Review of Agricultural Spray Notification Systems

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Abstract

Farmworker exposure to agricultural pesticide drift is a high priority concern for pubic health. We conducted a systematic review of pesticide spray notification systems throughout the world. Telephone interviews, emails, and program websites were used to document residential and commercial notification systems used in New Zealand, the United Kingdom, China, Canada, and the United States. Direct notification methods such as sign posting, telephone calls, and personal visits have been used for many years in the agricultural industry. Recent advances in mobile communications technologies, precision agriculture, and farm data analytics have made remote notification methods more user-friendly. Assuming that costs, work burdens, and legal liabilities are minimized, a remote farm-to-farm spray notification system appears to be a promising means by which to prevent farmworker exposure to pesticide drift. Implementation of such agricultural workplace spray notification systems will require engagement of key stakeholders, including pesticide applicators, farm owners and managers, farmworker groups, research and education communities, and state agencies.

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Introduction

Pesticide drift, or the off-target movement of pesticides, represents a key cause of not only crop damage and contamination but also occupational and bystander illness. Nationally, drift has been shown to account for 37-68% of pesticide illnesses among United States (US) agricultural workers (CDPR 2008; Calvert 2008). Compared to residential exposure to pesticide drift, illness from occupational exposure tends to be reported with similar frequency but higher severity (Lee 2011). The off-target movement of pesticides in Washington State is a continuing health concern for agricultural workers and residents alike (Lu 2000; Koch 2002; WA DOH 2010; 2013). In a 2010 report the Washington Department of Health (WA DOH) identified "inadequate communication between applicators and other workers or neighbors" as a key preventable factor that contributed to pesticide drift events (WA DOH 2010). A May 12, 2014 press release issued by WA DOH indicated that 15 pesticide drift events resulted in approximately 60 people, mostly orchard workers, becoming ill over a two-month period, which equaled the total number of cases in an average year (WA DOH 2014). One of these events involved 20 farmworkers in a cherry orchard and highlighted a gap in worker notification requirements (Calvert 2015). In response to the spike in work-related drift exposure incidents, WA DOH renewed its call for improved communication between farms, handlers, and workers as a high priority issue for prevention. Currently, there is no system in place to notify workers or employers of applications that will be taking place on adjacent property.

Recent advances in mobile and web-based technologies have increased capacity for rapid, one-way public notification systems that businesses, government agencies, educational institutions, and many private groups are utilizing to enhance their emergency preparedness by communicating actionable risk (ANSI-HSSP 2008; Wood 2012). Examples of this are messages receivable after voluntary self-subscription to a notification system that sends automated email or Short Message Service (SMS) messages. Such notifications are not only crucial for life safety during events such as severe weather, chemical spills, flooding, fires, or evacuation notices, but also have utility in precision agriculture and possibly workplace alerts. The framework for an agriculturally-based electronic notification system already exists to some degree. SMS and email notifications have been used by organizations in New Zealand, the United Kingdom, China, Canada, and the United States. None of these programs has the stated goal of preventing occupational exposure to pesticide drift on adjacent land, but many possess the potential to be modified to serve this purpose. We conducted a review to understand historic and current uses of spray notification systems and their applicability to occupational settings.

Methods

We identified two pesticide spray notification systems in Washington State and four agriculturally-based pesticide notification systems in other parts of the world: SprayWatch (SprayWatch 2014), Spraydays (ADAS 2005), DriftWatch (FieldWatch 2014a), and the Pesticide Eco-Alternatives Center (PEAC 2009).

Using resources available from program websites or informational calls and emails, we recorded basic information about year of origin, current use, location, and model type for each system. Additionally, we developed six categories about worker notification to summarize our findings: notification method ('flexibility of method' in Table 1), amount of lead time needed to reassign workers to new job tasks ('minimum lead time'), distance between notifying and notified parties ('between-party range'), information about pesticides applied ('message content about pesticides'), ability to use on a mobile phone for work purposes ('mobile-friendliness'), and cost for a spray notification service ('estimated cost per year').

