The Health Consequences of the ICI Fire

Report to the Minister of Health on the Health of Firefighters in the Fire at the ICI Riverview Store, Mount Wellington, Auckland, 21 December 1984

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Introduction

1. On 21 December 1984, the Riverview, Mount Wellington, Store of ICI (NZ) Limited was seriously damaged by fire. The store is a major distribution warehouse and contained substantial quantities of chemical products, including pool chemicals and herbicides and pesticides for agricultural use in New Zealand and the Pacific. The New Zealand Fire Service extinguished the fire, using complements of up to eighty-six firefighters. Over the next seven days Fire Service attendance at the site was required to dampen down hot spots, to stand-by in case of further fire or chemical spill, and to assist in the clean-up. Equipment and appliances used at the premises were handled or cleaned by firefighters who may not have attended the site of the fire. Approximately 141 firefighters attended the fire on 21 December and in total approximately 340 were involved in fighting the fire and in the clean-up of the site and equipment used at it. (See Appendix I.)

2. The fire was known to have involved the combustion of toxic chemicals, some of which were the subject of existing public concern. It immediately became the focus of considerable public anxiety. Concerns were raised as to the effect on public health of fall-out from the plume of smoke released by the fire, the environmental damage caused by chemically contaminated water run-off from the site, and the direct contamination of people involved in the suppression of the fire and subsequent clean-up of the site. Public anxiety may have
been exacerbated by conflicting statements about the chemicals involved and their risk, the scientific uncertainty about the combustion products of the fire and their toxicological effect, and the apparent absence of a strategy to anticipate and address public concerns.

3. Within a few days of the fire, more than thirty firefighters reported symptoms consistent with exposure to a toxic substance. Initial skin rashes resolved but numbers of firefighters continued to report recurrent skin problems, memory loss, irritability, lethargy and other symptoms. These symptoms were persistent for a number of firefighters. Several months after the fire, 200 firefighters were diagnosed as suffering from "chemical poisoning" by a diagnostic method not generally accepted by conventional medical practitioners. Six firefighters have been medically retired on the grounds of illness attributed to attendance at the ICI fire. Public controversy about long-term effects of exposure to chemicals known to have been present at the fire has continued, with particular concern being expressed about the risk of cancer in firefighters exposed and birth defects in their children. In December 1988 a firefighter, Mr Tony Jennings, died of leukaemia. Press reports linked the disease to his attendance at the ICI fire.

4. Against this background, the Minister of Health on 21 March 1989, set up this ministerial advisory committee to investigate the effects of the ICI fire on the health of firefighters. The committee was required

"(1) To arrange for a suitably qualified medical practitioner (hereafter called "the Investigator"),—

(a) To collect health information from all firefighters involved with the fire that occurred at the ICI Riverview Store, Mount Wellington, Auckland, on the 21st day of December 1984, or with the aftermath of that fire; and

(b) To analyse the health information collected pursuant to paragraph (a) of this clause; and

(c) To submit a report to you [the Ministerial Advisory Committee] on the health information collected under paragraph (a) of this clause (which report shall include the results of the analysis carried out pursuant to paragraph (b) of this clause):"
(2) On receipt of the report of the Investigator, to consider the report and to review the current state of health of each of those firefighters:

(3) To determine (if possible) whether or not health problems experienced by any of the firefighters since the fire are attributable in whole or in part to their involvement with the fire or its aftermath:

(4) To recommend what further action (if any) should be undertaken in respect of—

(a) Those firefighters involved with the fire or its aftermath who have developed health problems since the fire but who are satisfied with the medical treatment that they are receiving or have received; and

(b) Those firefighters involved with the fire or its aftermath who have developed health problems since the fire but who are not satisfied with the medical treatment that they are receiving or have received:

(5) To review the present health procedures applicable to firefighters involved in chemical fires—

(a) During such fires:

(b) Immediately following any such fire:

(c) By way of long-term medical surveillance—

and to recommend whether any changes need to be made to these procedures:

(6) To inquire into and make recommendations on such other matters as appear relevant:

5. The Committee sought submissions and information relevant to its functions by direct invitation to thirty-one individuals and organisations known to have information relating to the ICI fire and its aftermath or a special interest in the matter. It also advertised the terms of reference and its interest in receiving submissions and information in newspapers in general circulation throughout New Zealand. All firefighters known to have been involved in the ICI fire or the clean-up that followed it were also invited to make written submissions.

6. Thirty-five written submissions were received by the Committee. A number of those who responded with written submissions were
also invited by the Committee to supply additional information or to attend meetings of the Committee to answer questions.

7. A list of those who made written submissions to the Committee is to be found in Appendix VII to this report. We are grateful to all those who took the considerable trouble to put information before us in this way. In many cases, the submissions were lengthy and comprised information compiled at considerable personal cost. In all cases, the information put forward has been extremely valuable to the work of the Committee.

8. All firefighters known to have been involved in the fire or the clean-up which followed it were written to. They were given copies of the Committee’s terms of reference, and advised of the investigation to be undertaken. Those firefighters who subsequently participated in the study were also invited to indicate whether they wished to speak with members of the Committee. As a result, more than fifty firefighters were interviewed by members of the Committee.

9. To fulfil the requirement in the terms of reference “to arrange for a suitably qualified medical practitioner . . . to collect health information from all firefighters involved . . .”, the Committee appointed Dr Deborah Read as investigator and decided to collect health information by means of

- a detailed questionnaire which sought to obtain information relating to the firefighters’ present health problems, medical history before and after the ICI fire, exposure at the fire, medical treatment and social and occupational history
- tests of organ function by lung function test, blood analysis (full blood count, liver and renal function), and electrocardiogram
- psychological testing comprising a general health questionnaire designed to measure distress and a battery of neuropsychological tests designed to measure brain dysfunction.

10. A total of 245 firefighters in Auckland were investigated in this way. In addition, the questionnaire and tests (with the exception of the electrocardiogram test) were undertaken by a referent group of 217 Wellington firefighters. The referent group was required to permit a comparative cohort epidemiological study for the purposes of the inquiry into a possible causal connection between the fire and any health problems experienced by the Auckland firefighters and to
assess any health risk attaching to the group. It was also needed to provide norms against which the neuropsychological tests could be assessed, since it was considered that existing studies using the tests did not provide satisfactory norms.

11. We should like to record our special thanks to the Wellington firefighters who participated in the study. There must have seemed little appreciable personal benefit to them in submitting to the tests and questionnaire. Without their help it would not have been possible to do the epidemiological study.

12. The results of the investigation are relevant both to the epidemiological study, to assess whether firefighters who attended the ICI fire are particularly at risk of health problems, and to the review of the current state of health of each of the firefighters, required by the terms of reference.

13. We are extremely grateful to all those firefighters who participated in what must have been an intrusive, time-consuming and at times stressful exercise for them. The terms of reference we were given could quite simply not have been discharged without their support. In addition, their comments in the questionnaire and at interviews gave us insights which could not have been obtained from any other source. They brought vividly home to us the fact that living with the aftermath of the ICI fire has taken a considerable personal and family toll which should not be lost sight of in impersonal statistical analysis.

14. We have been impressed by the fairmindedness and thoroughness of the suggestions made to us by firefighters. In many cases where health problems are ascribed to presence at the ICI fire, the firefighters have proffered other explanations including pre-existing marital strain, family bereavements and even "mass hysteria" as alternative reasons why they have suffered from ill-health. A number, in reviewing their actions at the fire, blamed themselves for deficiencies in safety management of others and in their own personal observance of breathing apparatus and decontamination principles. In many cases firefighters from all ranks made thoughtful proposals for improvement of fire service management, equipment and practices. We were impressed with the range of talent contained within the Fire Service and hoped that the organisation of the Fire Service is capable of capturing the initiative demonstrated to us.
15. In addition to the investigation of the firefighters, the Committee reviewed the scientific literature on toxicological effect and chemical combustion and commissioned from Dr Major Eilenberg, a psychiatric specialist, a report as to the psychiatric and psychological impact of the fire and its aftermath upon the firefighters. That report is annexed as Appendix II. It also commissioned from the Swedish Poison Information Centre, a world authority on toxicology, a short report on the health effects of the ICI fire, by review of the reports already published. Its report is annexed as Appendix IV.

16. The present study has been preceded by four significant reports upon aspects of the ICI fire. They are:

1. The report prepared on behalf of the No 1 Region (Auckland) of the New Zealand Fire Service, *Report on the Fire at ICI New Zealand Limited's Riverview Store, Mt Wellington, 21 December 1984*, which is referred to throughout this report as the “Fire Service Report”. The report is dated 31 January 1985 and deals with details of the fire and its aftermath and the role of the New Zealand Fire Service. It concludes with recommendations relating to storage of hazardous chemicals, firefighting procedure, health of personnel and protective clothing. The issues addressed by these recommendations are referred to further in this report. In some cases they have been acted upon. Recommendations of particular relevance to this inquiry, however, are for
   - early attendance of a doctor at the scene of a fire or incident where the health of personnel may be affected by hazardous substances
   - continuing arrangements for monitoring the health and welfare of personnel affected by this fire.

   The first recommendation has not been acted upon and we consider that the second recommendation has not been fully implemented.

2. *Report to the Director-General of Health on the Circumstances Relating to a Fire at the ICI Warehouse, Bowden Road, Mt Wellington, 21 December 1984*, a report prepared in January 1985 by the then Medical Officer of Health for the Auckland District (and referred to in this report as the “Health Department Report”). This report, also, contained recommendations relevant to the present investigation and in
particular proposed medical surveillance of firefighters injured during the incident.

3. *The ICI Fire, A Report to the Minister for the Environment*, Commission for the Environment, 1985. This was a report of the investigations and reviews carried out by a number of government departments and agencies in relation to the ICI fire to determine what procedures should be established to avoid such incidents in the future.

4. Health Consequences of the ICI Fire a report by Associate Professor W I Glass in November 1985 to the New Zealand Fire Service. The report was commissioned to investigate the health consequences of the ICI fire. It described symptoms reported by those who attended the fire as falling into three main symptom complexes: the skin, the respiratory system and the central nervous system. It recommended in particular the collection of basic health measurements for firefighters, with annual examinations and routine post-fire health review.

It proposed the setting up of an occupational health service. The occupational health service has now been established, although not entirely along the lines proposed by Professor Glass, but the other recommendations have not been acted upon. The report indicated that it could not provide a "final answer" to the health problems experienced by the firefighters because "the systematically obtained health information so necessary for a 'final answer', even if that were possible, was simply not available".

17. We have drawn heavily on material contained in all these reports. They do not cover exactly the same ground as is required by our functions. The Fire Service and environmental reports are mainly concerned with firefighting and environmental impact. The report by Professor Glass, as he acknowledges, lacks the systematically obtained health information which we were required to obtain. Since all the reports on the ICI fire were prepared soon after the event they do not give the present perspective on the persistence of problems and subsequent events. This includes the effects of the diagnosis by EAV testing (described in paragraph 38) of chemical poisoning in 200 of the firefighters. None of the reports to date has managed to answer the continuing anxiety of the firefighters.
18. Other reports of relevance to our inquiry are

- *The Report to the Director-General of Health of the Task Force on Chronic Agricultural Chemical Poisoning Notifications*, June 1986 (the Maling Report), and

19. Both deal with diagnosis by electro-acupuncture techniques and the Brinkman Report is also relevant because 2,4,5-T was present in the ICI fire and was a major focus of concern.

20. It needs to be acknowledged at the outset that there are serious problems in addressing an event such as the ICI fire from a distance of five years. Investigations for toxic absorption have become unfeasible for most of the toxins known to have been present at the ICI fire, because their persistence in the body is exhausted. Systematic collection of information relating to exposure and symptoms is prejudiced by difficulties in the recall of events. In the absence of objective baseline information, progression or improvement of symptoms cannot be studied adequately. Positions may have been established, particularly in response to continued public controversy, scientific uncertainty and compensation difficulties. Understandable anxiety may have become chronic and sick roles accepted.

21. Moreover, as one might expect, aspects of the ICI fire and the health management of the firefighters at the time now have a dated air; the organisation of the Fire Service and the safety procedures observed by it have not remained static. Some lessons of the ICI fire have been learned and changes made. In an inquiry which requires us to make recommendations about the future treatment and present health procedures applicable, it is necessary to assess circumstances which are quite different from those existing at the fire and immediately after it. The most significant of these changes are

- the new fireground procedures adopted by the Fire Service for use in chemical fires
- improved decontamination procedures and equipment
- moves to upgrade breathing apparatus and the procedures for its use and improved protective clothing
22. The hindsight possible at this distance may also be misleading. We have expressed in this report considerable misgivings about the safety management of the fire, management of the health concerns of the firefighters arising out of the fire, and treatment and diagnosis of the firefighters. In many cases, firefighters and health professionals in positions of authority have expressed to us self-criticism and doubt about actions taken by them at the time of the fire and subsequently. That these criticisms may be appropriate with hindsight does not mean that the individuals taking decisions at the time are to be blamed for their conduct. We are very conscious of the fact that it is easy to second-guess at leisure decisions taken under the exigencies of the moment or in the context of substantial public controversy. If we are to learn from the mistakes of the ICI fire it is necessary to review events critically with a view not to attributing blame, but to devising procedures for the future.

23. We are concerned that expectations for a study of the type we have undertaken should be realistic. A number of firefighters welcomed our study on the basis that it would demonstrate “whether I am sick or not” or “whether I am chemically poisoned or not”. We recognise that for most firefighters these are the critical questions. They are not, however, in the present state of scientific knowledge capable of categorical answer. We are able to conclude that

- the firefighters do not exhibit present damage to critical organs
- the symptoms described by the firefighters are real and not imaginary
- the incidence of cancers and birth defects among Auckland firefighters is what would be expected in a normal population
- some firefighters suffered symptoms from exposure to toxins at the time of the fire
- it is unlikely that the central nervous system symptoms of the firefighters are a result of organic brain damage indicating toxicity
- it is likely that the central nervous system symptoms of the firefighters are a result of long-lasting (chronic) anxiety due to stressors resulting from their involvement in the ICI fire and
that these symptoms should improve with alleviation of their anxiety.

24. These conclusions are opinions, based on the material collected together in this report. They are not capable of exact proof. They are based on our assessment of the information and our own professional opinions. The Committee included an epidemiologist, a toxicologist, and an occupational health specialist. We recognise that some will find support in the information we have collected for other explanations and that others will find the tests selected unconvincing. It means that firefighters will have to accept a certain measure of uncertainty. But we hope that most firefighters will be able to accept our opinion and feel relieved of considerable concern.
II

The Investigation

1. SCOPE

25. The terms of reference required us to arrange for a suitably qualified medical practitioner to collect health information from all firefighters involved with the ICI fire.

26. It was necessary for us to determine at the outset what information we wished to obtain from the investigation, in order to fulfil our other functions. The terms relevant to the collection of information from firefighters were to

- assess the present health of the firefighters
- determine whether any health problems suffered by them since the fire could be attributable to the fire
- consider any appropriate action in respect of those firefighters satisfied with the medical treatment they have received since the fire and those who are not satisfied
- review health procedures applicable to firefighters involved in chemical fires.

2. APPROACH

27. It was known at the outset that a large number of firefighters in Auckland were involved in the fire. Those involved were asked to
complete a questionnaire (attached to Appendix I) which was designed to indicate their involvement at the fire and any health problems which may have resulted. A variety of tests was devised to evaluate critical organs.

28. Since it was known that central nervous system (CNS) symptoms were prominent amongst the involved firefighters a battery of tests was designed to evaluate brain function.

29. It was felt that the results would have much more meaning if a group comparison could be made with a referent group, which was subsequently taken from Wellington firefighters.

30. Thus the investigation of the health of firefighters involved with the fire is in two parts:

   The first is *Present Health Status Inquiry* (paragraphs 33–78) which allows for an evaluation of individual abnormalities.

   The results from Auckland are then used in a group comparison with similar testing performed on Wellington firefighters. This is the second part, *Causality and Assessment of Risk: the Epidemiological Study* (paragraphs 79–107).

31. Care must be taken not to generalise from the results within the Auckland firefighters who may show individual variation. Conversely group comparison data should not be used to imply that individual abnormality exists.

32. It is important to appreciate that we have used the words “acute” and “chronic” in their medical sense, rather than in a lay sense. Acute symptoms are therefore those which are an immediate or primary result of toxic exposure or illness; the symptoms themselves may be trivial or serious. Chronic symptoms are long-standing.

3. PRESENT HEALTH STATUS INQUIRY

A. INVESTIGATION

33. To answer the questions as to the present health status of the firefighters, it was decided to

   • test for damage to the lungs, heart and organs of excretion (being the organs most likely to be affected by toxins). The tests comprised an electrocardiogram (ECG), lung function
test and blood tests (full blood count, liver and renal function)

• compile a detailed health status profile by questionnaire (attached to Appendix I) for completion under supervision by each firefighter

• seek health status information about the firefighters by questionnaire completed by their spouses

• obtain information as to the psychological health of the firefighters by
  - The General Health Questionnaire (GHQ) designed to measure distress and
  - a battery of neuropsychological tests which attempt to measure organic (physical) brain damage.

(i) Biological Testing

34. In determining the biological tests appropriate to ascertain the current health status of the firefighters, we were concerned that the investigation should be no more intrusive and expensive than was warranted by the known effects of the toxins to which the firefighters may have been exposed. The organs of excretion and the lungs were chosen as being those most likely to show the effects of exposure to toxins. We were of the view that if the results of the tests gave cause for concern, then further testing would be considered. In the event, the tests threw up no more abnormalities than would be expected in a normal population sample, and further testing was not considered necessary.

35. The methodology used in obtaining and analysing the ECG, blood and lung function tests is described in Appendix I. The results of the blood samples were interpreted with reference to population norms. Lung function and ECG tests were interpreted by clinicians independently of the laboratory reports. Abnormal test results were reviewed by a member of the Committee and, after retesting of some firefighters for initially borderline or false-positive results, those with abnormal blood, lung or ECG results were referred to their own medical practitioners for review.

36. We did not consider it appropriate to attempt to take biological measurements of toxins that might be present in the body. There are
various appropriate and valid methods available for such measure-
ment. Techniques such as gas chromatography and liquid chromato-
graphy (coupled with mass spectroscopy) and nuclear magnetic
resonance make it possible to measure chemicals in the system up to
parts per trillion. We considered that testing of all the firefighters for
the presence of chemicals by such methods was uncalled for unless
the results of the initial survey indicated a probability of a toxic
explanation for clinical symptoms. Our reasons were

- the testing process is intrusive, requiring the subject to pro-
vide a large quantity of blood or removal of a body fat
sample (biopsy)

- the testing is extremely expensive

- the technology is sensitive and specific. Using such tech-
niques it is possible to measure to parts per trillion but at
these very low levels it is difficult to establish toxicological
effect; the presence of a toxin at a minute level in the body
does not necessarily mean that it is harmful

- the only chemicals to which the firefighters might have been
exposed at ICI with a half-life in the body which would
enable them to be detected by this technique are the dioxins
(of which the most toxic is 2,3,7,8-TCDD) which are known
to have a half-life of up to four years. (The biological half-life
is a term which describes the time taken for the quantity of a
substance in the body to be reduced by half. Reduction of the
substance is by all routes of excretion and metabolism.)
Dioxin was investigated in connection with the ICI fire, with
negative results. It is further discussed below at paragraph
329 in a review of the known toxicology of the chemicals
present in the ICI fire. Mass testing of all the firefighters for
the presence of dioxins did not seem to us to be warranted
unless indicated by other investigation.

37. At a later stage of the investigation, we saw one firefighter who
has symptoms of scarring acne (though not of the appearance of
chloracne, which is one of the symptoms of dioxin exposure). The
firefighter concerned had a history of long exposure at the fire and it
was decided to test him for the presence of dioxins on the basis that,
because of the scarring acne, he was a more likely subject for investi-
gation than firefighters without such symptoms. The results of the test
showed very low levels of dioxin, consistent with the levels normal as “background” in the general population.

38. A total of 200 of the firefighters in 1985 were diagnosed as suffering from “chemical poisoning” (specifically 2,4,5-T and/or paraquat) by a diagnostic method using Electro-Acupuncture according to Voll (EAV). EAV testing depends upon measurement of skin resistance over acupuncture points which are said to reflect the condition of various internal organs. The measurement of resistance is sensitive to the pressure used by the therapist on the probe and is therefore, even if a valid diagnostic tool, only partly objective. While it is accepted that needles inserted into acupuncture points can be manipulated in ways which will relieve symptoms, particularly pain, whether acupuncture points can provide any information regarding internal organs is controversial.

39. The diagnosis of poisoning or other toxic effect by EAV is achieved by handing the patient a vial of the possible toxin to see if it will “normalise” any abnormal reading. The vial can also be inserted into the circuit leading from the probe to the measuring apparatus. The toxic material is completely isolated from the circuit by glass.

40. Such a procedure cannot be understood by conventional science and, so far, no blind procedure (using blank solutions in the vial unknown to the operator) has been performed to check the validity of the readings. As with any other diagnosis, the method used cannot be proved by improvement of symptoms after treatment based on EAV diagnosis, because of the “placebo effect” described in paragraph 151. Symptoms described prior to an EAV diagnosis of toxic cause may be due to some completely unrelated reason which responds to placebo. It is also dangerous to assume that asymptomatic patients with an EAV toxic diagnosis will become ill and symptomatic in the future. The task force on Chronic Agricultural Chemical Poisoning Notifications (the Maling Report) and the Ministerial Committee on the Possible Health Effects of Manufacture of 2,4,5-T in New Plymouth (the Brinkman Report) concluded that the EAV technique could not be accepted as a rational or valid method of diagnosis.

41. The EAV diagnostic procedure is therefore a serious contradiction to known scientific accepted knowledge and has remained untested systematically and objectively in a manner which would support its validity.
42. In the absence of any scientific explanation for the validity of EAV testing for toxicity as an appropriate diagnostic tool, we believed that it was not appropriate to include such a test in our investigation.

(ii) The Health Status Questionnaire

43. The questionnaire (which is annexed to Appendix I) was designed for self-administration under supervision. It covered exposure history, medical history, and social and occupational history.

44. In the absence of objective measurement of exposure, detailed records of medical history (including any record of pre-exposure baseline health data), the firefighters' answers to the questions are the principal source of information from which we have worked. A survey conducted by the Fire Service and the Union in 1985 has been a useful check upon answers given in the current questionnaire. But, as is inevitable with a retrospective study, errors in recollection (commonly referred to as "recall bias") may affect the information. That effect is likely to be exacerbated by the length of time between the fire and the questionnaire. In addition, particularly when firefighters are asked to describe medical symptomatology, there is scope for confusion in terminology and significance.

(iii) The Spouses' Questionnaire

45. A questionnaire for spouses was included in the investigation, after representations from the Auckland firefighters. They expressed the view that often spouses have a better perception of health problems than the person directly affected. The questionnaires enabled a degree of cross-checking between firefighter and spouse perception and also enabled a better understanding of the effect on families.

(iv) Psychological Testing

46. Central nervous system symptoms (irritability, memory impairment, mood changes, impaired concentration and so on) were known to have been of particular concern to the firefighters. Such symptoms are an indication of dysfunction which may be due to organic (physical) effects on the brain or a result of emotional disturbance. Organic effects may be reversible or permanent. Organic dysfunction is a pointer to neurotoxicity (that is, impairment of the brain due to the action of a toxic agent).
(a) The General Health Questionnaire (GHQ)

47. The GHQ is a standard and internationally used symptom questionnaire. It measures the emotional symptoms of ill-health. Although like all self-reporting of symptoms it has to be treated with some caution (because it requires a subjective assessment by a subject who may lack insight or be motivated to exaggerate or minimise symptoms), it is a useful general indication of distress.

(b) The Neuropsychological (NP) Tests

48. Neuropsychological assessment (commonly referred to in this report as NP testing) measures brain dysfunction, as objectively as possible.

49. Toxicological investigation around the world is making increasing use of neuropsychological testing to establish neurotoxicity. The Swedish Poison Information Centre, which was consulted about the inquiry, recommended such testing as particularly useful in an inquiry such as this into toxic effect. Since a number of the chemicals known to have been present in the ICI fire have neurotoxic effect (occasionally in the case of some chemicals after acute exposure to high levels, but more commonly after repeated or prolonged exposure), we considered it important as part of this investigation to attempt to find out whether the central nervous system symptoms of the firefighters are a result of organic brain damage.

50. A difficulty with using neuropsychological tests is that they are a comparatively recent tool in toxicological assessment and are not yet fully standardised for all population groups. To date they have been used either in small studies or on groups which may be atypical. The tests used to measure neurotoxicity are largely derived from tests used in the case of brain trauma, especially in cases of concussion. Neurotoxicity may produce brain changes which are subtle and not structural and which cannot be checked by neurophysiological tests. Poor test results may be caused by neurotoxicity or may be due to a condition which pre-exists the toxic exposure (such as concussion or low intelligence or low level of education). Perhaps of particular significance to this study, poor test results may be affected by stress

   • at the time of testing (to produce a false-positive response)
   • as a secondary consequence of a degree of real brain dysfunction
• as a result of psycho-social stressors resulting from the fact or belief of exposure. Fear of brain damage itself may be a significant stressor. (See D. E. Hartman Neuropsychological Toxicology, New York, Pergammon Press, 1988)

51. For reasons such as these, some experts suggest that neurotoxicity should not be accepted on the diagnosis of poor test results alone, but should be arrived at after considering test results and clinical evaluation.

52. The advantages of neuropsychological testing, however, are that
- neurotoxic symptoms may not be detectable without such methods or may measure early damage not otherwise detectable
- such tests are comprehensive, enabling different functions of the brain to be assessed
- the tests are safe and not intrusive.

53. In settling the form of the investigation, we included a number of questions designed to eliminate confounding by pre-exposure and post-exposure factors for poor test results. That exercise aims to minimise the risk that poor test results may be unrelated to exposure.

54. We also administered the NP tests to a comparative group of Wellington firefighters, to obtain satisfactory norms. All firefighters are regularly exposed, in the absence of correct use of breathing apparatus, to carbon monoxide and other neurotoxins. The Wellington group's test responses were however comparable to the reliable norms available for some of the neuropsychological tests in the battery, which we considered provide a sufficient cross-check for normalcy. The methodology used is more fully described in the psychologists' report annexed to Appendix 1.

55. In the case of the epidemiological study also involving the Wellington group as a reference, comparisons between the two groups need to take into account biases (see discussion at paragraphs 97-100).

56. We did not have the resources to undertake a psychiatric clinical assessment of each of the firefighters, to be used with the test results in forming a conclusion as to neurotoxicity or brain damage. Nor did we think that such an exercise was warranted in the absence of poor test results for all firefighters. We did compare our consultant
psychiatrist's clinical interpretation of the symptoms described with the test results. Where symptoms described are suggestive of possible or probable brain dysfunction, and the tests results are poor, we have drawn a conclusion that a firm diagnosis of neurotoxicity would require clinical elimination of other causes by more complete medical history than is possible in a self-administered questionnaire, as well as clinical examination and more detailed testing.

57. The battery of neuropsychological tests used was devised and administered by Auckland psychologists. The full description of the tests and method employed is contained in their report, annexed to Appendix I.

B. THE RESULTS OF THE INVESTIGATION

(i) The Biological Tests

58. Twenty-five firefighters in the Auckland group tested abnormally. The results were reviewed by a physician and in most cases were of a minor nature. The individuals were advised of the results and referred for further opinion where necessary.

(ii) The Health Status Questionnaire

(a) Exposure

59. Ninety-three percent of the firefighters believed they were exposed to chemicals at the time of the ICI fire.

(b) Symptoms Described

60. A total of 214 firefighters report health problems, the majority with an onset since the 1984 fire. Only 12% of those surveyed have no history of problems.

61. Ninety-five of the ICI firefighters studied (that is to say 39% of the group) consider that their general health has been affected as a result of the fire.

62. The Auckland firefighters in the study report an average of 2.9 health problems, the majority of these with an onset since the fire. The most common problems reported by the firefighters are
memory loss. Thirty-four percent (83) of the firefighters report this as an ongoing problem with an onset since 21 December 1984.

- skin problems. A total of 29.5% (72) of the Auckland firefighters report skin rash or lesions with an onset since December 1984. There is no association between ongoing skin problems and a history of skin problems before the fire, or a history of allergy.
- irritability. Irritability is reported by 29.5% (72) of firefighters as a problem with an onset after December 1984.
- mood changes, fatigue. Fatigue, loss of interest, impaired concentration, insomnia, headache and mood changes are also common problems with an onset after December 1984 (see Appendix I, Table 6).

63. Other symptoms described by firefighters include ataxia, nausea, night sweats (particularly with a chemical or sweet smell), anxiety and loss of confidence.

64. There is no association between age and health problems reported.

(c) Impact of Health Problems

65. A substantial measure of concern is expressed by firefighters. In particular:

- Fifty percentage of those tested are uncertain as to whether their general health has been affected by the ICI fire.
- Twenty-two percent of the firefighters report that their health problems have affected their personal relationships.
- A percentage of 10.7 of the firefighters express uncertainty about the future and anxiety.
- in the open-ended questions a number of firefighters expressed uncertainty about the diagnosis of “chemical poisoning” by EAV technique and the consequences for their health should the diagnosis be correct.
- long-term health effects, particularly of cancer and birth defects, are of particular concern.

66. A number feel betrayed by the Fire Service and by the Accident Compensation Corporation (for the events described in paragraphs
139–141). Others mention the demoralising effect of professional scepticism about their symptoms. Some mention a perceived social stigma in having attended the ICI fire. There is apprehension that the full story may not be known about the chemicals in the fire. Remarks include

“I worry for the future. For my career and the effect on my children.”

“Whether I am poisoned or not I do not know. That has caused me mental strain. . . . I was told by Dr Tizard that poisoning may be dormant, with no symptoms, for long periods. I do not know whether his diagnosis is correct. I currently feel OK but if Dr Tizard is correct then I do need a second opinion or medical assistance. This uncertainty has caused me a lot of concern.”

“Will it cause medical problems in old age?”

“Dr Tizard had warned that with healthy and fit people it might take time before side effects were felt.”

“I want peace of mind. Dr Tizard planted a seed of doubt when he said if you haven’t got these symptoms now, you will have in three years.”

“. . . Basically, I just want to know whether I am affected or not.”

“I am unsure as to whether I have received any danger to my health. My health may fail in ten to twenty years. Who knows?”

“I am uncertain as to what is going to happen in the future—will the problem go away, or get worse.”

“I am worried as to the long-term effect (cancer, degenerative problems, birth defects).”

“I am hoping that testing will one way or another ascertain whether the stress problems were a result of the fire and therefore allow me to cope better with the present problem I have.”

“I hope this study will show once and for all whether our health is deteriorating because of age or accelerated by our working conditions.”

“We need to know [if we have chemical poisoning] . . . We would be more prone to cancer than the other
people. This could happen in 10, 20 years time. I don’t know.”

“My son (2) picks up viral infections.”

“My son has eczema. I am concerned as to whether this exposure could affect my children’s health.”

“I worry about the reports about birth defects and miscarriages.”

“There are rumours about deformed children.”

“I am fearful of the future, worried about the baby’s health.”

“It is a worry . . . wondering whether there is an underlying problem.”

“I am worried about cancer as a few firemen have recently died from leukaemia.”

“I can’t prove that my mind and body has changed. They have. It’s frustrating.”

“I’ve heard there is a treatment in the US which is an approved method for treating chemical poisoning.”

“ACC have said none of the symptoms are ‘permanent disabilities’ so we’ve given up any hope of being acknowledged as having medical problems.”

“Our own doctor didn’t want to know.”

“I felt put down by doctors, the Fire Service and the Occupational Health Nurse.”

“I feel that persons such as myself will never know. It is a stigma.”

“The Fire Service and the ACC have just done nothing and anything that they do they are forced into doing and you have to battle for every God-damn thing. . . . Everything we are entitled to, we have to fight for. . . . Perhaps I feel now I did have a medical problem, perhaps I now do have a psychological problem, but if I have, those bastards have got nobody to blame but themselves.”

“Should ICI be held responsible for not admitting what chemicals were in the fire?”
test result (see Appendix I for methodology) and falling within any of the psychiatric categories (thirteen firefighters) are recommended for reassessment.

C. CONCLUSIONS AS TO PRESENT HEALTH STATUS

72. Without clinically assessing each of the firefighters, the conclusions to be drawn from the information gathered are necessarily tentative.

73. Twenty-five firefighters had clinically significant abnormal blood, lung function, and/or ECG results. All were given the results of their test responses and advised to seek further investigation from their own medical practitioners. Actual incidence of disease among those who tested abnormally is not known but there was no consistent clinical pattern of abnormality. Indeed, in most cases, the test results demonstrated only minor deviations from the norms.

74. The symptoms described by the firefighters fall predominantly into two categories: skin and central nervous system.

75. Directly after the fire, twenty firefighters were seen by a skin specialist, Dr Greig. Her report is important for the purposes of our inquiry because it is a specialist opinion on and description of symptomatology experienced acutely at the time of the fire. Of the twenty firefighters described by Dr Greig, one had a chronic, pre-fire psoriasis which worsened after the fire. Three had scrotal rashes of a severe acute irritant dermatitis type and one of these was complicated by infection and required hospitalisation before it resolved. The remaining firefighters had folliculitis, in some instances being long-standing. Folliculitis is an inflammation around a hair which is usually associated with some infection in the hair follicle, as it was in most of these cases. Heat and some irritant chemical persisting in the follicle may have made the situation worse. Folliculitis responds to topical antibiotics and careful washing of the affected area. It may however recur particularly in conditions of heat or deficiency in skin care. None of the rashes described by Dr Greig was chronic, in the true sense, apart from the psoriasis. Dr Greig’s reports indicate that the skin conditions she treated responded to treatment and resolved. Dr Greig was able to say that none of the firefighters seen had rashes which fitted the description of chloracne. It is not known how many
of the twenty firefighters seen by Dr Greig have had recurrence of their skin problems.

76. Dr Fetherston (the Regional Medical Officer of the Auckland Region of the Fire Service) also saw about fifty firefighters soon after the fire, most of whom had folliculitis on their legs. Two had chronic skin problems thought to be unrelated to the fire.

77. Seventy-two firefighters report ongoing skin complaints which are not specified. Because the health of the firefighters has not been monitored over the past five years it is not clear to what extent the problems experienced are recurrent, continuous, or work-related. We are therefore unable to assess them but believe they ought to be reviewed by the firefighters’ own medical practitioners and by the Occupational Health Service.

78. The central nervous system symptoms are again difficult to assess without detailed clinical review. Because of the need to eliminate the possibility of organic brain damage, we consider that a specific strategy needs to be devised for retesting and, if necessary, treatment of the thirteen firefighters affected. Those who have central nervous system symptoms and those who indicate distress should have available to them assistance in the way of counselling or stress management, as recommended below.

4. CAUSALITY AND ASSESSMENT OF RISK: THE EPIDEMIOLOGICAL STUDY

(A) THE INQUIRY

79. We are required to try to ascertain the cause and effect between involvement with the fire or its aftermath and health problems of the firefighters. Implicit in our reference (in the terms requiring us to recommend further action) is the need to try to assess any continuing risk for the firefighters arising out of their involvement in the fire or its aftermath. We decided to undertake a comparative study using Wellington firefighters as a referent group. It is important to recognise that an epidemiological study, being a group comparison, in most circumstances cannot be directly applied to individual participants in the group. An epidemiological study is concerned with probabilities for the entire group. Whether an individual within the group...
become ill cannot be confidently predicted from the causative or risk assessment for the group as a whole.

(i) Establishing Causal Connection

80. Epidemiology is concerned with the distribution and determinants of disease in the populations studied. Determination of causal links between a suspected factor and a specific disease is one of the main uses of epidemiology. The process of ascribing causation is essentially inferential.

81. The inference may be substantially more confident where a dose-response relationship can be discovered. For this reason, a dose-response relationship must be looked for in a study such as this. But, except in the case of an intervention study (when doses can be measured and responses closely observed) it is unlikely that a simple dose-response relationship will be discovered even if accurate information regarding exposure is available. In the case of an event such as the ICI fire, where there are no objective measurements of actual exposure, it is almost impossible to expect such a relationship to be discovered.

82. Other important criteria relevant to causality include the internal consistency of results, consistency with other studies and plausibility in terms of existing scientific knowledge.

83. In the case of investigation of environmental causes of disease with a long latent period, an epidemiological study has to allow for a number of deficiencies in the data available. These include

  • lack of satisfactory exposure data
  • the multiplicity of potential confounding factors (that is to say other causative agents)
  • frequent lack of pre-exposure data to provide a baseline against which to measure effect
  • the recall bias inherent in most studies
  • difficulties in obtaining suitable normative controls against which to measure effect.

84. In the case of studies some time after the exposure, difficulties of recall bias and the additional problems of post-exposure confounding factors exacerbate the difficulties of the study.
85. For these reasons, whether health problems suffered by ICI firefighters are attributable to their attendance at the fire cannot be proved by epidemiological study in any absolute sense. Rather, the epidemiological study gives an indication of probability which must be supported by other evidence. In the case of this report, the conclusions we have drawn as a matter of opinion on causality are based on review of present scientific knowledge about toxicology and psychology, and some clinical assessment of the symptomatology of the firefighters as subjectively reported and (wherever possible) independently verified, as well as the epidemiological study undertaken.

(ii) The Epidemiological Study

86. The aim of the study is to determine what health effects may have been suffered by the ICI firefighters. It is necessary to recognise that firefighters, in carrying out their normal duties, may be exposed to noxious agents which may have harmful effects on their health.

87. In deciding on a study design it was necessary to bear in mind the need to evaluate the two main variables, exposure and response, for correlations (including a dose-response relationship) in a defined group of exposed firefighters. A comparative group of firefighters unexposed to the ICI fire was required to provide baseline estimates of the neuropsychological tests used (see above paragraphs 47–55). The unexposed group enabled the comparison of symptom prevalence and organ function between exposed and unexposed populations. The use of such a referent group and the existence of a cohort of firefighters exposed to a specific incident of concern, means that the study can be classified as a “comparative cohort study”.

88. In designing the study several considerations had to be borne in mind:

- a period of four years had elapsed since exposure occurred in December 1984
- exposure was known to be to a mixture of chemicals, some toxic, and their combustion products; and the means of exposure may have been by skin contact, inhalation or ingestion
- precise exposure information was most unlikely to be available
the fire itself and its aftermath had given rise to much public anxiety and ongoing media coverage which may have had an effect on the firefighters’ perception of their own health

- by the very nature of their occupation, firefighters had been exposed to noxious substances, including chemicals, both before and after the ICI fire

- by the nature of their occupation, firefighters continue to be subject to varying amounts of stress which may have health effects over the longer term

- a reference group for comparative purposes would be essential. This group should reflect the “normal” exposure for firefighters and be available for investigation

- constraints of time and financial resource

- the need for confidentiality.

89. In addition to these general considerations, there were four specific concerns

- occupational group baselines were lacking for most of the tests concerned with psychological function. Population norms available for some tests were not suitable for New Zealand

- background levels of exposure to chemicals were not available

- background levels of exposure and psychological effect among a general population of firefighters in New Zealand were not available

- although good response was expected from the Auckland firefighters, there was every reason to be concerned about such response from any “control” group selected. The referent group had to be regarded essentially as volunteers, with attendant problems of selection bias.

90. The study involved 462 firefighters in total.

91. Out of the firefighters who attended the ICI fire 245 participated in the study, out of a total of 340 who were identified as having some involvement with the fire.

92. The referent group were volunteers and comprised 217 Wellington firefighters. These were the firefighters who were available at the time and were comparable to the study group in years of service. A
further five firefighters were tested but found to have had less than four years service. Their data was excluded from statistical analysis. The total number of Wellington firefighters eligible for selection was 350 but only a proportion of these were available and were approached.

93. The studies in Auckland and Wellington were conducted four months apart. Both groups completed the Health Status Questionnaire, the General Health Questionnaire and the neuropsychological test battery. Both groups had blood tests but electrocardiograms were omitted for the referent group because of cost, given the low rate of abnormality found in the Auckland firefighters. Lung function tests were also done for the Wellington group but were omitted from the epidemiological study because of difficulties in ensuring strictly comparable data, due to operator variation.

94. The spouses' questionnaire was completed only by spouses of some of the firefighters who attended the ICI fire. It was not supervised and the response rate was only 44.7%.

95. A detailed description of the methodology and the tests used for the study is given in Appendix I.

96. No confounding factors were found among age, years in service, marital status, exposure to stressful events, and hobbies. The potential effects of alcohol and tobacco consumption on organ function were more difficult to control for without using detailed and specific questionnaires. This was considered to be unnecessary and only some general questions were included to assess both alcohol and tobacco consumption.

97. Bias by observer variation (of particular concern in the administration of psychometric and other organ function tests and their interpretation) was dealt with by using one laboratory for analysis of blood, and one team of psychologists for psychometric testing.

