Report

Literature Review

Health impacts of the aerial spraying of pesticides and Methodologies for detecting health impacts in an exposed population

June 2004

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Introduction

PHI is required to provide an analytical framework for the analysis of health outcomes relating to aerially applied pesticide, as part of the Fall Web Worm eradication programme being carried out by MAF. This review informs on the health effects of the aerial spraying of pesticides, and the methodologies previously used to measure these health effects.

The aerial spraying of pesticides is a method of eradication for pests such as the Gypsy Moth. Spray programs have been carried out in countries such as Canada, the United States, and New Zealand, and have generally been state-sponsored. In these spray programs, the pesticide can also be applied through ground sprayings.

A commonly used chemical compound for aerial sprayings is Foray 48B, which contains the bacterium *bacillus thuringiensis kurstaki* (Btk). Btk is found naturally in the environment, and specifically targets the larvae of moths and butterflies (Gibbs, 1996). In New Zealand, the commercial product Foray 48B is registered for use in aerial and ground sprayings against the species Gypsy Moth, White-Spotted Tussock Moth and Painted Apple Moth. It was used to successfully eradicate the White-Spotted Tussock Moth in Auckland in 1996-1997.

Health effects in humans due to the aerial spraying of pesticides have been studied throughout a number of eradication programmes. Population-based surveillance has generally failed to show any adverse health effects from aerial sprayings. However, small numbers of residents in spray zones have self-reported symptoms potentially linked to the sprayings. These include upper and lower respiratory problems, gastrointestinal problems, skin rashes, eye irritation, neuropsychiatric problems and flu-like symptoms. Methods used for health surveillance during sprayings include passive surveillance, case control studies, population-based surveys, and focus groups.

The Ministry of Agriculture and Fisheries in New Zealand wishes to develop an analytical framework for the analysis of population health impacts from sprayings carried out in any region in the country. This report aims to review the evidence for the health impacts of the spraying of pesticides in residential areas. In particular, the review will focus on aerial sprayings, and on the health impacts of the pesticide Foray 48B. Furthermore, it will review methodological techniques for carrying out health surveillance during spray programmes.

Methods

Selection criteria

Aim of review

The aim of this study was to review evidence for any health impacts of the spraying of pesticides of insecticides such as Foray 48B (Btk), on residential populations. Particular subjects of interest were health outcomes, health service access and delivery issues, and methods for health surveillance and studying health impacts from the sprayings.

Study inclusion criteria

This search included studies published up until May 2004, and was limited to those in the English language. Both primary and secondary sources were included. The population of interest was individuals living within an aerial spray zone, and whether they had suffered any health effects potentially caused by the aerial spray programme.

Study exclusion criteria

This review excluded studies that focused on

- -The effects of spray programmes on animals or the environment.
- -The health impacts caused by aerial spraying of crops
- -Health impacts on pilots of aerial sprayings
- -Health impacts on spray workers

Search keywords used

Keywords used:

Aerial spraying, aerial application, aerial delivery, ground spraying, pesticide, insecticide, Foray 48B, bacillus thuringiensis kurstaki.

These were combined with the following keywords:

Health, illness, disease, symptoms, psychological, psycho-social, exposure, risk, GIS, Geographic Information Systems.

The particular search methods and results can be found in the appendix.

Search sources

The review covered several different sources of information:

Bibliographic databases:
- PubMed
- Psychinfo
- ISI Web of Science
- ProQuest
- Index New Zealand
- Te Puna New Zealand

Review databases:
-DARE, NHS, EED and the HTA

Government website: The government websites of health departments and forestry departments in New Zealand, United States and Canada were checked for aerial spraying health impact documents.

Citation references were also used, in order to identify further reports that are in the "grey" literature.

Appraisal methodology

The results have been summarised in the following section. In addition to this, key articles have been summarised in tables (see appendix). These tables include the site of the study, the sample, methodology, results and limitations of the study. Further studies have also been mentioned, and tables in the appendix include these studies, with abstracts and/or a summary of results. These latter studies were often not available in full. A list of excluded studies has also been included.

Result of literature search

The literature search found eight studies to appraise. These were mainly in peer-review journals or government reports. There were further 17 studies of interest identified; most have been briefly summarised, and are included in tables in the appendix. Some studies were excluded from this review, because they either had no abstract, were editorials, or were primarily on topics in the excluded criteria.

Summary of findings

Health effects of pesticide sprayings (Foray 48B)

The literature search identified several health-monitoring studies carried out after aerial sprayings of Btk pesticides conducted in Canada, United States and New Zealand. These population-based surveillance studies found no evidence for health impacts from Btk, although some symptoms potentially related to aerial sprayings have been identified by communities exposed to the sprays.

There has been no evidence for severe health effects from Btk. The Auckland health surveillance programme, Operation Ever Green, found no significant increases in the number of birth defects, underweight births or meningococcal cases in the spray zones (Aer'aqua, 2001). Surveillance conducted during this study also found no invasive infections caused by Btk, no cases of anaphylaxis, and no accidents involving children, bicycles or pedestrians. Furthermore, no studies have found an increase in the use of hospital emergency rooms during Btk aerial spraying programmes (Anon, 1999; Aer'aqua, 2001; Noble *et al*, 1992).

Many studies have conducted lab tests to determine whether Btk has caused infections. Lab swabs taken from wounds and normally sterile sites have not positively identify Btk as an active pathogen in any swabs. In the Washington State study, no active Btk isolates were found (Anon, 2001), while in British Columbia, seven isolates were identified as Btk, but were all ruled to be contaminants (Anon, 1999). In Oregon, 55 positive Btk isolates were identified; of those, 52 were classified as 'probable contaminants', while the other three swabs were inconclusive (Green *et al*, 1990). Globally, there have only ever been two cases reported where Btk has caused infections, and both have been in people with severe burns or blast injuries, who were therefore already very susceptible to infection (Siegel, 2001).

However, studies have also identified a range of symptoms associated with aerial sprayings of Foray 48B, as self-reported by small proportions of residents in spray zones (Petrie *et al*, 2003; Anon, 1999; Anon, 2001; Aer'aqua, 2001; Hales *et al*, 2004). These symptoms generally involve irritation of the throat, nose, eyes or skin, as well as headaches, chest tightness, and flu-like symptoms such as stomach discomfort or diarrhoea. Self-reported health of residents was also impacted by aerial sprayings. An Auckland study found that exposed residents' overall perception of health declined after aerial sprayings ($p=0.0001$) (Petrie *et al*, 2003).

Some neuropsychiatric problems were also found during health surveillance in Auckland, including sleep problems, difficulty concentrating and dizziness (Petrie *et al*, 2003). These symptoms may be caused by anxiety about the spray programmes. Other studies have found that the community can get very anxious about possible health effects from the sprays, which may in itself be a public health problem (Hales *et al*, 2004; Kahn *et al*, 1992). Possible

measures to relieving anxiety include keeping the public well informed (Kahn *et al*, 1990).

There has been concern that some groups of people are more sensitive to aerial sprayings than others. Studies carried out on asthmatics have investigated whether they are adversely affected by aerial sprayings. A case-control study on child asthmatics in Canada found that the spray had no effect on asthma (Pearce *et al*, 2002). Petrie et al (2003) found no significant difference in self-reported symptoms before and after an aerial spraying for asthmatics. A study in Auckland also identified no new cases of asthma or worsening of symptoms, as reported to GPs and hospitals in the spray area (Aer'aqua, 2001). However, in Washington State, a total of seven people from an estimated population base of 6,600 were reported as having an asthma attack or a worsening of asthma symptoms during spraying, although individual exposure levels to the spray were not measured during this study, and thus direct association with the sprayings cannot be assumed (Anon, 2001).