We defined year of origin as the first year of use, current use as presence or absence of existing operations, and location as the country of deployment. Model type was described as the connection between notifying and notified parties (e.g. applicator-to-farmer, applicator-to-resident, and registry). We defined applicators as the subset of handlers in the act of applying pesticides, farmers as individuals holding on-site farm leadership positions (e.g. owner, manager, or work crew supervisor), and residents as community members living in a nearby agricultural region. The applicator-to-farmer model is preferred for worker notification because it encourages the exchange of spray information between neighboring farms to protect workers. However, no such model exists. Thus, model type for current systems were either applicator-to-resident or registry. We defined the applicator-to-resident model as one in which residential bystanders receive notification from an applicator—or in the case of schools—parents, guardians, and employees receive notification from the school. Registries are broadly defined as systems in which an applicator receives notification based on a list of sensitive individuals or crops nearby.

Subcategories for 'flexibility of method' were voice (call or message), SMS/text message, in-person (visits), and email. Those for 'minimum lead time' were less than 2 hours and greater than or equal to 2 hours. 'Between-party range' was subcategorized as less than or equal to 0.5 mile and greater than 0.5 mile. Subcategories for 'message content about pesticides' were pesticide name, crop sprayed, target pest, pesticide label, signal word, and mixing tank recipe. For mobile friendliness, 'Yes' represented a system that was currently usable via SMS/text or email on a mobile device and 'Possible' represented a system that used only calls or other non-mobile forms of communication, such as in-person visits, in-writing, or posting. 'Estimated cost per year' was defined as the possible cost to applicators according the following subcategories: under $100, $100-200, more than $250, or undefined.

As described in a United Kingdom study (ADAS 2006), spray notification methods can be grouped into two broad categories: property-based direct notification and field-based remote notification. Property-based direct notification describes a system in which applicators notify residents of each adjacent property via direct contact, typically in writing such as a leaflet, a personal telephone call, or an in-person visit. Field-based remote notification involves a system in which applicators create a notification for a field, but do not have direct contact with residents. Residents of any adjacent properties are either notified automatically or seek the information themselves, typically via the internet, automated telephone messaging, or public rights of way (PROW) notice boards posted in visible locations around sprayed fields. Distinctions are also made between notification and disclosure. Notification was defined as supplying information *before spraying* about the proposed field location, pesticide product, and/or date. Disclosure was defined as fulfilling requests from the public *after spraying* about the same parameters plus other factors such as application rates or weather conditions (ADAS 2006).

Findings

Basic information and summaries of worker notification categories for the notification systems are provided below. We describe these systems in chronological order based on year of origin. Briefly, the systems originated between 1994 and 2009 in New Zealand, the United Kingdom, China, Canada, and the United States. No systems fit the ideal between-farm worker notification model described as applicator-to-farmer. Notification methods were largely electronic and consisted of various combinations of telephone messages, emails, SMS, and sign posting. The definition of proximity varied from shared borders only to county or state.

Sensitive Persons – Washington. Since 1994, the Washington Pesticide Application Act has allowed pesticide-sensitive individuals in Washington to register annually with the state and be contacted by applicators in writing, in person, or by telephone at least two hours before making landscape or right-of-way applications near their homes. This applicator-to-resident model requires notification of application date and time but not information about the pesticide applied. Applicants must provide their name, street address, and telephone number and the same information for each property adjacent to their place of residence. For right-of-way applications, adjacent property is defined as that portion of the property within one-half mile of the applicant's place of residence. All land listed constitutes the pesticide notification area for that applicant (RCW 17.21.420; 17.21.430).

SprayWatch – New Zealand. SprayWatch is an applicator-to-resident model that was developed in 2002 to help New Zealand applicators meet legislative requirements and allow residents to take preventative measures such as closing windows, locking up animals, avoiding hang-drying clothes outside, and covering vegetable gardens. For example, Rule 13 in the Bay of Plenty Regional Air Plan specifies that "the owner/occupier or agent must notify the occupier of any adjoining properties within 50 [meters] of that agrichemical use" (Environment Bay of Plenty 2003). The rule requires notification at least 12 hours before spraying about site and date of application; name and type of chemical; and applicator name, address, and phone number. Property owners or spraying contractors add their agricultural land and neighbor contacts into a system that uses personal identification numbers (PINs) to protect privacy. The system automatically sends a message to each contact number at a time and in a format—voicemail, text, or email—specified beforehand by the neighbor. Calls cost NZ$ 1.32 per recipient after a one-time activation NZ$ 8.00 charge for each new property. If a farmer makes 7 sprays to a property with 5 recipients, for example, the cost of notification is approximately NZ$ 47.00 per year (Spraywatch 2014).