98. Recall bias is difficult to avoid in a study which goes back a period of four years. It was possible to verify some responses by using a questionnaire administered in 1985 and individual medical records made available with the consent of the firefighters. It was expected that the Auckland group would recall in greater detail exposure to toxins and chemicals in general, because of the increased awareness of such matters as a result of their involvement in the ICI fire and its
aftermath. The exposed group had lived with the fire and its after-
math for more than four years. During that period they had under-
gone considerable stress due to a variety of factors including media
attention, the general background of community concern about
chemicals, and compensation and employment concerns.

99. Of particular concern, is selection bias in both groups. Ninety
Auckland firefighters who were involved in the ICI fire did not par-
ticipate in the study. While the reasons for their non-participation are
not known in most cases, it is possible that they included firefighters
who perceive themselves to be healthy and who are therefore not
motivated to participate in a study about health problems. The Wel-
lington group were volunteers. It is possible that those in Wellington
who believe themselves to have existing health problems may not
have wished to participate in the study.

100. These biases and the problem of confounding are difficult to
cope with either by study design or analysis, but require to be borne
in mind when interpreting the results.

(B) THE RESULTS OF THE EPIDEMIOLOGICAL STUDY

101. The full results are set out in Appendix I. In summary

• the level of distress as measured by the GHQ in Auckland is
  significantly higher than the level of distress in Wellington
  (the ICI group score with a median of 4 (4 being accepted as
  a measure of distress in a normal population), as compared
  with a median of 2 for the referent group

• with the exception of the blood cell indices, the grouped
  blood tests indicate no significant difference between the
  Auckland and Wellington firefighters. Such variations as did
  exist between the two groups were within the normal range

• the incidence of ongoing skin complaints is significantly
  higher among the ICI firefighters than their Wellington
  counterparts

• central nervous system symptoms are significantly higher
  among the ICI firefighters than the Wellington group

• test responses to the neuropsychological tests are poorer
  among the ICI firefighters than the Wellington firefighters
• the poor test responses to the neuropsychological tests are particularly grouped in the tests concerned with psycho-motor skills and timed responses

• self-reported health problems are significantly higher among the ICI firefighters than the Wellington group

• no dose response can be discerned

• there is little difference between the Auckland and Wellington groups for such indications of social stress as family death or change of marital status; ongoing stressful events; smoking and alcohol history or involvement in other chemical fires or other exposure to chemicals (although the Wellington group reports greater exposure)

• a significantly greater number of ICI firefighters rate their enjoyment of life as less now than in 1984 (18.2% compared to 6.4%)

• there were no more cases of cancer or birth defects among the Auckland firefighters as compared to the Wellington group

• use of the Fire Service Occupational Health Service is significantly greater in Wellington than Auckland (38.8% as compared to 22.0%).

102. The neuropsychological test results are particularly important in assessing causality because

• they are objective (whereas the GHQ results and the symptoms described are largely subjective)

• they may support an organic basis for symptomatology and a toxicological explanation.

103. For this reason, it is important to look critically at the NP test results. A matter of concern in their interpretation is the fact that the relative risk of poor results between the ICI firefighters and the referent group, at 1.32, while statistically significant, is below the usual cut-off accepted in epidemiological studies of 1.5. In interpreting the tests it is necessary to recognise that the reliability of the data is critical: a small variation may completely erode the difference between the groups (see Appendix I). In particular, it is necessary to consider
whether the results are false-positives as they would be if, for example, they were affected by abnormal pre-exposure functioning of the individuals tested (where the pre-exposure functioning was low), or if affected by stress caused by the testing process itself

the impact of "biases" as described above at paragraphs 97–100.

104. The ICI firefighters and the referent group were comparable as to past (that is to say, pre-ICI fire) medical history, reproductive history, cigarette and alcohol consumption and indicators of psychosocial stress, such as change of marital status. The groups were also comparable in age and years within the fire service (which was taken, in the absence of better data, to indicate comparable pre—and post-ICI fire exposure history at other fires).

105. It is sometimes suggested that some individuals are particularly susceptible to toxins and that the health problems arising out of the ICI fire were to a large extent the result of the sensitivity of a particular group. While the suggestion is in general correct, the epidemiological study does not support a distribution of health problems in a manner to suggest that a group of particularly susceptible individuals is responsible for a skew in the results. Detailed statistical analysis shows that the relative risk shown by the study applies to the entire group and not just to a subgroup.

106. Altogether, if accepted at face value, the epidemiological study demonstrates that the Auckland firefighters have had a greater risk of ongoing skin complaints, distress, general health problems and central nervous system symptoms than their Wellington counterparts. It is unlikely that selection and other biases fully explain the result. The Auckland firefighters have a slightly higher risk than their Wellington counterparts of scoring poorly on the neuropsychological tests. All comparisons between the Auckland and Wellington groups may be affected by unknown confounding factors, but the results of the study suggest that the Wellington group is a good control and that the ICI fire and its aftermath is a causative factor in some of the difference between the groups.

107. It should be noted that, because of the absence of pre-fire baselines and monitoring since the fire, it is not possible to say that the Auckland group has a present risk of further health problems. We
do not know whether the problems experienced by the firefighters are reducing, increasing or remaining static.
III

History of the Fire and its Aftermath

1. BACKGROUND
A. THE NEW ZEALAND FIRE SERVICE

"Our job can be and is a dangerous occupation and chemical incidents have become the challenge of the 80's." (New Zealand Fire Service Submission to the Committee)

"... so much is pushed to the side ... If I'm going to put my life on the line or my health on the line, or whatever, I don't mind, but for Christ's sake stand by me if something goes wrong. And this is the bit that's upset me and so many others. That only by kicking up a hell of a fuss were we getting something done ...." (a firefighter)

(i) Structure

108. The New Zealand Fire Service is large by world standards. It employs 2,500 permanent staff and relies upon a further 7,500 volunteer firefighters, who are critical to the service provided but who are not paid. At the ICI fire, twenty-eight Fire Service personnel are known to have been volunteers (only nineteen of them were in the study group).
109. The Fire Service has been a national service only since 1976. It was apparent to us from the submissions and interviews that there is still a feeling that amalgamation has not worked well for Auckland, which had considerable pride in its own procedures and personnel. The integration of the Service was implemented progressively. At the time of the ICI fire many of the changes were still new, in particular, a recent policy of promoting executive officers out of their old area meant that there was some suspicion at the ICI fire of senior executive officers. The Divisional Commander on duty at the time of the fire (in fact, a most experienced executive officer) was from North Shore and was thought by some of the officers and men to have had insufficient experience with Auckland procedures.

110. The Commission continues to be viewed with considerable suspicion by many of the officers and firefighters, although the events since the ICI fire (in particular, the handling by Headquarters of the initiative, supported by senior executive officers and the Union, to bring in Dr Tizard, (as to which, see paragraph 208 below)) may well have exacerbated that perception.

111. Auckland was probably the first brigade to introduce standardised fireground procedures by which firefighting is conducted. Over the past four years national procedures, based on the Auckland model, have been progressively put in place.

112. The changes in command meant that at the time of the ICI fire Auckland had recently lost some very well respected senior executive officers. A number of firefighters expressed to us the opinion that the problems at ICI would never have occurred if the former commanders had been in control.

113. At the time of the ICI fire there was, therefore, already a climate of suspicion and resentment of the changes to command structure and the loss of Auckland identity.

114. The Fire Service is structured on military lines. It is hierarchical. The Service is divided into six geographic regions, covering the whole of New Zealand. Administration (based in Wellington) is treated as a seventh “Region”. The Number One Region is headquartered in Auckland and extends from North Cape to Mercer. At the time of the ICI fire, the Regional Commander was Mr Armstrong, who remained Regional Commander until the end of March 1986. The Region is further divided into a number of Fire Areas. The
Auckland City area (Number 1A Area) was under the command of Mr Sampson, who remains Area Commander. He had at the time of the ICI fire only just taken up his appointment. Under the Commander Number 1A Area were four district commanders. On the night of the ICI fire the Duty District Commander for Auckland was Mr Derrick, from the Northern District. The ranks below the District Commander, for permanent firefighters, are

- Assistant Commander
- Divisional Officer
- Senior Station Officer
- Station Officer
- Senior Firefighter
- Firefighter.

115. Ranks above and including Assistant Commander are classified as "Executive Officers". The Auckland line organisation is further divided into four watches (Green, Red, Brown and Blue) with a non-operational watch (Black) providing support services (fire safety, technical liaison, communications, maintenance, stores, administration).

116. Five executive officers took part in the ICI firefighting and clean-up operations. In addition, the Regional Commander, Mr Armstrong, and the Area Commander, Mr Sampson, visited the site, although neither took command of it. Volunteer units present included members from the Papakura, Papatoetoe and Devonport stations and the Fire Police.

117. The Fire Service response to a fire is according to an alarm system, which is a system of mobilisation leading to a set response according to available personnel and other resources. A fifth alarm is the most serious turnout. At the time of the ICI fire, the Auckland Area had never mobilised to the extent of a fifth alarm. In the ICI fire a fourth alarm was called, at a comparatively late stage of the fire, as recognition of the number of firefighters required on site rather than because the fire had escalated. The alarm system does not represent any assessment of particular hazard, beyond the resource level required to fight the fire.

118. The Fire Service does have a colour response system for dealing with hazardous materials which are not involved in fire. While
the alarm system may be thought a fairly crude method for classification of a chemical fire presenting special hazards, we were informed by the Fire Service that the response is flexible, and that Regional Commanders are expected to set up procedures for specific response requirements in the case of hazardous fires (for example, a system of notification of technical advisers).

119. The management of a large number of people in what is a dangerous occupation requires special skills. Progress through the Fire Service hierarchy seems to depend largely upon fireground experience. (It has been suggested to us that the alarm response system is also used to assess command experience.) Top management in the New Zealand Fire Service agreed that traditionally the Fire Service has been more operations-minded than management-minded. Our own impression is that the New Zealand Fire Service, for this reason, was not well equipped as an organisation to respond to an event such as the ICI fire and its aftermath which was outside usual operational experience.

120. Perhaps because of the reliance upon operational experience, formal training, particularly in safety management, seems to us to be insufficiently stressed. Compulsory training is required only up to the level of senior firefighters. There are suggestions that such training as does take place may not always be particularly effective: a Wellington survey undertaken by the New Zealand Firefighters' Welfare Society in 1986 about exposure to chemical hazards indicated "a lack of training and understanding of procedures to be used".

121. Those who want to be Station Officers are effectively required to undertake a further course. Three further levels of courses are offered, up to a level suitable for Assistant Commanders but are not compulsory. There is no compulsory continuing education required of executive officers (who comprise 10% of the Service). Hazardous materials courses are available, though not compulsory, for executive officers. In the case of hazardous substances, the result is that the officer in charge of the fire is unlikely to have had formal training in the management of chemical fires or chemical spills. The Service relies instead, we were told, upon the officer's accumulated experience and upon the technical assistance available at the time through local experts or, in Auckland, the Technical Liaison Officer. The Fire Service does not provide specialist training courses in health and safety supervision for officers. The incident commander at a fire
cannot be guaranteed to have any particular skills in health and safety supervision.

122. The hierarchical structure of command, moreover, means that experts on site are usually outranked or not part of the command structure at all (as in the case of the Technical Liaison Officer). It is quite clear that, on the fireground, no one has authority who is not in the command structure. We were told that the Technical Liaison Officer in Auckland made a worthwhile contribution to fire management after he learned not to tell firefighters what to do: "firefighters don't take orders from civilians".

123. Some firefighters we spoke to (including executive officers) suggested that "the Fire Service looks after its own and doesn't respond well to criticism". No formal audit process to review incidents is required. For that reason, we were told, at least one senior officer refused to file a report critical of conduct of the ICI fire on the basis that it would be "censored". Given that background of suspicion, it is perhaps not surprising that a number of firefighters and officers described the Fire Service Report on the ICI fire as a "whitewash". These attitudes, we believe, contributed to a climate in which subsequent communication from the Fire Service Commission and action by it in relation to the ICI fire was viewed with some cynicism.

(ii) The Union

124. The ICI fire co-incided with a period when the Northern Firefighters' Union (the Northern Fire Brigades' Employees' Industrial Union of Workers—since absorbed into the New Zealand Professional Firefighters' Union) was seeking to negotiate better conditions for its members. Superannuation and medical benefits were current issues. Some who spoke to us expressed the view that the ICI fire became an important lever in the Union's negotiations, and that the Union was interested to maintain the issue of the ICI fire as a live one. Some concern about the position of the Union was expressed to us by a number of firefighters. The Union is now (since 1988) a national one and executive officers are now also represented by it. Auckland firefighters, in particular, are acknowledged by the Union to have been unhappy with the admission of executive officers. Certainly, some firefighters in conversations with us doubted whether they could rely upon the Union to represent their interests where safety issues arise out of executive officer management.
(iii) Health Services

125. Regular medical check-ups are a controversial issue in the Fire Service. At the time of the ICI fire and at present, the only medical information collected about all firefighters is on their entrance into the Service, when general medical histories are taken. At this time they are also physically examined and their vision is tested. When they reach the age of forty-five years three-yearly medical checks are required. After amendment to the Fire Service Act 1975, annual tests will be required from about March 1990. Their introduction is regarded with considerable suspicion because it is feared that they put firefighters’ jobs unfairly at risk. For this reason perhaps, it has been agreed that fitness checks will be conducted by officers, rather than firefighters having a medical assessment. Fears such as these may also partly explain why the monitoring of the health of the ICI firefighters has not been undertaken. The lack of health monitoring means that measurement of exposure to hazards generally is hampered by lack of pre-exposure information.

126. At the time of the ICI fire, there was no Occupational Health Service in place for the Fire Service. The Fire Service had a principal medical officer, based in Wellington, and regional medical officers, but their practical role was largely confined to pre-employment medical checks and to the medical boarding procedure for retirement from the Service on medical grounds (see paragraph 129). The Principal Medical Officer is retained to give general advice to the Fire Service on matters of health but no formal system had been set up to secure the involvement of any of the medical officers in incidents. The Principal Medical Officer himself told us that he prefers not to deal directly with the firefighters because he would risk his objectivity for his other functions if he did so. He did not see the medical officers including himself as providing treatment. There were no plans in place for managing treatment, testing or monitoring health problems in firefighters exposed to occupational risk. Suspicion about confidentiality and the use to which the Fire Service might put health information has also been given to us as a reason why the Occupational Health Service, set up largely in response to the ICI fire, has not been more effective in dealing with ICI health problems.

notes that 218 firefighters were injured in fires in 1987 alone. Non-fire incidents substantially outnumber actual fires. Only 9.4% of all Fire Service call-outs involve structure fires. Attendance at road accidents is a cause of considerable stress. Long periods are spent at the station maintaining equipment, practising procedures, exercising or waiting.

128. Despite the stresses of firefighting life, and in particular the strains of regular attendance at motor vehicle accidents, the Fire Service has never provided a system for dealing with stress, either by informal peer debriefing or professional counselling. The Principal Medical Officer told us that he personally did not favour introduction of psychological support services because he is of the view that such services themselves may create distress.

(iv) Medical Boarding

129. The whole issue of "medical boarding" (retirement from the Service on medical grounds) seems to us to be viewed with considerable suspicion by firefighters. A number expressed concern that the Occupational Health Service was compromised by a failure to distance itself from the medical boarding procedure. (It has been decided since this inquiry started that Regional Medical Officers, who are the doctors attached to the Occupational Health Services, will no longer be involved in medical boarding procedures.)

(v) Attitudes to Fire Risk

130. The call to a major structure fire is an exciting event. Many of the firefighters we interviewed described the "high" they felt at, and immediately after, the ICI fire. Some explained failure of safety procedures at the fire, particularly in the use of breathing apparatus, as a result of the excitement of the moment. "Firefighters love to fight fires" was a common remark. As one firefighter said:

"I think we are more aware of it, of the chemicals, chemical side of things. But as initial firefighting goes, it's the old 'let's get in and put it out before it develops'. It's sort of, it is a funny thing being a fireman. It's the flame thing—you have to go and chance and put it out. It goes against the grain to stand back... That is why I think a lot of these sort of things happen because
that is what we are trained to do: to get in and put it out quick, get it over and done with."

131. In the past, it is clear that exposure to smoke and fumes has been taken lightly. There is an attitude which has not yet died out that those who are tough can take smoke, that burning ears are the best safety indication for a firefighter, and so on. Breathing apparatus use was not standard until comparatively recently.

"... There is an expression used in the Service—'smokey'—because the guys think they are tough if they become a smokey. They don’t worry about breathing gear sometimes. They go to a small house fire, for example, and they won’t wear their breathing gear because that was what they were used to in the old days. Today they have got a bit more strict on it and you have to wear your sets pretty well everywhere you go now. But back there a lot of guys would not worry about the breathing gear. They’d say ‘it’s only a bit of smoke’ and they would go in. I am sure a lot of those guys are going to suffer later in life, you know."

(vi) Dealing with Hazardous Incidents

132. In New Zealand the whole area of management of hazardous substances is currently under review. At present, there is little overall co-ordination of importation, transportation, storage and use of chemicals. Of particular importance to this investigation is the fact that there is no present compulsory system in place for on site notification of the contents of buildings used to store hazardous chemicals. Voluntary use of the HAZCHEM system of labelling required for road transportation is now used by members of the Chemical Industry Council. It may be expected that the Hazard Control Commission, to be set up under the Resource Management Bill, will be charged with making such a system compulsory. A major Occupational Safety and Health Bill is presently being prepared and may set up systems for dealing with dangerous substances in the workplace. We were told that it seems likely that the Hazardous Substances Technical Liaison Committee (HSTLC) (on which in Auckland the Technical Liaison Officer of the Fire Service serves) will be retained in some form and that Fire Service expert technical information will continue to rely upon such committees in most areas. Auckland is the
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only region where the Fire Service employs a Technical Liaison Officer (TLO) but in other parts of the country local expertise is identified and used. (For example, in Dunedin the Fire Service obtains technical information from the National Poisons Centre.)

133. The Auckland Fire Service at the time of the ICI fire had in place some formal procedures for dealing with spilled hazardous substances and hazardous substances in fire. Decontamination and the use of protective clothing were provided for but actual fireground management was left to the discretion of the site commander. More detailed procedures are now in place including requirements that "the principal firefighting action shall be to contain the fire until specific information is available. No salvage work or close proximity firefighting shall be carried out until specific information is available."

134. The job prescription for the Technical Liaison Officer, which was in place at the time of the ICI fire, does not specify any distinct role in health information. The TLO's operational duties are to attend hazardous incidents and give advice to the officers in charge on "brigade operations and procedures". It is interesting in this connection to note that the Hazardous Chemicals Information Section of the National Poisons Centre (now called the National Toxicology Group) which was established over a decade ago specifically to provide information to emergency services was not contacted at the time of the fire. Mr Woodward, Chief Executive (Operations and Planning) of the New Zealand Fire Service Commission, is quoted (in The New Zealand Fire Fighter Journal) as saying that the Centre does not say how to deal with the spillage or fire and that "the medical aspect is out of our sphere of interest . . . ."

135. The role of the Technical Liaison Officer at the ICI fire itself is also consistent with a primary responsibility to assist with technical information of value in fire suppression (see paragraph 173 below).

(vii) Communication

136. Communication, both within the Fire Service and in relation to the public was essentially reactive at the time of the ICI fire. Communication with the press at the time of the fire was at the discretion of the officer in charge of the incident. Present procedures specifically mention communication with the press, and a media
liaison officer can be designated by the incident commander. After the fire, most communication to members of the Fire Service was by way of brigade notices, posted on noticeboards at the stations. Dealing with the press was a matter for the discretion of the individual commander. There was no monitoring of press information about matters relating to the Fire Service. Today the Fire Service has a news magazine for all members and employs a Press Officer.

(viii) Protective Clothing

137. In 1984, the uniforms worn by the firefighters for close-in firefighting were wholly unsuitable as protection against chemical splashing. In particular, the overtrousers, although flame retardant, were permeable to liquid chemicals and contaminated water. Chemical protection gear was available, but unsuitable for in-close firefighting (because it was made of PVC which would melt in the high temperatures). After the ICI fire, a Committee was set up to bring in more suitable clothing. New uniforms have been settled upon after considerable trial and some controversy within the Fire Service. Made of PVC, the close-in (level two) gear is resistant to splashing, although proper chemical protection is provided only by use of the level three and four suits, which are not suitable for close-in firefighting. The new uniforms are being progressively commissioned throughout the country at the moment. Breathing apparatus has also been upgraded since the fire: positive pressure sets (which reduce the risk of leak) are now standard and the improved two-step positive pressure set is being progressively introduced.

(ix) Cost

138. The financing of the Fire Service has recently been a matter of study by Strategos Consulting Group. Clearly, the cost of the Fire Service and the funds available to it affect the Fire Service response to matters of concern in this inquiry. Extension of the functions of the Occupational Health Service is an example. It would be unrealistic in this report not to be conscious of the extent to which this factor may have constrained initiatives in the past and is relevant to future directions.
B. THE NEW ZEALAND ACCIDENT COMPENSATION CORPORATION

139. The New Zealand Accident Compensation system, which provides for payment for medical treatment and earnings-related benefits in the case of injury by accident is a significant background factor in the history of the ICI fire. Under the existing Accident Compensation Act 1982, compensation is only payable for “accident”. If the Accident Compensation Corporation declines to treat a claim as arising out of “accident”, the person affected is faced with a time-consuming and often expensive legal battle to prove causation. Occupationally-induced illnesses have always been problematic. Where psychological or psychiatric illness is the result of the “accident”, the Accident Compensation Corporation has acknowledged to us that

“We do regard psychological effect with more suspicion than medical effect.”.

140. The Government has announced (in the Budget speech, 1989) that the Accident Compensation scheme is to be extended to cover illness as well as accident. The ICI fire illustrates the human anxiety caused by the present division. A number of firefighters have told us of their fears that, should their health deteriorate, they will not be able to prove that exposure in the ICI fire caused their illness and that they will therefore be ineligible for treatment and earnings-related compensation. The Corporation managers we interviewed, acknowledged that

“this area of claim is in the grey area of disease and injury. Without reliable medical evidence, we’d probably put symptoms which develop after a long period down to disease.”

141. Arising out of the ICI fire, the Accident Compensation Corporation has received a total number of sixty-seven claims. All but two are from members of the New Zealand Fire Service. Ten are awaiting review or appeal.

C. OTHERS PRESENT AT THE ICI FIRE

142. Although the ICI firefighters were the most numerous group exposed at the fire, a number of other people were also involved. Our
terms of reference were specific to firefighters, but we received information from a number of others who claim to have been affected by their attendance at the fire. A number have expressed disappointment that our terms of reference did not enable us to look more closely at their circumstances. Others affected include

- Traffic Officers. Ministry of Transport personnel have expressed concern to us that they may have been exposed to unknown and unexplained effects. Some officers, we were told, had to operate within smoke. The Ministry of Transport submission to the Committee mentions informal reports of illnesses suffered by Traffic Officers who attended, but says that nothing is definitely known by the Ministry

- Police. A submission received from the Police Department indicates that no personnel are known to have suffered health problems

- Dangerous Goods Inspectors. Two Dangerous Goods Inspectors have suffered health effects as a result of exposure at the fire. The symptoms described by them are comparable to the central nervous symptoms of the firefighters. One has developed Guillain-Barre syndrome

- Ambulance Workers. The St John’s Ambulance reports that some of the ambulance workers are known to have developed symptoms. Dr Tizard reported to us that he has treated two ambulance officers for problems arising out of exposure at the fire

- Workers employed in the clean-up. We have heard suggestions that these may have been the most exposed group of all because they worked without any protective clothing. Nothing is known of them

- the Public. The Tamaki City Council objected to the inquiry being limited to firefighters. Little, however, is known about health effects on members of the public in the area, although Dr Tizard has reported that he treated six “civilians” for effects of the ICI fire and we were given information of a public meeting in Mount Wellington at which health problems and concerns were voiced. We also had a submission from the Mount Wellington Branch of the Labour Party dealing with local concerns, and were supplied by it with a dissertation by Ms Jackie Stoddart (referred to in paragraph 145) which referred to 200 local residents (those living
within one kilometre of the warehouse) surveyed by a reporter

• ICI workers. Detailed information is known about the ICI workers involved in the fire or clean-up. Unlike the firefighters, ICI personnel were all seen by the ICI doctor before they went home on 21 December, Dr Hanley. They were given blood and urine tests as soon as possible after exposure and thereafter have been monitored. Acute reaction was confirmed by the ICI doctor. The symptoms he described immediately after the fire were smoke and chemical irritation of eyes, nose, ears, throats, lungs, and skin. Medical treatment “appeared to be highly successful at this stage”.

“Initial clean up period produced headache, nausea, excessive sweating, dysentery, thirst and aggravation to conjunctivitis, otitis externa, pharyngitis and gastritis. Fumes as from stenching agents required in some chemicals added to the problems. Also, the effects of tons of Na ash required in the clean up produced a light caustic burn to all areas of exposed skin. Day 9 onward: local irritation to eyes, skin rash mainly due to Na ash, pharyngitis and severe degree of stress symptoms and signs from the necessary prolonged work and exhaustion . . . To date [June 1985] results have been very satisfactory in view of the length of time of exposure in the clean up to chemicals and their concentrates. Only one member of the ICI staff suffered any direct loss of work time due to paraquat burns”.

143. The ICI doctor was of the view that there were no long term adverse health effects but the Committee has been contacted by two ICI workers who have complained of central nervous system symptoms and, in one case, skin cancers. One man who wrote directly to us and who held a senior position in the company has become increasingly worried about deterioration in his health including

“Inability to concentrate for any period of time, loss of memory, night sweating and sleeplessness, loss of dexterity, impaired sexual function, general tiredness . . . . I am concerned that the symptoms are becoming progressively more apparent and would be grateful for any
assistance you could offer to enable me to identify the cause of my deteriorating health.”

D. PUBLIC CONCERN ABOUT AGRICULTURAL CHEMICALS

144. The ICI fire occurred at a time when use of chemicals in agriculture was a matter of substantial public concern. In relation to one of the chemicals in the fire, 2,4,5-T, the public concern led in 1986 to the establishment of a ministerial advisory committee to inquire into the manufacture of 2,4,5-T in New Plymouth. Environmental groups and experts had expressed concern about the toxic effect of chemicals such as these. Their similarity with chemicals such as those used in “Agent Orange”, the herbicide used in Vietnam and linked to birth defects, was a matter of public and media discussion.

145. The ICI Mount Wellington Fire Labour Party Liaison Committee submitted for consideration a dissertation by Ms Jackie Stoddart on “Paraquat, 2,4,5-T and other Toxins related to Dis-ease and Natural Healing” written for her naturopathic training. It proposes that poisoning may be insidious with subtle symptomatology that progresses to permanent damage. It cites the likelihood of accumulation of some toxins particularly in fat, from where they may be released after exercise or fasting to produce symptoms. The paper discusses various toxins in more detail and stresses the use of high level technology such as mass spectroscopy to measure very small amounts of chemical.

146. Ms Stoddart surveyed ninety-six people who attended the fire, for symptoms of ill-health. She also refers to a questionnaire used by reporter Tracey Williams which elicited responses from 200 residents living within one kilometre downwind of the ICI fire. The symptoms reported by the questionnaires and elicited from individual case histories are very variable but many are in the psychological/neurological category. Of note is that of the ninety-six people surveyed, twenty-eight reported pregnancies with five miscarriages, three dying at full term from ‘defects’. Of the 200 residents surveyed half were reported as having rashes and of thirty pregnancies there were three deformities and eight miscarriages.

147. Unfortunately there was no referent group in this survey and it is not at all clear how one can ascribe any causality to the problems reported. This even applies to the distressing number of adverse birth
events. The dissertation is a good description of symptoms reported, which supports our own study results, and is a signal of concern in those interviewed.

148. Ms Stoddart mentions some diagnostic procedures; we have commented on EAV diagnosis of poisoning in paragraphs 38–42. Other unproven methods of diagnosing poisoning should be seen in the same light. We cannot recommend any detoxification procedure as being useful for symptoms such a long time after exposure.

E. CONVENTIONAL AND ALTERNATIVE MEDICINE

149. The toxicity of widely used agricultural chemicals is still a matter of scientific uncertainty, making authoritative rebuttal of even extravagant claims unconvincing. This gap in what is known in scientific terms is sometimes filled by alternative medicine practitioners who explain symptoms in terms of chronic toxicity, treatable by homeopathic means. Some also suggest use of hyperbaric oxygen and vitamin C in high doses. A substantial proportion of the firefighters were diagnosed as suffering from chemical poisoning by a controversial diagnostic method (EAV) and received a combination of homeopathic remedies, and/or vitamin C in high doses and hyperbaric oxygen treatments. Diagnosis and treatment in this way is not generally accepted by orthodox medical practitioners who regard none of the three techniques as having any proven therapeutic benefit over that of the “placebo effect”. The health treatment of the firefighters therefore resulted in a clash between conventional and unconventional health practice.

150. Conventional medical knowledge has built up over the years from individual ideas and single (anecdotal) observations which have then been tested by carefully designed procedures using close comparisons as far as possible. The aim is to exclude chance effect, spontaneous improvement for reasons other than the treatment tested, and the so-called placebo effect.

151. The placebo effect means that treatments may appear to have strikingly beneficial results through psychosomatic mechanisms which are still incompletely understood. The effects can include physical as well as psychological changes. For instance, it can be demonstrated that blood pressure and even plasma lipids can be altered by the administration of a placebo. It seems that the response may vary
from person to person and from time to time. Strong psychological reinforcement by a caring therapist and a convincing positive environment also improve the response of the patient. Treatment which is understandable to the patient, which is strongly promoted to relieve symptoms (particularly in multi-symptomatic individuals who have failed to get relief elsewhere) is particularly likely to succeed, at least temporarily. About 30% of such patients will get relief of symptoms to a greater or lesser extent.

152. Most alternative medical therapy has not been tested to exclude the placebo effect. Often it is not easy to develop experimental procedures that will do this.

153. Pragmatically, this matters little to those patients who respond to alternative medical treatment, providing no underlying disease which would respond better to conventional medical treatment is disguised by slight symptomatic improvements leading to delays in definitive treatment.

154. Many firefighters sought relief from their symptoms from practitioners of alternative medicine. Although we have not accepted diagnosis by EAV testing, we would not want to be taken as suggesting that alternative medical therapy may not provide symptomatic relief for patients. Homeopathy has been practised for 150 years since it was introduced by Hahnemann. The principle is based on “like treating like”. Extreme dilutions of toxins known to produce the symptoms the patient suffers from are administered. Sceptics say the dilutions are too dilute to be effective but one clinical trial, well conducted, has shown that homeopathy is at least as good as therapeutic doses of aspirin in rheumatoid arthritis. Other convincing reports add support to the idea that the therapy is more powerful than just placebo, although the scientific evidence is not extensive.

155. Vitamin C in high doses may act as a scavenger for free chemical radicals which may induce tissue damage. This form of therapy at the moment rests on theory and some animal experimental evidence. No convincing clinical trial exists proving effectiveness in any disease, particularly in detoxification from poisons.

156. Hyperbaric oxygen increases tissue oxygenation and some toxins are detoxified by oxidation, but this therapy is unproven by any clinical trial for the clinical indications that the firefighters presented.
157. The use of exercise and heat to mobilise fat and therefore fat soluble toxins has been recommended by some therapists. In theory it seems plausible as a strategy and there is limited evidence to support the idea that toxins may be released from body fat into the blood following such treatment. The fate of the toxin may then be excretion or reabsorption into fat stores, or absorption into other lipid tissues such as the brain. What actually happens is unknown but if absorption into the brain results, such a process would be more likely to cause harm than good, particularly since most fat soluble toxins produce nervous system symptoms as their major manifestation. While toxins stay in body fat, they form an inert reservoir away from vital organs, only released slowly into the circulation at low levels. Upsetting this equilibrium may increase neurotoxicity.

F. CONCLUSION

158. It is against this background, productive of uncertainty, insecurity, suspicion and fear that the ICI fire and its aftermath needs to be understood.

2. THE EVENTS
A. SAFETY MANAGEMENT ON THE FIREGROUND

159. There were serious deficiencies in safety management at the fire. This conclusion is partly supported by the Fire Service and Department of Health reports on the fire. It was amply borne out by the information given to us and the opinions expressed by firefighters and executive officers, a number of whom accepted some responsibility for the result. Of especial concern was the method of fire attack used, the discipline on the fireground, the use of breathing apparatus and the clothing worn by the firefighters.

160. For a significant period, the fire seems not to have been treated as a chemical incident. Procedures in place today require fire attack in the case of fire involving a hazardous substance to emphasise containment and avoid close-in firefighting until the hazard is assessed. Where close-in fighting cannot be avoided the number of personnel exposed should be limited to those absolutely necessary. While those procedures were not formally required in 1984, we were told that good firefighting practice was to apply the same principles.
161. Some shift in the methods used to fight the fire is apparent in the Brigade record of events. At 1702 Assistant Commander Mears took command. He learned that there were chlorine cylinders at the back of the building, and that the yard and the warehouse contained anhydrous ammonia and LPG “and chemicals of unknown composition or quantity”. “Because of the contents of the area, hand-held deliveries were changed to monitors to provide a better reach and not expose personnel to further explosions.” At 1730 (after Divisional Commander Derrick had taken command) it is recorded that hand-held deliveries were being used where monitors could not reach, and at 1834 (more than half an hour after the first firefighters reporting “burning sensations” to their legs and feet were treated by St John’s Ambulance officers) ground monitors were changed to hand-held deliveries and it is noted that “Access being gained to seat of fire”. There was a further change of command at approximately 1900 when Assistant Commander O’Sullivan relieved Divisional Commander Derrick. At 2311 crews were withdrawn from the building because of “late information” that chemicals could be affecting firefighters. That change came sixteen minutes after the number of firefighters injured is reported as having reached seventeen, after some had been sent to hospital, and eleven minutes after the decision had been taken to telephone all those who had gone home after the change of shifts to advise them to go to hospital if they were suffering any symptoms of exposure to chemicals.

162. Some of those firefighters and officers who expressed views on the management of the fire to us were of the opinion that the danger to the public from chlorine gas in cylinders stacked outside the rear wall of the building meant that there was no option but to attack the fire as aggressively as possible, despite the risk of exposure in close-in firefighting. That was the view expressed in the Fire Service report on the fire which criticised management of the fire only once the danger from the chlorine gas was past. Others expressed the view that the fire was being effectively fought using monitors, and that there was no need to send firefighters in with hand-held deliveries at 1730. Some support for that view may be found in the fact that at 1730 the fire is reported to have been “surrounded and successfully cut off from the remainder of the warehouse and confined to approximately 40% of the building”. Some officers and firefighters were of the view that, even if the risk from the chlorine gas cylinders required exposure of firefighters, the numbers exposed should have been limited to those
required for the specific purpose of containing the risk. Instead, it is suggested, too many personnel were exposed. Still other firefighters, including some senior officers, were of the opinion that the fire attack was at times not according to any centrally controlled plan.

“All the firemen are thinking of is getting that delivery in there and putting the fire out. . . So while you may sit there and think, well, the bloody fools did it wrong, you are right, we did do it wrong, there is no doubt about that”.

“The thing was, well the building was going, and all the action was on. . . In retrospect, the incident was treated as a major fire, rather than a chemical incident.”

“The Fire Service is good at firefighting and dealing with chemical spills. They are opposite approaches. When the same incident is both, the procedures are not entirely settled. It depends on an individual assessment. Now, with hindsight, we should have withdrawn men straight after whiteout. . . [we] should have stopped firefighting and pulled them out. Orders were given to withdraw and fight from a safe position when the fire was held. . . but I don’t think the officers accepted the orders to pull out.”

“The officer ranks failed in ICI.”

“Command and control at the ICI fire was atrocious. . . It is a pity there was not an inquiry into the firefighting at ICI. . . The men should not have walked through chemicals.”

 “[We were sent into the building], and approximately, say, quarter of an hour after we had been doing that, they realised how serious it was and they gave orders to withdraw the personnel. Then they fought it from the outside in front. So that was the first rule that went wrong: we should never have been put inside the building and exposed to it.”

“We should have stayed out and done it from the outside.”

“The men should have been left on monitors, fighting the fire from the outside. . . There was no need to have hand-held lines once the fire was knocked down.”
"[The incident was treated as a fire rather than a chemical incident,] partly as a result of management inadequacy and partly as a result of circumstances involving perceived danger to the public."

163. A number of officers, including one of the officers who commanded the incident, told us of instances of firefighters disobeying orders of officers and firefighters disobeying orders to pull out of the building and to decontaminate.

164. The clothing worn by the firefighters was wholly inadequate to protect them from chemical contamination. In particular, the overtrousers of the regular uniforms, while fire retardant, were permeable to water and liquid chemicals. The large quantities of water used to suppress the fire mixed with the chemicals released from their containers. Firefighters were in some cases required to wade through chemical-contaminated run-off.

165. There is widespread agreement that breathing apparatus was not used properly at the fire. In particular, most firefighters not actually inside the building were apparently not wearing breathing apparatus. Executive officers acknowledged that they, too, walked around the site without wearing breathing apparatus. One report indicated that

"many wearers were noticed to still have a BA tally on their set [the procedure is to leave the tallies with the Breathing Apparatus Tally Officer as a record of the firefighters to be accounted for]. Some were very blackened. At one count up to twenty tallies were still on set being worn”.

166. This report was confirmed by other firefighters to us and there seemed to be a number of instances of firefighters going into the building who had not taken off their tallies.

"Entry control was not always well controlled. A fire policeman was put in charge of one board. A fireman on return to pick up his tally was told by the Entry Control Officer 'I wondered where you were’”.

167. A number of firefighters told us that they disliked wearing breathing apparatus unless absolutely necessary because it further restricts visibility and the ability to communicate. (In the case of fully
enclosed protective clothing radio communication is available, though not used in New Zealand.)

168. Decontamination at the fireground and upon return to the station was wholly inadequate. Initially, dams were set up by St John's Ambulance, and firefighters who complained of burning, particularly on their legs, were put to sit in the shallow pools. Quantities of soda ash were added to the water, apparently as a decontaminant (for effect, see below paragraphs 296–298). Not all personnel were decontaminated in this way. Some of the most seriously affected firefighters (one of whom had been kneeling in chemicals) had no decontamination at all. Decontamination procedures in place in the Auckland Area were not adhered to. All exposed personnel should have been decontaminated. Instead, only those who complained of burning were. The existing procedures would have required firefighters to be hosed down and issued with clean clothing. The decontamination baths were not an adequate method for dealing with the chemical exposure. Those who made use of them in many cases were left standing around in their underclothes and towels. Many firefighters put contaminated clothing back on after their bath. Firefighters who had not been decontaminated ate, drank and smoked. The decontamination unit (a tender with equipment for decontamination and additional clothing) was called to the site of the fire at a comparatively late stage (arriving at 1825). It was not used for some time and, when it was, it was simply to provide paper clothing for those who had been through the soda ash baths. Firefighters going off duty were told to shower thoroughly at their stations but some officers have reported to us that orders to shower were ignored by some of the firefighters.

169. Decontamination procedures for equipment and clothing were advised to members of the Fire Service on 22 December after an on-site meeting of the Fire Service, Police, Ministry of Transport, St John's Ambulance, Department of Health, Department of Labour, Auckland Regional Authority and ICI. Technical information relating to chemicals was supplied in particular by the Fire Service's Technical Liaison Officer, the Chief Chemist of the Auckland Regional Authority and by ICI. Medical input was through the Medical Officer of Health, Dr Stephenson. No contact was made with the National Poisons Centre for advice and the then Medical Officer of Health commented to the Committee that
“With the benefit of hindsight, we should have contacted the Poisons Centre, but we had so little information and thought we could rely on the ARA chemist and ICI. I now see that an independent opinion would have been preferable.”

170. The failures in safety management led to uncertainty and insecurity which may have been exacerbated by lack of confidence in the command structure (referred to in paragraphs 109–113).

B. On-Site Information about Chemicals Present

171. There is some disagreement between the Fire Service and ICI as to the information available to the Fire Service about the chemicals on site, their quantities and location, during the course of the fire and the clean-up. The Fire Service report on the fire indicated that

“Although the Fire Service knew chemicals were stored at the premises and the general nature of these, no detail of the actual chemicals was available at the time of the fire.”

172. No on-site labelling, such as the HAZCHEM system of notification now used by ICI in the rebuilt store, existed on the premises at the fire. The Fire Service report of the incident suggests that satisfactory information about the contents of the building and the location of the material within it was not available until the next day. It has been suggested (for example, by the Union and by Dr Stephenson), that the conduct of the firefighting, and the decontamination and treatment of firefighters was hampered by this lack of knowledge. On the other hand, it is clear that verbal information was available at an early stage of the fire from senior ICI employees about brands stored, their chemical components and their location within the building.