Many studies have relied on reports of people visiting their doctor or the hospital with symptoms, in order to study health effects from spraying programs. However, there is some evidence to suggest that many people that experience symptoms do not visit a health care provider. This may lead to an underreporting of symptoms in some passive surveillance studies. For example, an Auckland-based study found that a statistically significant increase in some symptoms was not reflected in an increase in the number of visits to GPs or hospitals (Petrie, 2003). The Washington State study found that from 59 people with symptoms reported to health authorities, only seven had sought help from health care specialists for their symptoms (Anon, 2001). In comparison, a random survey of residents in the same spray zone found that 3 to 9% of people (an estimated 200-600 people) suffered at least one symptom (Anon, 2001). It should be noted that this survey had several flaws, including potential bias from a small sample size.

Demographics

Some studies reported health effects according to demographic variables such as age, gender, ethnicity, and socio-economic status.

At a general level, census population counts have been used to determine the population in aerial spray zones, and to calculate denominator populations for comparisons with non-spray areas (Anon, 1999; Aer'aqua, 2001). Some studies used demographics of spray-affected populations in order to ensure representativeness between study groups (Petrie *et al*, 2003; Anon, 1999; Aer'aqua, 2001). However, demographics were only included as a variable in health outcomes in a few studies.

Studies found that females are more likely to report spray-related symptoms than males. One study found that symptom reports by females outnumbered

male reports two-to-one, with 66% of symptom reports made by females (Anon, 2001). In a British Columbia study, callers to a telephone helpline were mainly female (83%) (Anon, 1999). This study also found that females were more concerned about health effects from aerial sprayings, and they were not as likely to support the spray program as males. During an Auckland spray program, concern was expressed for pregnant women, although no health impacts were found for them through health surveillance (Aer'aqua, 2001).

It has been suggested that children are more likely to suffer health impacts from aerial sprayings than others, although there is no firm evidence to back these reports. There is general community concern for health impacts of spraying on children (Aer'aqua, 2001; Hales *et al*, 2004). An Auckland study found that people were more likely to report impacts on their children's health than on their own (Petrie *et al*, 2003). Another study carried out on children with asthma failed to find any association between worsening of symptoms and aerial spraying (Pearce, 2002). In the Washington study, 8.5% of symptom reports were for children under 10, although this was unable to be compared to the denominator population in this age group (Anon, 2001). One study found that younger adults were more likely to be concerned about health effects than other adults (Anon, 1999). Concern has been expressed about health impacts on the elderly (Hales *et al*, 2004), although there have been no specific studies on this population group.

Only a few studies reviewed reported health impacts by ethnicity. An Auckland study found that Non-Europeans were not as likely to respond to a follow-up survey (Petrie *et al,* 2003). Focus groups on Maori, Pacific Islanders and migrant groups in Auckland found anecdotally that there was a general lack of information about sprayings for these communities, especially for Maori and Pacific communities (Hales *et al,* 2004). Furthermore, there was a need for information about sprayings and related health effects to be available in different languages.

Socio-economic status (SES) was not generally included in surveillance studies. Health surveillance in Auckland examined SES patterns using NZDep96 for spray areas, and found that the distribution did not affect the conclusions of their health surveillance (Aer'aqua, 2001). The British Columbia study did not consider SES determinants on health, but found in their general survey that those on higher incomes were more likely to report excellent physical and/or mental health (Anon, 1999).

Conclusion:

Females are more likely to report health symptoms from aerial sprayings, and to be more concerned about health effects from sprayings. There is much community concern about the health effects on children, although studies have not generally shown children to be more at-risk than other groups. In a New Zealand setting, some ethnic groups experienced barriers to accessing information about spray programs, particularly in their own languages.

Methods for measuring health effects of aerial sprayings

Overview

A variety of surveillance methods have been used to monitor the health of residents during aerial spray programmes. Often a combination of several techniques are used, in order to gain the best possible picture of any health effects suffered by exposed residents. These different methodologies are discussed below.

Passive surveillance

Passive surveillance methods rely on people reporting or seeing health authorities about symptoms related to sprayings. Passive surveillance can be carried out in a number of ways. One form is to monitor any increases in the use of health services during the spray programme. Previous studies have used statistics such as the number of people with pesticide-related symptoms who visit a GP, emergency rooms, hospitals, or alternative health practitioners (Anon, 1999; Aer'aqua, 2001; Kahn *et al*, 1992). One previous study in New Zealand also monitored databases on notifiable diseases and health conditions, such as pregnancy outcomes, meningococcal disease and autoimmune difficulties (Aer'aqua, 2001). These methods of surveillance have the potential to identify all severe health effects possibly related to sprayings that are reported to health care providers.

A further way of passive surveillance is to test all swabs provided to medical laboratories during the spray programme. The presence of active Btk cultures may indicate that the spray has caused infections. While previous studies have identified Btk-positive cultures, all of these have been determined to be probable contaminants or have had inconclusive results (Green *et al,* 1990; Anon, 1990).

Another method of health surveillance is by providing a toll-free helpline number for concerned residents to ring, in order to report health symptoms that they believe are caused by the spraying, and to seek medical advice. Where hotline services have been provided, they have received many calls from residents, in relation to symptom reports, as well as a variety of other spray-related issues.

Limitations

There are certain limitations related to the use of passive surveillance. Small numbers in both numerator and denominator populations can cause problems with passive surveillance, as it is often very difficult to detect any changes with statistical significance, over and above background ratesof symptoms. In this respect, passive surveillance techniques can sometimes be insensitive to small changes in health service use.

The reliance on self-reporting of health symptoms to a telephone hotline or to a health authority is also likely to underestimate the number of people suffering from symptoms, due to a number of reasons. The symptoms will

only be picked up if the person either reports their symptoms to a health authority and/or telephone hotline, or seeks medical assistance. People are more likely not to report symptoms if they are not aware of the request to report symptoms, if they feel uncomfortable reporting symptoms to the health department and/or agricultural department carrying out the work, or if people feel that their symptoms are too minor to report (Anon, 2001). Self-reporting of symptoms to hotlines also means that the symptoms are in many cases not confirmed by a health specialist, and a definite diagnosis cannot be made.

Case-control studies

Case-control studies have been carried out on small samples of residents in spray zones (Pearce *et al*, 2002; Petrie *et al*, 2003)). These types of studies often include a comparison between symptoms before and after a spraying, as well as both in and out of the spray zone.

This type of study takes into account background rates of symptoms, as well as a comparison between exposed and non-exposed populations. For example, seasonal variations in the environment can cause the similar symptoms to spray symptoms, in people predisposed to hay-fever.

Retrospective cohort studies can also be conducted on specific at-risk populations. Brody *et al* (2004) studied a cohort of all pregnant women exposed to pesticide sprayings of malathion in the years 1988-1995, with exposure levels calculated for each week of pregnancy. Adverse pregnancy outcomes were compared with normal pregnancy outcomes to detect any influence from aerial sprayings; no association was found.

Limitations

It is important in case-control studies that non-exposed controls are in fact not exposed to the aerial spray. In one of the experiments where a control group was used, the controls also measured positive to exposure to Btk (Pearce, 2002). This is a possible confounder in the study, as significant differences between exposed and non-exposed cannot necessarily be determined.

Population-based surveys

Another form of health monitoring is the use of random surveys on residents living within a spray zone. This has the advantage of not only identifying people who would have reported their symptoms anyway, but also those who have minor symptoms. Surveys can be conducted either face-to-face, on the telephone, or through a mailed written questionnaire.

Limitations

Studies identified through this literature search that have used population-based surveys have suffered from some limitations. The response rates of surveys are often relatively low. In one Auckland study, the response rate was very good for the initial questionnaire (93%) but was lower for the written questionnaire after the sprayings (63% of initial respondents) (Petrie *et al*, 2003). This may have lead to bias in the results, as those people who have

noticed spray-related symptoms are more likely to respond to surveys. In the same study, another limitation was that the recall time period was longer for the post-spray questionnaire than the pre-spray questionnaire. This may also have led to bias, with more symptoms being detected after the spraying. Furthermore, if some people have moved away from the away during the sprayings, they may not be contactable and thus not able to participate in the survey.

