



## Symptom complaints following aerial spraying with biological insecticide Foray 48B

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### Abstract

**Aim** To investigate the effect of aerial *Bacillus thuringiensis* (Foray 48B) spraying on self-reported symptom complaints, health perceptions, and visits to healthcare providers.

**Methods** Two hundred and ninety two residents within the Ministry of Agriculture and Forestry (MAF) West Auckland spray zone were recruited by a door-to-door survey of homes within the most intensively sprayed area ten weeks prior to the first aerial spraying. Participants completed a symptom checklist and a questionnaire measuring health perceptions. Three months after the start of spraying, 181 (62%) of the original participants responded to a similar postal questionnaire. Symptom reports, health perceptions and visits to healthcare providers were compared between the baseline and the follow-up questionnaire. Rates of symptom complaints in respondents with previously diagnosed asthma, hay fever, or other allergies were compared to those in respondents without these prior health conditions.

**Results** Symptom complaints increased significantly following the aerial spraying, in particular: sleep problems, dizziness, difficulty concentrating, irritated throat, itchy nose, diarrhoea, stomach discomfort, and gas discomfort. Analyses showed a significant increase in symptoms in those participants with a previous history of hay fever. While overall self-ratings of health decreased following the spraying, most residents saw their health as unaffected by the spray programme, and there was no significant increase in visits to general practitioners or alternative healthcare providers.

**Conclusions** Aerial spraying with Foray 48B is associated with some adverse health consequences in terms of significant increases in upper airway, gastrointestinal, and neuropsychiatric symptoms, as well as a reduction in overall perception of health in the exposed population.

Following the discovery of the painted apple moth in West Auckland in 1999, an eradication programme was instituted by the Ministry of Agriculture and Forestry (MAF). This programme initially involved ground spraying in the area of the outbreak, and subsequently included aerial spraying in a targeted area of West Auckland starting in January 2002. The spray area included the suburbs of Te Atatu South, Glendene, Kelston, Glen Eden and the Avondale Peninsula, and contained a population of approximately 13 500 residents. The spray programme was expanded later in the year to include other Auckland suburbs, after moths were found outside the initial aerial spray zone.

The spray (Foray 48B) contains spores of *Bacillus thuringiensis kurstaki* (Btk) in a solution derived from the bacterial culture medium. This spray has been used in a

number of similar eradication programmes, including the white-spotted tussock moth programme (Operation Evergreen) in the eastern suburbs of Auckland in 1996. Previous health assessments of the effects of this aerial spray have been based on the monitoring of a variety of health services after the spraying. In the case of Operation Evergreen, this included surveillance of consultation patterns at sentinel general practices and birth outcomes at catchment hospitals two years following spraying. No increased risk of adverse events was detected in the exposed population.<sup>1</sup>

Aerial spray programmes generate a great deal of anxiety in the communities exposed to the spray and there is currently a lack of data on the effect of Foray 48B on symptom complaints and perceptions of health as opposed to its effect on the rates of medically diagnosed illness. In this study, we investigated self-reported symptoms before and after exposure to Foray 48B.

## Methods

**Participants and procedure** The participants were residents within the most intensively sprayed area of the initial MAF aerial spray zone. Participants were recruited by a door-to-door survey of the homes identified by MAF as being within a 100 metre zone along the riparian margins of the Whau River, Wairau Creek and Waikumete Cemetery spray zones. With informed consent and ethics committee approval, residents aged over 18 were invited to participate in a survey of health and symptoms related to the aerial spray programme. Of the 315 residents approached to participate in the study, 292 agreed to participate (refusal rate = 7%). Baseline data were gathered at the end of October 2001, 10 weeks prior to the first spraying by MAF aircraft. At the end of March 2002, after the area had been sprayed on three occasions, study participants were asked to complete a postal questionnaire. Non-respondents were sent two reminder letters.

**Questionnaires** The baseline questionnaire was completed by participants at their homes in the presence of the research assistant. In this questionnaire, participants provided demographic information and also indicated whether or not they had previously been diagnosed with asthma, hay fever or other allergies. Participants were asked to indicate which, if any, of 25 symptoms they had experienced in the preceding four weeks. This symptom list was derived from the Subjective Health Complaint Scale.<sup>2</sup> This scale has been used previously in a New Zealand population and found to be a highly reliable means of assessing symptom complaints.<sup>3</sup> Participants were also asked to rate their overall health using a seven-point scale from “terrible” to “excellent”, and to state the number of visits they had made to a general practitioner (GP) or alternative healthcare provider during the past three months. The participants’ names and addresses were also collected by the research assistant in order that they could be sent a follow-up questionnaire.