173. The site manager and the store manager were on site at the time of the fire and gave information to the fire safety officers. The Mount Wellington Borough Council Building and Dangerous Goods Inspector arrived at the site at 1710, obtained “an up to date detail of the disposition of stock in the affected building, and communicated it to a Divisional Officer”. The ICI Regional Manager (Agricultural Products) arrived with the third or fourth appliance and went to the command room with the Technical Liaison Officer of the Fire Service, who had also just arrived. While the Technical Liaison Officer
went to inspect the building, the ICI manager remained in the command room and drew a map, indicating the location of the organophosphates. He advised the chemical and brand names of the products and indicated their flash points. The presence of paraquat and 2,4,5-T was already known to the Fire Service officers. He expressed the view to us that the senior Fire Service officers were not interested in that information. A former volunteer firefighter himself, he described the situation on the fireground as "chaos". He stayed on the fireground until approximately 2130. The Store Manager, no longer an employee of ICI, also indicated to us that attempts to give the firefighters information about the materials on the site were brushed off and the officers did not seem interested in such details. The Technical Liaison Officer advised us that he was initially particularly concerned with the threat posed by chlorine gas cylinders outside the building and immediately made a visual inspection of it.

174. A full inventory of the goods on the premises was printed out in Wellington and Auckland at 1710. The Auckland printout appears not to have been directly taken to the site because the office had closed down for the Christmas holidays, but the head office of ICI in Wellington sent senior executives (including the Operations Manager, Chemicals Group, who had responsibility within the company for all warehouses operated by the group) to Auckland with a copy of the inventory. Due to an airline pilots’ strike they did not arrive at the site until 0215. They were present the next morning at the on-site meeting which made decisions about the clean-up.

175. Whatever the exact sequence of events, and the precise extent of knowledge of the chemicals involved, it seems clear that there was at all times available to the Fire Service sufficient knowledge of the range of chemicals involved in the fire, their quantities and location for the purpose of effective firefighting, appropriate safety management and decontamination, and to enable initial decisions to be made about testing for exposure and treatment of symptoms.

C. The Health Response

176. At the fire, thirty-five firefighters were given first aid by the St John’s Ambulance Service (St John’s Ambulance records advised to the Committee in its submission). Most of those treated complained of burning sensations in the skin of their feet and legs. It was known
at an early stage of the fire that the chemicals in the store included the herbicides paraquat and 2,4,5-T and substantial quantities of pool chemicals. Six of the firefighters were taken from the site to hospital and treated in the Accident and Emergency Departments of Auckland Hospital and Middlemore Hospital (the numbers treated at each department are not able to be determined from hospital or St John's Ambulance records). Firefighters who had gone off duty (Green Watch) were telephoned at home at 11 pm on 21 December and advised to attend the Accident and Emergency Departments of Auckland Hospital or Middlemore Hospital if they developed health problems. The same advice was given to those currently on duty (Blue Watch). When Green Watch came on duty again for night shift on Sunday, 23 December, a number in the Central Station were found to have skin rashes. Approximately twelve were taken to Auckland Hospital where their symptoms were treated and they were discharged. Altogether, the exact number who attended the Accident and Emergency Departments as a result of the fire and the hospitals attended is not known, but during the three days from and including 21 December, thirty firefighters are known to have attended Accident and Emergency Departments at Auckland Hospital, Middlemore Hospital and North Shore Hospital. (Information obtained from those responding to questionnaires. See Appendix I.)

177. No one appears to have undertaken responsibility for communicating information about the chemicals involved and the tests or treatment appropriate to the Accident and Emergency staff. One of the firefighters attending reported being told by a doctor that he was being treated for “dioxin poisoning”. None of those attending were given blood or urine tests to determine exposure to chemicals. Neither the hospitals nor the Fire-Service made contact with the National Poisons Centre for information about the effects of the chemicals known to be involved, the symptoms of the firefighters, or general management and investigation of cases of suspected exposure to toxic substances.

178. It should be noted that fireground procedures adopted by the New Zealand Fire Service in January 1986 now require that where personnel feel unwell after an incident, “especially after a hazardous substance incident”, they are required to contact the Duty Divisional Officer. The Duty Divisional Officer must liaise to ensure the collection of “an overview of the situation and any likely impact on Fire
Service operations or services” and must make contact with the near-
est suitable hospital “to advise them of anticipated numbers and any
known contaminants”. The same fireground procedures set up a sys-
tem for maintaining contact with Fire Service personnel treated in
hospital.

179. From 22 December, newspaper, television and radio reports of
the fire expressed concern about the health and environmental
hazards of the “poison blaze” and the effects of “highly toxic sub-
stances such as 2,4,5-T and paraquat”. From 23 December there was
mounting concern about the possible presence of dioxin both as a
contaminant of 2,4,5-T and as a product of burning of 2,4,5-T. The
Environmental Group, Greenpeace, called for tests to determine
whether dioxin had been released. The Medical Officer of Health and
the Fire Service (citing assurances from ICI, the manufacturers of
2,4,5-T and the Technical Liaison Officer of the Fire Service) advised
that dioxin was not an issue.

180. The group of firefighters from Green Watch who had attended
Auckland Hospital on the evening of 23 December for skin com-
plaints, were unhappy with the treatment they had received. The Fire'
Service called in the Medical Officer of Health to attend a meeting
with them at approximately 8.45 pm. He arranged for a dermatolo-
gist, Dr Greig, to attend the meeting at 11 pm. Dr Greig took medical
histories, examined the rashes, sought advice from the National Poi-
sons Centre and concluded that the rashes were a contact dermatitis
causd by severe chemical skin irritation. Fourteen firefighters were
placed on accident leave. The rashes observed were predominantly
folliculitis, and “did not have the appearance of chloracne or of
chemical acne”, a usual symptom in cases of exposure to dioxins (the
Health Department Report). The firefighters at the meeting were
advised of Dr Greig’s opinion and told that blood and urine tests and
follow-up treatment with Dr Greig for their rashes would be arranged
through Dr Fetherston, a Regional Medical Officer with the Fire
Service.

181. From 24 December, blood and urine tests for firefighters with
symptoms were arranged by Dr Fetherston (the Régional Medical
Officer of the Auckland region of the Fire Service), to test for expo-
sure to organo-phosphates and paraquat. Ideally, such tests should
take place within twenty-four hours after exposure and, if contamina-
tion is a serious possibility, they should be repeated. Only those
firefighters complaining of symptoms were tested. The group of firefighters from Green Watch were tested on Monday, 24 December and the results, which were negative, were communicated to them at a further meeting attended by Dr Stephenson at 9.15 pm. Follow-up treatment was arranged with Dr Fetherston. Other staff were advised to see Dr Fetherston if they had any symptoms.

182. Altogether, Dr Fetherston saw approximately seventy firefighters for symptoms described as having an onset after the ICI fire, over a period of some months. The Fire Service at the time did not have an occupational health service. It retained the services, on a part-time basis, of a Principal Medical Officer based in Wellington, Dr Treadwell, with part-time regional medical officers in each region. All medical officers of the Service were general practitioners whose functions were in general to undertake the routine medical examinations prescribed for recruitment to the Fire Service, for fitness tests for those over the age of forty-five, and for retirement on medical grounds (medical boarding). Dr Treadwell had in addition supervisory and administrative responsibilities. In general, the medical officers were not involved in clinical treatment of firefighters, who were expected to attend their own general practitioners. Dr Fetherston, in his private capacity, was attended by a number of firefighters. The involvement of Dr Fetherston in a strategy for the general management of the health of those firefighters who attended the ICI fire was therefore unusual and a specific response by the Fire Service to the concerns of the firefighters. The strategy for management (testing and treatment) was not one that was in place at the time of the fire, but was worked out by Dr Stephenson and Dr Fetherston in response to increasing anxiety and criticism both within the Service and among members of the public days after the event. Although Dr Treadwell was involved in the decisions and was consulted and kept informed throughout by Dr Fetherston, he did not assume direct responsibility for dealing with the health problems of the ICI firefighters. That function was fulfilled initially by Dr Stephenson, the Medical Officer of Health, largely by default and at the request of the Fire Service. It followed on from his early involvement in the fire as a member of the Hazardous Substances Technical Liaison Committee and his role in dealing with public health concerns arising out of the fire.

183. Decontamination procedures for equipment and clothing, advised to members of the Fire Service on 22 December, were changed on 24 December to provide for more cautious treatment of
equipment, and for clothing to be bagged and withdrawn from service pending further testing. In the meantime, a number of firefighters (particularly the volunteer firefighters) had dealt with equipment and clothing in accordance with earlier orders.

184. ICI workers were reviewed by Dr Hanley, the ICI doctor, before they left the site on 21 December. He arranged for blood samples (in particular to measure cholinesterase levels), urine tests and (where indicated) lung function tests.

185. Dr Fetherston saw twenty-seven firefighters on Monday, 24 December. All had rashes, mainly with folliculitis. Dr Fetherston took blood tests and urine tests and referred those with skin rashes to Dr Greig. Twenty-two firefighters were placed off duty. The skin rashes were reported by Dr Greig to have resolved over the next few weeks. In early January 1985, a number of firefighters saw Dr Fetherston with symptoms of memory loss and clumsiness. Two firefighters were referred to a neurologist. No objective evidence of encephalopathy was found. Some firefighters were referred to Dr Dorothy Gronwall, a neuropsychologist, whose tests indicated some neuropsychological impairment.

186. In reviewing the initial treatment of firefighters with us, both the then Medical Officer of Health and Dr Fetherston expressed some criticisms of lack of strategy in the health management of the firefighters.

187. The health of the firefighters was not strictly the responsibility of the Medical Officer of Health but he assisted because he was already involved in the public health management of the incident, and because the Fire Service had no organised occupational health response.

"People like me imagine protective gear would mean the firefighters were not at risk. Most of our attention was on the environmental issues—the trees and the estuary. Our attention was diverted from the health of the firefighters. The Fire Service response to the medical problem was disorganised. There was no central medical control within the Fire Service. . . . I am certainly of the opinion now that the health of the firefighters was affected. I didn't at the time think there was a problem because I thought they were protected. I thought the
rashes were an irritant dermatitis caused by the soda ash. We don't get involved in clinical treatment as a general rule. With the benefit of hindsight, we should have contacted the Poisons Centre, but we had so little information, and thought we could rely on the ARA chemist and ICI. I now see an independent opinion would have been preferable. It is a deficiency in our service that we have no occupational health response. I was trying to do both that and the public health response. I was involved for about three weeks, but mainly in reaction to the press and Greenpeace. I felt hamstrung in not having sufficient information to pass on. We didn't realise the seriousness of the health problem soon enough. I should have taken the initiative more. I would have liked better information. We lacked resources because people were on holiday. It was difficult to work out what should be done and to implement it and I was trying to do that virtually by myself. . . . We failed to determine what investigations were required early on in the piece. Taking public anxiety about the environment and health into account, there was a need for a more co-ordinated media response. . . . I think the Fire Service should have accepted more responsibility to bring the experts in. It seemed odd for me to be in the central co-ordinating role. I'd never been involved in a fire of that magnitude with chemicals before. I spoke to the Superintendent of Auckland Hospital, but not early enough. I should have rung early to tell them the situation. I don't know why it took me so long.”

188. Dr Fetherston, in reviewing the health management of the firefighters commented,

“Doubt on our side contributed to the problem. We had no therapeutic strategy. With hindsight, we should have responded faster. We should have monitored exposure.”

189. The Personnel Officer at the time commented to us

“There was an emotional situation when the rashes appeared on the Sunday night. On the Sunday night, firefighters were already talking about Greenpeace,
dioxin etc. The doctors were not giving them any answers. Apprehension spread because the men knew that the decontamination procedures had not been followed. ... We were lulled into a false sense of security by the Health Department and by ICI. ... No-one had responsibility in an organised way. Dr Fetherston had no formal involvement or authority.”

D. PUBLIC CONTROVERSY

190. From 24 December, there was substantial media speculation as to possible health and environmental consequences of the ICI fire. The controversy centred on the presence of 2,4,5-T in the warehouse and reports, citing Dr Mann, lecturer in Environmental Studies, that dioxin could be formed from the combustion of 2,4,5-T. The Fire Services’ Technical Liaison Officer rejected this claim as being without foundation, citing ICI and “the manufacturer of 2,4,5-T”. The Medical Officer of Health also made a press statement indicating that dioxin was not an issue in the fire and rejecting claims that the authorities had reacted too slowly to potential danger. On 24 December the Minister for the Environment announced that the Commissioner for the Environment would report on the environmental consequences of the fire. By the end of December press reports that the fire “may have created and released dioxin, the most toxic chemical known to man” and that “firefighters could suffer the same painful fate as Agent Orange defoliant victims” were current.

191. In an about face, “because of growing concern among the firemen about the toxic effects of hazardous chemicals spilled in the December 21 fire”, it was announced that soil and debris at the ICI site would be tested for dioxin. Press reports noted that dioxin has been “linked to health and birth defects in children of Vietnam veterans ... and can cause leukaemia”. It was noted that Greenpeace had called for dioxin tests two days after the fire. Press reports indicated that the Minister of Health had announced that “firemen exposed to chemicals at the plant would be monitored long-term to see if any health problems developed”. The Area Commander of the Fire Service was quoted on 3 January as saying that firemen face thirty years of health tests. Delay in analysis of test samples taken, because of the holiday period, was a source of concern. The authorities were also criticised for not consulting the Toxic Substances
192. A Fire Brigade Routine Order on 3 January updated firefighters about treatment and tests but did not attempt to provide any information on the toxicological effect of chemicals at the fire. It advised that “in consultation with the DSIR and Health Department” clothing and other equipment was to be withdrawn and replaced “until such time as the experts can establish what level of contamination, if any, was present”. Analysis of uniform samples and equipment samples (to determine the degree of contamination) was reported as being held up by the holiday period. A report on the fire was to be written and personnel were encouraged to write in with their suggestions and criticisms.

193. A connection with the chemicals involved in the Bhopal disaster was raised in press reports. Testing announced for dioxin in clothing and soil samples was criticised by environmentalists as being (in the case of environmental samples) too late and (in the case of uniform samples) to a level insufficiently low. There were reports that six police were also ill as a result of the fire.

194. Dioxin tests undertaken by the DSIR on clothing and environmental samples proved negative. But environmentalists countered by saying that the tests had not measured to low enough levels. The Fire Service by Brigade Routine Order reported the Medical Officer of Health’s interpretation of the DSIR clothing analysis to mean that

- contamination by paraquat at the level present was of no significance to health
- dioxin was only present at extremely low levels, in the environmental tests and that, while tests were continuing on clothing, it was “most unlikely” that dioxin would be present in clothing
- a personnel survey would be undertaken, in conjunction with the Union, to record individual histories at the fire and
- new uniform initiatives were being undertaken.

195. The Union, in the meantime, arranged through Greenpeace to have fat samples tested in Sweden by Professor Rappe, an expert in
Chemical toxicology. The tests were organised by the Trade Union Health and Safety Centre.

196. Environmentalists criticised the DSIR report and in particular its "misuse" to reassure firefighters that formation of dioxin in the fire was unlikely. Against this background, the Union notified its members that it was not reassured and required a further opinion.

197. The Fire Service Report on the fire was published in mid-February and, with its revelation that a chlorine gas leak had been narrowly averted, drew ministerial and public praise for the skill and efficiency of the firefighting. In May, the New Zealand Fire Service announced the establishment of a protective clothing subcommittee, with Union representation upon it.

198. At the end of May, the results of the Union and Fire Service survey were released. It reported that twenty firefighters continued to suffer symptoms from the fire. Symptoms described were in general skin rash, unusual pimples, disturbed sleep, inability to concentrate, mood changes, tiredness, loss of memory, headaches, pain in joints and sweats. A report from the Commission for the Environment about effects of the fire had been announced by the Minister for the Environment on 24 December 1984. In reporting on a delay in the Commission for the Environment's response, an Auckland Star editorial in June said

"The firemen involved are justifiably concerned and anxious about what ails them, especially as they feel tests that could have been done here have not been carried out. . . . The injured firemen need every assistance—from the DSIR, ICI and the Fire Service—in tracking down the cause of their illness."

199. On 18 June, the Swedish test results were received. Although tests for the presence of 2,3,7,8-TCDD were not performed, the conclusion was that dioxin was most unlikely to be an explanation for the symptoms of the firefighters.

200. In June 1985, the Principal Medical Officer of the Fire Service and the Director of Personnel attended a meeting in Auckland to discuss continuing rumours of ill-health among the firefighters. The meeting was open to all those who had concerns and was attended by about thirty-five to forty people. Industrial action was being threatened. As a result, it was decided that Dr W I Glass would be
engaged by the Fire Service to review all material obtained since the fire which would affect the present and future health and welfare of firefighters who attended the fire, and to make recommendations as to further treatment and future action. In the meantime, the Fire Service required all those exhibiting symptoms related to the fire, whether or not they had had time off, to complete Accident Compensation Certificates. The Union at the same time reported to its members

"About twenty members are still suffering the aftereffects of the ICI fire, and they are all being treated, more or less independently of each other. As a means of finding a solution to this problem, we have asked Regional Commander Armstrong to try to arrange for a medical 'taskforce' to examine the affected personnel collectively, and he has agreed to try to give effect to our request."

201. Final DSIR test results were available at the end of July. They indicated some paraquat contamination of one pair of overtrousers and also high pH levels, sufficient to cause contact dermatitis.

202. Firefighters were advised by routine order that Dr Glass would see all who considered themselves to be affected by the fire.

203. On 29 July, the Fire Commission indicated to the Union that it

- would abide by the recommendations of Dr Glass relating to treatment, monitoring and welfare of those suffering incapacity as the result of the [ICI] fire and would accept Dr Glass's judgment as to cause
- would take all action necessary in relation to protective clothing after considering the report of the Protective Clothing Committee and Dr Glass
- would investigate a data retrieval system which permitted transmission of data to the fireground.

204. On 30 July the Union gave fourteen days notice of industrial action, seeking an assurance

- that the Commission would "take every available step to find a cure for our members who are suffering chemical injuries"
that protective clothing selected would be acceptable to the Union.

205. On 6 August, 1985, the Commission agreed

"...to take every possible step to ensure that a cure is found and given effect for those of its employees who are suffering as a result of the Mt Wellington, ICI fire. The Commission cannot categorically guarantee that a cure will be found but will work in close co-operation with the medical and scientific authorities to that end. In any case where the nature of the incapacity suffered by any such employee could reasonably be attributed to that fire along the line as suggested by Dr Glass, then that incapacity shall be deemed to be due to that fire."

206. During August, Dr Glass met with firefighters in a group meeting and individually. Forty-one firefighters who complained of symptoms, were interviewed by Dr Glass. Thirty-four had some skin effect, thirteen had respiratory symptoms (in only two cases had the symptoms persisted), thirty-four had central nervous system symptoms.

207. Dr Glass reported to the Fire Service in November 1985, and proposed the setting up of an Occupational Health Service for the firefighters.

208. In the meantime, before his investigation was completed, senior executive officers in Auckland and the Union sought authority from the Fire Service to permit any firefighters who wished to do so to attend Dr Tizard, a general practitioner who also uses alternative medicine techniques, for checks.

E. THE DIAGNOSIS OF “CHEMICAL POISONING”

209. In about April 1985, a senior executive officer in the Auckland Fire Service, who had been diagnosed after a positive blood test, as having glandular fever, attended Dr Tizard, complaining of lethargy and other symptoms consistent with the diagnosis of glandular fever. The officer attended Dr Tizard on the suggestion of the Assistant Commander (Personnel and Training) for the Auckland Fire Service. The Personnel Officer had been contacted by a member of the public who thought that the symptoms described in the press by the firefighters were similar to symptoms for which Dr Tizard had treated her
daughter. Dr Tizard diagnosed the officer by EAV technique (described in paragraphs 38–42) as suffering from chemical poisoning, specifically 2,4,5-T. The Regional Commander of the Auckland Fire Service also attended Dr Tizard at the same time and was diagnosed and received treatment for a complaint unrelated to chemical toxicity. Dr Tizard told us that the officer affected by 2,4,5-T was presented to him as being typical of those with symptoms arising from the ICI fire and that “it was decided that [the officer] would become an unofficial test case.”

210. The officer diagnosed as suffering from chemical poisoning was treated by Dr Tizard and reported relief of his symptoms. The officer raised the matter with the Principal Medical Officer of the Fire Service who had, however, already expressed his opinion to him that the resolution of symptoms was in accordance with the general progression of glandular fever. The officer recommended that “some, if not all” of the firefighters who had attended the ICI fire should be seen by Dr Tizard.

211. The matter was taken up by the Union which raised the issue of Dr Tizard’s treatment with the Regional Commander and with Dr Glass. The Union advised its members at the end of August that

“It may be possible for us to arrange for any member who attended the ICI fire, and who thinks that he or she may have suffered chemical poisoning at that fire, to visit Dr Tizard for checks to be made accordingly.”

212. At the beginning of September, Dr Glass agreed that the three most badly affected firefighters could be given an opportunity to go to Dr Tizard, to see if his treatment helped them. Two did so, and they reported some relief from their symptoms. The Union sought to have the Tizard treatment made available to the firefighters, citing the agreement between it and the Commission. In October, Dr Glass approved the use of Dr Tizard to treat “those who elect homeopathic treatment” on the basis that

“I believe Dr Tizard has shown his methods work and that is the most important thing. I would recommend therefore that those firemen with symptoms resulting from exposure to the circumstances of the ICI fire should be given the opportunity to seek treatment from Dr Tizard.”

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213. The Fire Service by Brigade Routine Order advised personnel that the Tizard treatment was available to them and that “it is intended to claim from the ACC (Accident Compensation Corporation) all costs that are involved in the treatment”.

214. The Assistant Commander (Personnel and Training) most efficiently arranged for all firefighters who wished to be tested, to attend diagnostic sessions. Dr Tizard himself attended a general meeting of Fire Service personnel to explain his diagnostic and treatment methods.

215. Over 200 firefighters were tested (but not always treated) by Dr Tizard. All but two were diagnosed as suffering from “chemical poisoning”. The Accident Compensation Corporation was contacted and agreed to the fees proposed for diagnosis and treatment of the ICI firefighters. Forty-three cases were assessed as requiring a month’s hyperbaric oxygen treatment. The other cases were offered homeopathic detoxification.

216. Thirty-eight people declined treatment and a total of 117 underwent detoxification by Dr Tizard. A further eighty-two were to have been offered detoxification treatment. Thirty-one of those treated were reported by Dr Tizard as having been asymptomatic. (These figures were supplied by Dr Tizard.)

217. In February 1986, the Accident Compensation Corporation suspended all payments based on the EAV diagnostic method, pending completion of a Department of Health inquiry into EAV testing. In June, the Maling Committee reported, and ACC declined to meet the costs of treatment based on EAV diagnosis. The Maling Committee Report has been criticised to us by the Union on the basis that no firefighters were seen by members of the Committee.

218. The number of firefighters who were diagnosed as suffering from chemical poisoning clearly came as a shock to the Fire Service. It was a substantial increase over the twenty firefighters who reported continuing symptomatology in May (in the Union survey) and the forty-one who had seen Dr Glass between August and October. On 25 November, the Assistant Commander (Personnel) reported to the Commander of the Auckland Region

“There is no doubt that as time goes on more and more firemen are suffering from the effects of attending the fire. The treatment that Dr Tizard is offering appears, at
this stage, to be improving the physical and mental health of his patients. Since the commencement of his treatment, staff now appear to be much more relaxed and are now prepared to talk about their health problems, and it is my view that they now feel that positive steps have been taken to find a solution to their problems.”

219. A Union representative was quoted in the press as saying that the Union had been worried for a period when the Fire Service appeared to be doing nothing, but with the advent of the Tizard treatment, it was now satisfied with the medical help being given to members.

220. On 13 March the Union wrote to the Commission asking for the Glass inquiry to be reopened “in view of the greatly increased numbers of firemen experiencing problems”. The suggestion was made that firefighters should be tested before and after they underwent the Tizard detoxification programme.

221. On 11 April the Union wrote to the Minister for Internal Affairs asking for an inquiry into the ICI fire. The letter expressed the belief that firefighters were entitled to know what their “medical and mental” future is to be. It referred to the apparent inability of medical services to cope. It expressed dissatisfaction with the medical authorities, and stressed that it was important for personnel to be reassured that their needs were being looked after by the authorities, and to be told about the current situation. “This was definitely not the case with the ICI fire.” Increased problems as time went on were cited and the fact that no one had been able to reassure the firefighters. Total lost shifts attributed to the ICI fire up to 1 April 1986 amounted to 1,598 shifts.

222. The Assistant Commander (Personnel) recommended to the Fire Service in April that staff who had begun treatment with Dr Tizard should be permitted to continue at Fire Service expense. He noted that staff who had yet to start treatment were placed under considerable additional anxiety and that if they elected to take the treatment and pay for it themselves “I propose to treat [time off duty during the treatment] as work accident unless I receive instructions to the contrary”. He raised concerns about what was to be done about the fact that medical compensation insurance had a two year cut-off from the date of the cause of injury.
223. In June 1986, Dr W I Glass's report on details of *An Occupational Health Service for the New Zealand Fire Service* was received. At the end of June a Steering Committee was set up to implement the proposals for an Occupational Health Service. It resolved to survey all personnel on treatments they had received and their satisfaction with the treatments, to provide information to enable an approach to the Accident Compensation Corporation. The Union had made the submission that "a considerable majority of those treated by Dr Tizard felt their health had improved, whilst only a minority of those being treated by other doctors reported any improvement".

224. In August, the Union reported to its members about a meeting with the Accident Compensation Corporation. It advised of the "total lack of concern by ACC" and the Fire Service Commission refusal to pay for Dr Tizard's treatment, on the basis that ACC should be paying for it. The Fire Service Commission offered to have Dr Fetherston organise treatment. The Union conclusion was "firemen now find themselves in the position where serious injury sustained while doing their job leaves them without the choice of treatment they should have". It was arranged that Dr Fetherston would provide full medical checks, including blood and urine tests, for all personnel awaiting treatment (reported to be ninety-three). Sixty wished to be reviewed in this way.

225. In October 1986, the Occupational Health Clinic was set up in the Auckland Fire Service. In December, Dr Fetherston indicated that it was impracticable to see so many ICI firefighters at the Occupational Health Clinic.

226. In January 1987 it was decided by the Occupational Health Committee that follow-up health assessment should be done by sending firefighters to their own doctors, with a covering letter from Dr Fetherston. The letter sent out for the doctors said

"It has been suggested that [those concerned about their health] should, where appropriate, undergo private tests possibly to detect any liver or kidney malfunction or abnormality together with urine tests and physical examination should you consider it appropriate as well as your clinical examination. Tests performed immediately after the fire were normal and in particular there was no evidence of organophosphate or paraquat poisoning. Many of the firemen developed a contact..."
dermatitis immediately after the fire but this has now resolved. There was no evidence of chloracne."

227. This letter was sent to sixty-seven firefighters.

228. In February 1987, the Union gave notice to its members that the news media was seeking information about health effects as a result of the fire. "In light of the current industrial situation, we feel it would be helpful" to give details. It sought information about

- birth defects or deaths
- marriage break-up
- psychological problems.

229. On 23 August, the *Sunday Star* reported that in

"grim sequel to the chemical fire ... one fireman is dying and others have fathered deformed babies after fighting the ICI inferno"

"... Their Union, their employer, and doctors agree that the illnesses are related to chemical contamination suffered at the ICI site."

230. It reported that eight firefighters had retired early, two children had died from birth deformities, one senior fireman had been diagnosed as dying of leukaemia and one child had been born with a hole in the heart. Otago University Medical School Professor of General Practice, Campbell Murdoch, was quoted as being convinced that the fire had broken down the firefighters' immunity and made them susceptible to infection and disease:

"A normal group of people would not have as many health problems."

231. On 30 August, 1987, the *Sunday Star* reported health problems suffered by firefighters, including birth deformities of children to firefighters under the heading "Fireman's Wife Aborts Baby".

232. In September 1987, the Union advised its members that

- the Fire Commission gets good marks for recognising ICI victims as work accidents for the purposes of sick leave, despite ACC non-reimbursement
- the Fire Service policy of arranging checks through the Occupational Health Service was all the employer could realistically do "at the current stage"
233. In December 1987, the Fire Service set up Occupational Health Services in the remaining five regions.

234. In May 1988, the Accident Compensation Appeal Authority, in a decision relating to an ICI firefighter, concluded

"The evidence is certainly clear that since the attendance at the ICI fire this appellant has suffered numerous problems and whether their cause be psychologically based or otherwise the evidence suggests to us that what triggered the problem was his attendance at the fire and therefore that the appellant is entitled to cover ... We have reached this decision on the evidence now available to us but because of the nature of the problems we consider that the appellant's condition should be monitored regularly. We hope that given adequate treatment the time will come when he no longer qualifies for compensation."

235. In July 1988, a Union notice to members sought co-operation in a questionnaire being put together by Ms Jackie Stoddart:

"She is very interested in talking to, or getting forms from, anyone who went to the fire and whose family have since had pregnancy or birth problems. ... There are continuing rumours of these problems but not substantiated information. It is natural that the parents involved do not wish to extend their agony but [the information would help all affected]."

236. In November 1988, the Auckland Occupational Health Nurse expressed by newsletter to firefighters that she was "astonished and distressed" to learn from the radio that "at least two hundred firefighters in the Auckland area are still suffering acute illnesses from toxins acquired in the 1984 ICI fire". She advised that only six had responded to invitations to see the nurse or the doctor.
237. In December 1988, an Auckland firefighter, Mr Tony Jennings, died of leukaemia which was linked in press reports to his attendance at the ICI fire.

F. TREATMENT OF FIREFIGHTERS

238. A total of 149 firefighters have received some form of treatment for symptoms ascribed to attendance at the ICI fire. Ninety firefighters have received no treatment including sixty-three who report problems with their health. Thirty-eight of the group of sixty-three who have health problems but have received no treatment describe central nervous system symptoms or combined central nervous system and skin complaints.

239. Eighty-nine are satisfied with the treatments they have received; 73 are dissatisfied with at least one of the treatments received. Of those with ongoing health problems 19 are not satisfied with the treatment they are receiving. Of those satisfied with treatment (89), 52 have been treated by alternative medicine, rather than orthodox medicine.

G. THE OCCUPATIONAL HEALTH SERVICE

240. The Occupational Health Service was introduced by the Fire Service in response to the problems in co-ordination of health assistance encountered at the ICI fire. A number of firefighters expressed concern to us about the confidentiality of occupational health service records.

241. As part of the reorganisation of the Occupational Health Service, job descriptions for medical officers and nurses have been produced.

242. The Fire Service Commission personnel we saw do not think it appropriate for either the nurse or doctor to be involved on the fireground. The Auckland Occupational Health Nurse has told us that she has asked to be notified of any calls to all fires exceeding second alarms but acknowledges that she is not always called. The New Zealand Fire Service submission to us however was of the view that

"The Brigade would now be able to involve the Occupational Health Service's professionals at a very early
stage of any incident that required the type of co-ordination we needed at the time of the ICI fire and in the post-fire period.”

243. The Regional Medical Officer (who is the doctor in charge of the Occupational Health Service), has the function of giving advice to Regional Commanders on matters of health, safety and welfare of employees. The Occupational Health Nurse has the same function to give advice and in addition has the function of “liaison as necessary with medical practitioners, hospitals and other community health and social agencies.” The Principal Medical Officer, who reports to the Commission through the Director of Personnel, has the general responsibilities

• to advise the Commission on all medical matters
• to co-ordinate and oversee Commission policy on medical matters
• to propose and subsequently implement changes in medical policy.

244. Detailed responsibilities of this officer include

• liaison, as necessary, with other medical services
• keeping the Fire Service Commission informed of any medical matters of more than ordinary consequence affecting the health of the Fire Service generally or individually
• co-ordination with Director of Training, Regional and Area Commanders as required.

245. The Occupational Health Service has among its functions “establishing and maintaining confidential health and statistical records”.

246. Despite the emphasis upon confidentiality, a number of firefighters are suspicious of the extent to which information maintained by the Service is confidential. That concern is perhaps accentuated by the fact that the Occupational Health Nurse reports and follows up on firefighters who are off work for more than two weeks. The point of reporting is to the Principal Medical Officer, who is the person with responsibility for medical boarding. The Nurse also interfaces with ACC about compensation payments. Only a third of the nurse’s time is taken with seeing people individually. The running
of health programmes and training courses takes up the major proportion of the time.

247. The Fire Service Commission has told us that it would like to do more through the Occupational Health Service, but is being hampered both by money and "Union suspicion". The Commission would like to see a screening system for health introduced which would enable detailed health monitoring. This has been met by firefighter resistance because of fears of job loss. A pilot system for Wellington is planned.

248. The New Zealand Fire Service believes that the Occupational Health Service has had a major beneficial impact on staff morale and wellbeing. "The transformation of the personal health of Auckland firefighters has to be seen to be believed."

249. The Union is supportive of the Occupational Health Service but criticises the fact that its Committee is no longer chaired by the Regional Doctor but the Regional Commander (exacerbating fears that the service is too close to the employer). It also criticises lack of specialist qualifications (specifically occupational health qualifications) of the doctors appointed as regional medical officers.

250. The firefighters were asked in our questionnaire for their thoughts about the Occupational Health Service. Forty-three were uncritical about the present service, making such comments as

- "The best that has happened to the Fire Service."
- "Excellent."
- "The only positive aspect of the ICI fire."

251. Twenty-five are critical of the Service citing

- the nurse's reported attitude to the ICI fire (see paragraph 236)
- the issue of confidentiality
- the fact that the Service does not monitor the health of the firefighters
- a failure to tackle stress management adequately
- perceived incorrect and old-fashioned advice
- lack of resources.
252. Sixty-nine other respondents regard the Occupational Health Service as "a step in the right direction" and "essential to have" but criticise it

- as not going far enough (in particular, in not dealing with occupational stress, in lack of resources, failure to treat volunteers, being spread too thin)
- for lack of confidentiality
- for lack of monitoring
- as lacking in fireground support "teeth"
- as being mainly concerned with general fitness and diet.

H. Volunteers

253. It was suggested to us by two volunteer firefighters interviewed that the Fire Service is not sufficiently concerned about the position of volunteers. Matters of concern to them were

- the fact that fire police were exposed to smoke at the ICI fire
- that volunteers did not seem to be noted in the records of those who attended the fire
- that volunteers were not considered in relation to the fire

"We have heard nothing from the Fire Service Commission at all and I think that is bad. It was only through what we read in the paper that we knew to ring up and find out what was going on. We never hear from the Fire Brigade Association. . . . I can say the volunteers got nowhere near the information that the permanents got. It was never passed on to us."

254. The Fire Service, in response, points to the fact that volunteers are bound by the same procedures and the Area Commander has the same responsibilities in relation to volunteers as permanent staff. While volunteers cannot at present use the Occupational Health Service (although it is planned to be extended to them) "... if anyone was involved in a hazardous incident, we'd get the Medical Officer to check them".
I. MEDICAL BOARDING

255. This term is used in the Fire Service to describe retirement on medical grounds from the Service.

256. It was evident to us in our investigation that medical boarding is a particularly sensitive issue among firefighters and the Union. It is one of the reasons why regular medical checks are opposed. The Fire Service, as the Principal Medical Officer explained it to us, simply does not have many operational jobs which can be classified as "light duties". That means that, in a service where fitness is extremely important, medical disability is often job-threatening. There is also a perception in the Fire Service that the Service is facing financial constraints in which job shrinkage is a real threat. The fear is that the opportunity may be taken to ease out people with slight medical problems which are not disabling. The Fire Service points to what it considers generous severance payments upon medical retirement, but for many firefighters who regard their job as a career and who love their work, financial considerations are not the only ones.

J. THE ROLE OF THE MEDIA

257. It has been suggested to us that part of the phenomenon of the ICI fire was that it occurred over the holiday period when very little real news was available and that it was therefore latched on to by journalists, hungry for news, who never let the story die a natural death. It has also been suggested that the news media have sensationalised the fire and the plight of the firefighters and added greatly to their distress.

258. We do not agree that media coverage of the fire has been excessive. The issue of chemical toxicity, and the plight of the firefighters seem to us to be legitimate matters for public concern. Nor has the news media (except in a few cases where articles or headlines may be thought to be unnecessarily alarming) done a bad job of putting forward the facts, particularly when one considers the lack of authoritative response to some of the matters raised during the past four years.

259. It is, however, part of the background of the ICI fire and lives of those affected for the past five years, that there has been continuous media interest and coverage of the effects of the fire and the
health of the firefighters. We consider that this continuing attention must have contributed to the sense of unease of the firefighters, particularly given the references to Agent Orange, dioxin, birth defects and cancers.
IV
Toxicology and the ICI Fire

1. THE PROBLEM OF TOXICOLOGICAL DIAGNOSIS

260. The evaluation of the effects of drugs and medicines is relatively straightforward because, at some point in development, carefully controlled experiments in humans have been performed at various doses given by a standard route (usually oral). These studies are easily compared with animal experiments and allow for a relatively confident interpretation of such pre-clinical work with human effects. Chronic effects, however, are always problematic because of the cost and difficulties of interpretation of long-term studies due to confounding factors, certainty of compliance with dosing, and drop-out of subjects.

261. For chemicals, only animal toxicity will have been performed. The effects upon humans are gauged by observation of exposure incidents. Such incidents will normally vary in

- the variety of routes of exposure (by contact through the skin, by inhalation and so on)
- levels of exposure
- knowledge of the actual chemical load.

262. Observations of exposure may be supported by epidemiological studies, which suffer from problems of confounding and doubt as to the degree of chemical load (in much the same way as single cases).
263. Unless a chemical produces unique effects or syndromes, diagnosis of human toxicological illness carries many uncertainties. Often reliance on animal studies is necessary for guidance, but interpretation is always difficult because of interspecies variation (this problem is particularly marked in assessment of neurotoxic effect).

264. The management of a single human case of chemical exposure depends upon

- estimation of the chemical load from exposure data or objective measurement
- detailed descriptions of the clinical picture, with as much objective data as possible
- chronology of the exposure and clinical picture, particularly the relationship between exposure and symptom development (and the converse when exposure ceases)
- establishment of an approximate clinical picture based on animal experimental evidence and a critical review of other human experience
- establishment of alternative hypotheses to explain the clinical syndrome
- a careful synthesis of the above to develop a working hypothesis
- consideration of rechallenge as a possible confirmation of the diagnosis or tentative treatment programmes which will, as far as possible, aid the diagnostic evaluation (that is to say, avoid symptomatic treatment as far as possible)
- definitive treatment based on the results of the preceding steps.

265. Very often poor exposure history, the lack of a specific clinical syndrome and the possibility of other reasonable explanations makes clear-cut diagnosis impossible.

266. Epidemiological studies provide extremely useful data against which single cases can be judged. Prospective studies often raise ethical difficulties and are relatively expensive and prolonged. Many retrospective studies suffer from problems of confounding, recall and/or systematic biases and inadequacies in exposure data, by which dose-response could be gauged.
267. Despite the limitations, carefully interpreted, epidemiological studies have been enormously helpful in a number of cases in strengthening the relationship between a chemical and disease. Whilst toxicological causality cannot be firmly established from epidemiological studies and requires other supporting evidence, the more studies which show a relationship, the more likely there is to be an association.

2. BACKGROUND TO TOXICOLOGICAL EVALUATION OF THE ICI FIRE

268. One explanation sometimes given for the health problems of the ICI firefighters is that the symptomatology is a result of a "threshold effect" by which the general load was added to by the products of the ICI fire in a way which pushed those affected over the clinical level. As one firefighter said to us: "The ICI fire was one fire too many". That explanation is not supported by the epidemiological study in the absence of any subgroup. It is, moreover, inherently improbable from what is known of the toxins present in the ICI fire for a threshold to have been crossed by so many at the same time. One would expect to discover similar thresholds being crossed by individuals after each major structural fire. It could also be expected that the Wellington firefighters would show a comparable pattern of symptom development through incremental exposure. That the epidemiological study does not show such a trend suggests that attendance at the ICI fire alone is the explanation for the symptomatology and the difference measured.

269. The ICI warehouse fire was unique in terms of the mixture of chemicals and their combustion products. The application of existing toxicological knowledge of the chemicals in the warehouse must consider possible interactions between them in the presence of heat and water. Very little is known of interactions between chemicals in a toxicological sense.

270. The combustion products from the fire are largely unknown since they depend upon the nature of the chemicals and the temperature of the fire. They may change with different stages of the fire. Some combustion products are inevitable consequences of fire, however, and their toxicology is known. Carbon monoxide is an example
of a toxin inevitably caused by combustion. Other products can be inferred from the chemicals and packing materials present.

271. A toxicological analysis will also need to include the possible effects of chemicals diluted by water both upon the skin and as a consequence of systemic absorption (through the skin or the lungs).

272. For these reasons, consideration of the known effects of the chemicals in the warehouse is inadequate to determine toxic effect. Any toxicological analysis of effect on the basis of known data of the ICI fire will be largely imperfect and deductions from known toxicological effects could be misleading.

273. The technique of comparing the health status of firefighters who fought the ICI fire with a matched referent group in Wellington is useful in evaluating health effects, although suffering from the disadvantages of distant recollection of exposure data and other recall bias. The objective measures used, however, are extremely useful to establish or refute ongoing illness on a group basis and can point to the need for further evaluation of individual cases.

274. An evaluation of the toxicology of the ICI fire therefore will need to consider

- the known toxicology of the chemicals present and their likely combustion products
- inferences that can be drawn from health effects observed in the epidemiological study
- the extent to which extrapolation from available data is justified.