Focus groups

One study used focus groups in order to identify health issues and concerns within a community exposed to aerial sprays (Hales *et al*, 2004). This method of surveillance is not able to identify the number of people affected, but only the range of symptoms experienced. It also gets the community involved in the spray programme and is an outlet for concerns and worries of residents.

Measuring exposure to spray

In many of the studies appraised in this report, the only measure of exposure is by classifying residents as either exposed or non-exposed, according to where they live in relation to the spray area. It is important to ensure there is a buffer around the spray area that is large enough to include all possible sites exposed to spray drift.

When individual exposure levels to the aerial spray have not been measured, it is very difficult to determine whether any reported symptoms are in fact caused by pesticide exposure. Spray exposure can be scientifically determined in a number of ways, to get a more accurate picture of pesticide exposure. One method is to measure exposure levels in the environment, for example at each house within the spray area. One study used Kromecote cards, which detected the spray droplets of the pesticide deposited on the card (Pearce, 2002).

Individual spray exposure can also be measured, by taking nasal swabs in people after sprayings. This method appears to be more sensitive than the Kromecote cards (Pearce, 2002). It can also take into account the varying exposure levels from person to person, according to their movements in and out of spray zones during the day.

Studies have been conducted on exposure levels before and after aerial sprayings of Btk. Some studies have found that Btk exists in the environment and human population even before an aerial spraying (Valadares de Amorim *et al,* 2001; Pearce, 2002). This indicates that it is important to record background rates of Btk exposure before a spraying, to use as a comparison. Furthermore, exposure rates after a spraying may differ according to whether a person stays indoors or outdoors, as concentrations are different between these two settings. Studies have found that the concentration rates of spray are initially higher outdoors than indoors, but the spray also disperses faster outside, compared to inside (Teschke *et al*, 2001).

GIS methods

Several studies have also made use of Geographic Information Systems (GIS) to assist with exposure models, to identify at-risk populations, and to analyse the association between spray exposure and disease outcomes. Studies have identified that it is important to have a reasonable level of spatiotemporal resolution when determining exposure levels, to avoid a misclassification of exposure levels (Rull & Ritz, 2003).

In creating an exposure model, a GIS can incorporate many different types of information. These include the drift and volatilization of sprays, as well as meterological conditions on spray days to allow for drift patterns (Brody *et al*, 2002; Maxwell *et al*, 2000). A GIS can also be used to determine the location of residents, and to identify at-risk populations who lie within a spray zone or a certain distance from a spray zone. Further uses of a GIS include calculating different exposure scenarios based on whether individuals are active or sedentary (Marty *et al*, 1994).

Conclusion

This review has found that there have been some studies already conducted on the health effects of aerial pesticide spraying, in the United States, Canada and New Zealand. These studies have found that the spray Foray 48B has no adverse health effects on exposed residents, although it may cause some symptoms in a small proportion of people.

Methods used for health monitoring systems include testing for increases in health service usage, monitoring calls to a dedicated telephone hotline, testing medical swabs for active Btk cultures, conducting random population-based health surveys, doing case-control or cohort studies, and using focus groups to identify any community concerns.

Exposure levels to aerial sprays can be scientifically measured through using nasal swabs in exposed individuals, or spray-drop deposit cards throughout the spray zone. Exposure levels can also be modelled through the use of a GIS, incorporating data on spray zones, the population base, and meterological data to determine any potential spray drift.

Appendix

Search strategies

Bibliographic databases :

- PubMed
- Psychinfo
- ISI Web of Science
- ProQuest
- Index New Zealand
- Google

PUBMED

1. aerial* (3573)
2. ground* (41,503)
3. spray* or application* or deliver* (521,754)
4. aerially applied (38)
5. ((1 or 2) and 3) or 4 (3,463)
6. pesticide* or insecticide* (45,646)
7. foray 48B (10)
8. bacillus and thuringiensis and kurstaki (330)
9. health* or illness* or disease* or symptom* or psycholog* or (psycho*social) (4,523,267)
10. risk* or exposure* (933,650)
11. GIS or Geographic Information System (1,299)
12. Results (7 or 8) (332)
13. Results (7 or 8) and (9 or 10 or 11) (35) – *foray 48B - related to this topic*
14. Results 5 and (6 or 7 or 8) (366)- *all aerially applied pesticides*
15. Results 14 and (9 or 10 or 11) (172)
16. Results (12 and/or 13) or 15 (199) – keep selected records

Psychinfo

1. aerial* OR ground* (15,502)
2. spray* or application* or deliver* (95,937)
3. aerially applied (0)
4. Results 1 and 2 (964)
5. Results 4 and (pesticide* or insecticide* or foray or kurstaki) (5) – keep selected

ISI Web of Science

1. aerial* (10,811)
2. ground* (>100,000)
3. spray* or application* or deliver* (>100,000)
4. aerially applied (65)
5. ((1 or 2) and 3) or 4 (1,606)

6. pesticide* or insecticide* (31,434)
7. foray 48B (32)
8. bacillus and thuringiensis and kurstaki (750)
9. health* or illness* or disease* or symptom* or psycholog* or (psycho*social)
10. risk* or exposure* (>100,000)
11. GIS or Geographic Information System (8,574)
12. (7 or 8) (756)
13. (7 or 8) and (9 or 10 or 11) (9) – *foray 48B - related to this topic*
14. Results 5 and (6 or 7 or 8) (73)- *all aerially applied pesticides*
15. Results13 or 14 (82) – keep selected records

ProQuest

1. aerial* (10,950)
2. ground* (203,373)
3. spray* or application* or deliver* (803,788)
4. aerially applied (9)
5. ((1 or 2) and 3) or 4 (11,210)
6. pesticide* or insecticide* (19,504)
7. foray 48B (5)
8. bacillus and thuringiensis and kurstaki (38)
9. health* or illness* or disease* or symptom* or psycholog* or (psycho*social) (1,771,271)
10. risk* or exposure* (599,742)
11. GIS or Geographic Information System (13,728)
12. (7 or 8) (39) – kept selected
13. Results 5 and (6 or 7 or 8) (304 – but only 33 scholarly journal publications and 2 reference reports) – keep selected

Te Puna – National bibliographic database
Searches in 'keyword anywhere'

1. Aerial spray* (90)
2. Aerial spray* AND health* (2) – keep selected
3. Foray 48B OR kurstaki (5)
4. Aerial* AND pesticide* AND health* (3)

Index New Zealand
Searches in 'keyword anywhere'

1. Aerial* AND spray* OR aerially applied (19)
2. Foray 48B OR kurstaki (5)

Review sites:

DARE, NHS EED and the HTA

1. foray (0)
2. aerial* spray* (0)

3. aerial (0)
4. bacillus thuringiensis (0)

Websites visited:

New Zealand
New Zealand Ministry of Health website – www.moh.govt.nz
- Search of publications in subjects 'Environmental Health' and 'Painted Apple Moth'
New Zealand Ministry of Agriculture and Fisheries website – www.maf.govt.nz

United States
www.health.gov
California Department of Health Services www.dhs.ca.gov

Canada
www.hc-sc.gc.ca
http://canada.gc.ca
http://www.cdc.gov - Centers for Disease Control and Prevention

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Next Section: Evidence Tables