In the follow-up questionnaire, participants were asked to repeat the symptom checklist and the self-rated health item, and to estimate the number of visits they had made to a GP or alternative healthcare provider during the previous three-month period. Participants also indicated whether or not they had changed their medication or taken any new medicines in response to the spraying and if they had discussed concerns related to the spraying with their GP or other doctor. Participants were asked to rate “How much was your health affected by the spray programme in your area?” and, if they had children at home, “How much was your children’s health affected by the spray programme in your area?” Both questions were rated on a five-point scale from “not at all” to “extremely”.

Statistical analysis was carried out using SPSS for Windows statistical software. Differences between the frequency of symptoms and self-rated health reported at baseline and follow up were analysed by comparing subjects who answered both baseline and follow-up questionnaires using paired sample t-tests. Differences in frequency of symptoms reported by participants who gave a history of asthma, hay fever or other allergies and by participants without these conditions were conducted using analysis of variance (ANOVA). Changes in the frequency of visits to GPs and alternative healthcare providers were analysed with non-parametric tests due to the skewed nature of these distributions.

## Results

The sample comprised 131 males and 161 females. Participants' ages ranged from 18–79 years, with a mean age of 42.1 years (SD = 15.2). Europeans made up 60.3% of the sample, Maori 7.5%, Pacific Islanders 13.5%, and other ethnic groupings 12%. These demographic characteristics are approximately the same as those identified for the total population of the spray area.<sup>4</sup> In total, 181 (62%) of the initial participants responded to the postal questionnaire. Non-respondents to the follow-up questionnaire were significantly younger ( $t(87) = 5.20, p = 0.001$ ), and more likely to be non-European ( $\Pi^2 = 19.46, p = 0.001$ ), but did not differ by gender ( $\Pi^2 = 0.85, p = 0.36$ ), number of baseline symptoms ( $t(285) = 0.69, p = 0.49$ ), previous diagnosis of asthma ( $\Pi^2 = .71, p = 0.39$ ), hay fever ( $\Pi^2 = 0.46, p = 0.49$ ), or rates of other allergies ( $\Pi^2 = 0.34, p = 0.56$ ).

**Table 1. Percentage of population reporting each symptom at baseline and following spraying**

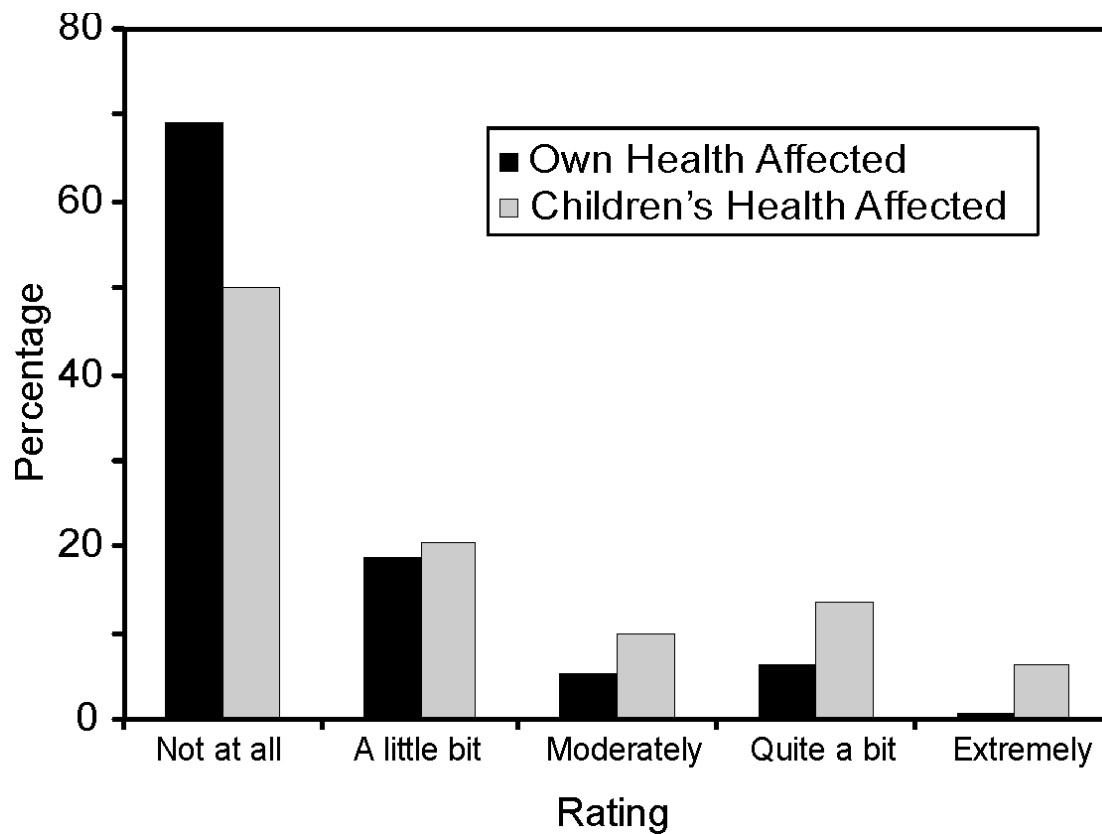
Health problem	Baseline % (n = 292)	After spraying % (n = 181)	Change %	t	p value
Headache	45.5	51.4	13	-1.9	0.06
Back pain	35.9	31.4	-13	1.87	0.06
Coughing	29.1	33.3	14	-1.7	0.10
Cold, flu	28.6	30.1	5	-0.5	0.60
Sleep problems	26.6	36.2	36	-2.2	0.03
Neck pain	23.9	25.0	5	0.15	0.89
Leg pain during physical activity	23.8	19.1	-20	0.9	0.37
Shoulder pain	20.3	23.9	18	-1.1	0.26
Arm pain	17.2	19.0	10	-0.7	0.48
Stomach discomfort	16.6	25.5	54	-2.2	0.03
Irritated throat	16.2	31.9	97	-3.7	0.0001
Itchy nose	16.2	23.2	43	-2.1	0.04
Migraine	12.8	14.8	16	-1.4	0.18
Dizziness	11.0	16.9	54	-2.5	0.01
Wheezing	10.0	13.0	30	-1.6	0.11
Diarrhoea	9.3	16.8	81	-2.2	0.03
Gas discomfort	8.6	16.8	95	-2.3	0.02
Chronic eye irritation	8.3	13.7	65	-1.8	0.07
Eczema	7.9	7.1	-10	0	0.99
Pain in ears	7.9	10.3	30	-0.7	0.49
Chest pain	7.2	8.7	21	-0.7	0.49
Extra heartbeats	6.9	10.3	49	-2	0.05
Constipation	6.2	6.5	5	1	0.32
Difficulty concentrating	5.2	12.5	140	-3.2	0.001
Blurred or double vision	5.2	9.8	88	-1.3	0.20