3. KNOWN TOXICOLOGY OF THE CHEMICALS PRESENT

275. A list of the chemicals held in the ICI store, as supplied by ICI, appears as Appendix III to this report. The list includes the quantity of products held in the store and, where the chemical is stored in solution, indicates the solvent used. A toxicological bibliography is attached as Appendix VI.
A. Organophosphates

276. A large quantity of organophosphates were present in the ICI warehouse, both in dry form and in solution. They are pesticides which act as neurotoxins by attacking the enzyme acetylcholinesterase, which is essential for nerve conduction. They are acute and powerful poisons, readily absorbed through the skin. They can also cause poisoning from inhalation. Onset of toxic effects from a single exposure can be from a few minutes to over an hour, the time not necessarily dependent on the degree of exposure. Symptoms are usually maximal at two to eight hours but can be subject to long-term relapse over a few days. Cases of persistence of symptoms for up to three months have been described, although in general long-term effects are known only from continued exposure. Both cognitive and emotional functions of victims may be affected.

277. Mild exposure causes headache, dizziness, weakness, anxiety, tightness in the chest, tremor of muscles (particularly tongue and eyelids), visual difficulty and constricted pupils.

278. Moderate exposure results in nausea, ataxia, increased salivation and tears, vomiting, sweating, abdominal pain and slow pulse.

279. Severe exposure adds diarrhoea, breathing difficulties with pulmonary congestion, incontinence, convulsions, coma and heart block.

280. The diagnosis of poisoning can be confirmed if blood is taken early to measure cholinesterase levels in plasma. The test is not totally reliable because of the wide normal variation in cholinesterase levels.

281. Early symptoms described by the firefighters could be explained in part by mild exposure to organophosphates in solution and absorbed through the skin or, a less likely explanation, by inhaled fumes. Measurement of cholinesterase levels was performed too late to have been very useful. Given that no major clinical case of organophosphate poisoning occurred, that the known action of the compounds on cholinesterase is reversible and temporary, and that the half-life of the involved chemicals (in animal experiments) is such that nearly total excretion occurs in twenty-four hours, it is safe to conclude that chronic ill-health other than the possibility of skin sensitisation would not have occurred.
B. ORGANOCHLORINES

282. These substances include the long-acting substance, lindane. They will dissolve in body fat and lipid membranes, including the nerve conduction material of the central nervous system. Their stability in the body fat reservoir accounts for their relative persistence in the body. Lindane has a half-life in the body of about 21 hours, making it the most persistent of the organochlorines in the warehouse. Organochlorines can be absorbed through the skin and could be vaporised for respiratory absorption.

283. Mild symptoms include dizziness, headache, nausea, tremor and anxiety. More serious exposure leads to vomiting, tremor and convulsions. Inhalation of vapour causes irritation of the nose and throat as well as eye irritation. Skin irritation is also caused by lindane.

284. These substances, as concentrates, may be dissolved in organic solvents such as kerosene which enhance skin absorption and add to their nervous system toxicology.

285. Early symptoms of the firefighters may have been in part due to organochlorines, but no firefighter was affected badly enough to have had convulsions. Even in the case of lindane, it is inconceivable that such exposure would lead to symptoms being present for more than three weeks: a figure of one week would fit more closely for a single exposure episode. Skin rash resolves after a few days, on discontinuation of exposure, with or without treatment.

C. DIPYRIDYLUM COMPOUNDS

286. These were represented by substantial quantities of paraquat and diquat. The acute toxicity of these compounds when ingested is extreme: as little as 10 milligrams per kilogram of body weight has been reported as fatal (indeed, some authorities quote as little as 4 milligrams per kilogram of body weight for paraquat). Diquat is rather less toxic. Inhalation toxicity is also great, but uncommon. Skin absorption is not extensive if the skin is intact, but does occur.

287. It is likely that the toxic effects are through conversion into highly damaging superoxides which occur particularly in the lungs, leading to progressive damage and irreversible respiratory failure or fibrosis. No tissue is, however, immune and liver and kidney damage
is also very prominent. With its less extensive blood supply, the brain
is less affected; unconscious patients may recover consciousness, only
to die of respiratory failure.

288. Paraquat is an irritant to the skin and mucous membranes,
causing burning and corrosive damage, sometimes after a delay in the
appearance of symptoms.

289. Paraquat might well be implicated in acute skin irritation but
it is most unlikely that paraquat would cause nervous system symp-
toms, short or long-term, without lung, liver or kidney damage being
present.

D. Pyrethroids

290. These are insecticides with low toxicity.

291. At high levels (more than 5 milligrams per cubic metre) anxi-
ety, twitching and nervousness occur. Even higher levels may lead to
convulsions and coma. Skin sensitisation can occur and might recur
on re-exposure, but other long-term effects are not reported after
exposure is discontinued. Inhaled fumes of this relatively stable
chemical and skin absorption might lead to short-term nervous sys-
tem symptoms, particularly anxiety and nervousness.

E. Coumarins

292. These compounds were represented by the very long-acting
substance, brodifacoum. They are anti-coagulants which act to
inhibit the liver’s production of clotting factors. Difficulty in stopping
bleeding or even spontaneous bleeding could persist for weeks or
even more after exposure. Little is known of the inhaled toxicity of
such compounds and skin absorption is probably not great, although
a few occupational problems (not due to ingestion) have been
reported. Single doses of coumarins are not dangerous. Long-term
exposure to coumarins (not with brodifacoum) has resulted in myo-
carditis, skin rash, bone marrow and liver damage. Even more rarely
gastro-intestinal effects, paralysis of ocular muscles and renal damage
have occurred. None of these effects are likely without evidence of
problems of coagulation preceding them. None of the firefighters has
reported problems with bleeding and it does not seem that these
compounds played any part in reported toxicity from the ICI fire.
F. SURFACTANTS

293. These compounds are variable, but generally low in toxicity. They are used as spreading or wetting agents, for example with herbicides. Because of their action they may increase absorption of other chemicals, either through the skin or after ingestion. In the lungs, they damage the substance, surfactant, which is responsible for maintaining potency of small airways. This can result in areas of lung collapse and pneumonia. Long-term effects of these substances are unlikely.

G. CHLORINE

294. An amount of pool chlorine was present as hypochlorite. This could release chlorine gas as a result of chemical action and/or heat.

295. Chlorine, when inhaled, has a strikingly acute irritant action resulting in intense inflammation and lung congestion. Even though almost immediate fatality is possible following a single deep inhalation, no long-term effects outside the respiratory system are known. Chronic bronchitis, however, may occur, with progressive shortness of breath and productive cough. This condition is worsened by any other exposure to lung irritants and smoking.

H. ACID AND ALKALI

296. These were present in a variety of forms and there may have been some mutual neutralisation. DSIR analysis of the firefighters' clothing at the time, however, showed high pH levels, indicating a preponderence of alkali. This would have been contributed to by the extensive use of soda ash by the firefighters at the fire as a skin decontaminant and in the clean-up. Both alkali and acid will produce a contact dermatitis on the skin, or even a burn, severe damage and scarring.

297. Alkaline material will also add to the damage produced by other material and the interaction of acid and alkali, though chemically neutralising, may also cause damage to the skin since the neutralisation process releases variable amounts of heat. Soda ash, used at the fire both in the clean-up and as a decontaminant, may be harmful to the skin and should not be used as a decontaminant.
298. Inhaled acid or alkali dust will produce respiratory damage in the same way as chlorine, but not usually to the same extent.

I. ASPIRIN

299. Alka-seltzer tablets, present in the ICI warehouse, contain aspirin. Apart from being acidic, aspirin may cause sensitisation. Indeed, because of its widespread use, some of the firefighters may have been allergic to it. Small amounts may have caused allergic symptoms such as asthma and dermatitis in allergic individuals. No chronic effect, apart from persistent sensitivity, would ensue from this single exposure.

J. ALUMINIUM AND COPPER SALTS

300. Aluminium was present in pool flocculants and copper was present in pesticides. Aluminium metal may also have been present as a packing material and volatised in the fire, leading to inhalation of aluminium. It is unlikely that the load of aluminium would be great and no symptoms referable to aluminium or copper toxicity occurred except for diarrhoea and vomiting which are non-specific. These symptoms would have occurred from ingestion, and would have been associated with burning in the mouth. In the absence of acute poisoning, chronic effects of aluminium or copper are unlikely.

301. Aluminium is under discussion as the causative agent in Alzheimer’s disease. But this association relates to the life-time accumulated load of aluminium. It is known that aluminium-induced brain dysfunction can occur after about three years in patients on renal dialysis in which aluminium is concentrated in the body from alum used as a flocculant in town water supplies. This gives some idea of the length of exposure needed even in people unable to excrete aluminium.

302. In the absence of any evidence of large amounts of aluminium and the characteristic acute symptoms, there is no reason to consider brain toxicity resulting from a single exposure. At worst the ICI fire could only have contributed a small additional amount to a life-long load from other sources of aluminium.

303. Almost no toxicity occurs with these chemicals unless they are ingested, but repeat chronic exposure of the skin may result in skin
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damage and absorption. It seems unlikely that much absorption would occur, except through damage by other chemicals, during this single episode.

K. SOLVENTS

304. Apart from water, some hydrocarbon solvents were present in the fire: petroleum distillates, aromatics (which may have included small amounts of benzene as part of a "hydrocarbon mix"), aldehydes and ketones. Because of their high flammability, it is likely that the petroleum distillates, aromatics, and methylethylketone would burn completely to carbon dioxide and water. Partial combustion to carbon monoxide and other hydrocarbons and vaporisation at lower temperatures are less likely possibilities.

305. Formaldehyde may have produced an irritant gas affecting the eyes particularly (causing tearing), and also causing respiratory irritation and coughing. Chronic exposure to formaldehyde produces, with high doses for a long time, respiratory cancer in animals but such effect has never been proved with humans.

306. The vapours of hydrocarbons and ketones (if present at all), may have contributed to dizziness and weakness in the firefighters. The chronic effects of these chemicals on the nervous system, bone marrow, liver and kidneys would not occur from a single exposure, particularly in the absence of severe acute toxic symptoms.

307. Leukaemia has been reported from chronic exposure to benzene but single exposures have not been associated with bone marrow neoplasias. Moreover, the amounts of benzene present at the ICI fire were small.

308. The combination of hydrocarbons with chlorine (present in the pool chemicals at the fire) on burning could theoretically produce dioxins (of which 2,3,7,8-TCDD is the most toxic). Whether this actually occurred would depend upon the co-incident presence of the substances in an appropriate form and at the correct temperature. It is considered unlikely that this happened and such a conclusion is supported by the absence of any appreciable amounts of any dioxin in any of the, admittedly few, measurements made either in New Zealand or in Sweden. It should be acknowledged that tests of blood samples from three firefighters conducted in Sweden were incomplete.
and, in particular, did not measure 2,3,7,8-TCDD, because of equipment failure. The small amount of evidence from the tests is, however, supported by the absence of the characteristic symptom of chloracne (a severe, scarring acne developing on the face in particular, after an itchy swelling and redness of the exposed area). Other symptoms of dioxin toxicity such as weakness, anxiety, irritability, muscle pain, neuropsychiatric abnormalities, porphyria, and liver damage are non-specific for dioxins and do not seem to occur in the absence of chloracne. Cancer, foetal abnormalities, and immunological depression have not been proved to be long-term effects of dioxins in humans, in spite of extensive research.

309. The possibility of a contribution of dioxins to the symptoms of the firefighters will continue to be raised because of its persistence in the body and its non-specific symptoms. Although controversy over dioxin toxicity keeps it in the public's attention, and it was suggested at the outset as a chemical to which the firefighters at ICI were exposed, there is no evidence of exposure to dioxin at the ICI fire. Although extremely persistent, the longest recorded half-life in the body of dioxin to date is four years. All chronic symptoms described are associated with the presence of chloracne. If the neuropsychological symptoms of the firefighters are to be ascribed to dioxin, this will be the first time that such an association has been seen following what must have been, at worst, slight exposure.

L. OTHER CHEMICALS

310. Many other chemicals were present in the warehouse, but it seems unlikely that they would add anything to the toxicity in the form they had in the warehouse. They would have contributed to the combustion products overall, but it is impossible to assess the extent or nature of their contribution.

M. COMBUSTION PRODUCTS

311. If heated to a high enough temperature, simple gaseous products are released, depending upon the elements present. Common amongst these are carbon dioxide and carbon monoxide, sulphur oxides, nitrogen oxides, metal oxides, hydrogen sulphide and hydrogen cyanide.
312. At lower temperatures, or at the periphery of high temperatures, fire volatilisation or sublimation of more stable chemical compounds occurs and chemical interactions may also occur to produce a wide range of more complex material. Some of the gaseous material may also interact.

313. The addition of water to such a “cocktail” provides another variable for possible chemical reactions. Moreover, water changes the temperature of the fire so that combustion products are not only variable with the material consumed at different times during the fire, but also according to the amount of water damping the temperature. Water may also cause some chemical reactions which actually release heat. More water soluble chemicals will tend to be removed from the fire base under some circumstances which will again change the chemical combinations possible with time.

314. From this discussion it can be seen that it is clearly impossible to generalise about products from any fire, let alone one in which so many chemicals were involved. Some chemical products are, however, invariable accompaniments of fires and some are likely in a fire of this sort and so worth special consideration.

N. CARBON DIOXIDE

315. This gas is a product of complete combustion of wood, other fossil fuels and hydrocarbons. It is also a natural product of respiration. High levels cause great distress to breathing, leading rapidly to unconsciousness and then profound metabolic disturbance. Unless anoxic damage occurs to the brain and nervous system with very severe exposure (in which the person affected would be unconscious), no chronic damage occurs.

O. CARBON MONOXIDE

316. When incomplete combustion occurs of wood, plastics and so on, carbon monoxide is formed. Carbon monoxide competes with oxygen within the body for transporting the red blood cells. The compound of carbon monoxide with haemoglobin in the red cell (carboxyhaemoglobin) is not only more stable than the equivalent oxygen compound, but also prevents the release of oxygen into the tissues.
317. The symptoms from carbon monoxide exposure not only depend upon the extent and duration of exposure, but also on the activity of the person exposed. This is clearly an important point in relation to firefighters who are engaged in strenuous activity when fighting fires.

318. Concentrations of 100 parts per million may not produce acute symptoms during an eight hour exposure, but carboxyhaemoglobin levels of above 5% will produce cardio-vascular effects with increased heart rate and vaso-constriction. This is thought to contribute on repeated exposure over time to fixed vascular disease such as atheroma and, perhaps, hypertension.

319. Exposure to 500 parts per million for an hour will produce symptoms of headache, shortness of breath on exertion and a blood carboxyhaemoglobin of about 20%. Longer periods will lead to blood concentrations of 40–50% with headache, nausea, irritability, shortness of breath, chest pain, confusion and faintness.

320. Exposure above 1,000 parts per million leads quickly to unconsciousness and death. Recovery may be complicated by permanent nervous system damage.

321. There is also evidence that repeated exposure to anoxia from carbon monoxide may result in gradually progressive nervous system damage, with memory loss and other brain dysfunction damage. Some ataxia and peripheral sensory loss may also occur. No firm evidence exists at the moment as to the level of carboxyhaemoglobin that can be tolerated on repeated exposure before aggregated damage may occur. It is, however, clear that firefighters are a group occupationally exposed to the risk of progressive carbon monoxide-induced nervous system damage. This toxicity could occur at any time and was no greater at the ICI incident than any other major structural fire. Thus it seems unlikely that carbon monoxide poisoning could solely account for so many individuals with ongoing symptoms from this incident taken alone or indeed if added to what must have been a variable previous exposure experience.
P. NITROGEN OXIDES

322. Inhalation of these gases produces acute cough, lung congestion and shortness of breath. Alteration to the blood (methaemoglobin) may occur. Apart from lung damage by way of bronchitis, chronic effects are unlikely.

Q. SULPHUR OXIDES

323. These have similar effects to the nitrogen oxides. Irritation of the eyes and mucous membranes may occur. Again, chronic lung damage is the only long-term effect likely.

R. HYDROGEN SULPHIDE

324. This gas can produce upper respiratory irritation, with cough, sore throat and eye irritation. Dizziness, confusion and loss of consciousness, together with lung congestion and depressed respiration occur with higher levels of exposure.

325. Repeated exposure causes low blood pressure, nausea, weight loss, ataxia and chronic cough. Lung and kidney damage may also occur. As with carbon monoxide, firefighters are occupationally at risk from repeated exposure to hydrogen sulphide. But in explaining symptoms which have been persistent since the ICI fire, there is no reason to assume very great exposure to hydrogen sulphide. The most prominent chronic symptom is a cough, a symptom not particularly reported by ICI firefighters.

S. HYDROGEN CYANIDE

326. This highly toxic gas can be absorbed through the skin as well as inhaled, in amounts that can cause rapid respiratory distress, alterations in consciousness, convulsions and death.

327. Repeated exposure to cyanide at low concentrations results in dizziness, weakness, lung damage, weight loss and mental deterioration. An ataxic neuropathy has been reported with chronic ingestion and depressed thyroid function.

328. There is no reason to suspect excess hydrogen cyanide at this fire; the same argument applies, therefore, as with carbon monoxide
and hydrogen sulphide in respect of the contribution of the ICI fire to aggregated toxicity of this compound.

T. DIOXINS

329. At the time of the ICI fire, concern was expressed about the possibility of dioxin (2,3,7,8-Tetrachlorodibenzo-p-dioxin: TCDD) being produced as a result of the pyrolysis of 2,4,5-T, which was present amongst the many chemicals involved in the fire. Under laboratory controlled conditions, the combustion of 2,4,5-T can result in its conversion to small amounts (0.6 parts per trillion of TCDD) to one part per million of 2,4,5-T burned. As has been discussed above at paragraph 308, the burning or heating of some hydrocarbons with chlorine, commercial and purified chlorophenates and pyrolysis of polychlorinated biphenyls (PCBs) contaminated with trichlorobenzenes, has resulted in the production of TCDD. The formation of TCDD from trace chemical reactions in fires has been postulated, but not verified.

330. TCDD can be destroyed by combustion in temperatures from 800°C (only slightly above its temperature of formation). The temperature in an uncontrolled fire may reach 1000°C or more. If it is conceivable that TCDD might be formed from the pyrolysis of 2,4,5-T in a fire, it might also be destroyed by the same fire. Should any TCDD be produced in such a fire and not destroyed, it would rise with the smoke plume and would quickly become heavily diluted to a level below current analytical detection limits. TCDD deposited on leaves and exposed to direct sunlight degrades with a half-life of little more than one hour. Present studies indicate that when TCDD is applied on soil, the half-life is about 50–55 hours. The low solubility of TCDD in water (at 0.2 parts per billion), given the millions of litres of fire run-off, would also reduce concentrations to below detection limits.

331. Because of the acute toxicity of TCDD, and because of its persistence, it is important to determine whether and to what extent contamination may have occurred. It is, however, hardly surprising that the DSIR tests taken some three days later indicated no dioxin in the environment surrounding the ICI warehouse at parts per trillion levels. (It should be noted that the United States Environmental
Protection Agency “Action Level” for TCDD is currently one part per billion.)

332. The Swedish testing of blood of three firefighters (only two of them exposed) for dioxin indicated no significant dioxins, but it should be noted that their results did not measure for 2,3,7,8-TCDD. The firefighter tested during the course of the present investigation (see paragraph 37) had dioxin levels at a normal “background” level, however. As discussed above in paragraph 309, there is no evidence that firefighters were exposed to dioxin and the symptoms described by the firefighters have never been reported as a result of dioxin exposure, in the absence of chloracne and after a single exposure to what would have been, at worst, low levels.

U. COMBUSTION OF PLASTICS

333. Plastics of various kinds were present in the ICI warehouse as packing materials. Plastics are long chains of molecules called polymers. At some temperature most polymers melt (though some decompose before melting) and eventually they burn, contributing significantly to the persistence of fire. Between these temperature extremes, a variety of decomposition products are produced. They may be volatile component molecules (monomers) such as styrenes, from polystyrene, together with small amounts of toluene and benzene. In turn, at higher temperatures, these compounds may decompose further to carbon monoxide and carbon dioxide. PVC (polyvinylchloride) decomposes to hydrogen chloride mainly, although still with some benzene and other hydrocarbons (for example, methane).

334. There are too many plastics to deal with each independently. What was in the warehouse is not completely known. Apart from the decomposition products already mentioned, the only other possibly toxic products are likely to have been aldehydes (from formaldehyde stored in the warehouse), hydrogen, cyanide, some metal oxides, sulphur oxides, isocyanates, and acrolein.

335. Apart from the hydrocarbons and carbon monoxide already discussed, the decomposition products are largely irritant to the eye, nose, mouth and lungs. There may therefore be striking acute discomfort and choking, but no general persistent toxic effect, unless the
lung irritation is severe enough or repeated often enough to cause chronic bronchitis.

336. Styrenes from polystyrene decomposition have effects like other hydrocarbons, causing upper respiratory and lung irritation and central nervous system effects. Since styrenes are particularly reactive, they may cause skin irritation and they are also mutagenic (producing changes in genetic properties of cells, often linked to cancer formation). Repeated exposure may result in chronic nervous system complaints of neuraesthenia (weakness, faintness and generally feeling unwell) and irritability, liver function abnormality and bone marrow suppression. These effects are usually reversible when exposure is discontinued.

4. TOXICOLOGICAL SUMMARY

337. Something happened at the ICI fire which separated it from other major fires in causing chronic symptoms affecting the central nervous system and the skin.

338. A toxicological explanation could be:
   - persistence of a very long-term toxin
   - additive effects of repeated medium persistent toxic exposures occurring in other fire incidents but particularly evident at the ICI fire
   - additive effects of chronic damage caused by chemical effect from exposure at other fires, but with greater effect at ICI
   - acute toxicity with persistence of symptoms for other reasons.

339. The possibility that there was no toxic effect should also be considered although there is evidence that skin damage occurred acutely and evidence of acute central nervous system symptoms. Such symptoms are described by firefighters to us but also were reported to doctors treating them at the time. They are similar to the symptoms reported for the ICI workers. There is no evidence that the respiratory symptoms exhibited by a few firefighters were of any exceptional significance at the ICI fire.

340. The circumstance of acute skin symptoms suggests a toxicological explanation, rather than a psychogenic one. It is clear from Dr
Greig's report that chloracne was not present in the twenty firefighters seen at the time of the fire. Three firefighters had a severe acute irritant dermatitis, one had chronic psoriasis which deteriorated after the fire and the remainder of the twenty firefighters seen had folliculitis. The precise complaints reported by seventy-two firefighters of ongoing skin problems needs to be viewed in relationship to the detailed information of the twenty people seen by Dr Greig and the possibility of chemicals causing a persistent rash.

341. The possibility that exposure to toxins at ICI could worsen pre-existing chronic skin conditions such as psoriasis seems probable and is demonstrated by one of the cases described by Dr Greig. The acute chemical contact dermatitis may alter the skin in such a way as to make the skin more prone to other insults of an irritative nature but generally this tendency should decrease with time unless the skin is ill-treated and repeatedly exposed to the irritants of either a chemical, physical or infective nature. The relapsing nature of the dermatitis on contact should be apparent.

342. Similar comment can be made about folliculitis although the relationship of this condition with chemical exposure is less certain. Heat, sweat and infection of hair follicles are the most likely predisposing factors and the condition may follow a relapsing course dependent upon the attention paid to skin care.

343. Some chemicals may sensitise the skin in such a way as to predispose an individual to dermatitis on exposure of the skin to minute amounts of the same chemical in the future or to hypersensitivity reactions such as urticaria (hives) on future exposure to the chemical by any route. Again, such reaction would be relapsing rather than truly persistent.

344. In the absence of any further diagnostic information about the skin rash it is difficult to conclude that the rashes were likely to be chronic (except for the pre-existing psoriasis). All the other skin conditions seen or likely to have been caused by chemical exposure are of an acute or relapsing intermittent nature and the relapsing condition would require dermatological and occupational health analysis of a type beyond the scope of this inquiry. Where relapse is due to re-exposure to the initiating chemical or to some other skin irritant, future management will need to be directed at avoiding such irritants. To determine which chemical may be causing sensitisation would be an enormous task requiring a detailed exposure history to

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chemicals since the fire and dermatological testing where indicated. Apart from the possibility of sensitisation by acute exposure at the fire, and relapse according to further exposure from time to time, there is no known toxicological justification for an explanation of chronic skin rash as a result of exposure to chemicals at the ICI fire.

345. As with the central nervous system symptoms, skin symptoms cannot be explained on the basis of existing knowledge in terms of chronic systemic toxicity as a result of exposure to chemicals at the fire.

346. Other explanations for skin problems should also be considered. In particular, non-specific and recurring skin complaints are often caused by stress. That stress was a factor is suggested by the circumstance that the epidemiological study was not able to find a connection between skin exposure at the fire and ongoing skin problems (although there was an association with skin exposure at the clean-up and ongoing skin problems). A connection between GHQ and ongoing skin problems did not reach statistical significance (the p value here was 0.08. A p value of 0.05 or less indicates a statistical significance).

347. The only very long-term toxins that may have been produced by the fire are the dioxins and, to a lesser extent, the furans. There is no evidence that firefighters were exposed to these chemicals and the symptoms do not fit with their known toxicological effects.

348. The only moderately persistent toxins that could explain the symptoms of the firefighters are the organochlorines. They would not have an effect lasting more than one to three weeks. Repeated exposure to maintain a systemic level is extremely improbable.

349. Additive damage can perhaps occur from some combustion products but the contribution of the ICI fire is most unlikely to be any greater than at any other fire. In these circumstances, a co- incidental crossing of a threshold level of symptomatology by so many firefighters at once is unlikely.

350. Much of the acute toxic potential at the ICI fire which made it different from others was the presence particularly of organophosphates, organochlorines and solvents which together would produce short-term central nervous system effects, including anxiety,
nervousness, unsteadiness and confusion. Several chemicals present could produce chemical dermatitis.

351. It is therefore reasonable to suppose that the extensive exposure of some firefighters to these substances would cause symptoms. The ongoing symptomatology is, however, extremely unlikely to be explained by chronic toxicity due to the ICI fire.
ICI firefighters were exposed not only to toxic chemicals, but also to significant psychological and social stresses over a substantial period of time. From the time of the fire to the date of this report, five years later, those stressors may have included:

- a belief, held by 93% of the firefighters, that they were exposed at the ICI fire to toxic chemicals
- uncertainty as to the toxins to which they were exposed and their effect
- uncertainty about the fire safety management of the fire
- continuing suggestion and media speculation about the long-term effects of their exposure
- continuing public anxiety about the use of pesticides and other chemicals, especially in agriculture
- the acknowledged limitations on scientific knowledge of the effects of toxins and the emergence of alternative viewpoints, not capable of scientific proof, to explain chemical toxicity
- continuing symptomatology, particularly of central nervous system (CNS) disorders
- strain upon family relationships resulting from CNS disorders such as personality changes and irritability
• lack of an effective strategy or leadership in diagnosis and treatment for symptoms, with indecisiveness and changes in direction of those in authority (Department of Health officials, the Fire Service and Accident Compensation Corporation)

• concern about compensation issues and problems of proof should their symptoms deteriorate, or should they develop symptomatology at a later stage as a result of their exposure to toxins

• loss of confidence in safety and personnel management in the Fire Service (as evidenced by the suspicion shown in relation to decisions made about protective clothing and in relation to the Auckland Occupational Health Service)

• concern about questions of medical boarding.

353. In these circumstances, we considered it important to examine the role of psycho-social stressors such as these in illness. Doctor Eilenberg, an Auckland psychiatrist, was commissioned to produce a report on the psychiatric and psychological health of the firefighters. His report is included as Appendix II and contains a review of the effect of psycho-social stressors on health generally.

354. We accept the discussion of the effect of stress upon health contained in Dr Eilenberg’s report and simply summarise here the main points.

355. It is well established that stress can cause or contribute to a number of health problems consistent with the chronic symptomatology of the ICI firefighters, including the non-specific skin complaints reported. Of particular importance is the role of stress on central nervous system symptoms. Memory impairment, irritability, loss of energy and so on are all central nervous system symptoms consistent with the anxiety occasioned by stress. Where stressors are long standing, and particularly where they are reinforced by shared group experience, then chronic anxiety with central nervous system symptoms may arise.

356. In the case of exposure to chemicals, it is extremely difficult to decide whether brain dysfunction (in cognitive and emotional operation) is due to

• direct organic (physical) effect of a neurotoxin
• a secondary stress-induced result of resolved symptoms due to acute toxicity (whether neurological or otherwise)
• a direct psychological reaction to knowledge of or belief in exposure.

357. It should be noted that symptoms which are caused by stress may respond to a placebo which purports to treat non-existent neurotoxicity. A wrong diagnosis of neurotoxicity, together with a treatment strategy, may therefore be effective in removing the stress which is the primary cause of CNS dysfunction. Stress which is a primary cause of CNS symptoms may be exacerbated by diagnostic or treatment indecision. On the other hand, diagnosis of neurotoxicity, where the real primary cause is stress, may exacerbate the stress, particularly if there is no or ineffective therapeutic strategy.

358. The ICI fire was unique not only in the chemical products it produced, but also in the psychological and social reaction it caused. A particularly important element in the mix was the diagnosis by Dr Tizard of “chemical poisoning” in 200 of those exposed.

359. Some of those firefighters diagnosed by Dr Tizard as having “chemical poisoning”, were clearly relieved by the diagnosis of some stress:

“Tizard said, if there was contamination by chemicals, he would be able to diagnose it. He gave us a diagnosis and we were given leadership. It took a lot of pressure off us.” (Personnel Officer)

“Many personnel expressed relief in being able to discuss symptoms, albeit briefly, and have demonstrated an apparent organic base.” (Doctor diagnosing)

“Our own doctor didn’t want to know ... Dr Tizard cared.”

“Dr Tizard was the first one, even if it was a year after or thereabouts, to take notice at all of these things.”

“It was a relief to know.” (Firefighters)

360. Other firefighters may have found the diagnosis stressful in itself, particularly when the strategy of treatment by Dr Tizard was withdrawn through Accident Compensation Corporation rejection of the diagnosis, and the ensuing controversy about the validity of the diagnosis in the first place:
“Although I personally didn’t think I was contaminated at ICI, [Dr Tizard] actually found that I was contaminated.”

“I had no symptoms. Dr Tizard did the test and he said ‘You’ve got paraquat poisoning’. I said ‘I haven’t got any of the symptoms that guys are complaining of.’ . . . He said ‘I’ll guarantee you that in three years you will have these symptoms.’ . . . At that stage, we had four children, our youngest just being born . . . It played havoc with my mind. . . . Plus with what was going on at the station with all the guys talking about it all the time, reliving the situation, constantly hashing it over. It never actually died. It was on our minds.”

“Dr Tizard had warned that with healthy and fit people it might take time before side effects were felt. . . . I worry for the future. For my career and the effect on my children.”

“I was diagnosed by Dr Tizard as having very high concentrations of paraquat and 2,4,5-T. I was to have had hyperbaric treatment. It never eventuated because of the ACC whitewash. Whether I am poisoned or not I do not know. That has caused me mental strain . . . I was told by Dr Tizard that poisoning may be dormant, with no symptoms, for long periods. I do not know whether his diagnosis is correct. I currently feel OK, but if Dr Tizard is correct then I do need a second opinion or medical assistance. This uncertainty has caused me a lot of concern.”

“I was tested by Dr Tizard and found to be contaminated by paraquat. I didn’t get treatment from Dr Tizard because of the investigation into him. I was tested by another doctor using the same test as Dr Tizard, who found no contamination. I seek assurance.”

“I want peace of mind. Dr Tizard planted a seed of doubt when he said if you haven’t got these symptoms now, you will have them in three years.”

“. . . Basically, I just want to know whether I am affected or not.”
361. Diagnosis of a psychological explanation for symptomatology is, like diagnosis of a toxicological explanation, ultimately a matter of inference from all the circumstances, including the toxicological explanation and the neuropsychological test results. It is, however, clear that the firefighters who attended the ICI fire were subject to severe psycho-social stressors over a prolonged period of time. Ninety-three percent believe they were exposed to chemicals at the fire. Thirty-nine percent believe that their general health was affected as a result of the ICI fire. Fifty percent are still uncertain whether or not their health has been affected as a result of the fire. More than half of the firefighters assessed by the General Health Questionnaire exhibit distress.

362. The symptomatology and uncertainty are common to a large group of people. Compensation issues, medical uncertainty and lack of leadership are all features of the psycho-social history. There is the significant feature of a confident but disputed diagnosis, with withdrawal of treatment strategy in a manner many regard as betrayal. There is an escalation in the numbers of those presenting with symptomatology before and after the diagnosis by Dr Tizard.

363. The existence of all these circumstances indicates a background of considerable stress. The symptoms of the firefighters are consistent with that stress.

364. It should be emphasised that a possible psychological explanation of symptomatology still gives rise to considerable concern about the health of the firefighters. The CNS symptoms described seriously compromise enjoyment of life. The symptoms are not at all imaginary. As Dr Eilenberg has reported, it is clearly established that the physiological effects of stress are as distressing as any physical disorder. If there is a psychological explanation for the symptoms this does not mean that the firefighters are being "neurotic" or "irrational".

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VI
Conclusions and Recommendations

1. ARE THE HEALTH PROBLEMS ATTRIBUTABLE TO THE ICI FIRE?

365. We are of the view that the epidemiological study demonstrates that the health problems of the ICI firefighters (their central nervous system symptoms, skin complaints and subjective distress) and their impaired performance of neuropsychological tests are attributable to their attendance at the ICI fire. If they had not attended the ICI fire, they would not be affected by these symptoms to the extent they have been and at a level significantly greater than the Wellington referent group. Although the risk of unknown confounders and biases cannot be eliminated, we consider that the strong probability is that attendance at the ICI fire is the major factor in their continued health problems.

2. ARE THE HEALTH PROBLEMS A RESULT OF CHEMICAL EXPOSURE?

366. Our conclusion as to the role of the ICI fire in the health problems of firefighters answers one of the main questions referred to us. In order to make recommendations as to further treatment and in
order to answer the firefighters’ concern as to their present risk, however, it is necessary to express an opinion about the reason for the connection between attendance at the ICI fire and the symptoms and poor test results displayed. The question is whether the symptoms are a result of chemical exposure at the fire or other reasons.

367. We accept that some firefighters had symptoms consistent with mild acute chemical exposure at the time of the fire. They were the skin and central nervous system disorders reported at the time, described by the firefighters, Dr Fetherston and Dr Greig. They are consistent with the symptoms described for the ICI workers by Dr Hanley. As the toxicological review indicates, there were chemicals present at the site which would account for the symptoms.

368. We consider the continuing symptoms displayed by the firefighters cannot be explained by long-term effects of chemicals. The only evidence for a toxicological explanation is the neuropsychological test results. As discussed above in paragraph 103, the results of the tests have to be viewed with some care because the relative risk between Auckland and Wellington (which is necessary to determine whether group results are poor) at 1.32 is marginal. At such a low statistical relative risk, the difference may simply reflect bias. Moreover, the significance may be wholly eroded by
- false-positive results in the testing (for which we have not rechecked),
- selection bias (for which see paragraphs 99–100 above).

369. The neuropsychological tests are designed to measure organic brain dysfunction, but may reflect dysfunction as a result of stress instead. In the case of the ICI firefighters, the poor test results are to be found in the tests which are speed timed or measure psychomotor ability, rather than cognitive ability. These are functions more likely to be affected by stress in the person tested.

370. We consider that the continuing symptoms displayed by the firefighters are a result of long-term and understandable stress caused by their involvement in the fire. Our reasons are
- a toxicological explanation is wholly inconsistent with what is known of toxicological effect (see paragraphs 337–351)
- the skin symptoms, which are non-specific, could be a result of skin sensitisation at the fire, but could also be explained by stress and emotional upset.
• the neuropsychological test results may not indicate a statistically significant group response (see paragraph 368 above) and may themselves measure dysfunction based on stress rather than neurotoxicity
• the GHQ results and the uncertainty, anxiety and existence of substantial stressors as a result of the social history of the fire, are all strong pointers to an emotional basis for the symptoms rather than a toxicological one.

3. THE NEED FOR ACTION

371. The Auckland firefighters who attended the ICI fire have reason to feel unhappy with events at and following the fire. In particular,

• they were exposed to chemicals in a manner which should not have been allowed to happen. The Fire Service organisation did not have in place a system which was adequate to protect them. We do not think it fair to blame individual officers and others for this state of affairs because we regard it as a result of deficiency in management, and in particular of safety management, in the Fire Service as a whole
• there was no co-ordinated health response at the fire and immediately after it to ensure that firefighters were properly tested for contamination and appropriately treated. Again, it would be wrong to criticise those who tried to fill the gap and improvise a system, after the event. The deficiencies in health assessment and management immediately after the fire were a consequence of the lack of any system for medical response at the time of the fire
• the firefighters were immediately the subject of public controversy and continue, five years later, to wait for authoritative reassurance about the chemicals to which they were exposed and their continuing health problems
• their concerns have been exacerbated by wrangling about compensation.

372. We are of the view that decisive action by the Fire Service Commission and the community in general is long overdue. Firefighting is a dangerous occupation which provides a critical community
service. The delay in grappling effectively with the phenomenon of the ICI fire has damaged many individuals and caused much family unhappiness. We think the ICI fire and its aftermath was a unique social phenomenon which requires a special response. We indicate below the response we consider to be appropriate. Some of our proposals have costs. Although we have been conscious of the need to be realistic about what the Fire Service and the community can afford, we think that the cost of the treatment strategy for the firefighters affected should be made available. It seems to us the least that can be done to make some amends for the fact that these people and their families have waited too long.

4. THE OCCUPATIONAL HEALTH SERVICE

373. The Occupational Health Service is a major response by the Fire Service to correct some of the deficiencies indicated by the experience of the ICI fire. It has a critical role to play in three of the areas where the fire revealed weaknesses in the safety system:

- co-ordination of health hazard information on the fireground
- co-ordination of medical responses to firefighters affected, including testing as well as treatment
- provision of after care to those affected, including the provision of stress debriefing, health monitoring and follow-up of appropriate treatment.

374. At present the Occupational Health Service does not appear to be welcome on the fireground and does not provide debriefing or stress counselling after incidents. Nor does the Occupational Health Service provide a health monitoring programme for firefighters. The service is not extended to volunteers, for reasons of cost. We think those gaps in the service should be filled, but the existence of the Occupational Health Service certainly addresses the major concern arising out of the ICI fire of lack of co-ordination of health response.

375. We are concerned that the survey showed that Auckland firefighters, despite their higher incidence of health problems, use the Occupational Health Service in Auckland less frequently than the Wellington firefighters. There seem to be two main concerns

- that the Service is too close to management
376. Both issues need to be addressed by the Occupational Health Service and by the Fire Service Commission. The results of this investigation may clear the air a little. It is necessary that it should, since the Occupational Health Service has an important role to play in overcoming the distress caused by the ICI fire.

377. Further measures to improve the Occupational Health Service and to make it more acceptable, should include

- reorganisation of the Service to distance it from personnel management (this distancing may have started. We have been advised for example that regional medical officers, who are attached to the Occupational Health Service, will no longer have a role in medical boarding)
- changes to the composition and operation of the Occupational Health Committee to bring it into line with the Code of Practice for Health and Safety Committees
- employment of staff who are qualified in occupational health (a matter raised with us by the Union).

5. FIREGROUND PROCEDURES

378. The system of fireground procedures which have been increasingly standardised and expanded since the time of the ICI fire, are an important response of the Service to some of the deficiencies apparent at the fire.

6. FURTHER ACTION REQUIRED FOR HEALTH PROBLEMS

379. Our terms of reference, in asking us what further action should be taken in respect of firefighters with health problems, drew a distinction between firefighters who are satisfied with the medical treatment that they are receiving or have received, and those who are dissatisfied. We have considered that the circumstances of the ICI fire and its aftermath are such that it is necessary to set up a strategy for treatment of ongoing symptoms, whether or not the firefighters are happy with the treatment they are receiving or have received. Those
who are satisfied with their treatment will probably not wish to take advantage of the strategies we propose. The unresolved health problems of the firefighters which can be attributed to their involvement in the ICI fire are skin problems, central nervous system problems, and the high level of distress.

A. SKIN COMPLAINTS

380. Seventy-two firefighters have ongoing skin rashes. The severity of these rashes cannot be gauged, and no diagnosis is possible, without clinical assessment. The firefighters should be encouraged to seek medical assessment and, if necessary, treatment for their skin conditions. Because it is possible that the skin complaints are occupationally induced, whether by sensitisation or as a result of heat and sweating because of working conditions (the most common ongoing symptoms of the Wellington firefighters are skin rashes also), the Occupational Health Service should monitor skin complaints among firefighters and provide education in skin hygiene and treatment.

B. PSYCHOLOGICAL EFFECT

381. Thirteen ICI firefighters had both poor neuropsychological results and symptoms falling within one of the psychiatric classifications. A further twelve had poor test results but no psychiatric symptoms.

382. Those firefighters who scored poorly in the neuropsychological tests and who fit within the psychiatric categories, clearly require further assessment.