Study bibliographic details	Sample and Interventions	Methods	Results	Limitations and Conclusions
Washington State Department of Health 'Report of Health Surveillance Activities: Aerial Spraying for Asian Gypsy Moth – May 2000, Seattle, WA' Seattle, Washington July 2001 www.doh.wa.gov/ehp/ts/pest.htm	Study setting: Two urban areas in Seattle, during and after three aerial sprayings of Foray 48B for Asian Gypsy Moth in May 2000. Area affected: about one square mile; approximately 2,200 businesses and properties and an estimated residential population of 6,600.	Study design: Passive surveillance of health reports from residents in aerial spraying zone. Data collected through: toll-free hotline, local health department, Dept of Health (and their interviews with family/friends), health care providers. Tests were conducted on all isolates of *Bacillus* species collected by clinical labs within a month of a spraying, to determine whether Btk was the cause of any infections. Outcome measures: A standardized form was used to record symptoms, demographic info, self-assessment of severity of symptoms, and any health care obtained. Exposure to Btk was not measured or confirmed – but patient addresses could be classified as either in/out of spray zone (with buffer). Noone was excluded based on where they lived.	42 people called the helpline with health complaints. In total, DOH surveillance found 59 persons in 50 households with at least one symptom linked to the sprayings; 52 reports were followed up. Most reports were received within 36 hours of a spraying, with the majority of complainants residing within or near spray boundaries. Twice as many females as males reported symptoms. 7 out of the 59 had seen a health care worker. Symptoms were classified as upper respiratory or nasal, irritant, airways, flu-like symptoms and skin rash. The most frequently reported symptoms were cough, headache, trouble breathing, sore throat, nasal congestion, and irritated eyes. Seven people reported worsening asthma or asthma attacks after at least one spraying; persons with asthma may be more sensitive to inhaling irritants, with Foray 48B a potential trigger. Medical labs received 13 isolates of Bacillus; no isolates were identified as Btk. Community concerns included: people asking for health reimbursement, people being more comfortable reporting health complaints directly to health authority rather than the Department of Agriculture hotline.	Study aim: To conduct health monitoring (passive surveillance) in order to identify serious reactions to Foray 48B aerial spraying within the community and to document self-reported health symptoms among residents. Limitations: Passive surveillance relies on residents, GPs and laboratories to report symptoms. It is likely to miss some disease events if people are unaware of the request to report symptoms, if they are uncomfortable reporting personal health info, or they feel their symptoms are too minor to report. A comparison with a random survey (Gilmore Research Group 2000) showed that between 3 - 9% of people had suffered symptoms that they attributed to the spraying, as compared to the 0.9% (59 out of 6600) actually reported to health authorities in this study. However, several sources of bias were identified in this study, including low response rate (61%), dislike for survey sponsors (Department of Agriculture), and poor recall six months after an event. It is almost impossible to determine whether symptoms were result of exposure to spray, since exposure not measured, and background rates of symptoms were not taken into consideration. All symptoms could be caused by a number of different factors (for example, allergy symptoms and infectious agents common at that time of year) and some of the people with health complaints had previous known conditions. Tests can however confirm if Btk is active in a bacterial infection. Conclusion: There is a gap between epidemiological tools (ie passive surveillance) and what residents experience. The comparison with the random survey showed marked difference between rates.

Study details	Sample and Interventions	Methods	Results	Limitations and Conclusions
'Surveillance for Acute Insecticide –related illness associated with mosquito-control efforts – nine states 1999-2002' Centers for Disease Control and Prevention MMWR July 11 2003 United States – Arizona, California, Florida, Louisiana, Michigan, New York, Oregon, Texas and Washington	Study setting: summary of health investigations into insecticide exposure Participants: Denominator not able to be obtained. Patients were identified who had been exposed to pesticide during April 1999- September 2002, in nine states in America. This study includes ground and aerial applications of insecticides for controlling populations of adult mosquitos. is not limited to aerial sprayings; it discusses all forms of pesticide poisonings.	Information gathered on those who had illnesses consistent with the definition for pesticide poisons. Records obtained through: following up media reports, reports by health care providers, poison control centres, self reported, state health departments, GPs and emergency rooms.	133 cases of acute insecticide-related illnesses were identified. 1.5% were definitely insecticide-related, 18.8% probable, and 79.7% possible. 27.3% were work-related. 71.4% of cases were associated with the pesticide malathion, and 27.8% with pyretides (which does not include Btk). Symptoms included were repiratory (66.2%) or neurologic (60.9%) dysfunction. The authors noted that 'anxiety about insecticide use for mosquito control also might have been responsible for symptoms'.	Limitations: The number of reported cases is most likely underestimated, as some symptoms may not be recognised as insecticide-related or may not have been reported to health authorities. There is the possibility of false positives, as there is no standard diagnostic test. This study only examines the health effects in nine states in America; the results are not necessarily representative in other states. Conclusions:

Study details	Sample and Interventions	Methods	Results	Limitations and Conclusions
'Symptom complaints following aerial spraying with biological insecitcide Foray 48B'. By Keith Petrie, Mark Thomas and Elizabeth Broadbent. New Zealand Medical Journal 116(1170): 354? New Zealand - Auckland	Study setting: West Auckland suburbs, before and after an aerial spraying of Foray 48B for Painted Apple Moth, in Jan 2002. Participants: Recruited by door-to-door knocking in the most intensively sprayed area of initial MAF aerial spray zone. 315 residents aged 18 or over were approached; 292 completed 'before' face-to-face questionnaire, and 181 completed the 'after' postal questionnaire.	Study design: Pre/post pair design. No control outside of spray zone. Methods: Questionnaires filled in by participants both 10 weeks before, in Oct 2001, and after an aerial spray program, in March 2002. Participants were asked about symptoms, 25 chosen from Subjective Health Complaint Scale. They were also asked about their use of health services.	Self-rated health declined significantly (p=0.0001) but there was no significant rise in number of visits to GP or alternative health services. There were significant increases in symptoms for those previously diagnosed with hayfever, but not with those with asthma or allergies. There were statistically significant increases in some symptoms. These can be classified into: -local effects on upper airway (irritated throat, itchy nose), due to local irritant effects of inhaled spray -neuropsychiatric response (sleep problems, difficulty concentrating, dizziness), perhaps due to sleep disturbances from low-flying planes in early morning, and increased anxiety in some residents about health effects of spray -gastrointestinal system (stomach discomfort, gas discomfort, diarrhea), from preformed endotoxin in spray, or Btk replicating in gut, or some other reason. Author's conclusion: Aerial spraying of Foray 48B is associated with some adverse health effects, with significant increases in upper airway, gastrointestinal and neuropsychiatric symptoms, and a reduction in the overall perception of health in the exposed population.	Study aim: To investigate the effect of aerial spraying of Foray 48B on self-reported symptom complaints, health perception and visits to healthcare providers. Limitations: -The response rate is relatively high for the initial survey, but much lower for post-spray survey. This could introduce bias, as those who have experienced symptoms are more likely to respond. -The study period included a seasonal change; March is a more likely time for hayfever symptoms to occur – however, not all symptom changes are consistent with allergen responses to pollen. -The recall time periods for two surveys (pre/post) are different, with post-spray having a longer time period to ensure inclusion of spray times. This may have resulted in a greater range and frequency of symptoms post-spray.