Spraydays – United Kingdom (UK). In 2005, the Royal Commission on Environmental Pollution (RCEP) of the UK released a report which, among other pesticide safety measures, called for pesticide use reporting and a pilot study to "explore how residents living next to farms can be notified in advance of pesticide use" (RCEP 2005). The pilot study tested several pre-application notification methods for residential properties within 25 meters of treated fields (i.e. applicator-to-resident model). One farmer used flags around the perimeter of a treated field as a visual method, two delivered written leaflets to nearby residences, three recorded telephone messages, and four used internet registration with automatic emails or text messages. Five farmers tested the use of public access point notices. After the field trial, investigators conducted telephone interviews to document the impressions of the farmers and nearby residents about the various pre-application notification practices (ADAS 2005).

A second report reviewed costs associated with the establishment of buffer zones, spray notification, and other changes in pesticide use practices (ADAS 2006). According to the report, approximately 11.5 million hectares of UK land was sectioned into 1.4 million fields, 25% of which shared a border with residential properties. This meant nearly 2 million residents lived on 650,000 properties that bordered potentially sprayed land. Assuming 100% public registration, farmers would have needed to make 3.1 million direct notifications and 1.3 million remote notifications per year. As a result, the most expensive method of spray notification would have been recorded telephone messages (£17 million) followed by leaflets (£16 million), local plans such as newspaper advertisements or public notices (£9.9 million), and internet registration with text or email (£2.9 million). The average estimated cost per farm for the internet registration option was £107 per year.

DriftWatch – United States (US) and Canada. Email-based spray notification about sensitive crops has occurred in the US since 2008, when researchers at Purdue University created a program that

has now expanded to twelve states in the US and one province in Canada. Like SprayWatch and Spraydays, DriftWatch utilizes remote notification. Unlike those programs, DriftWatch fits the registry model type since applicators, not residents or workers, are notified. It is a voluntary web-based program that allows farmers to identify, map, and communicate the location of high-value, pesticide-sensitive specialty crops such as tomatoes, fruit trees, grapes, hops, and apiaries in an effort to prevent or manage drift (FieldWatch 2014a; FieldWatch 2014b).

To register a producer location, an individual must own or manage a commercially produced specialty crop that covers at least one half-acre and submit basic information about the crop type, year, state, growing conditions, and active dates. A producer then defines the location of a sensitive crop site as a polygon by tracing the perimeter using a Google Maps™ application programmable interface (API). Owners and managers of registered sites, whose approvals need to be renewed annually by a State Data Steward, are also eligible to purchase DriftWatch "NO DRIFT ZONE" signs for posting around the perimeter (FieldWatch 2014c). Registered applicators can: (1) opt into receiving email notifications about new producer locations in their spray area based on one of four proximity settings (state/province, specific counties, custom area, or no alerts) and (2) view specific information about approved sites by clicking on balloons or pins available in the API polygons. Applicators may also search by crop types or growing conditions (FieldWatch 2014d).

In addition to registered producers and applicators, state departments of agriculture implement, administer, and support DriftWatch financially. Each department appoints an employee to be the State Data Steward who verifies accounts. Any individual may register for a free account, but the tool is intended for producers and applicators of commercially grown crops not homeowners (FieldWatch 2014e). Although individuals from the public may create a non-member user account at no cost, different membership-level fees increase access: member states ($24,500 first year, $6,500 annual maintenance), user members ($50 for producers, $100 applicators), licensee members ($500 for data distributors), sponsoring members ($10,000-50,000 depending on gross revenue), and associates ($100 for individuals) (FieldWatch 2014f).

Pesticide Eco-Alternatives Center (PEAC) – China. PEAC, a Chinese non-governmental organization whose mission is to promote safe and limited use of pesticides, successfully distributed over 10,000 SMS messages to farmers and rural residents during a pesticide safety awareness training campaign in 2009. The PEAC notification system fits the registry model, as it does not currently function as a pre-spray notification service for residents. PEAC members themselves did not write the software needed for the project and instead relied on a service designed by China Mobile Communications™, which allowed companies to send SMS messages to target audiences. The mobile service charged monthly fees based on the number of text messages successfully transmitted (PEAC 2009).