383. While we have expressed the view that poor neuropsychological test responses should not be treated as indications of brain dysfunction in the absence of psychiatric symptoms, we suggest it is wise to adopt a conservative position and to reassess all those who scored particularly poorly in two or more tests. (For this purpose we have not used the cut-off point used in the epidemiological study for comparison of the two groups which was based on a 10% cut-off in four tests, but instead have used a more clinically appropriate cut-off of 2.5% in two or more tests.) The number of individuals affected is twelve.
384. We are of the view that it is not realistic to send the total group of twenty-five with poor neuropsychological test results to seek their own further assessment. Neuropsychological testing is a specialised area of psychology. We recommend that special provision should be made for this group. They should be reassessed by psychologists familiar with such tests. If any retest with poor results, they should have the opportunity to be clinically reviewed by a psychiatrist who should have authority to seek neurological opinion, where appropriate.

385. The Committee considers that this reassessment should be the financial responsibility of the New Zealand Fire Service for both present and past employees who come into this category. Because of the need to maintain confidentiality of test results, however, we recommend that the reassessment should be organised independently of the Fire Service Commission. We suggest that responsibility for organising the assessment be assumed by the Minister of Health, who may delegate it to an independent medical practitioner.

C. OTHER SYMPTOMS

386. The central nervous system symptoms and the level of distress measured by the GHQ require a strategy for relief. We are of the view that the central nervous system symptoms are due to the stressors resulting from the fact of exposure to hazardous chemicals at the ICI fire, acute toxic symptoms in some firefighters, and the psycho-social history of the fire including in particular

- the sense of insecurity caused by failure to adhere to established safety procedures at the fire and inadequacies of uniform
- lack of an organised and authoritative health response to firefighters’ symptoms and anxieties about their exposure to toxins at the fire
- the fact of diagnosis of “chemical poisoning”
- scientific uncertainty and public debate about the chemicals to which firefighters were exposed and their effects.

387. This distress, which may have been present for much of the five years since the fire, requires an effective strategy from the Fire Service. We suggest that the Fire Service should ensure that the
Occupational Health Service in Auckland provides counselling from professional psychologists to all those who seek such assistance.

D. OTHER TREATMENT

388. Firefighters may prefer to seek follow-up health assistance from their own medical practitioners. In some cases, they may wish to seek alternative medical treatment.

389. Because we have expressed the view that the symptoms of the firefighters are not caused by toxins, we do not recommend "detoxification" as a course of action to relieve symptoms.

7. HEALTH AND SAFETY ON THE FIREGROUND

390. Our terms of reference ask us to review health procedures at, and immediately after, chemical fires. We have found it impossible to separate health and safety issues. We deal with fireground health and safety in terms of six considerations which were important in the ICI fire. They are

- storage and notification of chemicals
- protective clothing
- decontamination
- safety management
- training
- occupational health presence.

A. STORAGE OF CHEMICALS

391. Since implementation of the Report of the Commission of Inquiry into the Parnell Civil Defence Emergency in 1973, it has been the responsibility of the Fire Service to ascertain any chemical hazard in each Region, using the advice of the Hazardous Substances Technical Liaison Committee. This procedure has worked variably but it is quite clear, following the ICI fire, that foreknowledge of hazardous chemical stores is essential if emergency procedures are to be appropriate. Procedures must be put in place to ensure that the Fire Service has information on chemical stores readily available, that the nature of the hazard is known in advance and that the Database of the
National Toxicology Group is readily accessible for emergencies where additional information is required. Advice from the National Toxicology Group could also be used in planning strategies for dealing with potential emergencies involving chemicals. Fire Service procedures need to be revised to this end. In addition the whole question needs to be addressed in the context of the Resource Management Bill and the expected Occupational Safety and Health Bill: it is particularly important that the introduction of compulsory HAZCHEM labelling is not deferred.

B. PROTECTIVE CLOTHING

392. The protective clothing now being introduced represents a significant advance on the level of protection available at the ICI fire. The clothing at level two (the level suitable for close-in firefighting) now includes
   • a fire resistant overall or shirt and trousers
   • chemical splash resistant PVC jacket and trousers.

393. At level three, the clothing comprises a one-piece chemical splash suit. Level four is a fully encapsulated gas suit. It is proposed by the Union that each tender should carry two chemical splash suits, although the exact number to be supplied is not yet determined. Gas suits will be available in response to call.

394. Criticisms have been made to us relating to the clothing, but it became apparent that some of the criticism was out of date in that deficient trial uniforms earlier supplied had been replaced with better quality products.

395. One criticism, however, relates to the level two suits. They now provide splash resistance to chemicals (in marked improvement to the firefighting uniforms worn at the ICI fire) but are designed to be worn at any structural fire incident. A number of firefighters who made submissions to us were concerned that the suits were too hot for general firefighting use.

396. While the uniform has been considered for a substantial period of time, we remain concerned that the testing for metabolic heat was at a high temperature, thus minimising the comfort differences at
lower temperatures. The garments chosen were not those which performed best under the trial conditions (although the better performing garments were substantially more expensive, and we acknowledge that is an important consideration). An opinion obtained by us from Dr Laing of the Clothing Department of the Faculty of Consumer and Applied Sciences, Otago University (annexed as Appendix V), suggested that garment design needs to be considered carefully and properly field tested and doubted that had been done adequately.

397. We suggest that further consideration should be given to protective clothing, using further outside expertise and performing more extensive field tests. The new clothing is to be introduced to meet performance standards so that improvements in the clothing can be kept under review. This very sensible move away from settled prescription should facilitate further evaluation.

C. DECONTAMINATION

398. We had demonstrated to us the current decontamination procedures and equipment used by the Fire Service in Auckland. They represent a substantial improvement over the facilities and procedures available at the time of the ICI fire.

399. The procedure includes high pressure water decontamination of chemical suits while the firefighters wear breathing apparatus, segregation of washed equipment and clothing for further attention, and further showering of firefighters. The procedure we saw demonstrated was well controlled and conducted to allow maximum comfort and privacy.

400. We were of the view that the decontamination procedures demonstrated were good and that they should be introduced nationally.

D. SAFETY MANAGEMENT

401. Protective clothing and good decontamination procedures are only part of good safety management on the fireground. They may be admirable in theory, but inadequate in practice without an organisational commitment to their proper use.
402. At the ICI fire, all ranks demonstrated a lack of commitment to safety. Procedures established for use of breathing apparatus and for decontamination were not applied. Fireground assessment of the health risks to firefighters took too long. Options for fire attack may not have been sufficiently considered. Treatment of affected firefighters and proper health checks for those exposed were inadequate.

403. Although this report, of necessity, puts the fireground events at the ICI fire under a microscope, we did not gain the impression that the operation of the Fire Service at the ICI fire was aberrant: the failure to adhere to established procedures by individual firefighters and senior executive officers was just too widespread. The behaviour was consistent with the fireground "culture" described to us by a number of firefighters (see paragraph 130), and is consistent with the results of the Wellington survey referred to in paragraph 120. After reading a substantial volume of material and interviewing many firefighters and executive officers, we are bound to say that we do not think attitudes have changed substantially. The attitudes displayed in 1984 we have seen demonstrated in a number of interviews with people from all ranks.

404. In those circumstances, we think it would be quite unfair to blame individual people for what may have been largely an organisational deficiency. It is not possible to view safety management in the Fire Service with confidence. We question whether safety is given appropriate priority within the entire command structure of the Fire Service. We believe the matter must be addressed urgently and throughout the Fire Service. An organisational response is needed because it is not sufficient for consultant health and technical experts to be available only in support roles. Responsibility for fireground safety and health management needs to be built into the command structure. The matter should be addressed at the highest levels.

405. We do not think it appropriate for us to make firm recommendations on the response required, because it needs skills we do not have. The matter is, however, so important that we suggest the Minister of Internal Affairs should consider directing the Fire Service Commission to report with its proposals for improved safety management. We suggest a report should address

- the appointment of a Director of Safety and Health, reporting to the Chief Fire Commander and with the functions of
reviewing procedures and practice in each Region, with special emphasis on ensuring that technical and health liaison is properly provided. The Director of Safety and Health should be distinct from the Director of Personnel to avoid conflict between employment management objectives and health and safety objectives and to permit better focus on safety issues and systems. The Director of Safety and Health should oversee the operation of the Occupational Health Service which should not continue to report to the Director of Personnel on issues such as sickness leave claims and medical boarding.

- the adequacy of the present fireground procedures in fires involving hazardous substances
- compulsory and continuing training in hazardous substances fires and spill management for all executive officers (although, as appears from our recommendation on Training, we think such training should be introduced immediately and before the review suggested here is completed)
- a system of audit (preferably from outside the Region affected) of any fire or hazardous substances incident where the health of personnel is affected
- the monitoring of firefighter health for occupational disease
- the setting up and auditing of systems for liaison with hospitals and the National Poisons Centre
- the operation of the Occupational Health Service in line with the recommendations in this report
- the need to ensure that safety and health management of volunteer firefighters matches the standards applied to professional firefighters
- whether an Incidents Safety Officer with significant powers of intervention should be introduced into fireground management. At present, the fireground procedures make provision for a "Hazard Control Officer", "Decontamination Officer" and "Breathing Apparatus Control Officer" with important safety functions but, while acknowledging the need to retain a clear command structure on the fireground, we think an audit role, with powers of intervention, as is provided in some Fire Services in the United States, should be considered. We also think there is merit in ensuring that the Safety Officer should not be a specialised function. In any
hierarchical system based on seniority in general command, there are dangers in relying upon specialist officers because they may not have the authority needed. Moreover, a system of interchanging responsibility may ensure that fire safety procedures are known and committed to by all executive officers. What is needed is a climate in which each Site Commander is conscious that performance will be measured not just on the speed with which the fire is knocked down but in terms of the management of the safety aspects of the job.

- whether the present alarm system of response to fires is suitable in the case of fires involving hazardous substances.

E. TRAINING

406. We recommend that the Fire Service Commission introduces compulsory continuing training for executive officers, especially in dealing with chemical incidents, as a matter of urgency. The education needs to be continuing because change in this area is so rapid. The techniques appropriate for handling chemical fires have changed greatly over a comparatively short period of time. (We heard from some senior officers, for example, that the idea of allowing a chemical fire to burn itself out in some circumstances went against the grain of everything a firefighter was trained to do. That attitude is out of date and needs to be changed.)

F. OCCUPATIONAL HEALTH PRESENCE

407. We are of the view that at any hazardous substances fire, the full-time health professional of the Occupational Health Service, whether nurse or doctor, should attend the site to ensure that the health response is properly co-ordinated. In areas outside the main centres alternative equivalent arrangements should be made using local health professionals.

8. HEALTH AND SAFETY MANAGEMENT IMMEDIATELY AFTER THE INCIDENT

408. We have considered this matter also in terms of the deficiencies shown in the ICI fire. The main areas of concern are
• co-ordination of health services
• hospital response
• public health response
• debriefing after incidents.

A. CO-ORDINATION OF HEALTH SERVICES

409. Lack of co-ordination of health services is met by the Occupational Health Service. For the future, co-ordination of health response in the event of a similar incident will clearly be the responsibility of the Service. We therefore do not feel it necessary to make any further recommendation for co-ordination of health services.

B. HOSPITAL RESPONSE TO TREATMENT OF FIREFIGHTERS

410. No hospital contacted the National Poisons Centre for information in treatment of the ICI firefighters, in spite of the fact that the type of exposure was complex. Treatment was symptomatic, and at least in one reported case an inappropriate cause for symptoms was given ("dioxin poisoning").

411. The Auckland Area Health Board, in its submission to us, noted that treatment in such cases would usually be symptomatic. This is not adequate when delayed effects can occur with some chemicals.

412. Communication between the hospitals and emergency services must be adequate to identify the type and scale of exposure in a chemical incident. Communication with the public and media must ensure that accurate information is given when large scale incidents arouse reasonable public concern and interest. It appears from the submission we received from the Auckland Area Health Board that procedures for dealing with complex incidents involving chemicals short of major disasters do not exist. The hospitals rely on the decontamination performed by the Fire Service.

413. Hospitals may need to play a role in debriefing exercises with the Fire Service and should make sure that good co-operation exists prior to an emergency.

414. A number of firefighters complained to us of the treatment they encounter at Accident and Emergency Departments. We are
concerned that, particularly given the rapid turnover of staff in Accident and Emergency Departments, some formal written instructions dealing with incidents involving chemicals but which call for less than a disaster response should be drawn up.

C. PUBLIC HEALTH RESPONSE

415. The ICI fire was a major occupational health phenomenon from the first day. It was complicated by extensive public debate and the use of unorthodox diagnostic methods. Chemical toxins, according to established knowledge, seemed unlikely to produce the ongoing clinical symptoms complained of by the firefighters. The Department of Health was at the time involved in evaluating public concerns about 2,4,5-T and dioxin and was familiar with their clinical symptoms. Because of this background, it is perhaps not surprising that the Department of Health did not institute an investigation, particularly when reports were being evaluated and various expert opinions being sought.

416. On the other hand, the concerns of the firefighters were persistent and credible. It was clear that uncertainty existed over health effects and that misinformation abounded. A positive action and investigation by the Department of Health could have been most beneficial. It had the expertise to have focussed on the occupational health aspects immediately, while the people on the spot were preoccupied with the environmental effects and general concerns of the local residents. It is difficult to avoid some criticism of the fact that over four years have elapsed before a detailed review of the health effects of the ICI fire was commissioned.

D. DEBRIEFING AFTER INCIDENTS

417. We consider proper debriefing to be an important method of stress management, which should be available after all stressful incidents attended by firefighters. We suggest that débriefing should be organised through the Occupational Health Service, which can then call in specialist assistance where required.
9. LONG-TERM SURVEILLANCE

418. We have been asked to indicate what, if any, long-term surveil-
lance is recommended for firefighters subjected to chemical fires.

419. Firefighting is a high risk occupation. Although correct use of 
breathing apparatus and decontamination procedures will cut down 
the risk, exposure to toxins is an occupational hazard. All fires pro-
duce carbon monoxide (the effects of which are described at para-
graph 318) and even ordinary house fires can release hazardous 
toxins.

420. It is, therefore, extremely important that exposure to toxins 
should be measured wherever possible and that all firefighters 
undergo regular medical checks to measure for toxic effect and to 
provide a baseline against which subsequent exposure can be 
measured.

421. One of the main problems with toxicological diagnosis is deter-
mination of the type and extent of exposure. As has been demonstra-
ted by the ICI fire, this difficulty is particularly acute in chemical and 
other fires.

422. Both exposure and biological effect need to be measured.

A. EXPOSURE MONITORING

423. Exposure can be monitored at fires by the use of environmen-
tal monitors (which measure chemicals present in the atmosphere on 
the fireground) and by personal monitors, worn by the firefighters. 
These monitors can only provide an approximation of exposure but 
are extremely useful in toxicological analysis. We have seen a per-
sonal monitor. It is not bulky and is worn by firefighters on their 
uniform. Such personal monitors are used in other countries by 
firefighters. We recommend that the Fire Service investigate the feasi-
bility of both environmental and personal monitors.
B. HEALTH MONITORING

(i) After Chemical Exposure

424. Toxicological effects are best measured by biological tests, usually of blood and urine. Such tests should be performed for all possibly exposed individuals when there is a reasonable concern of exposure to a toxic hazard. It is not enough, and may be too late, to test only those firefighters who present symptoms consistent with toxic exposure. Because of the invasiveness of the procedures, it is not envisaged that testing should be performed after every fire, but such tests should be performed wherever the circumstances indicate a significant risk. That means that it will be necessary, at every fire, for a responsible officer to consider, after taking technical advice, whether such testing should be required.

425. When tests are done they should be exhaustive for the chemicals indicated. Thus, exposure to organophosphates would indicate immediate cholinesterase testing; exposure to paraquat would indicate urine analysis.

(ii) Regular Monitoring

426. Collection of information after known exposure may be of limited use. Health effects on firefighters after such exposure need to be measured against pre-exposure information. Moreover, because firefighters are at risk of regular exposure to toxins (particularly at low levels), it is important for their health to be kept under review as a check for incremental health effects.

427. We believe that on employment in the Fire Service and regularly at three-year intervals, firefighters should be checked by

- lung function test
- electrocardiogram (ECG)
- general blood tests, particularly to measure liver and kidney function
- chest X-ray.

428. Because firefighters are exposed to unknown but possibly carcinogenic chemicals, individual screening for cancer should be part of the regular monitoring. This should be a general clinical assessment with special investigative procedures only required if indicated by
individual risk factors. Since the possibility of cancer is of concern to the ICI firefighters, it is recommended that all those exposed (whether still employed by the Fire Service or not) should be monitored for twenty years as part of a general occupational study of firefighters.

429. We are of the view that neuropsychological testing is advisable for firefighters because of their potential occupational exposure to neurotoxins. It is essential that a baseline be established on employment. Routine retesting would not be necessary, but rather further testing would be as required.

430. We are aware that health monitoring is a controversial issue within the Fire Service, and is opposed by many firefighters. What is feared is loss of jobs, particularly in times of retrenchment of employment. It seems to us that it is necessary for firefighters, Union and Commission to acknowledge that firefighting, as an occupation, may take an enormous physical and emotional toll. If health problems are not identified, monitored and treated, individual health may be put at risk, occupational risks may not be properly appreciated (because health trends will not be apparent), and firefighters in dangerous situations may be put at risk by a colleague who is not functioning adequately. For these reasons, it seems to us that firefighter concern about jobs should be addressed directly, in employment packages which recognise the special risks of the Service, or by requirements of confidentiality, and should not be used to block the collection of essential information.

10. EAV TESTING

431. Two hundred firefighters were diagnosed by EAV testing as suffering from "chemical poisoning". The technique is unproved in any scientific way. We do not believe that EAV diagnosis should be accepted as proving "chemical poisoning". Nor do we accept that improvement in symptoms following treatment after EAV diagnosis is evidence of its diagnostic effectiveness.

11. ACCIDENT COMPENSATION CORPORATION

432. A major concern expressed by the firefighters, and a major contributing factor to their distress, is the issue of compensation. The
apprehension of the firefighters is not only that they will develop symptoms as a consequence of their exposure to the ICI fire, but that, if they do, they will be faced with the burden of establishing their claim.

433. We recognise that it is for the Accident Compensation Corporation to determine in individual cases whether the firefighters have suffered "personal injury by accident". This inquiry has illustrated, however, that the Corporation's processes can cause substantial expense and stress to those who claim compensation, particularly in the "grey area" acknowledged by the Corporation to exist in the case of occupational disease. In case it is of help to the Corporation, we suggest that it should consider the material referred to in this report, and in particular the epidemiological study and our conclusions upon it.

434. In general, we think the experience of the ICI firefighters illustrates how the present distinction between personal injury by accident and other sickness causes real hardship and unfairness in practice.

12. TESTICULAR TUMOURS

435. The occurrence of testicular tumours in three firefighters in Wellington is surprising. The significance of this finding requires careful epidemiological investigation for its occupational health significance. We recommend that such a study be instituted urgently.
Appendix I

REPORT TO THE MINISTERIAL ADVISORY COMMITTEE ON THE ICI FIRE

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Department of Community Health
Wellington School of Medicine
January 1990
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SUMMARY

A comparative cohort study involving 462 firefighters was carried out principally to meet Function 3 of the Ministerial Advisory Committee on the ICI fire. A study group of 245 firefighters involved in the ICI fire, Auckland on 21 December 1984 or with its aftermath, and a referent group of 217 Wellington firefighters completed a comprehensive health status questionnaire, and a battery of laboratory and neuropsychological tests. Spouse information was also available for almost 40 per cent of the study group.

Seventy-two per cent of firefighters who were involved in the ICI fire participated in the study. Information from a questionnaire administered in 1985 by the Fire Service and the Union showed that study group non-responders are slightly younger than participants, and predominantly had minimal respiratory and dermatological exposure.

Almost three times as many firefighters among the study group as the referent group spontaneously report problems with their health. The most common ongoing (current but not necessarily continuous) problems reported by the study group are memory loss, skin rash or lesions, and irritability. Skin rash or lesions is the most common ongoing problem among the referent group. However, whereas 32 per cent of the study group report ongoing skin complaints, only eight per cent of the referent group do. The difference in self-reported problems between the groups is most striking for psychiatric complaints. More than half of the study group, compared to only six per cent of the referent group, report psychiatric complaints which meet the criteria for one of four defined clinical categories of psychiatric dysfunction.

Whereas the health problems experienced by the referent group tend to have little or no effect on their lives, those of the study group commonly affect their relationships with others, in particular their families. In addition, almost three times as many study group as referent group firefighters rate their enjoyment of life, based on changes to their hobbies and interests, as less now than in 1984.

Twenty-nine per cent of the study group firefighters who report problems have no history of treatment. The problems reported by this group are predominantly central nervous system complaints. An EAV (electroacupuncture according to Voll) practitioner, rather than
a firefighter's general practitioner, is the most common agent of treatment for those with a history of treatment.

Past medical history; reproductive history; cigarette and alcohol consumption; and indicators of psychosocial stress, such as change of marital status, are similar for the two groups. There is also no evidence of a group difference in the occurrence of diagnosed cancer since 1984. The type of cancer is however different. Other occupational exposure to chemicals, including solvents; and use of the occupational health service, are greater among the referent group than the study group.

Spouses tend to report more problems with their partner's health than do the firefighters concerned. However, there are few instances of a firefighter not recognising that his/her health has been affected.

Blood test results, with the exception of more abnormal haematological indices for the referent group, are similar for the two groups. However, analysis of the results of neuropsychological testing suggests that the study group has an increased risk, albeit low, of "poor" results. This difference is predominantly a difference in performance on the sub-categories of psychomotor tests and timed tests in the test battery. The study group does not have an increased risk of "poor" results on memory tests and untimed tests. The observed difference is consistent with a number of different hypotheses including chance, selection bias, information bias, and/or a toxic effect. There is also a subjective level of distress among this group, as indicated by the results of the General Health Questionnaire, which is not apparent in the referent group.

There is no evidence of an overall dose-response relationship of respiratory or dermatological exposure with ongoing health problems, or with the results of laboratory or neuropsychological testing. However firefighters with ongoing skin problems are more likely to have had respiratory exposure and dermatological exposure, at the clean-up.

Selection and information biases; and the absence of adequate premorbid baseline data for comparative purposes for the study group firefighters, must be acknowledged in interpreting these results.
METHOD

TYPE OF STUDY

The epidemiological study undertaken to meet Function 3:

To determine (if possible) whether or not health problems experienced by any of the firefighters since the fire are attributable in whole or in part to their involvement with the fire or its aftermath

was a comparative cohort study.

STUDY GROUP

The study population comprised all firefighters or Fire Service employees who were involved in the fire at the ICI Riverview store in Auckland on 21 December 1984, or with its aftermath. Involvement ranged from firefighting, and stand-by and clean-up duties at the fireground; to the handling and/or cleaning of equipment and clothing from the fire at stations. All study participants were involved in one or more of these activities.

A letter from the Committee’s Chairperson, outlining the proposed investigation and inviting their participation, was sent to all firefighters identified by the Fire Service as having had some involvement with the ICI fire. A further group of firefighters, whose names and addresses had not been supplied, approached the Committee directly as a result of publicity about the investigation by the Fire Service, Professional Firefighters’ Union, and the media.

Questions as to the information being sought and the procedure to be followed were answered by the Committee at a meeting of firefighters on 20 April 1989 in Auckland. Firefighters at this meeting made a strong request for the inclusion of spouses as a source of information about their health. This was considered to be essential, as in some instances personality changes and other health-related effects may not be apparent to the firefighter concerned but recognised by his/her spouse.

Each firefighter who indicated his/her willingness to participate was sent an appointment time. This was accompanied by a consent form which summarised the investigation, and a letter explaining the nature of the information being sought in the questionnaire.
A detailed health status questionnaire (Appendix 1) was designed for self-administration under supervision. The questionnaire was divided into three sections, comprising exposure history, medical history, and social and occupational history. Pre-testing was carried out in Wellington among an unrelated occupational group. Possible difficulties maintaining the confidentiality of the questionnaire's content precluded pre-testing in another group of firefighters.

In addition to the questionnaire, tests of organ function were carried out to identify any areas of concern, and to provide a base-line against which further monitoring of the health of exposed firefighters, should that be necessary, could be measured. Testing comprised a lung function test, a blood sample and electrocardiogram (ECG), and a battery of neuropsychological tests. Blood tests included a full blood count, liver and renal function. Psychological testing included administration of the General Health Questionnaire (30 item GHQ). The tests selected are similar to those contained in the World Health Organisation’s Neurobehavioural Core Test Battery (1). Designed to identify early neurotoxicity in working populations exposed to demonstrated neurotoxic chemicals, this battery is currently undergoing international field evaluation. Details of the neuropsychological tests used and the rationale for their use are given in Appendix 6.

Each firefighter was asked to sign a consent form on his/her arrival. Consent was sought for participation in three parts of the investigation viz the questionnaire, the tests, and for access to personal records held by the Fire Service. Consent could be given for any one part of the investigation, except tests alone, and could be withdrawn at any time.

Questionnaire administration and testing was carried out in Auckland in May. In most cases the questionnaire and tests were completed at a single visit of approximately three hours. At this visit, neuropsychological testing preceded administration of the questionnaire and other tests. Neuropsychological testing took about one hour, and was administered on an individual basis by a psychologist. The questionnaire was self-administered under supervision to up to six firefighters simultaneously. Completion time was variable, depending on the extent of the firefighter’s health problems and the amount of detail provided. The ECG, blood and lung function tests
were performed by a local laboratory. In addition, a separate questionnaire for spouses to complete and return was available for those firefighters who requested one.

Lung function tests and the ECGs were interpreted by an occupational health physician and cardiologist respectively. This was done independently of the laboratory lung function and ECG reports. Abnormal test results were reviewed by a committee member, and some firefighters subsequently had further lung function testing at the Department of Respiratory Medicine, Greenlane Hospital, Auckland. Firefighters with clinically significant abnormal blood, lung function and/or ECG results were referred to their general practitioner for review.

Further psychological assessment was recommended for firefighters who have both two or more neuropsychological test results which are outside either the 2.5 or 97.5 percentile (depending on whether a low or high score is poor), and symptoms indicating one of the psychiatric categories. Firefighters with two or more poor test results, and no symptoms indicating psychiatric dysfunction, were offered further assessment if they consider themselves to be functioning below their normal level. The 2.5 and 97.5 percentiles correspond to the two-sided limits of the laboratory reference range for blood results.

**Referent Group**

The referent group population comprised firefighters with four or more years service, and no involvement in the ICI fire. The group was selected from Wellington. Five participating firefighters were found to have had less than four years service; their data were excluded from the statistical analysis. The number of eligible firefighters for a referent group in another region closer to Auckland, or in Auckland itself, was insufficient. There were 350 eligible firefighters in Wellington; 217 of those approached were able to participate.

The procedure followed for the referent group was identical except for exclusion of a meeting of the firefighters and the Committee, and exclusion of the spouses’ questionnaire and ECG. The ECG was excluded on the basis of the low level of abnormality detected in the Auckland group, and cost. The health status questionnaire was modified before administration to the referent group, so that reference to the ICI fire was excluded.
Review of the lung function test results resulted in a decision to omit them from the comparative study due to variations in the technical quality within the Auckland group, and a low level of abnormality. Hence the referent group lung function testing did not involve use of the same equipment and personnel.

Administration of the questionnaire and testing of the referent group occurred in Wellington in September. Blood was couriered to Auckland for analysis by the same laboratory that was used for the study group laboratory tests. Lung function tests were interpreted by a member of the Department of Respiratory Medicine, Wellington Hospital.

DATA PROCESSING AND ANALYSIS

Each section of the questionnaire was coded independently of the other two sections by the Investigator, and entered directly on to a computer using the Epi Info software package (2). This package includes a data editing programme. Double coding of each section was carried out until an error rate of less than one per cent was achieved. Double coding of the medical history was repeated on a sample of questionnaires by a committee member, to check the accuracy of medical interpretation.

To check the accuracy of recall of exposure history information, such information was extracted from questionnaires completed by the Auckland firefighters in January 1985 and compared with their 1989 responses. The 1985 questionnaire was administered by the Fire Service and the Northern Fire Brigades' Employees' Industrial Union of Workers (now the New Zealand Professional Firefighters' Union) to identify the involvement of personnel with the ICI fire; problems encountered with protective clothing and operational procedures; and health problems experienced since the fire. The 1985 exposure history information was substituted in all instances where there was disagreement between the two responses.

All computer files were subsequently transferred onto a mainframe computer, edited further, and merged.

Test results were also coded independently. Neuropsychological and liver function test results were entered twice for data editing purposes. Checking of the minimum and maximum values, rather than
double data entry, was done for other laboratory tests because of the time schedule and cost.

Results were analysed using the Statistical Analysis System (SAS) software package (3). The statistical tests used and test results are given in Appendices 3, 4 and 5 for questionnaire, laboratory and neuropsychological data respectively.

CLASSIFICATION OF SELF-REPORTED PSYCHIATRIC PROBLEMS

Four clinical categories of ongoing psychiatric problems were derived by Dr M Eilenberg from the range of commonly occurring central nervous system complaints. These complaints had an onset on or after 21 December 1984, and were listed spontaneously by the firefighters. The categories were defined as:

(1) Category I
   • the presence of mood disturbance in the absence of fatigue, loss of interest or motivation, and memory and/or concentration impairment

(2) Category II
   • the presence of fatigue, loss of interest or motivation, and mood disturbance in the absence of memory and/or concentration impairment

(3) Category III
   • the presence of memory and/or concentration impairment and either mood disturbance and/or fatigue, loss of interest or motivation

(4) Category IV
   • the presence of memory and/or concentration impairment in the absence of fatigue, loss of interest or motivation, and mood disturbance

For the analysis, all four categories were also combined to give one category of psychiatric dysfunction.

Firefighters with one of the above categories may have, coexisting, other central nervous system complaints such as headache, impaired coordination etc. These complaints were excluded by the psychiatric classification but appear in Table 5, p. 145.
EXPOSURE INDICES

Exposure history information was used to develop exposure indices for the fire, the clean-up, and fire and clean-up combined. Indices were weighted for time using categories of less than four hours, and four or more hours.

The fire exposure indices were derived from attendance at the fire on 21 December 1984, the firefighter's description of his/her activities and location at the fireground, inhalation of fumes, and direct and indirect skin contact with liquids.

The clean-up exposure indices were similarly derived from attendance at the fireground on the days following the fire, the firefighter's description of his/her activities, inhalation of fumes, and direct and indirect skin contact with liquids.

Wearing of breathing apparatus was not taken into consideration because of inadequate usage, and non-availability to all firefighters. The one-stage positive pressure apparatus which was available is also less effective than the two-stage positive pressure apparatus currently used. The occurrence of decontamination was similarly disregarded, since this was inconsistently performed, and at a variable time following contact.

General involvement of the firefighter and inhalation of fumes were combined to give respiratory exposure indices for the fire, the clean-up, and fire and clean-up combined. Direct and indirect skin contact were similarly combined to give dermatological exposure indices.

The respiratory and dermatological exposure indices are six-point scales.

(1) Fire, clean-up, and combined respiratory exposure indices

Attendance at the fire (or clean-up, or fire and clean-up) for four or more hours, close involvement, and inhalation of fumes is represented by a respiratory index of 1. If the firefighter was either closely involved or inhaled fumes, but not both, the index is 2. The same type of exposure as 1 and 2, but for less than four hours, gives a respiratory index of 3 or 4 respectively. Attendance at the fire (or clean-up, or fire and clean-up), marginal involvement, and/or uncertainty about inhaling fumes is a respiratory index of 5. A respiratory index of 6 represents non-attendance at the fire (or clean-up, or fire.
and clean-up), non-involvement, and/or no inhalation of fumes.

(2) Fire, clean-up, and combined dermatological exposure indices

Attendance at the fire (or clean-up, or fire and clean-up) for four or more hours, resulting in part of their clothing being soaked and direct skin contact with liquids, gives a dermatological index of 1. If either part of their clothing was soaked or there was direct skin contact with liquids, but not both, the index is 2. An index of 3 or 4 represents the same exposure as 1 and 2 respectively, but for less than four hours. Attendance at the fire (or clean-up, or fire and clean-up), and uncertainty about part of their clothing being soaked, and/or uncertainty about direct skin contact with liquids is a dermatological index of 5. Non-attendance at the fire (or clean-up, or fire and clean-up), no part of their clothing being soaked, and/or no direct skin contact is a dermatological index of 6.

Respiratory and dermatological exposure indices for non-responders were derived from the 1985 questionnaires. These are as comparable as possible to the indices for the responders for the fire and clean-up combined. The differences lie in the unavailability of the level of involvement of the firefighter, and the combination of direct and indirect skin contact into a single variable, for the fire and the clean-up.

LABORATORY INDICES

Population reference ranges for the laboratory data were those used by the Auckland laboratory analysing the blood. Nineteen of the 24 laboratory results were grouped into five categories. These were defined as:

1. HAEM 1—haemoglobin, haematocrit, mean cell volume, mean cell haemoglobin and red blood cell count

2. ESR —erythrocyte sedimentation rate

3. HAEM 2—white blood cell count, neutrophils, lymphocytes, eosinophils, basophils and monocytes

4. RENAL —urea and creatinine

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(5) LIVER —bilirubin, alkaline phosphatase, gamma-glutamyl transferase, alanine transaminase and aspartate transaminase

Each sub-index within each category was scored 1 if the result was outside the limits of the appropriate reference range, and 0 otherwise. Each category score is the number of component sub-indices scored 1.

NEUROPSYCHOLOGICAL IMPAIRMENT INDEX

With the exception of the Wechsler Adult Intelligence Scale (WAIS), from which two of the eight independent neuropsychological tests used were selected, normative data are often derived from samples which are too small, or not applicable to the general population, e.g., American college students. Hence for this study, the normative data were derived from the referent group. Score cut-off points for each of the 15 sub-tests were determined on the basis of the referent group approximate 10th and 90th percentiles, in conjunction with norms available for other populations. Either the 10th or 90th percentile was used, depending on whether a low or high test score indicates impairment. Scores outside this limit were considered “poor”.

Word fluency, Purdue pegboard, reaction time and digit span tests were each grouped to give one indicator of impairment. These indicators were based on at least one result from each group of test results being outside the appropriate limit. There were also indicators for copying and recall of the Rey-Osterrieth complex figure; digit symbol; and the Paced Auditory Serial Addition Test (PASAT). The PASAT score was used as an indicator if the firefighter was aged 40 years or less; and either could not do the test or scored outside the limit.

The indicator for each of these tests or group of tests was scored 1 if the result was outside the appropriate limit, and 0 otherwise. The overall index of neuropsychological impairment is the number of “abnormal” indicators. The maximum value of the index is eight.

BIAS

Three types of bias need to be considered in a study of this nature.
(1) Selection Bias

The motivation to participate in the study is likely to differ for the study and referent groups, in particular for those firefighters who have been medically boarded (retired on medical grounds). Whereas all Auckland firefighters boarded over the last four years are included in the study group, only a third (N = 4) of those in Wellington are in the referent group.

Within the study group population, the motivation to participate may also have differed. For example, it is possible that the non-responders did not participate because they have no health problems.

Although assurances about confidentiality were given, firefighters in Wellington with ongoing health problems may have chosen not to participate for fear of disclosure of this information to the Fire Service.

The effect of selection bias on the risk of “poor” neuropsychological test results is demonstrated in Appendix 2.

(2) Information Bias

Recall bias is to be expected given the amount of time that has lapsed since the fire (see Table 2, p. 142). It is possible that firefighters in the study group are also likely to remember health problems more accurately and thoroughly than other firefighters who have not participated in a comparable incident.

Some firefighters among both groups may have under-stated their ill-health for fear of possible job loss.

(3) Observer Variation

Observer variation was minimised by use of a self-administered questionnaire; the same laboratory for blood analysis; the same equipment and personnel for neuropsychological testing; and the same coder for all questionnaires.

CONFOUNDING

Confounding is a bias in the measure of an effect that is introduced by an extraneous factor. For example, the presence of health problems and “poor” neuropsychological test results is more likely with increasing age. To control for confounding, the referent group
was selected so that it was similar to the study group with respect to relevant risk indicators, such as age and years of service, except for the exposure (ie. the ICI fire) under study.

The age distribution in the two groups was virtually identical. Age was highly correlated with years of service for both groups.

Confounding by number of chemical fires attended since 1985 was not controlled for as the responses given indicated some confusion between spills and fires; difficulty recalling or obtaining such information; and debate over definition of a chemical fire since house fires often involve plastics and polyurethane foams, and shed fires often involve paints, solvents and pesticides.

There was no necessity to control for confounding by sex as there were only three females in the study group. No female firefighters in Wellington met the criteria of four or more years' service.

Group matching was done initially to potentially control for confounding as this was the most cost-effective option. The analysis indicated that there were no identifiable confounders.

RESULTS

RESPONSE RATE OF STUDY GROUP

Three hundred and forty individuals were identified as having had some involvement with the fire. This was determined from information supplied by the Fire Service; individuals who approached the Committee directly as a result of publicity about the investigation; and from the 1985 questionnaires.

Two hundred and forty-five individuals participated in the study, comprising a response rate of 72.1 per cent. The study group includes nine firefighters who no longer live in the Auckland region.

The nature of the firefighters' involvement in the ICI fire is given in Table 1.
One hundred and forty-one (57.6 per cent) responders attended the fire on 21 December. This was verified for 104 individuals from the 1985 questionnaires. Information from 1985 was substituted where there was disagreement between 1985 and 1989 responses (see Table 2, p. 142).

A further 37 individuals, for whom 1985 questionnaires were not available, reported attending the fire. Although error or inconsistency are not apparent in the exposure history information recalled in 1989, either or both could have occurred.

Fire attendance was verified for 32 non-responders from the 1985 questionnaires.

**STUDY GROUP NON-RESPONDERS**

Individuals were classified as non-responders if their involvement was able to be verified from the 1985 questionnaires. This excluded seven individuals whose names had been given to the Committee.

There were 95 non-responders, which includes nine volunteers and one female firefighter. Reasons for non-response include current address unknown (confirmed for one); resident overseas (confirmed for three); resident outside Auckland (confirmed for two); and death (confirmed for one). Nineteen non-responders were not known to the Committee until after the conclusion of the study group testing. Their involvement was established from the 1985 questionnaire.

Non-responders are slightly younger than responders with a mean age of 34 as compared to 38 years.
Exposure of the 95 non-responders was predominantly low. Fifty-nine per cent (N=56) had a respiratory exposure index of 5 or 6, and 82 per cent (N=78) had a dermatological exposure index of 5 or 6. The corresponding figures for responders are 28 per cent (N=68) and 38 per cent (N=93) respectively. Twenty individuals (21 per cent) who had little or no respiratory and dermatological exposure were also not involved in handling or cleaning equipment.

**VALIDATION OF EXPOSURE HISTORY INFORMATION**

Disagreement for attendance, time of involvement, inhalation of fumes, direct and indirect skin contact with liquids, for the fire and the clean-up, between the 1985 and 1989 data sets is given in Table 2.

The results suggest systematic bias in information recall towards an over-estimation of overall exposure by attendance at the fire, and for time involved at both the fire and clean-up. Exposure has, however, been under-estimated in 1989 for direct and indirect skin contact at both the fire and clean-up.

There is non-systematic bias in information recall for inhalation of fumes.

**Table 2: Validation of 1989 Exposure History**

<table>
<thead>
<tr>
<th></th>
<th>Fire No.</th>
<th>%*</th>
<th>Clean-up No.</th>
<th>%*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attendance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 “yes” but 1985 “no”</td>
<td>15</td>
<td>14.4</td>
<td>6</td>
<td>5.8</td>
</tr>
<tr>
<td>1989 “no” but 1985 “yes”</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>Inhalation of fumes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 “yes” but 1985 “unsure/no”</td>
<td>12</td>
<td>11.5</td>
<td>21</td>
<td>20.2</td>
</tr>
<tr>
<td>1989 “unsure/no” but 1985 “yes”</td>
<td>17</td>
<td>16.3</td>
<td>18</td>
<td>17.3</td>
</tr>
<tr>
<td><strong>Direct skin contact</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 “yes” but 1985 “unsure/no”</td>
<td>10</td>
<td>9.6</td>
<td>12</td>
<td>11.5</td>
</tr>
<tr>
<td>1989 “unsure/no” but 1985 “yes”</td>
<td>32</td>
<td>30.8</td>
<td>15</td>
<td>14.4</td>
</tr>
<tr>
<td><strong>Indirect skin contact</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 “yes” but 1985 “unsure/no”</td>
<td>13</td>
<td>12.5</td>
<td>12</td>
<td>11.5</td>
</tr>
<tr>
<td>1989 “unsure/no” but 1985 “yes”</td>
<td>19</td>
<td>18.3</td>
<td>23</td>
<td>22.1</td>
</tr>
<tr>
<td><strong>Time of involvement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 “4 or more hours” but 1985 “less than 4 hours”</td>
<td>33</td>
<td>31.7</td>
<td>21</td>
<td>20.2</td>
</tr>
<tr>
<td>1989 “less than 4 hours” but 1985 “4 or more hours”</td>
<td>4</td>
<td>3.8</td>
<td>11</td>
<td>10.6</td>
</tr>
</tbody>
</table>

*percentage of firefighters (N=104) for whom 1985 questionnaires were available
EXPOSURE HISTORY

Ninety-three per cent (N=222) of firefighters believe that they personally were exposed to chemicals as a result of their involvement in the ICI fire. Of this group, 24.8 per cent (N=55) spontaneously named pesticides and/or herbicides as the chemicals, either alone or in combination with other substances, which they believe they were exposed to.