Study details	Sample and Interventions	Methods	Results	Limitations and Conclusions
'Human Health Surveillance during Aerial Spraying for Control of North American Gypsy Moth on Southern Vancouver Island, British Columbia, 1999.' Vancouver Island, British Columbia, Canada This study was broken into several sections: -General population health (survey, GP/hospital monitoring, hotline calls, lab tests) -Asthmatic children (reviewed separately)	Study setting: An area of 13,398 hectares was sprayed on Southern Vancouver Island, in three sprayings May-June 1999. The area is mixed residential and rural, with an estimated residential population of 80,000. Participants: 1009 people randomly selected from inside (n=522) and outside (n=487) spray zone.	Survey: Two phone surveys on a random sample of phone numbers. N=1009 (522 in spray zone, 487 outside of spray zone). 81% of participants in the first survey agreed to take part in the second survey. The questionnaire consisted of a standardised form asking about mental and physical health, specific symptoms, and demographic and geographic data. In addition to this, passive surveillance nethods included: -Testing lab specimens for Btk. -Comparing hospital data to the previous year to detect any increases in health service use for pesticide-related symptoms, severity of symptoms. -Monitoring calls to a hotline.	Survey: There was no difference found in symptoms before or after spray, or between those in and out of spray zone. The best predictor of having symptoms was having those symptoms before spraying. Living in the zone was not a predictor of symptoms. A small number of symptoms were self-reported. Females and younger adults were more likely to believe spray to be harmful. Hospital data: There was no evidence for an increase in the number of hospital visits. Lab data: results found 7 samples with Btk – but Btk was considered to be a contaminant not a cause of infection in all cases. Author's conclusion: These surveillance techniques provided no evidence for a relationship between aerial spray and short-term health effects. Some self-reported symptoms were blamed on spray, but many of these were similar to symptoms before spray, and those experienced out of zone.	Study aim: ' To summarise and add to the current understanding of the public health effects of aerial spraying of Foray 48B and to monitor people in the spray zones for signs of potential health effects caused by the spray.' Limitations: -Self-reported health symptoms were not formally diagnosed by a medical expert. Therefore it is difficult to establish a link between sprayings and symptoms. -There is a lack of data on individual exposure to spray – thus it is hard to find direct association between symptoms and exposure. Objective measures of exposure are needed. - Calls made to the hotline were not matched to a control group, so only those motivated enough will call, and are not necessarily representative of the exposed population.

Study details	Sample and Interventions	Methods	Results	Limitations and Conclusions
'The effects of aerial spraying with Bacillus thuringiensis Kurstaki on children with asthma' Part of Southern Vancouver Island health surveillance program (British Columbia, Canada) By Marty Pearce, Brian Habbick, Janice Williams, Margaret Eastman, and Naureen Newman. Canadian Journal of Public Health 93(1): 21-25, Jan/Feb 2002	Study setting: Children aged 6-15 with asthma living within an area being aerially sprayed with Foray 48B. Children with asthma have been previously identified as a high-risk group in terms of health effects from aerial sprays. Children included in the study were those who had been hospitalized or had visited ER for their asthma, and had been referred to the AAE program. Subjects were chosen from those who were contacted and had agreed to participate, and who lived within the spray zone. Each subject was matched on age/gender with a child at least 1km away from the spray zone.	Study design: a pre/post matched pairs cohort design. The 29 selected children within spray zone were matched with 29 children outside of spray zone. Participants recorded their Peak Expiratory Flow, and symptoms (both asthma and non-asthma) before, during and after an aerial spraying. Exposure to Btk was measured using: -Kromecote card measure droplet deposits outside each participant's residence -nasal swabs from inside nose were taken the evening before each spraying, and two hours after spraying (with participants being told to stay indoors with windows/doors shut, until second swab taken).	This study detected no significant differences either between controls and subjects, or before and after spraying. There was no increased illness burden found, before or after sprayings, for any group. Exposure to Btk: Inside spray zone, 78% of Kromecote cards tested positive for droplets compared to 9% outside of zone (these ones were generally close to buffer). With nasal swabs: -five swabs were positive before first spray -large increase in positives after spraying, even though time lapse only 2 hours after -many children not in spray zone tested positive after sprayings. Author's conclusions: No adverse health effects were found for children with asthma, as a result of the aerial spraying of Btk.	Study aim: To determine if any association exists between aerial spraying of Foray 48B and an increase in asthma symptoms among children with asthma. Limitations: - The basis of subjects/controls was geographical location, but some of the control children were also being exposed to Btk (although authors note that this didn't appear to lead to any bias) -The selection of children was based on previous asthma symptoms – subjects possibly had better control of asthma due to differences in medications, and thus were less likely to suffer from symptom changes. -Children stayed inside for first 2 hours after spraying; this was initially a protective measure.

Study bibliographic details	Sample and Interventions	Methods	Results	Limitations and Conclusions
'Health Surveillance following Operation Ever Green: A programmed to eradicate the white-spotted tussock moth from the eastern suburbs of Auckland' Report to the Ministry of Agriculture and Forestry New Zealand Aer'aqua May 2001	Study setting: Btk was sprayed on eastern Auckland suburbs in 1996/7. A residential population of approx 80,000 lived in the spray zone, with a smaller group of 5000 subjected to a longer, more intensive spray period.	Several different methods of data collection were used, at the individual, local, regional and national level. 1. Self-reports by residents of their health concerns through a free telephone hotline; doctors were asked to report suspected pesticide-related illnesses 2. Sentinel GPs investigated patterns of illness within their practice 3. Databases – National congenital anomalies register, pregnancy outcomes, lab isolations of Bt, geographical distribution of meningococcal, child pedestrian and bike accidents 4. A register of exposed individuals was developed (participation rate 50.1%)	Self-reporting: The most common concern was 'fear of unspecified future disease', followed by headache and respiratory symptoms such as sore throat. Sentinel GPs: No adverse patterns were found. There was no identified new asthma, or extra consultation for existing asthma, and no increase in autoimmune disorders or lower respiratory problems. There were also no obvious patterns with headaches, eyes, skin, and upper respiratory problems. Databases: No statistically significant increases were found for any of the conditions mentioned. Author's conclusions: There were no statistically significant diseases or systematic problems reported that were attributable to the spraying. There were some self-reports about irritant ,respiratory, skin and eye symptoms at time of spraying.	Limitations: -Small number problems in trying to identify significant increases; it may not be possible to reject hypothesis due to power of study. -For the register, the forms were in English – this may lead to unequal opportunities and bias in results. -Self-reporting would miss those people who didn't report their symptoms to the authorities.

Study bibliographic details	Sample and Interventions	Methods	Results	Limitations and Conclusions
'Assessment of the potential health impacts of the 'Painted Apple Moth' aerial spraying programme, Auckland' Simon Hales, Virginia Baker et al Feb 2004	Study setting: Collecting information, mainly from focus groups, about health concerns, symptoms and effects related to Foray 48B aerial sprayings.	Focus groups, as well as additional community data collected.	Focus groups: The aerial spray programme has impacts on health and well-being. The most frequently reported symptoms were irritant, respiratory, gastrointestinal, flu-like, and skin rashes. Spraying especially affected those with pre-existing conditions such as hay fever and asthma. There was concern expressed for the young and elderly. There was also concern about the impartiality and effectiveness of MAF health service, and the lack of information about when the sprayings would take place.	Study aim: To receive, collect and summarize reports from a variety of sources on health concerns associated with the Foray 48B aerial spraying programme, to review the current scientific knowledge, and to recommend scientifically robust methods of further study. Limitations: Use of focus groups – can only report the range of symptoms, not the frequency amongst the community.

Study bibliographic details	Sample and Interventions	Methods	Results	Limitations and Conclusions
'Breast Cancer Risk and Historical Exposure to Pesticides form Wide-Area Applications Assessed with GIS' Julia Green Brody, Ann Aschengrau, Wendy McKelvey, Ruthann A. Rudel, Christopher H. Swartz, and Theresa Kennedy. Cape Cod, Massachusetts, United States. Environmental Health Perspectives 112:889-897 (2004).	Study setting: Assessing historical exposure to pesticides in Cape Cod, Massachusetts, using a GIS. Area affected: Cape Cod, population 227,000 in 2000. Pesticides such as organochlorine chemicals and malathion were widely used here for agriculture etc from the 1940s on.	Design: This is a case-control study. Subjects: 1,165 women who were residing in Cape Cod, Massachusetts and who were diagnosed with breast cancer in 1988-1995. 1016 controls were used. A GIS was used to geocode subjects' addresses to the study area. The GIS also provided modelling for pesticide exposure. This involved incorporating drift and deposition models, as well as the existence of tree buffers, to protect from spray drift.	There was no overall association found between breast cancer and exposure to pesticides at Cape Cod.	Limitations: There was some information missing in where pesticide was used in certain years, as well as historical address locations of subjects and controls. Exposure may be underreported, and thus will not appear in the model. Furthermore, exposure does not just come from site of residency, but also where a person moves during the day. This can affect their exposure levels, and a measure of exposure taken at the person's home does not always reflect the true exposure. Women who had shifted away from Cape Cod were not able to be included into the study; this may lead to bias.