The data were first analysed to examine differences between reported symptoms at baseline and following the commencement of the spraying programme. Overall, the total number of reported symptoms increased significantly from baseline (mean = 3.90, SD = 3.56) to follow up (mean = 4.78, SD = 4.48),  $t(156) = -2.99, p = 0.003$ . As can be seen from Table 1, participants reported increases in a number of symptoms

following the spraying. Significant increases were noted for the following symptom reports: sleep problems, difficulty concentrating, dizziness, irritated throat, itchy nose, diarrhoea, stomach discomfort, gas discomfort, and extra heartbeats.

At the baseline survey, 14.7% of participants reported they had previously been diagnosed with asthma, 24.6% with hay fever, and 19.2% with other allergies. To examine whether participants suffering from these conditions were affected by the spray programme, an analysis of variance was conducted for each of these groups compared to those without the diagnoses, controlling for their symptom scores at baseline. These analyses showed a significant increase in symptoms for participants with a history of hay fever ( $F(1147) = 5.30, p = 0.02$ ) compared with those participants not previously diagnosed with hay fever, but no significant increase for participants with a history of asthma ( $F(1151) = 2.19, p = 0.14$ ) or other allergies ( $F(1139) = 1.53, p = 0.22$ ) when compared with participants without these diagnoses.

**Figure 1. Percentage of participants reporting that their own health or their children’s health was affected by the MAF spray programme**



Participants’ self-rated health declined significantly from baseline (mean = 5.40, SD = 1.12) to follow up (mean = 5.08, SD = 1.21)  $t(175) = 3.69, p = 0.0001$ . However, there were no significant increases in the number of visits to the GP (Wilcoxon  $Z = -0.94, p = 0.35$ ) or to alternative healthcare providers (Wilcoxon  $Z = -0.39, p = 0.69$ ) following the spraying. Overall, 9.2% of participants reported discussing the effects

of the spray with their GP, and 6.5% reported changing their medication because of the spray. Most participants reported that their own and their children's health was not affected by the spray programme, with children's health more likely to be seen as being affected than the participants' own health (see Figure 1).

## Discussion

This study found significant changes in the pattern of symptom reports among residents exposed to aerial spraying with Foray 48B. The most notable change was a doubling in the rate of irritated throat following the spraying. Gastrointestinal symptoms also increased significantly following spraying, with increases in stomach and gas discomfort as well as in diarrhoea. Increases in sleep problems, dizziness and concentration difficulties were also noted. Hay fever sufferers were more likely to have increased symptoms following spraying, but no significant increases in symptoms were noted for asthmatics or participants with other allergies. Relatively few subjects considered that the spray programme had produced more than a moderate effect on their health, and there was no increase noted in the rate of consultations with either medical practitioners or alternative healthcare providers.