Of the study group, 7.3 per cent (N=18) were "maximally exposed". These individuals have respiratory and dermatological exposure indices from 1 to 4 for both the fire and clean-up. In contrast, 22.9 per cent (N=56) of firefighters had little or no respiratory and dermatological exposure (indices from 5 to 6).

Respiratory and dermatological exposure indices for the fire and clean-up combined are given in Table 3.

Table 3: Overall exposure indices

<table>
<thead>
<tr>
<th>Index</th>
<th>Respiratory</th>
<th>Dermatological</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>1 or 2</td>
<td>73</td>
<td>29.8</td>
</tr>
<tr>
<td>3 or 4</td>
<td>104</td>
<td>42.4</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>9.0</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
<td>18.8</td>
</tr>
</tbody>
</table>

Comments made about exposure include:

"On arrival at this incident there was no indication that chemicals were involved. I still have no knowledge of the chemicals that were present. I do know that unknown quantities of a variety of chemicals were mixed in unknown ratios at unknown temperatures. Therefore unknown compounds may also have been formed in the course of this incident, and there is no way to duplicate what occurred."

"...(Exposed to) 2,4,5-T and a purple red powder I believe to be dioxin."

"According to Matt Tizard I was exposed to paraquat but I personally don't know."
CHARACTERISTICS OF STUDY AND REFERENT GROUPS

The demographic characteristics of the study and referent groups are given in Table 4.

Table 4: Demographic characteristics

<table>
<thead>
<tr>
<th></th>
<th>Study Group (Auckland)</th>
<th>Referent Group (Wellington)</th>
</tr>
</thead>
<tbody>
<tr>
<td>age: range (in years)</td>
<td>23–64</td>
<td>24–59</td>
</tr>
<tr>
<td>mean</td>
<td>38.6</td>
<td>38.2</td>
</tr>
<tr>
<td>sex: males</td>
<td>242</td>
<td>217</td>
</tr>
<tr>
<td>females</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>years of service: range</td>
<td>4–42</td>
<td>4–41</td>
</tr>
<tr>
<td>volunteers</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>medically boarded</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>

The study group includes three individuals who are now retired.

The group of volunteer firefighters includes 10 Fire Police in Auckland and 5 Fire Police in Wellington.

Marital status does not differ significantly between the two groups (p > 0.05).

SELF-REPORTED HEALTH PROBLEMS

Thirty-nine per cent (N = 95) of the study group firefighters consider that their general health has been affected as a result of the ICI fire. Eleven per cent (N = 28) report their health to be unaffected, and almost 50 per cent (N = 121) express uncertainty.

The number of health problems experienced by each firefighter in the study group ranges from nil (N = 30) to ten (N = 3), with a mean of 2.9. Among the referent group the number ranges from nil (N = 141) to eight (N = 1), with a mean of 0.6. Significantly more firefighters in the study group have a history of health problems (p < 0.001). Sixty-six per cent (N = 141) of the referent group report no history of problems in contrast to 12 per cent (N = 30) of the study group.

Among the study group, there is no association between age and a history of nil, or one or more, health problems (p > 0.05).
Firefighters with a history of health problems are more likely to have had respiratory exposure at the fire (92.9 per cent cf 82.2 per cent; \(p = 0.040\)), and dermatological exposure at the fire (96.2 per cent cf 81.2 per cent; \(p = 0.002\)), than those without problems. There is no association between history of health problems, and respiratory or dermatological exposure at the clean-up (\(p > 0.05\) for both tests).

An association was found between ongoing skin problems, respiratory exposure, and dermatological exposure, at the clean-up (see Skin problems, p. 147).

The problems listed by both groups of firefighters are predominantly central nervous system and skin complaints. Details are given in Table 5.

Table 5: Number of problems experienced by system

<table>
<thead>
<tr>
<th></th>
<th>Study Group</th>
<th>Referent Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>central nervous system</td>
<td>391</td>
<td>39</td>
</tr>
<tr>
<td>skin</td>
<td>115</td>
<td>26</td>
</tr>
<tr>
<td>respiratory</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>cardiovascular</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>gastro-intestinal</td>
<td>27</td>
<td>17</td>
</tr>
<tr>
<td>urinary</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>sex</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>musculo-skeletal</td>
<td>29</td>
<td>21</td>
</tr>
<tr>
<td>non-specific</td>
<td>99</td>
<td>9</td>
</tr>
</tbody>
</table>

N=701

N=137

Notes:

"Central nervous system" includes problems such as memory loss, impaired concentration, headache, depression, anxiety, insomnia, impaired coordination etc.

"Skin" includes problems such as rash, pimples, sores, itch, etc.

"Respiratory" includes sore throat, cough, asthma etc.

"Cardiovascular" includes chest pain, palpitations, hypertension etc.

"Gastro-intestinal" includes loss of appetite, weight disturbance, nausea and/vomiting, indigestion, abdominal pain, bowel disturbance etc.

"Urinary" includes urinary frequency, prostatitis and discolouration of urine.

"Sex" includes impotence, loss of libido and testicular problems.

"Musculo-skeletal" includes back pain, joint pain and/stiffness and/swelling, muscular pain etc.

"Non-specific" includes fatigue, lethargy and night sweats.

**ONGOING SELF-REPORTED HEALTH PROBLEMS**

The most common ongoing problems with an onset since 21 December 1984 are memory loss (N=83; 34.0 per cent), skin rash/lesions (N=72; 29.5 per cent), and irritability (N=72; 29.5 per cent) for the
study group; and skin rash/lesions (N=15; 7.0 per cent) for the referent group. Other common ongoing problems are listed in order of decreasing frequency in Tables 6 and 7.

Table 6: Most common ongoing problems since 21 December 1984 among study group (N=244)

<table>
<thead>
<tr>
<th>Problem</th>
<th>Number of Firefighters</th>
<th>Percentage of Firefighters</th>
</tr>
</thead>
<tbody>
<tr>
<td>memory loss</td>
<td>83</td>
<td>34.0</td>
</tr>
<tr>
<td>skin rash/lesions</td>
<td>72</td>
<td>29.5</td>
</tr>
<tr>
<td>irritability</td>
<td>72</td>
<td>29.5</td>
</tr>
<tr>
<td>fatigue, loss of interest/motivation</td>
<td>57</td>
<td>23.4</td>
</tr>
<tr>
<td>impaired concentration</td>
<td>49</td>
<td>20.1</td>
</tr>
<tr>
<td>insomnia</td>
<td>29</td>
<td>11.9</td>
</tr>
<tr>
<td>headache</td>
<td>28</td>
<td>11.5</td>
</tr>
<tr>
<td>depression, mood changes</td>
<td>22</td>
<td>9.0</td>
</tr>
<tr>
<td>anxiety, tension, loss of confidence</td>
<td>17</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Table 7: Most common ongoing problems since 21 December 1984 among referent group (N=214)

<table>
<thead>
<tr>
<th>Problem</th>
<th>No. of Firefighters</th>
<th>% of Firefighters</th>
</tr>
</thead>
<tbody>
<tr>
<td>skin rash/lesions</td>
<td>15</td>
<td>7.0</td>
</tr>
<tr>
<td>joint pain, swelling/stiffness</td>
<td>12</td>
<td>5.6</td>
</tr>
<tr>
<td>irritability</td>
<td>6</td>
<td>2.8</td>
</tr>
<tr>
<td>tinnitus/hearing loss</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>abdominal pain</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>insomnia</td>
<td>4</td>
<td>1.9</td>
</tr>
<tr>
<td>bowel disturbance</td>
<td>4</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Psychiatric Problems

More than half of the study group report ongoing psychiatric complaints which fit the four categories of psychiatric dysfunction (p < 0.001). Group comparisons by diagnostic category are in Table 8.

146
Table 8: Psychiatric dysfunction

<table>
<thead>
<tr>
<th>Category</th>
<th>Study No.</th>
<th>%</th>
<th>Referent No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category I</td>
<td>26</td>
<td>10.7</td>
<td>6</td>
<td>2.8</td>
</tr>
<tr>
<td>Category II</td>
<td>9</td>
<td>3.7</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Category III</td>
<td>71</td>
<td>29.1</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Category IV</td>
<td>32</td>
<td>13.1</td>
<td>4</td>
<td>1.9</td>
</tr>
</tbody>
</table>

N = 138 56.6  N = 13 6.1

Note: Psychiatric categories I-IV are defined on p. 135.

More firefighters among the study group than the referent group have Category I (10.7 per cent cf 2.8 per cent; p = 0.002); Category II (3.7 per cent cf 0.5 per cent; p = 0.023); Category III (29.1 per cent cf 0.9 per cent; p < 0.001); or Category IV (13.1 per cent cf 1.9 per cent; p < 0.001).

Category II was omitted from further analysis because of the small number of firefighters with such symptomatology.

Among the study group, for each of the other three psychiatric categories and for all four categories combined, there is no association with age; years in the Fire Service; or respiratory or dermatological exposure at the fire or clean-up (p > 0.05 for 24 tests). There is also no association with alcohol intake, which was crudely categorised as drinking 0–3 days per week and 4 or more days per week (p > 0.05 for 4 tests).

SKIN PROBLEMS

More firefighters among the study group than the referent group have ongoing skin problems with an onset since the time of the fire (32.4 per cent cf 7.9 per cent; p < 0.001).

There is no association between ongoing skin problems, and a history of skin problems before the fire, or a history of allergy (p > 0.05 for both tests).

Firefighters with ongoing skin problems are more likely to have had respiratory exposure at the clean-up (43.2 per cent cf 27.0 per cent; p = 0.016), and dermatological exposure at the clean-up (43.1 per cent cf 27.9 per cent; p = 0.031). There is no association for respiratory or dermatological exposure at the fire (p > 0.05 for both tests).
IMPACT OF HEALTH PROBLEMS

The health problems experienced by the study group most commonly affect inter-personal relationships (N=47; 22.0 per cent), in particular relationships with family members. In contrast, those experienced by the referent group tend to have little or no effect. Seven per cent (N=15) of the study group firefighters are aware of an effect on their work performance. Table 9 gives details of other effects.

Table 9: Impact of self-reported health problems

<table>
<thead>
<tr>
<th></th>
<th>Study No.</th>
<th>Study %</th>
<th>Referent No.</th>
<th>Referent %</th>
</tr>
</thead>
<tbody>
<tr>
<td>lack energy/ tired/ moody/ irritable</td>
<td>32</td>
<td>15.0</td>
<td>10</td>
<td>13.7</td>
</tr>
<tr>
<td>uncertainty about future/ anxiety</td>
<td>23</td>
<td>10.7</td>
<td>7</td>
<td>9.6</td>
</tr>
<tr>
<td>inter-personal relationships</td>
<td>32</td>
<td>15.0</td>
<td>3</td>
<td>4.1</td>
</tr>
<tr>
<td>inter-personal relationships and lifestyle</td>
<td>7</td>
<td>3.3</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>lifestyle</td>
<td>13</td>
<td>6.1</td>
<td>5</td>
<td>6.8</td>
</tr>
<tr>
<td>inter-personal relationships and work performance</td>
<td>6</td>
<td>2.8</td>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>work performance</td>
<td>7</td>
<td>3.3</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>inter-personal relationships, lifestyle and work performance</td>
<td>2</td>
<td>0.9</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>personal discomfort/ frustration/ embarrassment</td>
<td>19</td>
<td>8.9</td>
<td>9</td>
<td>12.3</td>
</tr>
<tr>
<td>personality change</td>
<td>7</td>
<td>3.3</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>little or no effect</td>
<td>32</td>
<td>15.0</td>
<td>13</td>
<td>17.8</td>
</tr>
<tr>
<td>other/ other combination</td>
<td>5</td>
<td>2.3</td>
<td>3</td>
<td>4.1</td>
</tr>
<tr>
<td>don't know/ unsure/ missing data</td>
<td>29</td>
<td>13.6</td>
<td>17</td>
<td>23.3</td>
</tr>
</tbody>
</table>

N=214                          N=73

Comments include:

“I was diagnosed by Dr Tizard as having very high concentrations of paraquat and 2,4,5-T poisoning. I was to have had hyperbaric treatment. This never eventuated. Whether I am poisoned or not I do not know. This has a certain amount of mental strain on me.”

“I have no problems that I could attribute to ICI. However, I am still quite concerned about possible long term effects. Two weeks would not go by without me thinking about it and more often when the fire etc. is in the news. I fear that many of us may suddenly start dying off in the future for inexplicable reasons. This has affected my views on long-term relationships.”
“The skin problems are a nuisance. The memory problems create a certain amount of stress and a need to write things down.”

“My quality of life has been affected. I used to enjoy beaches and swimming but now I find it embarrassing to go swimming because of my skin condition.”

“Loss of friends because of mood changes. Don’t do as much as I used to sportwise. Don’t work as much as I used to.”

“They have created problems at home with my marriage and with my relationship with the children. I have had to alter my method of doing things and I have stopped playing sports—my ..(sport) was getting hopeless with the lapse in concentration.”

“Don’t attempt tasks unless I know I can finish them easily. I have had to cut back my participation in secondary work and sport.”

“I often think a lot of people, including myself may have been subject to a mass hysteria type thing which led to us being unable to decipher whether or not we were affected by chemical poisoning. I may believe I haven’t changed, others do, which makes one feel worse. Yet it’s nothing one can lay his hand on.”

“My life has altered dramatically since the ICI fire. I don’t know if it can all be blamed on that incident, but I do know that it has deteriorated considerably from a health and mental wellbeing point of view. My wife and family have suffered along with me and the extra pressure put on me to control my moods and temper have made life more difficult. I find it harder to handle situations and do tend to panic more. Most of the time it is ill-founded panic.”

TREATMENT AMONG THE STUDY GROUP

Some type of treatment is being or has been received by 149 firefighters. In contrast, 90 report no treatment.

Ninety-nine firefighters are being or have been treated by an EAV (electroacupuncture according to Voll) practitioner with homeopathy, and/or intravenous vitamin C and hyperbaric oxygen. General practitioners are also a common treatment agent (N=66).

Treatment was rated by the firefighters as “unsatisfactory”, or “satisfactory”. In addition there is a group who have had no treatment, but report health problems.
(1) "Unsatisfactory" Treatment

Seventy-three firefighters report one or more "unsatisfactory" treatments. There are 107 such treatments, with each firefighter having up to five (mean 1.5). Nineteen firefighters are receiving ongoing "unsatisfactory" treatment. This treatment is predominantly for skin (N=8) or central nervous system (N=6) problems (see Table 13, p. 151).

"Chemical poisoning" (N=29) is the most common problem for which "unsatisfactory" treatment is ongoing or has been received, followed by central nervous system (N=20) problems. Details are given in Table 10.

Table 10: Problem for which treatment is or has been "unsatisfactory"

<table>
<thead>
<tr>
<th>Problem</th>
<th>No. of Firefighters</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;chemical poisoning&quot;</td>
<td>29</td>
</tr>
<tr>
<td>central nervous system</td>
<td>20</td>
</tr>
<tr>
<td>skin</td>
<td>16</td>
</tr>
<tr>
<td>non-specific</td>
<td>3</td>
</tr>
<tr>
<td>other</td>
<td>9</td>
</tr>
<tr>
<td>multi-system</td>
<td>14</td>
</tr>
<tr>
<td>missing data</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes:
Includes ongoing "unsatisfactory" treatment(s) (Table 13, p. 151).
"Chemical poisoning" was spontaneously reported by firefighters. It is a diagnosis given by electro—acupuncture according to Voll (EAV).
"Central nervous system" includes problems such as memory loss, impaired concentration, headache, depression, anxiety, insomnia, impaired coordination etc.
"Skin" includes problems such as rash, pimples, sores, itch etc.
"Non-specific" includes fatigue, lethargy and night sweats.
"Other" includes respiratory, cardiovascular, gastro—intestinal and musculo-skeletal problems.
"Multi-system" refers to two or more problems from different systems, e.g., central nervous system and skin.

Forty-three firefighters who are receiving or have received "unsatisfactory" treatment, name an EAV practitioner as the agent of the "unsatisfactory" treatment. Fifty-two firefighters name other health practitioners (Table 11).
Table 11: Agent of “unsatisfactory” treatment

<table>
<thead>
<tr>
<th>Health Practitioner</th>
<th>No. of Firefighters With One or More Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>general practitioner</td>
<td>32</td>
</tr>
<tr>
<td>dermatologist</td>
<td>2</td>
</tr>
<tr>
<td>physician/surgeon</td>
<td>3</td>
</tr>
<tr>
<td>psychologist/counsellor</td>
<td>2</td>
</tr>
<tr>
<td>occupational health nurse</td>
<td>3</td>
</tr>
<tr>
<td>EAV practitioner</td>
<td>43</td>
</tr>
<tr>
<td>other health practitioner (excludes doctors)</td>
<td>10</td>
</tr>
<tr>
<td>missing data</td>
<td>3</td>
</tr>
</tbody>
</table>

Some firefighters are receiving or have received more than one “unsatisfactory” treatment from the same person, or same type of health practitioner.

The main reason for rating treatment as “unsatisfactory” is no or temporary effect. Other reasons are given in Table 12.

Table 12: Reason for rating treatment as “unsatisfactory”

<table>
<thead>
<tr>
<th>Reason</th>
<th>No. of treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>no or temporary effect</td>
<td>77</td>
</tr>
<tr>
<td>side effects</td>
<td>10</td>
</tr>
<tr>
<td>disbelieve diagnosis or diagnostic method*</td>
<td>5</td>
</tr>
<tr>
<td>no follow-up *</td>
<td>4</td>
</tr>
<tr>
<td>other</td>
<td>8</td>
</tr>
<tr>
<td>missing data</td>
<td>3</td>
</tr>
</tbody>
</table>

N=107

* treatment agent is an EAV practitioner

(2) “Satisfactory” Treatment

Eighty-nine firefighters report one or more “satisfactory” treatments. There are 129 such treatments, with each firefighter having up to five (mean 1.5). Thirty firefighters are receiving ongoing “satisfactory” treatment, with the majority for central nervous system (N=6) problems (Table 13).
Table 13: Problem for which ongoing “satisfactory” or “unsatisfactory” treatment is being received

<table>
<thead>
<tr>
<th>Problem</th>
<th>No. of Firefighters</th>
<th>With One or More Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>“Satisfactory”</td>
</tr>
<tr>
<td>central nervous system</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>multi-system</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>skin</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>musculo-skeletal</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>gastro-intestinal</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>respiratory</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>cardiovascular</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>“chemical poisoning”</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>non-specific</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
“Central nervous system” includes problems such as memory loss, impaired concentration, headache, depression, anxiety, insomnia, impaired coordination etc.
“Multi-system” refers to two or more problems from different systems e.g., central nervous system and skin.
“Skin” includes problems such as rash, pimples, sores, itch etc.
“Musculo-skeletal” includes back pain, joint pain and/ stiffness and/ swelling, muscular pain etc.
“Gastro-intestinal” includes loss of appetite, weight disturbance, nausea and/ vomiting, indigestion, abdominal pain, bowel disturbance etc.
“Respiratory” includes sore throat, cough, asthma etc.
“Cardiovascular” includes chest pain, palpitations, hypertension etc.
“Chemical poisoning” was spontaneously reported by firefighters. It is a diagnosis given by electro-acupuncture according to Voll (EAV).
“Non-specific” includes fatigue, lethargy and night sweats.

“Chemical poisoning” is the most common problem for which “satisfactory” treatment is ongoing or has been received. Further details are given in Table 14.

Table 14: Problem for which treatment is or has been “satisfactory”

<table>
<thead>
<tr>
<th>Problem</th>
<th>No. of Firefighters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With One or More Treatments</td>
</tr>
<tr>
<td>“chemical poisoning”</td>
<td>30</td>
</tr>
<tr>
<td>central nervous system</td>
<td>20</td>
</tr>
<tr>
<td>skin</td>
<td>14</td>
</tr>
<tr>
<td>non-specific</td>
<td>9</td>
</tr>
<tr>
<td>other</td>
<td>26</td>
</tr>
<tr>
<td>multi-system</td>
<td>14</td>
</tr>
</tbody>
</table>

Notes:
Includes ongoing “satisfactory” treatment(s) Table 13.
“Chemical poisoning” was spontaneously reported by firefighters. It is a diagnosis given by electro—acupuncture according to Voll (EAV).
“Central nervous system” includes problems such as memory loss, impaired concentration, headache, depression, anxiety, insomnia, impaired coordination etc.
“Skin” includes problems such as rash, pimples, sores, itch etc.
“Non-specific” includes fatigue, lethargy and night sweats
“Other” includes respiratory, cardiovascular, gastro-intestinal, musculo-skeletal and urinary problems.

“Multi-system” refers to two or more problems from different systems e.g., central nervous system and skin.

The main treatment agent is an EAV practitioner, followed by general practitioners (Table 15).

Table 15: Agent of “satisfactory” treatment

<table>
<thead>
<tr>
<th>Agent</th>
<th>No. of Firefighters</th>
</tr>
</thead>
<tbody>
<tr>
<td>With One or More Treatments</td>
<td></td>
</tr>
<tr>
<td>general practitioner</td>
<td>34</td>
</tr>
<tr>
<td>dermatologist</td>
<td>2</td>
</tr>
<tr>
<td>physician/surgeon</td>
<td>6</td>
</tr>
<tr>
<td>psychologist/counsellor</td>
<td>6</td>
</tr>
<tr>
<td>psychiatrist</td>
<td>2</td>
</tr>
<tr>
<td>Accident and Emergency doctor</td>
<td>1</td>
</tr>
<tr>
<td>minister of religion</td>
<td>2</td>
</tr>
<tr>
<td>EAV practitioner</td>
<td>43</td>
</tr>
<tr>
<td>other health practitioner (excludes doctors)</td>
<td>9</td>
</tr>
<tr>
<td>missing data</td>
<td>1</td>
</tr>
</tbody>
</table>

Some firefighters are receiving or have received more than one “satisfactory” treatment from the same person, or same type of health practitioner.

Twenty-four firefighters report both “satisfactory” and “unsatisfactory” treatments.

Twenty-four firefighters give details of treatment, but no rating. For sixteen, the treatment agent is an EAV practitioner, and for six a general practitioner. It is not surprising that some firefighters found it difficult to rate an EAV practitioner’s treatment, since “chemical poisoning” may be diagnosed in the absence of any subjective complaints.

A number of comments were made about treatment, in particular that given by Dr M. Tizard:

“It was the best that was offered to us by anyone.”

“(Satisfactory). although not fully effective. More of a calming influence in that somebody recognised there was a problem.”
"I did not have current symptoms when I was tested. I had no faith in the testing method or result. I took the treatment on the basis of 'It might be good for me and it can't harm me.'"

"I didn't have any faith in his findings of myself having paraquat poisoning and hence didn't have any of his treatment."

"Whether Tizard is on the level or not, I feel the best thing he did for me was to give me back my hope."

(3) No Treatment

Sixty-three firefighters give a history of no treatment, yet report up to ten problems with their health (mean 2.4). Central nervous system problems account for most of the "no treatment" group, followed by non-specific complaints such as fatigue, and skin problems (Table 16).

Table 16: Health problems of ICI firefighters with no history of treatment

<table>
<thead>
<tr>
<th>System</th>
<th>No. of Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>central nervous system</td>
<td>91</td>
</tr>
<tr>
<td>non-specific</td>
<td>25</td>
</tr>
<tr>
<td>skin</td>
<td>23</td>
</tr>
<tr>
<td>respiratory</td>
<td>4</td>
</tr>
<tr>
<td>gastro-intestinal</td>
<td>4</td>
</tr>
<tr>
<td>musculo-skeletal</td>
<td>3</td>
</tr>
<tr>
<td>cardiovascular</td>
<td>1</td>
</tr>
</tbody>
</table>

N=151

Note: Systems are defined on p. 145.

Thirty-eight (60.3 per cent) of the 63 firefighters in this group currently meet the criteria for one of the four psychiatric categories. Sixteen (25.4 per cent) have a skin problem, of whom nine also have one of the psychiatric categories.

For some of the problems which are not ongoing, no treatment may reflect that the problem was of brief duration rather than treatment was sought, and was either unavailable or not given. Similarly, those with ongoing problems may not have sought treatment for a variety of reasons.
MEDICAL HISTORY

(1) First Aid and Hospital Attendance at the Time of the Fire

Fourteen firefighters received first aid at the fireground. Thirty firefighters (21.4 per cent) who attended the fire went to an Accident and Emergency department (Auckland Hospital N=20; Middlemore Hospital N=9; North Shore Hospital N=1) within 2 to 3 days of the fire. Skin complaints were the most common reason for attendance. Other reasons are given in Table 17.

Table 17: Reasons for attending an Accident and Emergency Department following the ICI fire

<table>
<thead>
<tr>
<th>Reason</th>
<th>No. of Firefighters</th>
</tr>
</thead>
<tbody>
<tr>
<td>central nervous system eg headache, dizziness</td>
<td>5</td>
</tr>
<tr>
<td>skin eg rash, burns</td>
<td>13*</td>
</tr>
<tr>
<td>respiratory eg sore throat, breathlessness</td>
<td>3</td>
</tr>
<tr>
<td>combination of the above</td>
<td>8</td>
</tr>
<tr>
<td>other</td>
<td>1</td>
</tr>
<tr>
<td><strong>N=30</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Includes one firefighter who was later admitted to hospital because of his skin problem

(2) Hospital Admission

No significant difference exists between the study and referent groups for number of firefighters with a history of hospital admission (p > 0.05). There is also no difference for hospital admissions for central nervous system or skin problems occurring either before or after 21 December 1984 (p >0.05 for 4 tests).

(3) Allergy

There is no difference in the prevalence of allergy among the two groups (p >0.05).

(4) Medical Boarding

Six firefighters (2.7 per cent) from the study group consider that medical boarding is a definite or probable outcome in their case (Table 18). Nine have already been boarded, and a further 11 have left the Fire Service for health or other reasons such as change of job and retirement.
Table 18: Medical boarding

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>definitely yes</td>
<td>4</td>
<td>1.8</td>
</tr>
<tr>
<td>probably yes</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>unsure</td>
<td>36</td>
<td>16.0</td>
</tr>
<tr>
<td>unlikely</td>
<td>70</td>
<td>31.1</td>
</tr>
<tr>
<td>definitely no</td>
<td>73</td>
<td>32.4</td>
</tr>
<tr>
<td>missing data</td>
<td>40</td>
<td>17.8</td>
</tr>
</tbody>
</table>

N=225

It is interesting to note that 34 firefighters who answered "No" to "Have you been medically boarded?", then did not answer the following question relating to the possibility of boarding. This may reflect the sensitivity of boarding as an issue among the group.

(5) Reproductive History

There is no significant difference between the study and referent groups in the history of one or more miscarriages, terminations or stillbirths, either before or after 21 December 1984 (p > 0.05 for 6 tests).

The number of firefighters' partners with pregnancies involving birth abnormality, where the partner was aged less than 35 years, also does not differ between the two groups (p > 0.05).

The abnormalities reported showed no consistent pattern and ranged from mild deformities to gross defects in both groups.

(6) Cancers

There is no significant difference in the incidence of diagnosed cancers in the last four years between the two groups (p > 0.05). The type of cancer is given in Table 19.

Table 19: Cancers diagnosed among firefighters since 21 December 1984

<table>
<thead>
<tr>
<th></th>
<th>Study</th>
<th>Referent</th>
</tr>
</thead>
<tbody>
<tr>
<td>skin</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>bone</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>lung</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>testicular</td>
<td>-</td>
<td>3</td>
</tr>
</tbody>
</table>

N=7        N=6
One firefighter involved in the ICI fire is known to have died from acute myeloid leukaemia.

The three testicular cancers found in the referent group require comment. This was an unexpected finding. All three diagnoses had been confirmed and occurred during the period 1985 to 1989 in firefighters aged 32, 37 and 46 years. Even though these may be a chance occurrence, further study should be made of their occupational significance.

(7) Drug History

The number of firefighters currently on prescription medications does not differ between the two groups (p > 0.05). Similarly, there is no difference in the use of sleeping pills in the last three months (p > 0.05). However, there is greater use of over-the-counter medications in the preceding three months among the study group (37.6 per cent cf 25.8 per cent; p = 0.012).

Social and Occupational History

(1) Psycho-Social History

There is no significant difference between the two groups in the preceding four years for stressors such as change of marital status; moving house; or death of a family member or close friend (p > 0.05 for 4 tests).

A greater number of firefighters from the study group listed one or more subjectively stressful events experienced since the fire (67.5 per cent cf 56.5 per cent; p = 0.036). This is not surprising given that the fire is identified as a stressful event by some. Stressful events common to both groups include domestic and financial concerns; examinations and promotion within the Fire Service; and attending motor vehicle accidents or fires involving fatalities. There is no difference between the two groups for ongoing stressful events (p > 0.05).

There is no difference between the two groups in the number of current hobbies (p > 0.05). However, more firefighters among the study group rate their enjoyment of life as less now than in 1984 (18.2 per cent cf 6.4 per cent; p 0.001). This crude measure of enjoyment of life is based on changes to their hobbies and interests since 1984.
(2) *Smoking and Alcohol*

Current and past cigarette smoking status and consumption does not differ significantly between the two groups (p > 0.05 for 4 tests).

Likewise, there is no difference in the number of current alcohol drinkers, or in the frequency of alcohol consumption in the preceding six months (p > 0.05 for both tests).

There is no evidence that alcohol consumption has increased more among the study group than the referent group since the time of the ICI fire (p > 0.05).

(3) *Other Exposure to Chemicals*

There are marginally more firefighters among the referent group than the study group whose hobbies involve solvent use (22.3 per cent cf 14.9 per cent; p = 0.053). Lead use is similar among the two groups (p > 0.05).

Previous occupational exposure to chemicals (including solvents) is significantly greater among the referent group (46.3 per cent cf 33.3 per cent; p = 0.006). Since becoming a firefighter, secondary employment involving exposure to chemicals is also greater among the referent group (34.8 per cent cf 24.4 per cent; p = 0.018).

(4) *Occupational Health*

Use of the Fire Service occupational health service is significantly greater among the referent group (38.8 per cent cf 22.0 per cent; p < 0.001). The number of firefighters the occupational health nurse is responsible for is less in Wellington than in Auckland, although the Wellington service was established one year later in 1987.

(5) *Chemical Fires*

Eighty-three (35.8 per cent) of the study group have attended one or more chemical fires since the ICI fire, compared with 94 (45.4 per cent) of the referent group.

Firefighters among the referent group who have attended a chemical fire during the last four years report ongoing health problems more than those who have not attended such a fire (43.6 per cent cf 28.3 per cent; p = 0.032). This may be a result of exposure or reflect a tendency for firefighters to be more aware of their health following such exposure.
ELECTROCARDIOGRAM (ECG) AND LUNG FUNCTION TESTS

There were three (1.2 per cent) abnormal ECGs (left bundle branch block; Wolff-Parkinson-White syndrome; pacemaker) among the study group.

Eighteen (7.4 per cent) of the study group had abnormal lung function test results. The variations in the tests were quantitatively small and did not indicate any consistent syndrome of clinical abnormality. Some of the group were smokers or treated asthmatics, and it was considered that the changes in these subjects could be thus explained. As a double check seven firefighters in whom there was no possible explanation for minor abnormalities were referred for more detailed lung function testing and review by a respiratory physician. All seven had normal lung function on this review.

LABORATORY TESTS

Fewer firefighters in the study group than in the referent group have abnormal HAEM 1 (9.1 per cent cf 18.7 per cent; p = 0.003) and abnormal HAEM 2 (17.8 per cent cf 26.9 per cent; p = 0.044). There is no significant difference between the groups for ESR, renal and liver sub-indices (p > 0.05 for 3 tests). For details refer to Appendix 4, Table 4.2.

Group comparisons of the individual laboratory variables are outlined in Appendix 4, Table 4.1.

There is no association between Category III, Category IV (defined on p. 135), or ongoing skin problems, and laboratory abnormality for each of the five sub-indices for the study group (p > 0.05 for 15 tests).

Laboratory abnormality for each of the sub-indices is not associated with respiratory or dermatological exposure at the fire (p > 0.05 for 10 tests); or the clean-up (p > 0.05 for 9 tests) with the exception of the renal sub-index. Three per cent of firefighters who had dermatological exposure at the clean-up have renal abnormality. This is significantly fewer than the 11.2 per cent with renal abnormality who had no such exposure (p = 0.043).
Neuropsychological Tests

Appendix 5, Table 5.1 lists the group comparisons for the individual tests.

The mean scores for individual tests for the two groups are compared with published norms in Appendix 5, Table 5.2. When mean scores are considered, the firefighters in general performed as well as one might expect on the basis of published norms. However, standard deviations tend to be greater on some tests. This may reflect the difference in characteristics between the various normative populations and the study group. Skewness was also noted in much of the firefighters’ data, possibly the result of a sub-group of less healthy individuals.

(1) Neuropsychological Impairment (NPI) Index

Table 20 shows the distribution of neuropsychological impairment based on the number of test scores outside the appropriate percentile (10th or 90th) among the two groups.

Table 20: Neuropsychological impairment

<table>
<thead>
<tr>
<th>NPI Index</th>
<th>Study Number</th>
<th>Study %</th>
<th>Referent Number</th>
<th>Referent %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90</td>
<td>37.0</td>
<td>90</td>
<td>41.5</td>
</tr>
<tr>
<td>1</td>
<td>70</td>
<td>28.8</td>
<td>71</td>
<td>32.7</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>16.5</td>
<td>36</td>
<td>16.6</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>9.5</td>
<td>14</td>
<td>6.5</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>4.5</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>2.9</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>0.4</td>
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</table>

N=243 N=217

A simple non-parametric test showed no strong evidence to suggest a difference in the study and referent group distributions (p > 0.05). However, further examination of the two distributions through theoretical modelling did provide statistical evidence of a group difference.

The mean of the distribution for the referent group is 0.97 and the variance is 1.12. The ratio is 1.16, close to the theoretical value for a Poisson distribution of 1.0. A formal chi-square test of goodness of fit
confirmed that the referent group data are consistent with a Poisson distribution of independent random "poor" psychological test scores ($p > 0.05$).

This Poisson distribution did not fit the study group distribution ($p < 0.001$). The study group mean is 1.28 and the variance is 1.96. The ratio of 1.53 suggests some "clumping" of these data which is observed particularly in those having four or more "poor" psychological test scores.

Thus there is some evidence that the study group has an increased risk of "poor" psychological testing. On average, each study group firefighter has "poor" scores on 1.28 tests. In contrast, each referent group firefighter has, on average, "poor" scores on 0.97 tests. Comparing these two rates of "poor" test scores gives a relative risk of 1.32 (95 per cent confidence interval (C.I.) 1.11–1.57; $p = 0.002$). In other words, the risk of firefighters from the study group having "poor" test results is 1.3 times greater than for the referent group. This pattern is consistent with a number of different hypotheses including chance, selection bias, information bias, and/or a toxic effect. The difference is primarily due to the twenty firefighters who have "poor" scores on four or more tests.

Grouping the neuropsychological tests into sub-categories of psychomotor tests (PASAT, Purdue pegboard, Rey Copy, Compreact and digit symbol) and memory tests (Word fluency, Rey Memory and digit span) gives a relative risk of 1.5 (95 per cent C.I. 1.33–1.71) and 1.05 (95 per cent C.I. 0.84–1.31) respectively. Further grouping of the tests into those that are timed (PASAT, Word fluency, Purdue pegboard, Compreact and digit symbol) and those not timed (Rey Copy, Rey Memory and digit span) gives relative risks of 1.6 (95 per cent C.I. 1.41–1.78) and 0.9 (95 per cent C.I. 0.72–1.17). The group difference is thus largely due to a difference in the psychomotor and timed tests sub-categories.

Examination of all data available for those firefighters with a NPI index of four or more does not reveal a common group characteristic. Factors considered include respiratory and dermatological exposure indices; alcohol intake; previous head injury; previous psychiatric illness; and other exposure to chemicals, including solvents. However the mean age (44.2 years) is greater than that of the total study group (38.6 years). The mean years of service for this sub-group is 18.4 years compared to 15.7 years for the total study group.
The results suggest a difference in distribution of the neuropsychological impairment index for the study group for Category III (mean = 1.5 cf mean = 1.2; p = 0.048), but not Category I, Category IV, or all four categories combined (p > 0.05 for 3 tests).

Table 21 compares the reported health problems of the study and referent groups for those firefighters with a NPI index of four or more.

Table 21: Health problems of firefighters with a neuropsychological impairment index of four or more

<table>
<thead>
<tr>
<th></th>
<th>Study</th>
<th>Referent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category I</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Category II</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Category III</td>
<td>8*</td>
<td>—</td>
</tr>
<tr>
<td>Category IV</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>other problems</td>
<td>5**</td>
<td>1</td>
</tr>
<tr>
<td>no problems</td>
<td>3***</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes:
Psychiatric categories I-IV are defined on p. 135.
* Includes one firefighter for whom no details of medical history were available, and whose spouse reports problems suggestive of Category III.
** "Other problems" includes other central nervous system, skin, gastro-intestinal etc problems.
*** Includes one firefighter whose spouse reports problems suggestive of Category II.

If information from spouses is included, 13 (65.0 per cent) of the study group with a NPI index of four or more meet the criteria of one of the psychiatric categories. Some of these firefighters have other coexisting health problems such as skin complaints or other central nervous system problems.

Possible explanations for the absence of reported problems are a lack of insight; denial; fear of possible job loss; or poor neuropsychological test specificity.

Six (9.5 per cent) of the study group firefighters who report health problems but no treatment, have a NPI index of four or more. This contrasts with four (5.5 per cent) firefighters from the "unsatisfactory" treatment group.
There is no association between the NPI index and respiratory or dermatological exposure at the fire or clean-up (p > 0.05 for 4 tests).

There is no association between a NPI index of less than four, or a NPI index of four or more and the psychiatric categories (p > 0.05 for 5 tests).

There is no correlation between the NPI index and laboratory sub-indices (p >0.05 for 4 tests), apart from a weak correlation with HAEM 2 (r = 0.14; p =0.030).

(2) General Health Questionnaire (GHQ) Score

General health questionnaire (GHQ) scores for the study group (median score =4) are significantly higher than for the referent group (median score = 2) (p =0.001). This indicates that there is a subjective level of distress among the study group.

Twenty-four (38.1 per cent) of the study group firefighters who report health problems but no treatment, have a GHQ score greater than four, compared to 46 (63.0 per cent) of the “unsatisfactory” treatment group.

GHQ score is not associated with respiratory or dermatological exposure at the fire or the clean-up (p > 0.05 for 4 tests).

Firefighters among the study group with psychiatric dysfunction have higher GHQ scores (median score = 6) than other firefighters (median score = 3) (p =0.001). GHQ scores for firefighters with Category II (median score = 8; p =0.052) or Category III (median score = 6; p = 0.027) are higher than those without such symptomatology. It is important to note however, that there are only nine firefighters with Category II. There is no association between GHQ score and the other psychiatric categories (p > 0.05 for 2 tests).

There is no association between GHQ score and ongoing skin problems (p > 0.05).

No correlation exists between the NPI index and GHQ score (p > 0.05).

Spouses’ Questionnaire

Although 86.5 per cent (N=180) of study group firefighters who were married or in a de facto relationship took a questionnaire, the
response rate was only 51.7 per cent (N=93). This represents an overall response rate of 44.7 per cent of all spouses, which is too low to allow other than tentative conclusions to be drawn from the data.

For the majority (64.5 per cent; N=60), there was agreement between the firefighter’s and spouse’s responses as to whether or not the fire has affected the firefighter’s health. Three spouses report that their partner has been affected and his response is “not affected”. There is no instance of a spouse disagreeing with a firefighter’s response of “affected”.

Half of the spouses (N=47) report more problems with their partner’s health than does the firefighter concerned. The number of firefighters who report more, or the same number of problems as their spouses are approximately equal.

There tends to be agreement for a general measure of enjoyment of life based on hobbies and interests (62.0 per cent; N=57). Twenty-five spouses rate their partner’s enjoyment of life as “less”, when the firefighter’s response is “more” or “about the same”.

Comments include:

“In my opinion, my husband appeared to suffer some effects of the ICI fire for about 1–2 years and appeared to improve after treatment. My husband appears to suffer no ill effects from the ICI fire now, but what could happen in the future?”

“I am very thankful that someone initially went to Dr Tizard to be treated. If it wasn’t for his treatments, I hate to think what our lives would be like now.”

“. . . Many of the problems are personality changes since ICI. It is noticeable to me and to others that knew him before the fire. But outsiders assessing the situation would just not be able to comprehend what we have gone through.”

“. . . The first year after ICI my husband had a terrible time with his short-term memory. I had to be responsible for everything that went on in his life.”