Citation	**Abstract/Summary**	**Summary/notes**
Valadares de Amorim, G., Whittome, B., Shore, B., & Levin, D. B. (2001). Identification of Bacillus thuringiensis subsp. kurstaki strain HD1-like bacteria from environmental and human samples after aerial spraying of Victoria, British Columbia, Canada. *Applied and Environmental Microbiology, 67*(3), 1035.	ABSTRACT: Aerial applications of Foray 48B, which contains Bacillus thuringiensis strain HD1, were carried out on 9 to 10 May, 19 to 21 May, and 8 to 9 June 1999 to control European gypsy moth (Lymantria dispar) populations in Victoria, British Columbia, Canada. A major assessment of the health impact of B. thuringiensis subsp. kurstaki was conducted by the Office of the Medical Health Officer of the Capital Health Region during this period. Environmental (air and water) and human (nasal swab) samples, collected before and after aerial applications of Foray 48B, both in the spray zone and outside of the spray zone, were analyzed for the presence of strain HD1-like bacteria. Random amplified polymorphic DNA analysis, cry gene-specific PCR, and dot blot DNA hybridization techniques were used to screen over 11,000 isolates of bacteria. We identified bacteria with genetic patterns consistent with those of B. thuringiensis subsp. kurstaki HD1 in 9,102 of 10,659 (85.4%) isolates obtained from the air samples, 13 of 440 (2.9%) isolates obtained from the water samples, and 131 of 171 (76.6%) isolates from the nasal swab samples. These analyses suggest that B. thuringiensis subsp. kurstaki HD1-like bacteria were present both in the environment and in the human population of Victoria prior to aerial applications of Foray 48B. The presence of B. thuringiensis subsp. kurstaki HD1-like bacteria in human nasal passages increased significantly after the application of Foray 48B, both inside and outside the spray zone.	Btk was found to be present in the environment and human population before a spraying of Btk pesticides. There was a significant increase in the concentrations of Btk in nasal swabs after the Foray 48B spraying, both in and out of the spray area.
Brody, J., Vorhees, D., Melly, S., Swedis, S., Drivas, P., & Rudel, R. (2002). Using GIS and historical records to reconstruct residential exposure to large-scale pesticide application. *J Expo Anal Environ Epidemiol., 12*(1), 64-80.	ABSTRACT: Investigation of pesticide impacts on human health depends on good measures of exposure. Historical exposure data are needed to study health outcomes, such as cancer, that involve long latency periods, and other outcomes that are a function of the timing of exposure. Environmental or biological samples collected at the time of epidemiologic study may not represent historical exposure levels. To study the relationship between residential exposure to pesticides and breast cancer on Cape Cod, Massachusetts, historical records of pesticide use were integrated into a geographic information system (GIS) to estimate exposures from large-scale pesticide applications between 1948 and 1995. Information on pesticide use for gypsy moth and other tree/vegetative pest control, cranberry bog cultivation, other agriculture, mosquito control, recreational turf management, and rights-of-way maintenance is included in the database. Residents living within or near pesticide use areas may be exposed through inhalation due to drift and volatilization and through dermal contact and ingestion at the time of application or in later years from pesticides that deposit on soil, accumulate in crops, or migrate to groundwater. Procedures were developed to use the GIS to estimate the relative intensity of past exposures at each study subject's Cape Cod addresses over the past 40 years, taking into account local meteorological data, distance and direction from a residence to a pesticide use source area, size of the source area, application by ground-based or aerial methods, and persistent or nonpersistent	This study used GIS to estimate historical exposure levels from pesticide sprayings between 1948 and 1995. The GIS model included the drift and volatilization of the sprays, as well as the distance and direction of residences from the spray area, the size of the original spray area, the type of application (aerial or ground), and whether the pesticide was a persistent or non-persistent type of chemical.

	character of the pesticide applied. The resulting individual-level estimates of relative exposure intensity can be used in conjunction with interview data to obtain more complete exposure assessment in an epidemiologic study. While the database can improve environmental epidemiological studies involving pesticides, it simultaneously illustrates important data gaps that cannot be filled. Studies such as this one have the potential to identify preventable causes of disease and guide public policies.	
CDC. (1999). Surveillance for acute pesticide-related illness during the medfly eradication program - Florida, 1998. *MMWR, 48*, 1015-1018.	ABSTRACT: The Mediterranean fruit fly (Medfly) (*Ceratitis capitata,* Wiedemann) is an exotic insect that can damage approximately 250 fruit and vegetable plant species and is a serious threat to domestic agriculture. During the spring and summer of 1998, pesticides were used by federal and state agriculture authorities to eradicate Medfly infestations that had been detected in portions of five Florida counties. This report summarizes surveillance data, describes probable and possible cases of illness associated with the eradication effort, and provides recommendations for future Medfly-eradication programs.	Possible adverse health effects from an population of 132,000 exposed to malathion sprayings were collected from reports to state health and agriculture authorities. This was done through monitoring telephone hotlines and GPs. This enabled crude rates to be calculated, although there is no baseline incidence rate to use as a point of comparison.
Gilmore Research Group (2000) Asian Gypsy Moth Spray Project: a follow-up survey. A report prepared for the Washington State Department of Agriculture, November 20, 2000.	Unavailable, but referred to in: Anon. (2001). *Report of Health Surveillance Activities - Aerial Spraying for Asian Gypsy Moth - May 2000 Seattle.* Olympia, WA: Washington State Department of Health. A random telephone survey of 339 residents in the spray area found that 9% of people thought that the health of them or someone in their household was affected by the sprayings. This represents between 3 and 9% of all residents.	The limitations to this survey include low response rate (61%), the poor relationship between the Department of Agriculture (running the survey) and the community, and the long recall period of six months. This could have lead to some bias in the results.
Green, M., Heumann, M., Sokolow, R., Foster, L., Bryant, R., & Skeels, M. (1990). Public health implications of the microbial pesticide Bacillus thuringiensis: An epidemiological study. Oregon, 1985-86. *Am J Public Health, 80*(7), 848-852.	ABSTRACT: Bacillus thuringiensis var. kurstaki (B.t.-k) is a microbial pesticide which has been widely used for over 30 years. Its safety for a human population living in sprayed areas has never been tested. Surveillance for human infections caused by B.t.-k among Lane County, Oregon residents was conducted during two seasons of aerial B.t.-k spraying for gypsy moth control. Bacillus isolates from cultures obtained for routine clinical purposes were tested for presence of Bacillus thuringiensis (B.t.). Detailed clinical information was obtained for all B.t.-positive patients. About 80,000 people lived in the first year's spray area, and 40,000 in the second year's area. A total of 55 B.t.-positive cultures were identified. The cultures had been taken from 18 different body sites or fluids. Fifty-two (95 percent) of the B.t. isolates were assessed to be probable contaminants and not the cause of clinical illness. For three patients, B.t. could neither be ruled in nor out as a pathogen. Each of these three B.t.-positive patients had preexisting medical problems. The level of risk for B.t.-k and other existing or future microbial pesticides in immunocompromised	*Bacillus* isolates from medical labs were tested during an aerial spraying of Btk in Oregon in 1985-1986. 55 cultures of Btk were found; 52 were classified as probable contaminants, and the other 3 were inconclusive.

