-harm. Oregon has the highest prevalence of mental illness among youth and adults in the nation. (10) This highlights the need for programs and agencies to collaborate on prevention and intervention efforts. The World Health Organization has identified five key components to preventing pesticide-related suicides:

1. Review and recommend improved pesticide policies
2. Implement sustainable surveillance of pesticide data
3. Improve the medical management and mental health care of people with pesticide poisoning
4. Provide training at various levels, and
5. Develop or strengthen community programs that minimize the risks of intentional and unintentional pesticide poisoning. (11)

Their report presents three case studies that test this intervention:

1. In China, combining household pesticide lockboxes with community education about suicide prevention
2. In India, central communal storage of pesticides, and
3. In Sri Lanka, safely securing pesticides within households. (11)

The main findings of these case studies are that restriction of pesticides alone is not an adequate suicide prevention method, and must be paired with community leader involvement, community education, and outreach. (11) It is unlikely that all pesticides used as suicide methods will be banned. Therefore, Oregon communities must be aware of the dangers of pesticides and provided with resources if they or someone they know is struggling with suicidal thoughts or tendencies.

B. Hispanic people are overrepresented in pesticide exposures in Oregon.

This is the first PEST analysis to address race and ethnicity. Ethnicity data showed that Hispanics were overrepresented in PEST data, accounting for 21.5% (n = 130) of the exposures, compared to the 12.3% estimated Hispanic population in Oregon in 2015. Per the American Industrial Hygiene Association, Hispanics are overrepresented in agriculture, overall, one of the most hazardous industries. (12) Ensuring that pesticide safety information is culturally specific and accessible is essential to reduce this impact. PEST collected no language data for this study period. However, Hispanic farmworkers have reported language as a large barrier to understanding pesticide safety. (13) Companies should ensure that product labels are available in a variety of languages, including Spanish. Additionally, Oregon pesticide education programs should emphasize conducting training in English, Spanish and other languages present in the workforce.

C. Rural counties in Oregon continue to be disproportionately burdened by cases of acute pesticide-related illnesses.

As shown in Figure 2, some populations in rural counties (Tillamook, Coos, and Curry) are disproportionately affected by cases of acute pesticide-related illnesses with >40 cases per 100,000. The high rates for these counties are likely the result of large one-time pesticide exposure events in each county described above. Other rural counties, such as Baker and Morrow counties, show high case rates. However, these rates are not stable due to the small number of cases and small population size. Counties that had 16 or fewer cases had unstable rates. There is no empirical evidence that can show why rural counties are overburdened with pesticide exposures. However, a logical conclusion is that the higher number of agricultural activities occurring in rural Oregon creates more chances for people in those counties to be exposed to pesticides.

D. Residences continue to be where most pesticide exposures occur.

Cases occurring in residences show that a main factor of these exposures was improper application. Other leading causes of these exposures include drift and improper or inadequate personal protective equipment (PPE). Many of these exposures involved pesticides available for purchase by the public, also known as general-use pesticides. These pesticides do not require a pesticide applicator's license for purchase. This shows the need for education for the public on safe pesticide handling. Manufacturers need to ensure effective communication of safe handling and storage information required on the label by law. Also, it is the responsibility of the user to understand:

- Proper pesticide use, and
- The label.

E. Most pesticide exposures are not work-related.

The current study found that most pesticide exposures are not work-related as in the 2002–2007 and 2009–2011 reports. This presents an interesting situation, as workplace exposures are easier to regulate and improve through new policies (for example, recommend enforcement of PPE use). There also tend to be more legal ramifications for violating workplace safety standards. The three most common activities accompanying non-work pesticide exposures were:

1. Routine outdoor activities that did not involve pesticide application
2. Applying pesticides, and
3. Routine indoor activities that did not involve pesticide application.

Considering these factors, OHA needs to better educate the public about:

- Using pest management practices that reduce the amount of pesticide needed, and
- Needing to read and follow safe handling, use and storage information on the label, including required PPE.

Manufacturers can aid in this effort by:

- Providing labels in different languages, and
- Making the print large and interesting.

Since two of the top exposure categories do not involve pesticide application, workers and others who apply pesticides should ensure people nearby know:

- The implications of exposure
- When and where applications are taking place, and
- The time limit for safe re-entry.

Read below about exposures of bystanders that may arise from workplace pesticide applications.

F. Drift is a leading contributing factor to pesticide exposure.

Drift was the leading contributing factor and type of exposure in this study period. Drift can cause injury to people and crops. Drift exposures can also be insidious since those exposed cannot protect themselves, as they cannot predict when drift will occur. Pesticide applicators are responsible for preventing drift. They can do so through measures such as a pre-application assessment of nearby sites that are particularly at risk for drift exposures. These areas include:

- Sensitive crops
- Organic fields
- Beehives
- Bodies of water
- Shallow groundwater
- Homes
- Schools
- Hospitals
- Nursing homes (14)
- Foraging areas, and
- Subsistence lands.