“. . . Generally we all seem to have learned to live with all this, but it is a worry—never knowing if he is going to get worse or better, always wondering if there is an underlying problem. There seems to be a lot of unanswered questions.”
"...Where once he had an easy-going nature and was placid, he is now very impatient with people as well as things that may go wrong, even little insignificant happenings. He is very quick to anger and can explode at the slightest thing upsetting him. He can't cope with more than one problem or event at any one time and has become very forgetful even with small matters and can usually only cope by writing everything down and making lists for everything he has to do."

"Memory problem causes arguments at times; is very annoying to live with and sometimes important things that should get done, don't. He can be very short-tempered with the children for no apparent reason. He gets moody and shuts himself away for hours at a time."

"I find my husband is like a child in remembering instructions. We go over and over them making most situations stressful. He does not remember things that have happened in past weeks etc. so that causes arguments."

"...My husband didn't have an arm chopped off, that would have been easy to diagnose. Instead he had complex mental and physical disorders. The only outward indication were spots on his hands and his legs... During this time—I've felt very isolated—the only information available to me was in the newspapers. Our own doctor 'didn't want to know' for fear of doing the wrong thing. I thought my husband was the only one suffering from mental disorders and as wives we were given very little information on what was wrong and what was being done to help our husbands."

REFERENCES


APPENDIX 1
The Health Status Questionnaire
HEALTH STATUS PROFILE OF
FIREFIGHTERS INVOLVED IN THE ICI FIRE
IN AUCKLAND IN DECEMBER 1984

ALL ANSWERS GIVEN WILL BE STRICTLY CONFIDENTIAL.
PLEASE DO NOT RECORD YOUR NAME ON THE ANSWER SHEETS.
Individuals will not be identified in any report based on the information provided.

Please answer the following questions.
When alternative answers are given, please tick the appropriate box.
If extra space is required, please continue your answer on the back of the appropriate page.

PERSONAL DETAILS

1. Station

2. Date of birth
EXPOSURE HISTORY

3. Did you attend the ICI fire on 21 December 1984?
   YES ☐  NO ☐  If NO, go to Q.16 page 7

4. For how long were you present at the fire?
   LESS THAN 1 HR ☐
   1 HR OR MORE BUT LESS THAN 4 HRS ☐
   4 HRS OR MORE BUT LESS THAN 8 HRS ☐
   8 HRS OR MORE ☐

5. What was your involvement at the fire?
   ...
   ...
   ...
   ...
   ...
   ...

6. Please indicate the location of that involvement on the map of the site on the following page. (Mark location with a cross X.)
FIRE APPLIANCE LOCATION PLAN

M.O.T. POLICE

BOWDEN RD

CLEMOW DRIVE

2 MARKED APPLIANCE STANDING BY

G.FDs

G.FDs

GABADOR PL

M.O.T.

2 MONITORS

4 LPD & 2 MONITORS

3 LPD & 1 MONITOR

A.H.I

I.C.I.

COMALCO

FIRE APPLIANCE LOCATION PLAN
fr: NZ FIRE SERVICE REPORT
JAN 1985 p.26
7. What protective clothing were you wearing on 21 December?

- NORMAL FIREFIGHTING GEAR THROUGHOUT [ ] go to Q.9
- CHEMICAL PROTECTIVE GEAR THROUGHOUT [ ] go to Q.9
- CHANGED FROM ONE TO THE OTHER [ ]

8. How long was it before you changed from normal firefighting gear to chemical protective gear?

- LESS THAN 1 HR [ ]
- 1 HR OR MORE BUT LESS THAN 4 HRS [ ]
- 4 HRS OR MORE [ ]

9. (a) Was breathing apparatus available for your use?

- YES [ ]
- NO [ ] If NO, go to Q.10

   If YES
   (b) Did you use breathing apparatus?

- YES, ALL THE TIME [ ]
- YES, SOME OF THE TIME [ ]
- NO [ ]
10. (a) Was any part of your clothing soaked by other than pure firefighting water?

<table>
<thead>
<tr>
<th>YES □</th>
<th>UNSURE □</th>
<th>NO □</th>
<th>If NO, go to Q. 11</th>
</tr>
</thead>
</table>

If YES or UNSURE,
(b) Describe what part(s) was soaked and with what liquid(s) (if known)

<table>
<thead>
<tr>
<th>Part of clothing</th>
<th>Liquids – describe (if known)</th>
</tr>
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<tr>
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</tbody>
</table>

11. (a) Did your skin, mouth or eyes come into direct contact with liquid(s) other than pure firefighting water?

<table>
<thead>
<tr>
<th>YES □</th>
<th>UNSURE □</th>
<th>NO □</th>
<th>If NO, go to Q. 12</th>
</tr>
</thead>
</table>

If YES or UNSURE,
(b) Indicate what the liquid was (if known) and what part(s) of you was in contact with the liquid(s).

<table>
<thead>
<tr>
<th>Part of body</th>
<th>Liquids – describe (if known)</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
12. (a) Were you decontaminated at the site?

YES ☐  NO ☐  If NO, go to Q. 15.

If YES,
(b) How were you decontaminated?

..................................................................................................................................................
..................................................................................................................................................

13. (a) Did you put contaminated clothing back on after you had been decontaminated?

YES ☐  NO ☐  If NO, go to Q. 14

If YES,
(b) Did you have any choice in which clothes you put on?

YES ☐  NO ☐

14. What was the approximate time interval between your contact with the liquids you have described and your decontamination?

LESS THAN 30 MIN ☐

30 MIN OR MORE BUT LESS THAN 4 HRS ☐

4 HRS OR MORE ☐

15. Did you inhale any fumes?

YES ☐  UNSURE ☐  NO ☐
16. (a) Were you involved at the scene of the fire in the days following the fire?

YES [ ]

NO [ ] If NO, go to Q.24 page 10

If YES,

(b) What was your involvement?

...........................................................................................................................................................................................
...........................................................................................................................................................................................
...........................................................................................................................................................................................
...........................................................................................................................................................................................

17. Overall, for how long were you present at the scene in the days following the fire?

LESS THAN 1 HR [ ]

1 HR OR MORE BUT LESS THAN 4 HRS [ ]

4 HRS OR MORE BUT LESS THAN 8 HRS [ ]

8 HRS OR MORE [ ]

18. What protective clothing were you wearing in the days following the fire?

NORMAL FIREFIGHTING GEAR THROUGHOUT [ ]

CHEMICAL PROTECTIVE GEAR THROUGHOUT [ ]

CHANGED FROM ONE TO THE OTHER [ ]
19. (a) Was breathing apparatus available for your use?

   YES □       NO □  If NO, go to Q. 20

   If YES,
   (b) Did you use breathing apparatus?

   YES, ALL THE TIME □
   YES, SOME OF THE TIME □
   NO □

20. (a) Was any part of your clothing soaked in the days following the fire?

   YES □       UNSURE □       NO □  If UNSURE or NO,
   go to Q. 21

   If YES,
   (b) Describe what part(s) was soaked and with what liquid(s) (if known)

   Part of clothing          Liquids – describe (if known)

   ...........................................................................................................
   If not known (tick) □

   ...........................................................................................................
   □

   ...........................................................................................................
   □

   ...........................................................................................................
   □

   ...........................................................................................................
   □

   ...........................................................................................................
   □

   ...........................................................................................................
   □
21. (a) During the clean-up process, did your skin, mouth or eyes come into direct contact with liquid(s)?

YES □  UNSURE □  NO □  If NO, go to Q.22

If YES or UNSURE,

(b) Describe what the liquid was (if known) and what part(s) of you was in contact with the liquid(s).

<table>
<thead>
<tr>
<th>Part of body</th>
<th>Liquids – describe (if known)</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

22. (a) Were you decontaminated?

YES □  NO □  If NO, go to Q.23

If YES,

(b) How were you decontaminated?

..............................................................................................................................
..............................................................................................................................
..............................................................................................................................
..............................................................................................................................
..............................................................................................................................

(c) What was the approximate time interval between your contact with liquid(s) and your decontamination?

LESS THAN 30 MIN □

30 MIN OR MORE BUT LESS THAN 4 HRS □

4 HRS OR MORE □
23. Did you inhale fumes?

YES □  UNSURE □  NO □

24. Away from the scene of the fire, were you involved in handling or cleaning contaminated clothing and/or equipment from the ICI fire?

YES □  NO □  If NO, go to Q.27 page 11

25. For how long were you handling or cleaning contaminated clothing and/or equipment?

LESS THAN 30 MIN □
30 MIN OR MORE BUT LESS THAN 4 HRS □
4 HRS OR MORE □

26. (a) Did you take any precautions during the handling or cleaning of the contaminated clothing and/or equipment?

YES □  NO □  If NO, go to Q.27

If YES,
(b) Please describe:

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
27. (a) Do you believe that you personally were exposed to chemicals as a result of your involvement in the ICI fire?

\[ \text{YES } \square \quad \text{NO } \square \quad \text{If NO, go to Q.28} \]

If YES,
(b) Which chemicals do you believe you were exposed to?

........................................................

........................................................

........................................................

........................................................If not known (tick) \[ \square \]

28. (a) Have you been involved in any chemical fires since the ICI fire?

\[ \text{YES } \square \quad \text{NO } \square \quad \text{If NO, go to Q.29 page 13} \]

If YES,
(b) Fill in the details for each fire below.

\[ \text{When (month & year)} \quad \text{Where (site)} \]

1 .......................................................Fire at ....................................................

List chemicals involved (if known): .................................................................

........................................................Chemicals not known (tick) \[ \square \]

Describe protective clothing worn: .................................................................

........................................................Breathing apparatus used? \[ \text{YES } \square \quad \text{NO } \square \]

If no further chemical fires, go to Q.29 page 13.
When (month & year)  Where (site)  
2 ........................................19 ......................................................
Fire at ......................................................................................
List chemicals involved (if known): ........................................................................
........................................................................................................................................
Chemicals not known (tick) □
Describe protective clothing worn: ............................................................................
........................................................................................................................................
Breathing apparatus used? YES □ NO □
If no further chemical fires, go to Q.29 page 13.

When (month & year)  Where (site)  
3 ........................................19 ......................................................
Fire at ......................................................................................
List chemicals involved (if known): ........................................................................
........................................................................................................................................
Chemicals not known (tick) □
Describe protective clothing worn: ............................................................................
........................................................................................................................................
Breathing apparatus used? YES □ NO □
If no further chemical fires, go to Q.29 page 13.

When (month & year)  Where (site)  
4 ........................................19 ......................................................
Fire at ......................................................................................
List chemicals involved (if known): ........................................................................
........................................................................................................................................
Chemicals not known (tick) □
Describe protective clothing worn: ............................................................................
........................................................................................................................................
Breathing apparatus used? YES □ NO □

If you run out of room, tick box □ and continue on the back of this page.

If no further chemical fires, go to Q.29 page 13.
MEDICAL HISTORY

29. (a) Did you receive first aid at the ICI fire site on 21 December 1984?
   YES []  NO []  I WAS NOT PRESENT AT FIRE SITE []

   If YES,
   (b) Please describe:

   ........................................................................................................

30. (a) Did you attend an Accident & Emergency department within 2-3 days of the fire?
   YES []  NO []  I WAS NOT PRESENT AT FIRE SITE []

   If YES,
   (b) Give name of hospital ............................................................................

   (c) What was the problem?

   ........................................................................................................

   (d) What was the treatment you received?

   ........................................................................................................

   (e) Were you given any tests?
   YES []  NO []

   If YES,
   (f) Indicate which tests

   BLOOD TEST(S) []  LUNG TEST(S) []

   CHEST X-RAY []  HEART TRACING (ECG) []

   OTHER (Specify) ........................................................................

31. (a) Do you consider that your general health has been affected as a result of the ICI fire?
   YES []  UNSURE []  NO []  If NO, go to Q.36 page 27

   If YES or UNSURE,
   (b) Give details for each problem with your health (mental & physical) on a separate page as follows.
Problem 1

1. Description of problem ........................................

2. When did it start?  month .................. 19 .......
   When did it finish?  month .................. 19 .......
   If ongoing (tick) □

3. Does the problem come & go, or is it constant?
   COMES & GOES □       CONSTANT □

4. If the problem is ongoing, overall do you consider that it has
   IMPROVED □       GOT WORSE □       STAYED THE SAME □

5. (a) Does anything make the problem better?
   YES □       UNSURE □       NO □

   If YES,
   (b) What? ..............................................................

6. (a) Does anything make the problem worse?
   YES □       UNSURE □       NO □

   If YES,
   (b) What? ..............................................................

7. (a) Did you ever have a similar (or the same) problem before the ICI fire?
   YES □       UNSURE □       NO □

   If YES,
   (b) Approximately when did you have it? ........................................
   (c) For how long did you have it? ..............................................

Give further comments if you wish.

..................................................................................
..................................................................................
..................................................................................

Give details for the second problem on the next page. If no further problems, go to Q.32 page 22.
Problem 2

1. Description of problem

2. When did it start? month 19
   When did it finish? month 19
   If ongoing (tick) 

3. Does the problem come & go, or is it constant?
   COMES & GOES □ CONSTANT □

4. If the problem is ongoing, overall do you consider that it has
   IMPROVED □ GOT WORSE □ STAYED THE SAME □

5. (a) Does anything make the problem better?
   YES □ UNSURE □ NO □
   If YES, (b) What?

6. (a) Does anything make the problem worse?
   YES □ UNSURE □ NO □
   If YES, (b) What?

7. (a) Did you ever have a similar (or the same) problem before the ICI fire?
   YES □ UNSURE □ NO □
   If YES, (b) Approximately when did you have it?
   (c) For how long did you have it?

Give further comments if you wish.

Give details for the third problem on the next page. If no further problems, go to Q.32 page 22.
Problem 3

1. Description of problem

2. When did it start?  month ............. 19 .......
   When did it finish?  month ............. 19 .......
   If ongoing (tick) ☐

3. Does the problem come & go, or is it constant?
   COMES & GOES ☐   CONSTANT ☐

4. If the problem is ongoing, overall do you consider that it has
   IMPROVED ☐   GOT WORSE ☐   STAYED THE SAME ☐

5. (a) Does anything make the problem better?
   YES ☐   UNSURE ☐   NO ☐
   If YES,
   (b) What? .................................................................

6. (a) Does anything make the problem worse?
   YES ☐   UNSURE ☐   NO ☐
   If YES,
   (b) What? .................................................................

7. (a) Did you ever have a similar (or the same) problem before the ICI fire?
   YES ☐   UNSURE ☐   NO ☐
   If YES,
   (b) Approximately when did you have it? ...........................................
   (c) For how long did you have it? ...................................................

Give further comments if you wish.

......................................................................................................................
......................................................................................................................
......................................................................................................................

Give details for the fourth problem on the next page. If no further problems, go to Q.32 page 22.
Problem 4

1. Description of problem

2. When did it start?  month .................. 19 ........
   When did it finish?  month .................. 19 ........
   If ongoing (tick) ☐

3. Does the problem come & go, or is it constant?
   COMES & GOES ☐  CONSTANT ☐

4. If the problem is ongoing, overall do you consider that it has
   IMPROVED ☐  GOT WORSE ☐  STAYED THE SAME ☐

5. (a) Does anything make the problem better?
   YES ☐  UNSURE ☐  NO ☐
   If YES,  (b) What? .................................................................

6. (a) Does anything make the problem worse?
   YES ☐  UNSURE ☐  NO ☐
   If YES,  (b) What? .................................................................

7. (a) Did you ever have a similar (or the same) problem before the ICI fire?
   YES ☐  UNSURE ☐  NO ☐
   If YES,  (b) Approximately when did you have it? ....................
   (c) For how long did you have it? ...........................................

Give further comments if you wish.

Give details for the fifth problem on the next page. If no further problems, go to Q.32 page 22.
Problem 5

1. Description of problem .............................................................................................................................................

2. When did it start?  month ..........  19 .....  
   When did it finish?  month ..........  19 .....  
   If ongoing (tick) □

3. Does the problem come & go, or is it constant?  
   COMES & GOES □  CONSTANT □

4. If the problem is ongoing, overall do you consider that it has  
   IMPROVED □  GOT WORSE □  STAYED THE SAME □

5. (a) Does anything make the problem better?  
       YES □  UNSURE □  NO □

   If YES,  
       (b) What? .............................................................................................................................

6. (a) Does anything make the problem worse?  
       YES □  UNSURE □  NO □

   If YES,  
       (b) What? .............................................................................................................................

7. (a) Did you ever have a similar (or the same) problem before the ICI fire?  
       YES □  UNSURE □  NO □

   If YES,  
       (b) Approximately when did you have it? ..............................................................................
       (c) For how long did you have it? .........................................................................................

Give further comments if you wish.
...........................................................................................................................................................................
...........................................................................................................................................................................
...........................................................................................................................................................................

Give details for the sixth problem on the next page. If no further problems, go to Q.32 page 22.
Problem 6

1. Description of problem

2. When did it start? month........... 19.............. When did it finish? month........... 19..............

3. Does the problem come & go; or is it constant?

4. If the problem is ongoing, overall do you consider that it has improved, got worse, stayed the same?

5. (a) Does anything make the problem better?

6. (a) Does anything make the problem worse?

7. (a) Did you ever have a similar (or the same) problem before the ICI fire?

Give further comments if you wish.

Give details for the seventh problem on the next page. If no further problems, go to Q. 32 page 22.
Problem 7

1. Description of problem

2. When did it start? month .......... 19 ....
When did it finish? month .......... 19 ....
If ongoing (tick) ☐

3. Does the problem come & go, or is it constant?
   COMES & GOES ☐   CONSTANT ☐

4. If the problem is ongoing, overall do you consider that it has
   IMPROVED ☐   GOT WORSE ☐   STAYED THE SAME ☐

5. (a) Does anything make the problem better?
   YES ☐   UNSURE ☐   NO ☐
   If YES, (b) What?

6. (a) Does anything make the problem worse?
   YES ☐   UNSURE ☐   NO ☐
   If YES, (b) What?

7. (a) Did you ever have a similar (or the same) problem before the ICI fire?
   YES ☐   UNSURE ☐   NO ☐
   If YES, (b) Approximately when did you have it?
   (c) For how long did you have it?

Give further comments if you wish.

Give details for the eighth problem on the next page. If no further problems, go to Q. 32 page 22.
Problem 8

1. Description of problem

2. When did it start? month.........................19..............
   When did it finish? month.........................19..............
   If ongoing (tick) ■

3. Does the problem come & go, or is it constant? COMES & GOES [ ] CONSTANT [ ]

4. If the problem is ongoing, overall do you consider that it has improved [ ], stayed the same [ ], got worse [ ], or didn't change [ ]

5. (a) Does anything make the problem better? YES [ ] NO [ ] UNSURE [ ]
   (b) What? ..............................................

6. (a) Does anything make the problem worse? YES [ ] NO [ ] UNSURE [ ]
   (b) What? ..............................................

7. (a) Did you ever have a similar (or the same) problem before the ICI fire? YES [ ] NO [ ] UNSURE [ ]
   (b) Approximately when did you have it? ...
   (c) For how long did you have it? ...

Give further comments if you wish.

If you run out of room, tick box □ and continue on the back of this page.

If no further problem(s), go to Q 32, page 22.
32. Overall, how have the problems with your health affected you?

33. (a) Have you had (or are you receiving) treatment?

(TREATMENT includes for example counselling, diet, homeopathy, antibiotics, hyperbaric oxygen, vitamins, acupuncture, minerals, chiropractic, colonic irrigation etc.)

YES ☐ NO ☐ If NO, go to Q.34 page 25.

If YES,
(b) Please fill in the details for each treatment

Treatment 1

List the problem(s) for which the treatment was given.

What was the treatment?

When did it start? month.............. 19........
When did it finish? month.............. 19........
If ongoing (tick) ☐

Name of person giving treatment .................................................................

How would you rate the treatment?

SATISFACTORY ☐ UNSATISFACTORY ☐

If UNSATISFACTORY, why?

If no further treatment, go to Q.34 page 25.
Treatment 2

List the problem(s) for which the treatment was given.

What was the treatment?

When did it start? month ............. 19 ..........
When did it finish? month ............. 19 ..........
If ongoing (tick) □

Name of person giving treatment ........................................................................

How would you rate the treatment?
SATISFACTORY □ UNSATISFACTORY □

If UNSATISFACTORY, why?

If no further treatment, go to Q.34 page 25.

Treatment 3

List the problem(s) for which the treatment was given.

What was the treatment?

When did it start? month ............. 19 ..........
When did it finish? month ............. 19 ..........
If ongoing (tick) □

Name of person giving treatment ........................................................................

How would you rate the treatment?
SATISFACTORY □ UNSATISFACTORY □

If UNSATISFACTORY, why?

If no further treatment, go to Q.34 page 25.
Treatment 4

List the problem(s) for which the treatment was given.

What was the treatment?

When did it start?    month................... 19.........
When did it finish?  month................... 19.........
If ongoing (tick)    

Name of person giving treatment

How would you rate the treatment?

SATISFACTORY    UNSATISFACTORY

If UNSATISFACTORY, why?

If no further treatment, go to Q.34 page 25.

Treatment 5

List the problem(s) for which the treatment was given.

What was the treatment?

When did it start?    month................... 19.........
When did it finish?  month................... 19.........
If ongoing (tick)    

Name of person giving treatment

How would you rate the treatment?

SATISFACTORY    UNSATISFACTORY

If UNSATISFACTORY, why?

If you run out of room, tick box    and continue on the back of this page.
If no further treatment, go to Q.34 page 25.
34. (a) Have you had a consultation or assessment which did not result in any treatment? (TREATMENT as defined in Q.33)

   YES □ NO □ If NO, go to Q.35

if YES,
(b) Please fill in the details for each consultation or assessment

<table>
<thead>
<tr>
<th>Name of person seen</th>
<th>When seen (year)</th>
<th>Reason for consultation eg ACC, second opinion, other (please specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

35. (a) Have you tried treating yourself?

   YES □ NO □ If NO, go to Q.36 page 27

if YES,
(b) Please give details for each self treatment

Self Treatment 1

List the problem(s) for which you treated yourself.

What was the treatment?

When did you start? month .................... 19 ...........
When did you finish? month .................... 19 ...........
If ongoing (tick) □

How would you rate the treatment?

Satisfactory □ Unsatisfactory □

if UNSATISFACTORY, why?

If no further self treatment, go to Q.36 page 27.
Self Treatment 2

List the problem(s) for which you treated yourself.
..........................................................................................................................................................

What was the treatment?
..........................................................................................................................................................

When did you start?  month .......................  19 ...........
When did you finish?  month .......................  19 ...........
If ongoing (tick) □

How would you rate the treatment?
Satisfactory □  Unsatisfactory □

If unsatisfactory, why?
..........................................................................................................................................................

If no further self treatment, go to Q. 36 page 27.

Self Treatment 3

List the problem(s) for which you treated yourself.
..........................................................................................................................................................

What was the treatment?
..........................................................................................................................................................

When did you start?  month .......................  19 ...........
When did you finish?  month .......................  19 ...........
If ongoing (tick) □

How would you rate the treatment?
Satisfactory □  Unsatisfactory □

If unsatisfactory, why?
..........................................................................................................................................................

If you run out of room, tick box □ and continue on the back of this page.
If no further self treatment, go to Q. 36 page 27.
36. (a) Have you ever been admitted to hospital at any time in your life for any reason?

Yes □

No □ If NO, go to Q.37

If YES,
(b) For each stay in hospital, please list:

[If admitted in 1984, please indicate BEFORE or AFTER (whether it was before or after the ICI fire on 27 December)]

<table>
<thead>
<tr>
<th>Year</th>
<th>Reason for admission</th>
<th>Approximate length of stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
<tr>
<td>19</td>
<td>..........................</td>
<td>BEFORE □ AFTER □</td>
</tr>
</tbody>
</table>

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37. Have you ever had any of the problems on this list which have not involved hospital admission?

Circle if YES, and tick a box to show whether it was BEFORE, AFTER or BEFORE & AFTER the ICI fire on 21 December 1984.

<table>
<thead>
<tr>
<th>CIRCLE if YES</th>
<th>BEFORE</th>
<th>AFTER</th>
<th>BEFORE &amp; AFTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin rash eg eczema, dermatitis</td>
<td>1</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Psoriasis/severe acne</td>
<td>2</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Asthma</td>
<td>3</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Bronchitis/pneumonia</td>
<td>4</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Heart problem</td>
<td>5</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>High blood pressure</td>
<td>6</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Stomach ulcer</td>
<td>7</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Diabetes</td>
<td>8</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Liver problem</td>
<td>9</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Bowel problem</td>
<td>10</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Bladder/prostate problem/difficulty passing urine</td>
<td>11</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Arthritis/rheumatic problem</td>
<td>12</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Back problem</td>
<td>13</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Stroke</td>
<td>14</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Depression/mood problem</td>
<td>15</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Anxiety/nervousness</td>
<td>16</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Sleep problem</td>
<td>17</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Memory/concentration problem</td>
<td>18</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Conditions</td>
<td>CIRCLE if YES</td>
<td>BEFORE</td>
<td>AFTER</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Balance/coordination problem</td>
<td>19</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Impotence/sexual difficulties</td>
<td>20</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>More than 1 headache a week</td>
<td>21</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Migraine</td>
<td>22</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Epilepsy/fits/blackouts</td>
<td>23</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Head injury/concussion</td>
<td>24</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>25</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Other cancer(s)</td>
<td></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Specify:</td>
<td></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Other problem(s)</td>
<td></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Specify:</td>
<td></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
38. (a) Are you allergic to anything?

YES □   NO □  If NO, go to Q.39

(a) If YES,
(b) Please give details and approximate year of onset

<table>
<thead>
<tr>
<th>Year of onset</th>
<th>Details of allergy</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>.................................</td>
</tr>
<tr>
<td>19</td>
<td>.................................</td>
</tr>
<tr>
<td>19</td>
<td>.................................</td>
</tr>
<tr>
<td>19</td>
<td>.................................</td>
</tr>
<tr>
<td>19</td>
<td>.................................</td>
</tr>
</tbody>
</table>

39. Please indicate the outcome of every pregnancy your sexual partner(s) has had. For multiple births eg twins, list each child on a separate line.

(If no pregnancies tick box □ and go to Q.40 page 34.)

Pregnancy 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Live birth</th>
<th>Still birth</th>
<th>Miscarriage</th>
<th>Termination</th>
<th>Approximate age of mother at the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>............................. yrs</td>
</tr>
</tbody>
</table>

Did this child have birth defects?

YES □  UNSURE □  NO □

If YES, please give details of the defect(s)

.................................

If no other pregnancies, go to Q.40 page 34.
### Pregnancy 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Live birth</th>
<th>Still birth</th>
<th>Miscarriage</th>
<th>Termination</th>
<th>Approximate age of mother at the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19 yrs</td>
</tr>
</tbody>
</table>

Did this child have birth defects?

<table>
<thead>
<tr>
<th>YES</th>
<th>UNSURE</th>
<th>NO</th>
</tr>
</thead>
</table>

If YES, Please give details of the defect(s)

If no other pregnancies, go to Q.40 page 34.

### Pregnancy 3

<table>
<thead>
<tr>
<th>Year</th>
<th>Live birth</th>
<th>Still birth</th>
<th>Miscarriage</th>
<th>Termination</th>
<th>Approximate age of mother at the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19 yrs</td>
</tr>
</tbody>
</table>

Did this child have birth defects?

<table>
<thead>
<tr>
<th>YES</th>
<th>UNSURE</th>
<th>NO</th>
</tr>
</thead>
</table>

If YES, Please give details of the defect(s)

If no other pregnancies, go to Q.40 page 34.
### Pregnancy 4

<table>
<thead>
<tr>
<th>Year</th>
<th>Live birth</th>
<th>Still birth</th>
<th>Miscarriage</th>
<th>Termination</th>
<th>Approximate age of mother at the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Did this child have birth defects?**

- **YES** □
- **UNSURE** □
- **NO** □

**If YES,** please give details of the defect(s)

- ...
- ...

**If no other pregnancies, go to Q.40 page 34.**

### Pregnancy 5

<table>
<thead>
<tr>
<th>Year</th>
<th>Live birth</th>
<th>Still birth</th>
<th>Miscarriage</th>
<th>Termination</th>
<th>Approximate age of mother at the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Did this child have birth defects?**

- **YES** □
- **UNSURE** □
- **NO** □

**If YES,** please give details of the defect(s)

- ...
- ...

**If no other pregnancies, go to Q.40 page 34.**
Pregnancy 6

<table>
<thead>
<tr>
<th>Year</th>
<th>Live birth</th>
<th>Still birth</th>
<th>Miscarriage</th>
<th>Termination</th>
<th>Age of mother at the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Did this child have birth defects?

- [ ] Yes
- [ ] Unsure
- [ ] No

If YES, please give details of the defect(s):

If you run out of room, tick box [ ] and continue on the back of this page.

If no other pregnancies, go to Q.40 page 34.

Pregnancy 7

<table>
<thead>
<tr>
<th>Year</th>
<th>Live birth</th>
<th>Still birth</th>
<th>Miscarriage</th>
<th>Termination</th>
<th>Age of mother at the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Did this child have birth defects?

- [ ] Yes
- [ ] Unsure
- [ ] No

If YES, please give details of the defect(s):

If you run out of room, tick box [ ] and continue on the back of this page.

If no other pregnancies, go to Q.40 page 34.
40. (a) Have you been medically boarded?

YES □  NO □  If YES, go to Q.41

If NO,

(b) Do you think that medical boarding is a possibility in your case?

DEFINITELY YES □
PROBABLY YES □
UNSURE □
UNLIKELY □
DEFINITELY NO □

41. Have you had any care or counselling from the Fire Service occupational health service?

YES □  NO □

42. Any comments about the Fire Service occupational health service?

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
43. (a) Are you currently on any medicines or pills prescribed by a doctor?

YES ☐  NO ☐  If NO, go to Q.44 page 36.

If YES,
(b) Please fill in the details for each of your medicines or pills

1. Name of medicine/pill .................................................................
   How long has it been prescribed for you? ......................................
   What problem was the medicine or pill prescribed for? ..................

   If no other medicines/pills, go to Q.44 page 36

2. Name of medicine/pill .................................................................
   How long has it been prescribed for you? ......................................
   What problem was the medicine or pill prescribed for? ............... 

   If no other medicines/pills, go to Q.44 page 36.

3. Name of medicine/pill .................................................................
   How long has it been prescribed for you? ......................................
   What problem was the medicine or pill prescribed for? ............... 

   If no other medicines/pills, go to Q.44 page 36.

4. Name of medicine/pill .................................................................
   How long has it been prescribed for you? ......................................
   What problem was the medicine or pill prescribed for? ............... 

   If no other medicines/pills, go to Q.44 page 36.

5. Name of medicine/pill .................................................................
   How long has it been prescribed for you? ......................................
   What problem was the medicine or pill prescribed for? ............... 

   If no other medicines/pills, go to Q.44 page 36.
44. In the last 3 months, how often have you used pills to help you sleep?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEVER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2 TIMES IN 3 MTHS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABOUT ONCE A MONTH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

45. (a) In the last 3 months, have you taken any medicines or pills NOT prescribed by a doctor at least once a week? (eg painkillers, laxatives, QuickEze)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If YES, (b) Please list:

1. 
2. 
3. 
4. 
5. 

If NO, go to Q.46
SOCIAL AND OCCUPATIONAL HISTORY

46. Marital situation: Which of these applies to you now?

NEVER MARRIED  □  MARRIED OR DE FACTO  □
WIDOWED  □  SEPARATED  □
DIVORCED  □

47. (a) Have there been any changes in your marital situation since joining the Fire Service?

YES  □  NO  □  If NO, go to Q.48

If YES,
(b) Please give details:

<table>
<thead>
<tr>
<th>Year of change</th>
<th>What change? (eg married, separated, lived with partner)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 ........</td>
<td>........................................................................</td>
</tr>
<tr>
<td>19 ........</td>
<td>........................................................................</td>
</tr>
<tr>
<td>19 ........</td>
<td>........................................................................</td>
</tr>
</tbody>
</table>
48. (a) Have you moved house in the last 5 years?

     YES ☐  NO ☐  If NO, go to Q.49

   If YES,
   (b) Please give the year of each move

1.  19 ............
2.  19 ............
3.  19 ............
4.  19 ............
5.  19 ............

49. (a) Since you joined the Fire Service, have any of your close friends died?

     YES ☐  NO ☐  If NO, go to Q.50

   If YES,
   (b) Please give the year of death for each friend

     First friend  19 ............
     Second friend 19 ............
     Third friend  19 ............
50. (a) Since you joined the Fire Service, have any of your family members died?

YES □ NO □ If NO, go to Q.51

If YES,
(b) Please give these details for each death

<table>
<thead>
<tr>
<th>Relationship to you (e.g. mother, wife etc)</th>
<th>Year of death</th>
<th>Lived with you?</th>
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<tbody>
<tr>
<td></td>
<td>19 ...........</td>
<td>YES □ NO □</td>
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<td>YES □ NO □</td>
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<td>19 ...........</td>
<td>YES □ NO □</td>
</tr>
<tr>
<td></td>
<td>19 ...........</td>
<td>YES □ NO □</td>
</tr>
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</table>

51. Thinking about all aspects of your life, please list the most stressful event(s) since joining the Fire Service, and indicate the approximate date of each event.

- Month ................ 19 .............. to month ................ 19 .............. If ongoing (tick) □
- Month ................ 19 .............. to month ................ 19 .............. If ongoing (tick) □
- Month ................ 19 .............. to month ................ 19 .............. If ongoing (tick) □

Give further comment if you wish.

- ...........................................................................
- ...........................................................................
- ...........................................................................
- ...........................................................................
- ...........................................................................
- ...........................................................................

208
52. Please list your main hobbies and interests, and say whether you are more or less involved in them now than in 1984:

(If no hobbies or interests tick box □ and go to Q. 57 page 41.)

**Tick the one which best describes you**

<table>
<thead>
<tr>
<th>Name of interest</th>
<th>Since 1984:</th>
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<tr>
<td></td>
<td>Now do it more</td>
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</table>

53. Looking at the changes to your hobbies and interests, would you say:

*(Tick one box)*

- I NOW ENJOY LIFE MORE □
- I NOW ENJOY LIFE ABOUT THE SAME □
- I NOW ENJOY LIFE LESS □
54. If you now **DO LESS** or have **GIVEN UP** on some interests or hobbies since 1984, answer this question.

If you now **DO MORE** or the **SAME**, go to Q.55.

<table>
<thead>
<tr>
<th>Name of interest</th>
<th>Reason for <strong>DOING LESS</strong> or <strong>GIVING UP</strong></th>
</tr>
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</table>

55. Do any of your hobbies or interests involve the use of solvents or glues?

- YES ☐
- NO ☐

56. Do any of your hobbies or interests involve the use of lead?

- YES ☐
- NO ☐

57. What is your age? .............................................

58. In what year did you join the Fire Service? 19............

59. For how many years have you been in the Fire Service?

   Number of years = .....................
60. (a) Thinking of the time between leaving school and joining the Fire Service, did you have any full or part-time permanent job(s)?  

(PERMANENT JOB means lasting 3 months or more)  

| YES ☐ | NO ☐ If NO, go to Q.61 |

If YES,  
(b) Give details for each job:  

<table>
<thead>
<tr>
<th>Job title</th>
<th>Nature of the work</th>
<th>Average number of hours worked a week</th>
</tr>
</thead>
<tbody>
<tr>
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<td>hrs=...............................</td>
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<tr>
<td></td>
<td></td>
<td>hrs=...............................</td>
</tr>
</tbody>
</table>

61. (a) Since joining the Fire Service, have you had another source of paid employment at any time?  

| YES ☐ | NO ☐ If NO, go to Q.62 |

If YES,  
(b) Give details for each job:  

<table>
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<tr>
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<th>Nature of the work</th>
<th>Average number of hours worked a week</th>
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</thead>
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<td>hrs=...............................</td>
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<td></td>
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<td>hrs=...............................</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hrs=...............................</td>
</tr>
</tbody>
</table>

211
62. (a) Has the pattern of your time off work changed as a result of illness or accident since the ICI fire?

   YES [ ]  NO [ ] If NO, go to Q.63

   If YES,
   (b) How has it changed?

   A LOT MORE TIME OFF WORK [ ]
   A LITTLE MORE TIME OFF WORK [ ]
   A LITTLE LESS TIME OFF WORK [ ]
   A LOT LESS TIME OFF WORK [ ]

63. Do you currently smoke cigarettes?

   YES [ ]  NO [ ] If NO, go to Q.65

64. On average, how many cigarettes do you currently smoke a day?

   LESS THAN 10 [ ]  10-20 [ ]
   20-40 [ ]  MORE THAN 40 [ ]

   Now go to Q.66, page 44.

65. (a) Are you an ex-smoker?

   YES [ ]  NO [ ] If NO, go to Q.66

   If YES,
   (b) In which year did you stop smoking?  19 ............

   (c) Before you tried to give up smoking, on average how many cigarettes did you smoke a day?

   LESS THAN 10 [ ]  10-20 [ ]
   20-40 [ ]  MORE THAN 40 [ ]
66. (a) Do you currently drink alcohol?
   YES ☐ NO ☐ If NO, go to Q.67

   If YES,
   (b) Over the last 6 months, on how many days of the week (on average) did you drink alcohol?

   LESS THAN 1 DAY A WEEK ☐ 1-3 DAYS A WEEK ☐
   4-6 DAYS A WEEK ☐ EVERYDAY ☐

   (c) Over the last 6 months, what did you usually drink? (Tick all that apply)

   BEER ☐ WINE ☐ SPIRITS/LIQUERS ☐

67. (a) Since you joined the Fire Service, has the amount of your alcohol consumption changed?
   YES ☐ NO ☐ If NO, go to Q.68

   If YES,
   (b) Please indicate how your drinking has changed, and when the change(s) occurred?

   year 19 .......... STOPPED ☐ REDUCED ☐ INCREASED ☐ STARTED ☐
   year 19 .......... STOPPED ☐ REDUCED ☐ INCREASED ☐ STARTED ☐
   year 19 .......... STOPPED ☐ REDUCED ☐ INCREASED ☐ STARTED ☐

   213
68. Do you wish to see the committee to discuss any concerns about your involvement in the ICI fire?

YES ☐

NO ☐

69. Please give any further information or comments which you think are relevant to this study.

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Thank you for your cooperation.
APPENDIX 2

The Effect of Selection Bias on
The Risk of “Poor” Neuropsychological Test Results

THE EFFECT OF A KNOWN BIAS IN WELLINGTON

Two examples of the effect on the risk of “poor” neuropsychological testing if the eight medically boarded individuals in Wellington who did not participate had done so and had scored “poor” results, are shown below.

(1) The Wellington distribution would be increased by eight. Fitting these eight individuals into the categories of 2, 3, 4, or 5 “poor” test scores in the same proportion as observed for the 217 who were seen gives five more scoring 2, two more scoring 3, and one more scoring 4 “poor” scores (rounding to the nearest integer). Thus there would have been a total of 230 “poor” scores in Wellington, giving a rate of 230/225 = 1.02. Comparing the two rates of “poor” scores gives a relative risk of 1.25 (1.28/1.02), a decrease from the 1.32 observed.

(2) The four medically boarded individuals who were tested in Wellington scored 0, 2, 4, and 4. If it is assumed that the further eight who are boarded would have scored similarly, then the relative risk would also decrease to 1.25.

THE EFFECT OF A POSSIBLE BIAS IN BOTH WELLINGTON AND AUCKLAND

A further way to look at the effect of bias is to simulate a result of a combined “healthy worker” effect in Wellington (i.e., the unhealthy did not participate) and Auckland (i.e., the healthy did not participate). If it is assumed that twenty eligible individuals in each place did not participate, and that the twenty in Auckland scored 0 or 1 (in the proportions observed in Auckland) and that the twenty in Wellington scored 2, 3, 4 or 5 (in the proportions observed in Wellington), then the rate of “poor” scores becomes 1.22 (320/263) in Auckland and 1.09 (259/237) in Wellington. This gives a relative risk of 1.11.