	hosts deserves further study.	
Kahn, E., Berlin, M., Deane, M., Jackson, R., & Stratton, J. (1992). Assessment of acute health effects from the Medfly Eradication Project in Santa Clara County, California. *Arch Environ Health, 47*(4), 279-284.	ABSTRACT: Surveys were performed to assess the acute health effects of aerial application of malathion bait over a large urban area. Three indirect attempts to assess utilization of health care services were made: (1) surveillance of a major hospital emergency department was undertaken, (2) ambulance dispatches were reviewed, and (3) emergency treatments for asthma at a university hospital were reviewed. These assessments were negative but insensitive. Prevalence of self-reported symptoms was assessed with two surveys that were subject to severe time constraints. Personal interviews of the same individuals, before and after the spraying, were conducted: one was conducted by telephone and the other by residential visit. Results indicated no detectable increase in acute morbidity. Also, after the spraying, there was a decrease in anxiety-related symptoms.	The pesticide malathion was aerially sprayed over California in the early 1990s. Health service data showed no significant increases in the number of hospital emergency room admissions, ambulance call-outs or emergency treatments for asthma at the hospital. However, these were assessed as being insensitive. Surveys were conducted before and after sprayings; these detected no increase in acute morbidity but were subject to some limitations.
Kahn, E., Jackson, R. J., Lyman, D. O., & Stratton, J. W. (1990). A Crisis of Community Anxiety and Mistrust: The Medfly Eradication Project in Santa Clara County, California, 1981-82. *American Journal of Public Health, 80*(11), 1301.	ABSTRACT: Public anxiety of near panic proportions was created by the announcement of a plan to commence aerial application of malathion bait over a large urban area in California for the eradication of the Mediterranean fruit fly within four days. A risk assessment had reported the project entailed no significant risk to health but environmentalist groups and the media ignored the report. We describe the successful measures taken by State health workers to counteract the anxiety which itself constituted a serious public health problem. The most important measure was the rapid convening of a Health Advisory Committee composed of recognized experts and local professionals and leaders to provide an authoritative, respected and sympathetic voice to deal with the community's concerns. These experiences may be of value to other communities facing unwarranted anxiety over perceived environmental hazards.	Anxiety in a population exposed to aerial sprayings can also be considered a public health problem. It can be lessened through certain measures, including using experts and local professionals to explain the sprayings and deal with the community's concerns.
Marty, M., Dawson, S., Bradman, M., Harnly, M., & Dibartolomeis, M. (1994). Assessment of exposure to malathion and malaoxon due to aerial application over urban areas of southern California. *J Expo Anal Environ Epidemiol., 4*(1), 65-81.	ABSTRACT: The state of California conducted aerial applications of malathion (MA) bait over urban areas in the southern California air basin in order to eradicate the Mediterranean Fruit Fly (Ceratitis capitata). Concern about the potential human health effects of this activity prompted a risk assessment conducted by the California Department of Health Services. Estimates of potential human exposures to MA and its primary breakdown product, malaoxon, (MO) are based on assumptions of daily human activities which influence the rate of contact with MA and MO. Several exposure scenarios, representing a range of activity levels from sedentary to very active, are used as surrogates for a variety of human activities. For each exposure scenario, acute dose rates are calculated using both the mean and the mean plus 2 standard deviations (SD) (98% upper confidence limit (UCL)) of measured environmental values. Chronic dose rates are calculated using long-term averages incorporating degradation and multiple applications at 14 day intervals, and the estimated 98% UCL for these averages. Based on this model, estimated adult dermal	Models can be created to assess residents' exposure to aerially applied pesticides, based on their level of daily activity (sedentary to very active). For each exposure scenario, the maximum possible exposure level can be calculated with 98% confidence intervals, to determine whether exposure levels are within acceptable guidelines.

	doses (1-246 micrograms/kg-d) are up to about 2000-fold higher than the estimated inhalation doses (0.01-0.1 microgram/kg-d) but are comparable to the doses from ingestion of contaminated unwashed backyard vegetables (30-80 micrograms/kg-d). For the individual who does not consume backyard vegetables, therefore, almost the whole dose of MA or MO would be due to contacting contaminated surfaces with skin.	
Noble, M., Riben, P., & Cook, G. (1992). *Microbiological and epidemiological surveillance programme to monitor the health effects of Foray 48B Btk spray*. Report to the British Columbia Ministry of Forests.	Unavailable, but discussed in the review: Siegel, J. (2001). The mammalian safety of Bacillus thuringiensis-based insecticides. *J Invertebr Pathol., 77*(1), 13-21. Health effects associated with an aerial spraying of Btk were monitored in Canada. They were measured through examination of bacterial isolates for Btk, from lab samples gathered from laboratories, GP patients, hospital emergency department admissions. The study also monitored the health of spray workers, and reviewed the records of 26,000 telephone calls.	429 bacterial isolates were received; 325 isolates were confirmed as Bt, and 43 were pure cultures. The nasal swabs of patients in and out of spray zones found no difference in the percentage of Btk cultured, and no positive nasal swabs were associated with ill health effects. There was no difference in ER admissions or the number of phone calls. Some of the spray workers reported symptoms such as chapped lips, dry skin, and irritation in eyes, nose and throat.
Rull, R., & Ritz, B. (2003). Historical pesticide exposure in California using pesticide use reports and land-use surveys: An assessment of misclassification error and bias. *Environ Health Perspect., 111*(13), 1582-1589.	ABSTRACT: We used California's Pesticide Use Report (PUR) and land-use survey data to conduct a simulation study evaluating the potential consequences of misclassifying residential exposure from proximity to agricultural pesticide application in health effect studies. We developed a geographic model linking the PUR with crop location data from land-use surveys to assess the impact of exposure misclassification from simpler exposure models based solely on PUR or land-use data. We simulated the random selection of population controls recruited into a hypothetical case-control study within an agricultural region. Using residential parcel data, we derived annual exposure prevalences, sensitivity, and specificity for five pesticides and relied on the PUR plus land-use model as the "gold standard." Based on these estimates, we calculated the attenuation of prespecified true odds ratios (ORs), assuming nondifferential exposure misclassification. True ORs were severely attenuated a) when residential exposure status was based on a larger geographic area yielding higher sensitivity but low specificity for exposure, in contrast to relying on a smaller area and increasing specificity; b) for less frequently applied pesticides; and c) with increasing mobility of residents among the study population. Considerable effect estimate attenuation also occurred when we used residential distance to crops as a proxy for pesticide exposure. Finally, exposure classifications based on annual instead of seasonal summaries of PUR resulted in highly attenuated ORs, especially during seasons when applications of specific pesticides were unlikely to occur. These results underscore the importance of increasing the spatiotemporal resolution of	Misclassification of exposure from agricultural pesticide sprayings can lead to bias in studies on health effects. This study simulated the random selection of control subjects around a spray zone, and calculated odds ratios for different misclassification scenarios. True odds ratios were severely attenuated when exposure was classified only on large geographic areas, when certain pesticides were less frequently used, or when a population was more mobile. The conclusion of the study was that it is important to have reasonable spatiotemporal