Schools – Washington. Since 2009, day care centers and schools in Washington must follow specific notification and posting rules when using pesticides. Written notification describing a school's pest control policies should be provided to interested student guardians and employees. In this applicator-to-resident model, each school is expected to establish a system that notifies guardians and employees at least 48 hours before an application to school property. Notifications should include the pesticide product name, application date and time, location, pest to be controlled, and the name and phone number of a school contact. The main office of the school, the application site, and primary entry points are required to have signs posted for each school property that is treated. A school must also keep records of all applications to school property (RCW 17.21.415).

Strengths and limitations of existing spray notification systems

SprayWatch. SprayWatch has several strengths and a few limitations. In addition to having a near-optimal notification model and several methods, the program's credibility is accepted by spray contractors and members of the Regional Council because an "audit trail" shows message content and exact delivery times. Using the trail, SprayWatch has resolved all complaints in its 14-year history and has not gone to court. The system helps applicators comply with legal spray requirements, including privacy. Cost is likely the biggest limitation. While NZ$ 47.00 is a modest annual cost of notification for small operations, it can add up quickly for larger operations and spray contractor businesses. As stated by the SprayWatch managing director, "if a contractor has 200 clients and sprays 12 times per year and notifies an average of 4.5 neighbors at an average cost of NZ$ 1-30 per call, the contractor has an annual cost [upwards of] NZ$ 15,000" (SprayWatch 2014). Neighbors typically do not file complaints against each other, but when a complaint is made, the law has a high standard for proving that drift has occurred (SprayWatch 2014).

Spraydays. Despite some resistance to the idea of public spray notification, UK farmers (n =10) who participated in the method trials offered the following impressions: (1) public access notices were largely ineffective and required a considerable amount of work time; (2) internet notification was the preferred method for all four farmers that tried it since it was quicker and more flexible than field notices and leaflets; (3) recorded telephone messages were utilized by only a few neighbors, which demonstrated limited interest; (4) leaflets were considered effective by one of the two farmers who tried it, but they carried a substantial burden in terms of workload; and (5) flagging was seen as simple and straightforward by a farmer who suggested the added workload could be minimized if each farm had one large flagpole instead of many small perimeter flags. The same group of farmers also cited the following reasons for not wanting to adopt spray notification: unnecessarily alarming the public, unpredictability of spray date due to quick changes in weather, limited computer literacy, and increased work burden on those farmers with more residential neighbors (ADAS 2005).

A sample of 393 residents and 13 businesses (n=406) showed that 77% were interested in being informed when pesticides were sprayed on nearby farmland. By far, the preferred method for spray notification was leaflets (66%), but only 20% took any action after being notified. Registering with a dedicated website to receive information by email or text message was the second-most used method (7%). An increased awareness of a particular notification method generated more interest in using that method. Compared to the entire sample population, approximately 10-15% more of the leaflet trial participants preferred leaflets and 10% or more of the internet trial participants preferred the internet option (ADAS 2005). The UK's high population density, which was estimated to be at least one order of magnitude higher than New Zealand, Canada, or Australia, was cited as a reason for increased notification costs (ADAS 2006).

DriftWatch. Recent adoption by several states clearly demonstrates the strength of DriftWatch as a stewardship registry system in terms of growth, membership benefits, and lack of applicator liability. Various membership categories allow different levels of access to the DriftWatch program. Non-member users may access the DriftWatch website at no cost. Registered producers can record sites and purchase signs and registered applicators can receive email notifications. For paying members, the system provides support for participation, database management, data accuracy and integrity, and direct data feed subscriptions to applicators. Regarding liability, the legal opinion that DriftWatch sought found "pesticide labels set the standard of care" and that registration with the service did not increase applicator liability (FieldWatch 2014e). The opinion stated: "So long as an applicator follows label instructions for measures related to avoiding drift, as well as statutes or

regulations related to avoiding drift, an applicator's failure to use DriftWatch should not be [a] stand-alone basis to establish a claim for negligence or gross negligence" (FieldWatch 2014e). As such, the system may assist an applicator with avoiding drift and therefore reduce claims and overall liability, but the "liability related to any single incident remains the same" (FieldWatch 2014e). Another benefit of the system is its ability to assist users without computers or an understanding of the DriftWatch website. State Data Stewards offer assistance with creating accounts and mapping fields. Email is the preferred method of communication, but phone numbers and addresses can be used if someone does not have an email account. Although most states limit producer registration to commercial crops, hobby apiarists are generally approved (FieldWatch 2014e).