It was noteworthy that those symptoms that significantly increased in frequency following the aerial spraying, fell into three loose clusters. Sleep problems, difficulty concentrating and dizziness might be considered indicators of a neuropsychiatric response to the spray programme, while irritated throat and itchy nose may reflect local effects on the upper airway, and stomach discomfort, gas discomfort and diarrhoea suggest that there may be effects of the spray on the gastrointestinal system. The factors responsible for these symptom clusters may be different. The neuropsychiatric symptoms may result from sleep disturbance caused by the early morning spraying by low-flying aircraft, as well as increased anxiety in some residents because of the perceived risks of the programme. The upper airway symptoms may result from the local irritant effects of inhaled spray. The gastrointestinal effects may result from preformed endotoxin in the spray or from enterotoxin produced by *B. thuringiensis* replicating in the gut of exposed persons, or may be due to some other mechanism.

Previous work by others suggests that it is not unreasonable to expect that exposure to spray containing *B. thuringiensis* might cause health effects. Commercial sprays such as Foray 48B contain spores of *B. thuringiensis kurstaki*, spore-associated crystals of *B. thuringiensis kurstaki*-derived endotoxin, various volatile chemicals, and residual components of the medium in which the organism was cultivated. Health effects might be due to germination of spores to produce replicating bacilli, direct effects of the pre-formed endotoxin, or irritant or allergic effects of the nutrient or other components of the culture medium. Exposure to sprays containing *B. thuringiensis* commonly leads to human infection with the organism and an associated immune response.<sup>5,6</sup> In one study of farm workers who picked sprayed vegetables, positive skin test responses and IgG and IgE antibody responses to *B. thuringiensis* were common and were correlated with the intensity of exposure to the spray.<sup>6</sup> *B. thuringiensis* is almost indistinguishable from *B. cereus*, a relatively common cause of food poisoning, and produces an enterotoxin which is identical to that produced by *B. cereus*, although at a much lower level.<sup>7</sup> *B. thuringiensis* may have been responsible, at least in part, for an outbreak of gastroenteritis in a Canadian chronic care institution, where it was isolated from spice and from the faeces of four affected

patients, two of whom also had Norwalk virus in their faeces.<sup>8</sup> Thus, there appear to be a number of potential means by which the spray might cause human illness.

Previous research on the health effects of similar spray programmes has not found conclusive evidence of adverse health effects as a result of the spray. These studies have been largely based on monitoring the use of healthcare services,<sup>1,9,10</sup> isolation of *B. thuringiensis* from clinical specimens submitted for culture,<sup>9,10</sup> or specific studies of possible high-risk groups, such as children with asthma.<sup>11</sup> The current study differs from previous approaches by examining changes in symptom complaints in the population before and after being exposed to the spray and is therefore likely to be sensitive to changes in symptoms that are not presented to health services. In fact, individuals only present a very small proportion of physical symptoms to doctors, and the vast majority are managed through restricting activity and self medication.<sup>12</sup> The decision to seek medical care for symptoms is influenced by a wide number of factors, such as the perceived efficacy of medical treatment for the complaint, the presence of pain, level of disability, and economic considerations.<sup>13</sup>

There are a number of limitations of the study, which mean our findings should be interpreted with caution. Although the response rate to the follow-up questionnaire was relatively high for a study of this type, it is likely that people who perceived themselves as being affected by the spray would have been more inclined to respond. Furthermore, we cannot be certain that the changes in self-reported symptoms were a direct result of the spray programme, nor can we exclude the possibility that severe health effects occurred in a very small proportion of the people exposed to the spray. It is also possible that changes in exposure to pollen or other seasonal environmental factors may have contributed to the differences in symptom rates between the two surveys. The main pollen season in Auckland is from October to February, and this may have influenced upper airway symptom reports. However, we would not expect the changes in neuropsychiatric and gastrointestinal symptoms to be related to pollen exposure. Furthermore, the pattern of symptoms (no significant increase in eye irritation, wheezing, coughing) does not support an explanation based on changes in exposure to pollen. The use of a control group without spray exposure in future studies would help to resolve this issue.

While no significant differences in the frequency of visits to GPs or other healthcare providers were evident, it should be noted that the follow-up period may have been too short to pick up such changes in healthcare attendance. It should also be noted that the time period referred to in the initial symptom checklist was made longer in the follow-up questionnaire, in order to ensure all respondents had been exposed to the spray. This may be partly responsible for the overall increase in the number of symptoms found at follow up. However, it does not explain the unequal pattern of symptom changes found following spraying. Bearing in mind these limitations, the results of this study do suggest that aerial spraying with Foray 48B is associated with some adverse health consequences. Further research should focus on the potential effects of the spray on upper airway and gastrointestinal symptoms in populations exposed to it and should investigate the relationship between such symptoms and evidence of *B. thuringiensis* infection.

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