	pesticide exposure models to minimize misclassification.	resolution of exposure levels.
Siegel, J. (2001). The mammalian safety of Bacillus thuringiensis-based insecticides. *J Invertebr Pathol., 77*(1), 13-21.	ABSTRACT: The United States Environmental Protection Agency between the years 1961 and 1995 registered 177 products containing viable Bacillus thuringiensis (Bt). Numerous laboratory studies have demonstrated that Bt and Bt products are noninfectious and are toxic to mammals only at a dose > or =10(8) colony forming units (cfu) per mouse (a human equivalent based on the weight of >10(11) cfu). In contrast, as few as three vegetative cells of Bacillus anthracis can kill mice (a human equivalent of >10(3) cfu). There are only two literature reports of Bt infection in man between the year 1997 and the present, and all infected individuals had experienced either extensive burns or a blast injury, which predisposed them to infection. Two epidemiology studies conducted during large-scale aerial Bt serovar kurstaki spray campaigns reported no increased incidence of illness. Some recent papers have expressed concern about the production of Bacillus cereus enterotoxins by Bt isolates. Laboratory studies found no evidence of illness in rats and sheep fed Bt products, nor have epidemiology studies found increased incidence of diarrhea during Bt aerial spray campaigns. Increases in human antibody levels following exposure to Bt products have been reported but there was no increased incidence in asthma or other illness. Based on laboratory studies and field experience, Bt insecticides have an excellent safety record.	This review looked at the safety of Bt insecticides to mammals, including humans. It found that two cases of human infection by Bt have been reported; both people were already suffering from either severe burns or blast injuries. Epidemiological studies have found no increase in disease incidence during or after aerial sprayings. Human antibody levels have been found to increase after sprayings, but have not led to increased levels of asthma or illness.
Teschke, K., Chow, Y., Bartlett, K., Ross, A., & van Netten, C. (2001). Spatial and temporal distribution of airborne Bacillus thuringiensis var. kurstaki during an aerial spray program for gypsy moth eradication. *Environmental Health Perspectives, 109*(1), 47-54.	ABSTRACT: We measured airborne exposures to the biological insecticide Bacillus thuringiensis var. kurstaki (Btk) during an aerial spray program to eradicate gypsy moths on the west coast of Canada. We aimed to determine whether staying indoors during spraying reduced exposures, to determine the rate of temporal decay of airborne concentrations, and to determine whether drift occurred outside the spray zone. During spraying, the average culturable airborne Btk concentration measured outdoors within the spray zone was 739 colony-forming units (CFU)/m3 of air. Outdoor air concentrations decreased over time, quickly in an initial phase with a half time of 3.3 hr, and then more slowly over the following 9 days, with an overall half-time of about 2.4 days. Inside residences during spraying, average concentrations were initially 2-5 times lower than outdoors, but at 5-6 hr after spraying began, indoor concentrations exceeded those outdoors, with an average of 244 CFU/m3 vs. 77 CFU/m3 outdoors, suggesting that the initial benefits of remaining indoors during spraying may not persist as outside air moves indoors with normal daily activities. There was drift of culturable Btk throughout a 125- to 1,000-meter band outside the spray zone where measurements were made, a consequence of the fine aerosol sizes that remained airborne (count median diameters of 4.3 to 7.2 microm). Btk concentrations outside the spray zone were related to wind speed and direction, but not to distance from the spray zone.	This study examined the concentration of Btk after an aerial spraying. The outdoor concentration decreased quickly after the spraying, then more slowly over the following 9 days. The indoors concentration was initially 2-5 times lower than the outdoor concentration, but at 5-6 hours after the spraying, was higher than the outdoor spraying. The spray drifted up to 1 km outside of the spray zone; it is not clear whether it possibly travelled further.
Thomas, D., Petitti, D., Goldhaber, M., Swan, S., Rappaport, E., & Hertz-Picciotto, I. (1992).	ABSTRACT: We studied reproductive outcomes in a cohort of 7,450 pregnancies identified through three Kaiser-Permanente facilities in the San Francisco Bay Area, in relation to exposure to the pesticide malathion, applied aerially to control an infestation by the Mediterranean fruit fly.	This was a cohort study of all women (aged 17 and over) pregnant during aerial sprayings of

Reproductive outcomes in relation to malathion spraying in the San Francisco Bay Area, 1981-1982. *Epidemiology, 3*(1), 32-39.	We included in the cohort all women over age 17 who were registered at these facilities and who were confirmed as pregnant during the spraying period. Residence histories throughout the pregnancy were obtained by mailed questionnaire or telephone interview from 933 women with adverse outcomes and a sample of 1,000 women with normal outcomes, and were converted to geographical coordinates. We linked the coordinates for malathion spraying corridors with the residence coordinates to create individual exposure indices for each week of pregnancy. The statistical analysis compared each of the adverse pregnancy outcome groups against an appropriate control group using logistic regression or survival time regression approaches. After adjustment for various confounders, no important association was found between malathion exposure and spontaneous abortion, intrauterine growth retardation, stillbirth, or most categories of congenital anomalies. Gastrointestinal anomalies were related to second trimester exposure (odds ratio = 2.6), based on 13 cases and not specific to any particular International Classification of Diseases code.	malathion in the San Francisco bay area. 933 subjects were matched with a sample of 1000 controls. Addresses were geocoded and exposure levels measured for each week of pregnancy. No association was found between pregnancy outcomes and sprayings.
van Netten, C., Teschke, K., Leung, V., Chow, Y., & Bartlett, K. (2000). The measurement of volatile constituents in Foray 48B, an insecticide prepared from Bacillus thuringiensis var. kurstaki. *Sci Total Environ, 263*(1-3), 155-160.	ABSTRACT: Foray 48B, an insecticide prepared from Bacillus thuringiensis var. kurstaki (Btk), has been used for many years to combat infestations of Gypsy moths. Foray 48B also contains a large number of 'inert ingredients' which are not disclosed by the manufacturer. Gypsy moths usually enter the country through marine- and airports in close proximity to urban areas, which consequently need to be sprayed. The population affected often demands more detailed information than what is available including the potential presence of volatile organic agents which could be released during spraying, posing a potential health hazard. Four different methods were investigated using GC/mass spectrometry regarding their ability to capture volatile agents associated with Foray 48B. It was found that solid phase micro-extraction was most efficient in capturing volatile agents from the head-space of Foray 48B. Separate trials using 95:5% ethanol/isopropanol mixture and toluene in an impinger configuration were much less efficient. Standard techniques using activated charcoal tubes in the laboratory setting as well as in a field trial did not capture any compounds. It was concluded that the volatile agents associated with Foray 48B did not appear to constitute a significant health hazard and no one agent was a likely candidate to serve as a tracer for Foray 48B exposure.	The full list of ingredients in Foray 48B is not available. This study investigated the other volatile agents in Foray 48B, and found that they appeared not to pose any significant health hazard.
Ward, M., Nuckols, J., Weigel, S., Maxwell, S., Cantor, K., & Miller, R. (2000). Geographic information systems. A new tool in environmental epidemiology. *Ann Epidemiol., 10*(7), 477.	ABSTRACT: Geographic Information Systems (GIS) are useful tools for identifying populations with potential exposure to environmental contaminants. Using a GIS, features of the local environment around an individual's home, work, or school can be described. We present two examples illustrating methods and issues in identifying populations potentially exposed to agricultural pesticides and to toxic releases from the Toxic Release Inventory (TRI).METHODS: We used USDA Farm Service Agency records as ground reference data to classify a late summer 1984 satellite image into crop species in 3 counties in Nebraska. We located residences from a case-control study of non-Hodgkin's lymphoma (NHL) on the crop maps and calculated the distance to crop fields. Residences from a 4-center study of NHL were mapped and the distance to	GIS can be used to calculated exposure to pesticide sprayings. The model can include the distance to sprayings and possible drift patterns of the spray. GIS is a useful tool in environmental epidemiology studies.

	TRI sites was determined. RESULTS: Twenty-two percent of residences had crop fields within 500 meters of the home, an intermediate distance for the range of drift effects from pesticide applications. After accounting for the extent of primary drift from ground applications of pesticides, we estimated that 30 percent of residences were potentially exposed to crop pesticides. In the 4-center study, residence locations determined by address-matching methods and by a global positioning system were compared; the population 1 mile from specific TRI sites is described. CONCLUSIONS: These examples demonstrate the utility of a GIS in environmental epidemiology studies. A GIS can be a useful addition to questionnaire and other methods of exposure assessment in health studies.	