As it relates to worker notification, DriftWatch has some potential limitations. Notification does not follow the applicator-to-farmer or applicator-to-resident model, and as a result, does not necessarily occur before the time of application. Applicators are encouraged to engage in personal dialogue by taking advantage of producer contact information available from the system (FieldWatch 2014e). In the same manner that use of DriftWatch would not increase applicator liability, it might not decrease liability either. However, it is possible that "an applicator may effectively argue its use of DriftWatch prior to application is evidence, as part of a broader evidentiary showing of due care...that the applicator met the standard of care" (FieldWatch 2014e).

PEAC. The deputy director of PEAC reported that compared to other new tools such as websites and email, text messaging was quite suitable for low-resource rural areas because most farmers had mobile phones. PEAC's notification model was like another national program in China that provided an SMS-based farmer support service for pest management. The service used extension offices to convey messages from the national program headquarters to local farmers. PEAC's successful experience with text messaging also revealed some shortcomings with their approach: a need to collect individual phone numbers for target group members, an increased cost of sending messages to larger groups, and inefficient mechanisms for user feedback. Also, the messaging fee structure tended to increase costs when larger groups were notified. PEAC does not currently engage in pre-application spray notification. Despite these shortcomings, SMS has been an effective method for pesticide-related communication in China (PEAC 2009).

Conclusion

The exchange of actionable information about pesticide spray activity is vital for preventing worker exposure to drift. We envision a notification network in which farm managers and work crew supervisors serve as nodes of communication to prevent worker drift exposure. This approach appears to be a reasonable step toward reducing the workplace hazard of pesticide exposure among farmworkers. When notified of a neighboring spray, for example, farm managers could adjust work crew job tasks. With the advent of farm data analytics and the continued integration of technology into precision agriculture, there are many tools readily available for spray notification.

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Table 1. Review of existing pesticide spray notification systems

System	Basic Information				Worker Notification Categories					
	Year of origin	Currently in use	Location	Model type [1]	Flexibility of method	Minimum lead time	Between-party range	Message content about pesticides	Mobile friendliness [2]	Estimated cost per year
WA Sensitive Persons	1994	Yes	Washington, United States	Applicator-to-resident	Phone call In person In writing	2 hours	Within 0.5 miles; Shared border	Undefined	Possible	Undefined
SprayWatch	2002	Yes	New Zealand	Applicator-to-resident	Phone call SMS/text Email	12 hours	Within 50 meters	Pesticide name	Yes	One-time NZ$ 8.00 (US$ 6) fee per new farm plus NZ$ 47.00 (US$ 32) per farm for 7-8 notifications each year
Spraydays	2005	No	United Kingdom	Applicator-to-resident	Phone call SMS/text Email Posting Flagging In writing	Varies	Within 25 meters	Pesticide name Target pest Mixing tank contents	Yes	£ 107 (US$ 143) per farm for SMS/text or email
DriftWatch	2008	Yes	United States and Canada	Registry	Email Posting	Undefined	Custom area	Undefined	Yes	Varies by membership level: Individual: US$ 0 - 500 Group: US$ 6,500 - 50,000
PEAC	2009	Yes	China	Registry	SMS/text	Undefined	Undefined	Undefined	Yes	Annual fee charged based on number of successfully transmitted messages
WA Schools	2009	Yes	Washington, United States	Applicator-to-resident	Posting In writing	48 hours	On-site only	Pesticide name Target pest	Possible	Undefined

1. **Applicator-to-farmer:** notification between neighboring farms (e.g. orchard-to-orchard: from an orchard applicator to the manager of a neighboring orchard's work crew);
Applicator-to-resident: residential bystander receives notification from an applicator (e.g. from an applicator to a residential bystander);
Registry: applicator receives notification based on a list of sensitive individuals or crops nearby

2. For **mobile friendliness**, "Yes" means that the system is currently usable via SMS/text or email on a mobile device and "possible" means that the system uses only calls or other non-mobile forms of communication.