The Pesticide Environmental Stewardship website lists resources for applicators on the recognition and control of drift. Some tips to prevent drift are to:

- Choose a drift-reducing nozzle tip
- Avoid adverse weather conditions (for example, wind speeds, hot temperatures, temperature inversions, etc.), and
- Use drift-reduction technology such as spray shields and lower the boom height. (14)

Use of these can help protect the health of Oregonians.

Policy recommendations

Policy recommendations are to enhance and improve enforcement of existing policies to:

- Help prevent pesticide exposures
- Help restrict applications to the needed areas
- Require applicators to educate others about proper re-entry times
- Provide clear guidance on required signage (size and distance)
- Provide culturally specific language in labeling and signage to reduce inequitable access to pesticide exposure safety information
- Educate health care providers on how and when to report pesticide exposures to reduce underreporting of exposures, and
- Require the use of drift prevention technologies and practices to reduce drift-related cases, which make up a sizable proportion of PEST cases.

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Appendix A

Qualitative Report of PEST Cases Contributing Factor Narratives from 2014–2020

Background

PEST data contain a contributing factors variable with preset options and a narrative field as part of the SENSOR standardized variables. PEST uses the narrative field to describe contributing factors in greater detail. This adds information that may affect or aid the interpretation of the preset coding options. (3)

Methods

Out of 992 cases, 192 had a contributing factors narrative filled out. PEST further limited these data to contributing factors narratives that described the events that led to exposure, PEST removed narratives that only stated:

- Product names
- Unknown case sites, or
- References to equipment with no clear identification of any malfunctions or operator error (for example, "Terro Ant Killer Spray," "Tractor with boom sprayer," "unknown case site," "Raid bug bomb").

Thus, the final total of contributing factors narratives included in this analysis was 188. PEST evaluated the data to create thirty-four qualitative codes. PEST treated each code as equally specific and important.

Limitations

Contributing factors data were sparsely available in the 2011–2020 PEST data. All narratives come from 2014–2020 data. This is when PEST began completing the narrative field more consistently. Some contributing factors in narratives are the same because they are of the same event. Events that caused cases in multiple people may be more heavily weighted in this sample.

Results

The most commonly occurring codes were:

- Drift (27 occurrences); drift refers to narratives that mention the drift of pesticides.
- PPE (23 occurrences); PPE refers to narratives that mention PPE:
  - » Lack
  - » Inadequacy, and
  - » Misuse.

  This code does not include narratives that don't mention whether PPE is worn.
- Harm (21 occurrences); harm refers to narratives that imply misuse of pesticides in cases of self-harm, suicide and assault.

Discussion

Drift was also the most coded contributing factor using the preset codes in the contributing factors field (Table 10). School and drift were commonly coded together. Preventing or reducing drift could reduce the amount of acute pesticide-related illnesses in Oregon. The Environmental Protection Agency (EPA) introduced a solution to drift known as drift reduction technology (DRT), which includes:

- Drift-minimizing nozzles
- Spray shields, and
- Use of chemicals to minimize drift. (15)

Pesticide applicators should be educated on DRT. Companies that specialize in pesticide application should prioritize the use of DRT-certified application tools to reduce drift exposures in Oregon.

Next, proper PPE use may prevent the harmful effects of acute pesticide-related illnesses in Oregon. Many narratives that PEST coded for PPE mentioned the use of inadequate or ill-fitting PPE. Potential solutions would be to have more:

- Easily understandable labels, and
- Education about the dangers of using pesticides without adequate PPE.

Workplace exposures because of inadequate PPE also show room for improvement in education and enforcement of PPE use in the workplace.

Harm is a more difficult area for prevention and reduction due to intentional, rather than unintentional exposures. Also, the hierarchy of controls becomes less applicable. Harm was commonly coded with ingestion in cases involving suicide. This is because of the increase in self-harm and suicide through sodium nitrite ingestion. Research shows this is becoming a more common way for persons to commit suicide. (16) Sodium nitrite is easy to purchase online. It has also been made known as a method for suicide through suicide forums. (16) The influx of these cases demonstrates the need for:

- An increase in mental health outreach in Oregon, and
- Coordination between OHA and county health departments to provide appropriate resources for those at risk for self-harm or suicide.

Recommendations

This brief report only touches on one qualitative aspect of acute pesticide-related illnesses in Oregon from 2011 to 2020. It does not fully explain all contributing factors of acute pesticide-related illness in Oregon. Fields similar to the contributing factors narrative field (that is, free text response fields) should be qualitatively coded in the future to find more trends. This includes fields such as:

- Exposure communication (CEXPOCOMM)
- Event narratives (EVENTNARR)
- Health narratives (CHEALTHNARR)
- Occupational narratives (OCCNARR), and
- Diagnosis (CDIAGNOSIS).

This qualitative process should also include multiple coders to ensure there is agreement on codes. Further research can help show more specific details on what factors contribute to acute pesticide-related illnesses in Oregon. It can also provide insight into potential effective prevention interventions.

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