These simulations show that the effect of the possible selection bias would be to inflate the underlying relative risk. In other words is is possible that the real relative risk would be less than the 1.32 observed.
APPENDIX 3
Statistical Details of Analyses and Comparisons for Questionnaire Data

<table>
<thead>
<tr>
<th>Variable(s)</th>
<th>Test(*)</th>
<th>Value</th>
<th>P</th>
<th>RR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analyses within referent group:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age and:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>years of service</td>
<td>r</td>
<td>0.80</td>
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<td>Chemical fire(s) Y/N by:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>health problem(s) Y/N</td>
<td>C(1)</td>
<td>4.61</td>
<td>0.032</td>
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<td><strong>Analyses within study group:</strong></td>
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<tr>
<td>Age and:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>years of service</td>
<td>r</td>
<td>0.79</td>
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<td>Age by:</td>
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<td>health problem(s) Y/N</td>
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<td>0.59</td>
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<td>Psychiatric dysfunction Y/N by:</td>
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<td></td>
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<td>W</td>
<td>1.05</td>
<td>0.29</td>
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<td>W</td>
<td>0.07</td>
<td>0.95</td>
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<td>resp exposure index (fire)</td>
<td>X2(2)</td>
<td>2.17</td>
<td>0.34</td>
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<td>derrm exposure index (fire)</td>
<td>X2(2)</td>
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<td>0.18</td>
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<td>0.22</td>
<td>0.90</td>
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<td>0.46</td>
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<td>age</td>
<td>W</td>
<td>0.54</td>
<td>0.59</td>
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<td>years of service</td>
<td>W</td>
<td>0.79</td>
<td>0.43</td>
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<tr>
<td>age</td>
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<td>0.20</td>
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<td>W</td>
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<td>X2(2)</td>
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<td>1.58</td>
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Notes:
- Psychiatric categories I–IV are defined on p. 135
- "resp" = respiratory
- "derm" = dermatological
- RR = relative risk (or rate ratio where appropriate)
- CI = 95% confidence interval
- * Tests used are:
  - r: Spearman's rank correlation coefficient
  - W: Wilcoxon rank sum test (2 tailed)
  - C(df): continuity corrected chi-square for df degrees of freedom
  - X2(df): chi-square for df degrees of freedom
  - Fisher: Fisher's exact test for 2x2 tables
APPENDIX 4
Statistical Details of Analyses and Comparisons for Laboratory Data

The following variable abbreviations are used:

- HB: haemoglobin
- HCT: haematocrit
- MCV: mean cell volume
- MCH: mean cell haemoglobin
- RBC: red blood cell count
- ESR: erythrocyte sedimentation rate
- WBC: white blood cell count
- NEUT: neutrophils
- LYMP: lymphocytes
- EOS: eosinophils
- BASO: basophils
- MONO: monocytes
- UREA: urea
- CREAT: creatinine
- NA: sodium
- K: potassium
- BILI: bilirubin
- ALKPHOS: alkaline phosphatase
- GGT: gamma-glutamyl transferase
- ALT: alanine transaminase
- AST: aspartate transaminase
- PROT: total protein
- ALB: albumin
- GLOBS: globulins
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Notes:
1. "Stud." = study group
2. "Refr." = referent group
3. SD = standard deviation
4. The ANOVA and WILCOXON columns give the p-values for the parametric and non-parametric tests of differences between the two groups respectively. The Wilcoxon test is to be preferred if the absolute value of the coefficient of SKEWNESS is greater than about 0.4 in either group.
5. The missing data for the referent group was mostly caused by delayed delivery of the blood to the Auckland laboratory on one day, thereby preventing accurate analysis for some tests.
Table 4.2: Additional statistical tests

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<tr>
<th>Variable(s)</th>
<th>Test(*)</th>
<th>Value</th>
<th>P</th>
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<tr>
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<td>C(1)</td>
<td>0.12</td>
<td>0.73</td>
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</table>

| Esr by:                       |         |       |     |
| Category III                  | Fisher  | 1.00  |     |
| Category IV                   | Fisher  | 0.28  |     |
| skin problem(s)              | Fisher  | 0.28  |     |
| resp exposure index (fire)    | Fisher  | 1.00  |     |
| derm exposure index (fire)    | Fisher  | 1.00  |     |
| resp exposure index (clean-up)| Fisher  | 0.45  |     |
| derm exposure index (clean-up)| Fisher  | 0.70  |     |

| Haem 1 by:                    |         |       |     |
| Category III                  | C(1)    | 0.00  | 0.97 |
| Category IV                   | Fisher  | 1.00  |     |
| skin problem(s)              | C(1)    | 0.03  | 0.87 |
| resp exposure index (fire)    | C(1)    | 0.03  | 0.87 |
| derm exposure index (fire)    | C(1)    | 0.17  | 0.68 |
| resp exposure index (clean-up)| C(1)    | 0.27  | 0.60 |
| derm exposure index (clean-up)| C(1)    | 0.00  | 0.97 |

| Haem 2 by:                    |         |       |     |
| Category III                  | X2(2)   | 2.47  | 0.29 |
| Category IV                   | X2(2)   | 1.06  | 0.30 |
| skin problem(s)              | X2(2)   | 0.12  | 0.94 |
| resp exposure index (fire)    | X2(2)   | 0.24  | 0.89 |
| derm exposure index (fire)    | X2(2)   | 0.14  | 0.93 |
| resp exposure index (clean-up)| X2(2)   | 1.69  | 0.43 |
| derm exposure index (clean-up)| X2(2)   | 4.70  | 0.10 |

| Liver by:                     |         |       |     |
| Category III                  | X2(2)   | 1.85  | 0.40 |
| Category IV                   | X2(2)   | 4.05  | 0.13 |
| skin problem(s)              | X2(2)   | 0.29  | 0.86 |
| resp exposure index (fire)    | X2(2)   | 0.19  | 0.91 |
| derm exposure index (fire)    | X2(2)   | 1.20  | 0.55 |
| resp exposure index (clean-up)| X2(2)   | 1.65  | 0.44 |
| derm exposure index (clean-up)| X2(2)   | 4.99  | 0.08 |

| Renal by:                     |         |       |     |
| Category III                  | C(1)    | 2.88  | 0.09 |
| Category IV                   | Fisher  | 1.00  |     |
| skin problem(s)              | Fisher  | 0.81  |     |
| resp exposure index (fire)    | C(1)    | 0.00  | 0.95 |
| derm exposure index (fire)    | C(1)    | 0.05  | 0.83 |
| resp exposure index (clean-up)| C(1)    | 0.07  | 0.79 |
| derm exposure index (clean-up)| Fisher  | 0.043 |     |

Notes:
psychiatric categories III & IV are defined on p. 135
"resp" = respiratory
"derm" = dermatological
* Tests used are:
  C(df) continuity corrected chi-square for df degrees of freedom
  X2(df) chi-square for df degrees of freedom
  Fisher Fisher's exact test for 2X2 tables
APPENDIX 5
Statistical Details of Analyses and Comparisons for Neuropsychological Data

The following is a brief description of the tests used together with their variable names. Details are given in Appendix 6.

PACED AUDITORY SERIAL ADDITION TEST
PASAT Addition of a series of numbers played on tape at four different speeds.

WORD FLUENCY
MEANEASY Number of words produced in one minute, starting with an “easy” letter.
MEANHARD Number of words produced in one minute, starting with a “hard” letter.

PURDUE PEGBOARD
PURDUERT Manual dexterity using the right (or preferred) hand.
PURDUELT Manual dexterity using the left (or non-preferred) hand.
PURDUEBT Manual dexterity using both hands together.

REY-OSTERRIETH COMPLEX FIGURE
REYCOPY Copying of the figure.
REYMEMY Reproduction of the figure from memory after three minutes.

COMPREACT TEST
REACTLT Reaction time for the left visual field.
REACTCE Reaction time for the central visual field.
REACTRT Reaction time for the right visual field.

DIGIT SYMBOL
SYMBOL Filling in the correct codes for numbers shown in boxes on the test sheet in 90 seconds.

DIGIT SPAN
SPANFWD Repetition of a series of numbers forward immediately after they are presented.
SPANBWD Repetition of a series of numbers backwards immediately after they are presented.
SPANDIFF Difference between SPANFWD and SPANBWD scores.

GENERAL HEALTH QUESTIONNAIRE
GHQSCORE Score derived from 30 item screening test of psychological well-being.
Table 5.1: Neuropsychological comparisons

<table>
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<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Median</th>
<th>Skewness**</th>
<th>Z***</th>
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Note:
“STUD” = study group
“REFT” = referent group
* Significant differences between the two groups
** If the absolute value of the coefficient of SKEWNESS is greater than about 0.4 non-parametric tests e.g., Wilcoxon are preferable
*** Wilcoxon rank sum test (2 tailed)
Table 5.2: Group and other study neuropsychological comparisons

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</table>

Note:
“STUD” = study group
“REFT” = referent group
* Standard Deviation
** Study and referent group medians are given in Table 5.1
*** SPAN = SPANFWD + SPANBWD

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Table 5.3: Additional statistical tests

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<th>Variable(s)</th>
<th>Test(*) Value P</th>
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<td>NPI index goodness-of-fit of fitted Poisson model (**)</td>
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<td>GHQ score by:</td>
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<td>psychiatric dysfunction</td>
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<tr>
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<td>Category IV</td>
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<tr>
<td>skin problem(s)</td>
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</tr>
<tr>
<td>resp exposure index (fire)</td>
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<tr>
<td>derm exposure index (fire)</td>
<td>W 0.76 0.45</td>
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<tr>
<td>resp exposure index (clean-up)</td>
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<td>derm exposure index (clean-up)</td>
<td>W 0.41 0.68</td>
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<td>NPI index goodness-of-fit of:</td>
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<td>referent group Poisson model</td>
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<td>fitted Poisson model (**)</td>
<td>X2(4) 34.49&lt;0.001</td>
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<td>psychiatric dysfunction</td>
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Notes:
- psychiatric categories I-IV are defined on p. 135
- 'resp' = respiratory
- 'derm' = dermatological
- Tests used are:
  - r: Spearman’s rank correlation coefficient
  - W: Wilcoxon rank sum test (2 tailed)
  - C(df): continuity corrected chi-square for df degrees of freedom
  - X2(df): chi-square for df degrees of freedom
  - Fisher: Fisher’s exact test for 2X2 tables
- **: “Poor” test score rates per individual are 0.97 in the referent group and 1.28 in the study group (Mantel-Haenszel adapted for Poisson data (4): X21=9.87, p = 0.002)
- ***: Weighted to allow for the few individuals who did not do the occasional test
- ****: Controlled for age by using analysis of variance of ranked data

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APPENDIX 6

The Psychologists’ Report

REPORT TO THE MINISTERIAL ADVISORY COMMITTEE
ON THE I.C.I. FIRE

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Olina Carter

Julian P Reeves

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Auckland 5

January 1990
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ACKNOWLEDGEMENTS

We would like to acknowledge and thank the following people:

Dr Dorothy Gronwall Ph.D.

Neuropsychologist, Concussion Unit, Auckland Public Hospital. Dr Gronwall designed the battery of neuropsychological tests used in the assessment procedure and provided training.


Dr Ogden, Clinical Psychologist/Neuropsychologist at the University of Auckland, Psychology Department, advised on the administration and interpretation of the neuropsychological testing.

Professor Ivan Beale M.Sc.,(NZ),Ph.D.

Professor Beale of the University of Auckland’s Psychology Department advised us particularly on the appropriate statistical analysis of the neuropsychological data.
INTRODUCTION

Remuera Psychology and Counselling Centre was approached on 3 April 1989 and requested to assist the Ministerial Advisory Committee in the assessment of ICI firefighters. The Centre was asked to provide a team of psychologists to undertake neuropsychological testing as part of the assessment procedure.

Assessments of the Auckland firefighters were completed during May, and assessments of a referent group of Wellington firefighters were completed during September.

METHOD

SUBJECTS

Four hundred and sixty-five firefighters participated in the study. (The sample included three women.)

The study group comprised 245 Auckland firefighters each of whom had been in some way associated with the ICI fire. A total of 243 had neuropsychological testing.

The referent group comprised 217 firefighters from Wellington, not associated with the ICI fire, but who were members of the Fire Service at the time of the ICI fire. All were tested.

Ages ranged from 23 to 64 years, with a mean age of 38 years. Age distribution of the two groups was virtually identical.

Educational data was collected only on the Wellington sample, 54% of whom reported having School Certificate or higher academic qualifications.

Further details are given in the Investigator’s report (see Method).

TEST BATTERY

Dr D. Gronwall designed the battery of neuropsychological tests used in the assessment procedure, and has provided the following rationale. A full description of the tests is given in Appendix A.

"Selection of the Test Battery

There were three constraints on the selection of tests for the study."
The tests needed to be sensitive to subtle deficits in concentration, attention and memory, because these are the problems that the men who attended the fire complained of. A standard neuropsychological battery designed to detect the effect of gross localised lesions would have been inappropriate.

Because of the number of men to be tested, and because they would need to be tested individually, the battery was selected to ensure that all tests be completed within one hour.

Because of the potential interest the results of the study would have, it was decided to restrict tests to those that are widely used (and well known) and which are readily available. This ensured that the study could be readily replicated if necessary.

The following tests were used:

From the Wechsler Adult Intelligence Scale (WAIS), Digit Span and Digit Symbol. Both tasks are quick to administer, and there is a large literature on their use. Digit span includes both digits forward and digit back. Digits forward is a quick measure of the immediate auditory memory span, and digits back involves this skill “plus the ability to store a few data bits briefly and juggle them round mentally” (Lezak, 1979). A difference of three or more between the forwards and backwards digit spans is taken as evidence of a deficit in concentration. Digit Symbol was included:

(a) because it is the most sensitive of all the WAIS subtests to brain dysfunction, regardless of locus of lesion; and
(b) because it measures response speed, sustained attention and visuo-motor co-ordination.

The Paced Auditory Serial Addition Test (PASAT) has been widely used to document deficits in information processing ability after traumatic head injury. PASAT scores correlate significantly with measures of attention, and with reaction time, and the test has been shown to be sufficiently sensitive to detect impairment after mild concussion.

The controlled word fluency test was included

(a) as a filler between the four PASAT trials, and
(b) as a measure of frontal lobe as well as language function.
The Rey-Osterrieth Complex Figure tests:

(a) visuo-perceptual ability in the first part of the task where the subject is asked to copy the pattern; and

(b) memory in the second part, where he is asked to draw the pattern after a period of distraction. The technique of requiring recall after distraction and delay is the most sensitive method to detect memory dysfunction.

The Purdue pegboard was included as a standard measure of motor control and fine finger movement.

Finally, the Compreact test from the Life Sciences Computer Programmes for Cognitive Rehabilitation was used to measure reaction time. This test was selected because it is administered on a personal computer, and is used in several neuropsychological laboratories. Although there is not yet a solid literature base on the test, we already have normative data for New Zealand adults on this task.”

Rationale for the Addition of the GHQ 30 to the Test Battery

The General Health Questionnaire (GHQ) is a well-known internationally used symptom questionnaire developed by Goldberg. It is a brief, self-administered screening test aimed at detecting the emotional symptoms of ill health.

The form of the test known as the GHQ 30 was selected as a valid short form of the questionnaire.

The psychological tests selected follow very closely those which the World Health Organisation are using in their ongoing international studies as listed by Johnson (1987).

Training

Seven psychologists were used for testing the study group. Of these, four carried out 78% of the testing and these four psychologists also tested the referent group.
Dr Gronwall conducted a training session and this was followed by a four-hour laboratory to ensure that each administrator was completely familiar with the materials and procedures prior to the commencement of the project.

Each psychologist was issued with written administration notes to use for reference during the assessments.

THE TESTING ENVIRONMENT

Each subject was tested individually in a separate room.

Care was taken to minimise outside distractions, and to keep the lighting and temperature comfortable at all times.

Note:

The GHQ, a self-administered inventory, was on occasion taken in the group testing room, and completed prior to commencing the main health status questionnaire.

TEST MATERIALS

Stopwatch
Pencils and eraser
Blank paper
4 felt-tip pens (red, green, blue, black)
Purdue pegboard and pegs
Personal computer and Compreact software
Tape recorder and PASAT pre-recorded audio tape

Administration forms for:

PASAT and Word Fluency
Rey Copy
Digit Symbol
Digit Span
GHQ 30

Record forms for:

Purdue
Compreact
Post-test Interview and Examiner’s Comments

PROCEDURE

The firefighters were each assigned a code number for the study and were introduced by first name only to the psychologist.
The tests were administered in the same order for each subject:

1. PASAT
2. Word Fluency trials between PASAT trials.
3. Rey Copy
4. Purdue Pegboard
5. Rey Memory
6. Compreact
7. Digit Symbol
8. Digit Span

The GHQ was then administered.

Testing was preceded by a few minutes' conversation designed to put the subject at ease, and describe the format of the session.

A brief post-test interview enquired whether the subject felt any outside influence had affected his or her performance.

Any comments made by the examiner on the subject's performance were kept general and on a reassuring note.

Information which was volunteered spontaneously was noted on the protocol, as was any deviation from standardised testing procedure.

As the psychological testing formed only the first part of the full assessment procedure for each fire fighter, there was no enquiry into history, symptoms, or personal situation as would normally occur in a neuropsychological evaluation. Such information was not available to the test administrators during the study.

**Scoring**

All tests were marked by the examiner who administered the battery except for the Rey Figure Copy and Memory. Scores were transferred from the test protocol to a summary sheet and these were sent to Wellington for statistical analysis.
MARKING OF THE REY FIGURES

The marking of the Rey Figure drawings is problematic because subjective decisions are required of the marker.

It was, therefore, decided that the tests be marked blind by one psychologist with experience in the use of these tests. Auckland and Wellington tests were marked in tandem to cover for any drift in the marker's application of the scoring criteria. In addition, some tests were remarked at regular intervals during the marking process to assist in maintaining a uniform application of the criteria.

IMPAIRMENT INDEX

It was assumed that the Wellington referent group was representative of the normal population. Details are given in the Investigator's report (see Neuropsychological Impairment Index).

In the case where one test gave more than one score, for example the three subscores on the Compreact Test, any or all of these subscores beyond the cut off resulted in just one indicator of impairment.

Scores were combined in this way to minimise the undue weighting otherwise given to the tests that produced two or three subscores. The only exception to this was the Rey Figures. The Rey Copy and Rey Memory are considered to measure different functions and the score on each was considered separately.

Note:

(a) The GHQ score was not included in this analysis because as discussed previously the GHQ was not designed as a measure of neuropsychological impairment and was used in the battery to detect psychological symptoms of ill-health.

(b) The PASAT score was only included for subjects aged 40 or under. This decision was made because the author of the test suggests interpretation is uncertain when used with the older age group. (Gronwall, 1977)
RESULTS

Tables 5.1 and 5.2 Appendix 5 (Investigator’s Report) list the median, skewness, mean and standard deviation of the neuropsychological tests.

GENERAL COMMENTS

POSSIBLE CAUSES OF POOR TEST RESULTS OTHER THAN ORGANIC IMPAIRMENT

The effects of undue levels of anxiety during the administration of the tests could reduce performance.

Fatigue could result in impaired cognitive functioning.

Lack of interest in the testing, lack of cooperation, or malingering could result in poor scores.

Drugs, alcohol, stimulants or prescribed medications could affect test performance.

Feeling physically unwell could reduce scores.

Emotional distress, for example related to recent marital separation or a death in the family, could reduce performance.

The presence of a psychiatric disorder may impair test performance.

Poor education may lower scores on some tests.

In a screening procedure the administrator is not always aware of the presence of extraneous variables however much care is taken. Individual follow-up can sometimes allay concerns that the poor test results are attributable to organic impairment.

Underlying stress and anxiety may particularly influence those tests which have in themselves a stressing factor such as rapid completion to a time or demand motor skills. It is interesting that timed and psychomotor tests were those that were particularly badly performed by the firefighters.

Lezak (1983) states that the stress of fatigue or anxiety will cause test responses to plummet.
Gilanders and Touyz (1984) advise the tester “that sensory motor tests are particularly sensitive to fluctuations in concentration and attention” in subjects.

Following the comparison of neuropsychological test results between the study and referent groups (a relative risk of poor results of 1.32) an attempt was made to explain the small difference in favour of the referent group.

The tests were grouped into four sub-categories as follows:
Psychomotor: PASAT, Purdue Pegboard, Rey Copy, Compreact, Digit Symbol
Memory: Word Fluency, Rey Memory, Digit Span
Timed: PASAT, Word Fluency, Purdue Pegboard, Compreact, Digit Symbol
Not Timed: Rey Copy, Rey Memory, Digit Span.

Our view that anxiety would have a greater influence on test performance for the psychomotor and timed sub-categories was accepted by the Committee.

The following table indicates the number of failures in each sub-category for the study and referent groups and the relative risk of poor results.

<table>
<thead>
<tr>
<th></th>
<th>Study Group</th>
<th>Referent Group</th>
<th>Relative Risk</th>
<th>Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychomotor</td>
<td>211/243</td>
<td>125/217</td>
<td>1.51</td>
<td>1.33–1.71</td>
</tr>
<tr>
<td>Memory</td>
<td>100/243</td>
<td>85/217</td>
<td>1.05</td>
<td>0.84–1.31</td>
</tr>
<tr>
<td>Timed</td>
<td>227/243</td>
<td>128/217</td>
<td>1.58</td>
<td>1.41–1.78</td>
</tr>
<tr>
<td>Not Timed</td>
<td>84/243</td>
<td>82/217</td>
<td>0.91</td>
<td>0.72–1.17</td>
</tr>
<tr>
<td>All Tests</td>
<td>311/243</td>
<td>210/217</td>
<td>1.32</td>
<td></td>
</tr>
</tbody>
</table>

From the above analysis it is apparent that the major component of the difference is explainable by a difference in the psychomotor and timed test sub-categories.
POSSIBLE CAUSES OF COGNITIVE IMPAIRMENT OTHER THAN TOXIC EXPOSURE

Normal aging processes result in cognitive impairment, particularly memory problems and psychomotor slowing.

Psychiatric illness may result in temporary cognitive impairment. Psychomotor slowing is frequently seen in patients with clinical depression.

Chronic alcohol abuse or drug abuse may lead to organic impairment.

Trauma such as concussion may result in organic impairment, particularly if there have been several such events.

Various diseases of the central nervous system may lead to cognitive impairment.

Cognitive impairment is often temporary and reversible. Whether reversible or not, rehabilitation, advice and guidance can simplify daily living tasks, and reduce frustration for the person concerned and their immediate family.

EFFECTS OF AGING

Most of the tests used in this battery are known to be affected to some extent by aging, i.e. normal scores reduce with age. However, there is relatively little data available about the extent and speed with which this occurs, except for the WAIS subtests where age-related norms are available.

The number of older subjects in our referent group was insufficient to allow age-related analysis of the data.

It may therefore be necessary to relate mild cognitive impairment simply to normal aging processes for some of the older subjects whose results might cause concern from the initial screening procedure.

INDIVIDUALS WITH ACCEPTABLE TEST RESULTS WHO COMPLAIN OF MEMORY OR CONCENTRATION PROBLEMS

It must be noted that in this study we did not have accurate measures of previous levels of functioning.
It is entirely possible that the cognitive functioning of an individual could be markedly reduced without their scores dropping below the 10th percentile on any indicator. Our screening procedure would only have detected this had it occurred on a wide scale such that the group mean scores were reduced.

We would suggest that such a person may be aware of the frustrations of their reduced cognitive efficiency, particularly if they are employed in a role that requires a high level of mental processing. If any individual wished to explore further the possibility that their cognitive efficiency is reduced, while still being at a level usual in the rest of the population, a full neuropsychological investigation would be required to assess previous as well as current levels of functioning.

THE GHQ 30

In administering the test to the study group it became apparent that some may have been comparing their current feelings to those before the ICI fire, accepting that as their normal state. Others may have been giving a recall of feelings over the whole period following the fire. In the referent group no comparable incident was involved and the indication of how the subject was feeling was, as the GHQ asks, only over the last few weeks.

Thus the Auckland GHQ result may in part be taken to indicate distress averaged out over the whole time period following the fire.

GENERAL COMMENT ON THE PROCEDURES USED

If time had allowed for a pilot programme, some stream-lining of procedures would have been possible. However, given that there was initially only a matter of three weeks from the time we received the initial request to be involved with the study until testing was due to commence, and that in the final instance the Committee was only able to confirm the request for our participation three working days before testing had to start, we believe the procedures adopted were efficient and very successful.

CONSENT PROCEDURE

An appropriate consent procedure for the whole study including the neuropsychological tests was devised with due regard to current ethical guidelines on informed consent. This was followed for all subjects (see Investigator’s report, Method).
Appendix A

Description of Tests and Normative Date on Tests Used

Details of administration, scoring and normative data on each of the tests used in the battery are given below.

PASAT (Paced Auditory Serial Addition Test)

Description:

The PASAT is a measure of speed of information processing.

Total testing time is between 15 and 20 minutes for the first test and less than fifteen minutes for retests.

The subject is required to add sequentially a list of 60 random digits presented on a tape. Each number must be added mentally to the previous number and the answer given aloud. There are four trials with pacing from 1.2 to 2.4 seconds between the digits.

Administration and Scoring

The PASAT was administered and scored according to the administration guidelines provided by Dr Gronwall. Instructions are given verbatim, followed by a written demonstration of the task and an unpaced oral trial of 11 random digits. The subject is then given a paced practice using the tape recorder before commencing the four trials of the test proper.

The test is discontinued if the subject is unable to get at least the first three answers from the unpaced practice list correct, or if the subject scores less than 20 correct answers on the second trial (unless the subject scored more than 40 on the first trial).

The total number of correct scores on each trial are converted to time per correct response, and this is averaged for the four trials. (If the time score on one trial differs by more than 0.6 seconds from all the other trials it is discarded—if more than one trial differs from all others by more than 0.6 seconds, data from the whole session is considered unreliable and discarded. In this case the PASAT was administered again at the end of the battery.)
Interpretation

The PASAT particularly identifies subjects whose responses are slowed and those who have a mental tracking disability, resulting in impaired information processing. Post-concussion patients perform well below normal subjects on this test, their scores generally returning to a normal level within 30–60 days.

Normative Data

Normative data on the PASAT is from Dr Gronwall’s 1977 study. The study involved 90 New Zealand subjects. Ten accident cases without head injuries in each of four age group categories, (14–16, 17–25, 26–40, 41–45 years), plus 40 first year university students and 10 naval ratings all falling in the 17–25 year age group. (This being the usual age range of concussion victims.)

The Results for the Control Subjects Were

First test: Mean = 3.2 secs per correct response (SD = 0.25)
Retests: Mean = 2.6 secs per correct response (SD = 0.25)

(There is a significant practice effect between first and subsequent administrations of the test but subsequent practice effects have been found to be negligible.)

Dr Gronwall reports that the mean for the older age group was similar to the mean for the younger age groups, but the SD was larger. Therefore the results for the older age group were not included, and the results above refer only to the eighty control subjects in the combined age group 16–40 years. Dr Gronwall notes that these norms therefore are applicable only to people under 41 years of age.

WORD FLUENCY

Description

The subject is asked to give as many words as they can think of in one minute, starting with a specified letter of the alphabet. There are four trials, two with easy letters and two with hard letters.

Administration of the test takes approximately five minutes.
Administration and Scoring

Easy letters: a h d m w / b f p t s

Hard letters: q j v / y k u

The actual letter used was chosen at random by the examiner to minimise the possibility of subjects rehearsing the task.

The score is the average number of words produced in one minute. Productivity was averaged for the two easy letters and for the two hard letters.

Interpretation

This test provides a measure of frontal lobe and language function.

Low scores may indicate impairment of cerebral function. (However this test is also known to be influenced by education level and IQ, and the scores of brain damaged patients of higher IQ remain above the normal scores for subjects of low IQ, as shown in Investigator's Report, Appendix 5, Table 5.2.)

Normative Data

Borkowski et al, 1967, determined the associative value of each letter of the alphabet except x and z, in a normative study using control subjects who were not brain damaged.

The associative frequencies of the easy letters range from 10.00 to 12.50 (i.e., mean number of words produced in 60 secs).

The associative frequencies of the hard letters range from 4.32 to 5.91.

The standardisation group for assessing the associative frequencies of each letter was composed of 66 maternity patients in Iowa city. The mean age was 20 years and the mean pro-rated verbal WAIS IQ (information and arithmetic subtests) was 93.

The subjects for the study in Table 1 were 30 brain damaged and 30 hospitalised control patients. The brain damaged group had established diagnoses of cerebral disease and included 9 patients with right hemisphere lesions, 10 with left hemisphere involvement and 11 with diffuse or bilateral disease. Mean age was 41 years, pro-rated verbal
WAIS IQ was 93, and these did not differ significantly for the reference group.

From the entire sample, those with IQs above 100 (N = 10 per group) were compared with those with IQs below 90 (N = 10 per group).

Table 1: Productivity averages for letter pairs PT and FS for brain damaged and control patients at two levels of intelligence

<table>
<thead>
<tr>
<th></th>
<th>Mean (pt+fs/2)</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ&gt;100 Control</td>
<td>24.60</td>
<td>5.9</td>
</tr>
<tr>
<td>Brain damage</td>
<td>21.80</td>
<td>5.7</td>
</tr>
<tr>
<td>IQ&lt;90 Control</td>
<td>19.30</td>
<td>5.7</td>
</tr>
<tr>
<td>Brain damage</td>
<td>9.20</td>
<td>2.5</td>
</tr>
</tbody>
</table>

(Adapted from Borkowski et al 1967)

REY-OSTERRIETH COMPLEX FIGURE TEST

Description

This assessment procedure was devised to assess visuographic abilities and visuospatial memory.

In this test the subject is required to make a copy of a complex design.

Administration and Scoring

The subject is asked to copy a complex figure. There is no time limit and the figure remains in view. The examiner notes the approach that the subject takes to the task, and to aid in later analysis the subject is given a coloured pen to work with and this is exchanged for a different colour as the subject completes each section of the drawing. The same colours were used in the same order for every subject.

Three minutes later, and without having been warned the subject is asked to reproduce the design from memory.

The drawings are scored using the detailed scoring criteria which involve assessing the accuracy of each detail in the complex figure. The total score possible is 36.
Interpretation

The drawings are generally considered qualitatively in terms of the approach taken towards the task, and the sort of errors made. The drawings are also considered quantitatively in that the subject’s scores are compared with normative data. A poor score may indicate poor visual memory, or poor structural or planning ability in the visual area often characteristic of damage to the left frontal lobe of the brain.

Using the Rey figure as part of the present screening battery only the quantitative scores gained on the copy and recall tasks were considered.

Normative Data

This test is frequently used by neuropsychologists in individual assessments of visuo-spatial abilities following brain damage, and most have relied on normative data published in Lezak (1976) which was produced by Osterreith in 1944 using 60 adults aged 16–60 years and comparing this group with 43 adults who had sustained traumatic brain injury.

There are no standardised instructions for the administration and some differences in administration in different centres have become evident.

Ogden and Lamdin at the University of Auckland have addressed these problems and recently produced some new norms using New Zealand university students as a standardisation group. These are somewhat different from Lezak’s and also show that different forms of administration do affect the scores obtained. Thus further normative work is required to assist interpretation.

The New Zealand standardisation group consisted of 212 undergraduate psychology students aged between 17 and 52 years, the majority being under 25 years of age. Two thirds of the sample were women. They were divided into four groups to test different conditions of administration.

The same scoring criteria were used as were used in the ICI study.
Table 2: Percentile norms for accuracy scores obtained by adults on copy and memory trials of the Rey Figure Test from Lezak, 1979

<table>
<thead>
<tr>
<th>Trial</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Copy</td>
<td>31</td>
</tr>
<tr>
<td>Memory</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 3: New Zealand percentile norms for accuracy scores obtained by adults on copy and memory trials of the complex figure test (Ogden and Lamdin).

<table>
<thead>
<tr>
<th>Trial</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Copy</td>
<td>33.0</td>
</tr>
<tr>
<td>Memory</td>
<td>21.0</td>
</tr>
</tbody>
</table>

PURDUE PEGBOARD

Description

The Purdue Pegboard Test is a measure of manual dexterity. Developed originally for the selection of production workers, it has been found to be neuropsychologically sensitive and is an efficient screening technique for the detection of brain damage.

The test takes three or four minutes to administer and in this battery was used between the Rey Copy and the Rey Memory, where a three minute delay was required between the two procedures.

Materials

The Purdue pegboard and pegs
Stopwatch

Administration and Scoring

The subject is timed while placing 2mm pegs in a row of holes in the pegboard. Thirty seconds is allowed. The task is done first with the
right or preferred hand, then with the left hand, and finally using both hands simultaneously.

The score is the number of pegs placed correctly on each trial. There is a separate score for each of the three conditions.

Interpretation

Lezak gives cut-off scores developed for the Purdue pegboard and found to be 89% accurate in predicting brain damage in a study to test the efficiency of the Purdue pegboard in making diagnostic discriminations (Costa et al., 1963).

Table 4: Purdue pegboard test cutting scores for brain damage for two age groups

<table>
<thead>
<tr>
<th></th>
<th>Under age 60</th>
<th>60 and older</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right (preferred) hand</td>
<td>&lt;13</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Left (nonpreferred) hand</td>
<td>&lt;11</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Simultaneous (both hands)</td>
<td>&lt;10</td>
<td>&lt; 8</td>
</tr>
</tbody>
</table>

(Adapted from Lezak, 1976)

Normative Data

Male population norms are given from 865 industrial applicants and 481 college men and 1,958 veterans; female norms from 4,138 industrial applicants and 392 college women. This data was accumulated from users of the test in the USA and is offered by the publishers of the test. However, they strongly recommend that local norms be developed wherever possible to render interpretation of test scores more meaningful (Tiffin, 1987).
Table 5: General population norms for scores on the Purdue pegboard

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Male Industrial applicants</th>
<th>Male Veterans and students</th>
<th>Female Indust. applicant and students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>L</td>
<td>B</td>
</tr>
<tr>
<td>90</td>
<td>18.0</td>
<td>17.0</td>
<td>14.0</td>
</tr>
<tr>
<td>50</td>
<td>15.5</td>
<td>14.5</td>
<td>12.0</td>
</tr>
<tr>
<td>10</td>
<td>12.5</td>
<td>12.0</td>
<td>9.5</td>
</tr>
</tbody>
</table>

R = Right (or preferred hand),  
L = Left,  
B = Both hands simultaneously.  
(Adapted from Tiffin, 1987)

**Compreact Reaction Time Test**

**Description**

The simple reaction time test used in this study is not commercially available. The software developed by the Life Sciences Computer Programs for Cognitive Rehabilitation was made available to us by Dr Gronwall for the purpose of this research.

It is a computer-based test known as “Compreact” and administration takes some seven minutes. The subject responds to a visual stimulus on the computer screen by pressing the space bar on the keyboard.

**Administration and Scoring**

The subject is guided by instructions on the screen, and the reaction times are calculated by the computer. Median response times are recorded.

**Interpretation**

Slowed reaction times are frequently associated with organic impairment.
Normative Data

Normative data on New Zealand adults has also been made available by Dr Gronwall, and is shown in Table 6.

This data relates to males in two age groups, 17–29 years, and 30–49 years, employed at Auckland Hospital. Data was recorded from one test session after standard instructions. The median time scores were recorded.

Table 6: Reaction times on the Compreact Test for 60 normal male subjects

<table>
<thead>
<tr>
<th>Visual Field</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Visual Field:</td>
<td>0.30</td>
<td>0.24–0.32</td>
</tr>
<tr>
<td>Age 17–29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 30–50</td>
<td>0.31</td>
<td>0.20–0.37</td>
</tr>
<tr>
<td>Central Visual Field:</td>
<td>0.26</td>
<td>0.23–0.31</td>
</tr>
<tr>
<td>Age 17–29</td>
<td>0.27</td>
<td>0.23–0.31</td>
</tr>
<tr>
<td>Age 30–50</td>
<td>0.31</td>
<td>0.24–0.35</td>
</tr>
<tr>
<td>Right Visual Field:</td>
<td>0.31</td>
<td>0.25–0.35</td>
</tr>
<tr>
<td>Age 17–29</td>
<td>0.31</td>
<td>0.24–0.35</td>
</tr>
<tr>
<td>Age 30–50</td>
<td>0.31</td>
<td>0.25–0.35</td>
</tr>
</tbody>
</table>

N = 30 for each age group.
(From Gronwall, private communication)
There was no significant difference between the reaction times of the younger and the older group.

Gronwall further reports that there was no difference between skilled \( (n = 30) \) and unskilled groups. \( (n = 30) \). (Skilled being tradespeople and unskilled being hospital orderlies.)

**DIGIT SYMBOL**

*Description*

The Digit Symbol is a pencil and paper test from the Wechsler Adult Intelligence Scale.

The test form shows the numbers one through nine each associated with a code symbol. Below are ninety boxes with a number in the top half and the bottom half empty. The subject is required to copy the correct symbol below each number.

There is a time limit of ninety seconds.

*Administration and Scoring*

Administration followed the standard procedure set down in the WAIS manual (1955).

One point is scored for each correct symbol achieved within 90 seconds. Maximum score possible = 90.

*Interpretation*

Digit Symbol is generally considered to be one of the most sensitive indicators of cerebral dysfunction. Of all the WAIS subtests the score is most likely to be depressed even when brain damage is minimal. However, a poor score is not specific to brain damage; the test is sensitive to anxiety and the subject who is tense is also likely to have an impaired performance. There is also a decrease in scores with age as would be expected with a speed test. Table 7 shows this effect.
Normative Data

The Wechsler Adult Intelligence Scale has been very well standardised, particularly in the United States, using 1700 cases representative of the population of the USA in regard to age, sex, race, occupation, geographic region, urban-rural residence and education.

Scores for each test are converted to standard scores with a mean of 10 and SD of 3, according to the age group of the subject. See Table 7.

Table 7: Digit symbol scores by age

<table>
<thead>
<tr>
<th>Age</th>
<th>20–24</th>
<th>25–34</th>
<th>35–44</th>
<th>45–54</th>
<th>55–64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaled Score 7</td>
<td>40–43</td>
<td>34–39</td>
<td>30–35</td>
<td>24–26</td>
<td>17–21</td>
</tr>
</tbody>
</table>

**DIGIT SPAN**

**Description**

Digit Span is a sub-test of the WAIS. It is considered to be a measure of short-term memory and attention. The subject is required to repeat digit series forwards and backwards immediately after hearing them.

**Administration and Scoring**

Administration was according to the manual of the WAIS (1955).

The score is the number of digits in the longest series repeated without error on either the first or second trial.

We reported separately the score on Digits Forward and Digits Backward. The difference between the two scores was also reported.

**Interpretation**

Digits Forward measures immediate auditory memory span; Digits Backward is a more complex task involving the capacity to work with the information while it is held in memory. People who are easily distractible, or who are anxious, find the tasks difficult.
A large discrepancy between Digits Forward and Digits Backward can suggest the presence of an organic deficit. Lezak suggests that a difference of three or more may be taken as evidence of concentration difficulty. We have not been able to locate the research from which this assertion is made and it is unclear the frequency with which such a discrepancy is likely to occur in the normal population.

**Normative Data**

As already mentioned, the Wechsler Adult Intelligence Scale has been very well standardised.

Scores for each test are converted to standard scores with a mean of 10 and SD of 3, according to the age group of the subject.

For the Digit Span subtest the WAIS norms are for the score on Digits Forward + Digits Backward, whereas we considered the two scores separately. However Table 8 shows the combined scores for comparison.

**Table 8: Digit span scores by age**

<table>
<thead>
<tr>
<th>Age</th>
<th>20–24</th>
<th>25–34</th>
<th>35–44</th>
<th>45–54</th>
<th>55–64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaled Score</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>7–8</td>
</tr>
</tbody>
</table>

(Adapted from the WAIS manual, 1955.)

**GHQ 30**

**Description**

The General Health Questionnaire was designed as a self-administered screening test aimed at detecting psychiatric disorders among respondents in community settings.

This form consists of thirty questions, to which the respondent indicates a preferred answer by underlining one of the four options.

**Administration and Scoring**

Administration takes less than five minutes.

There are two methods of scoring, the Likert and the GHQ. In this study the GHQ form which considers the four point response scale as
bimodal was used, so that a choice marked in column 1 or 2 on the test form scored 0, and a choice in column 3 or 4 scored 1.

**Interpretation**

The GHQ is a screening procedure and does not make clinical diagnoses. The GHQ measures how much a subject feels that their present state is unlike their usual state, thus focusing on the emotional symptoms of ill health.

The GHQ can be used to compare the psychological health of two groups of subjects, by comparing the group scores on the GHQ. On an individual basis a cut-off score, usually between four and five for the GHQ 30, is taken to isolate potential “cases” of psychiatric disorder. The higher the threshold, the fewer false positives, but the greater chance of missing some cases.

The GHQ is an instrument which is open to the subject faking healthy or unhealthy should they be motivated to do so; hence the GHQ is not a suitable instrument for tasks such as personnel selection or the selection of possible adoptive parents.

There is a strong association between GHQ score and physical illness and this is one of the most likely reasons for the misclassification of subjects who are high scorers on the GHQ.

The GHQ is sensitive to transient periods of distress that may last only two or three weeks.

Age does not exert a strong effect on GHQ score.

**Normative Data**

The GHQ is an instrument which has been particularly well validated and has been used internationally in recent years, because of the ease of administration.

One of the most useful normative studies of the GHQ 30 was the Health and Lifestyle survey of the British Isles in which the GHQ was administered together with various other health related measures to a large representative sample of the British population (Cox et al 1987).
There were 6498 respondents and thus breakdown of the GHQ scores by various demographic variables was possible. This information is published in Goldberg and Williams, 1988. See Table 9.

Other GHQ 30 scores from sections of the population studied by Cox et al show how the percentage of high scorers increases in response to factors associated with social stress (Table 10).

Table 9: General Health Questionnaire (GHQ 30) scores from a random sample of 6498 respondents in the British Isles (Cox et al, 1987)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>% High Scorers (&gt;5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3.54</td>
<td>27</td>
</tr>
<tr>
<td>Female</td>
<td>4.41</td>
<td>33</td>
</tr>
</tbody>
</table>

(Adapted from Goldberg, 1988)

Table 10: GHQ 30 Scores for sections of the population unemployed or separated. (Cox et al, 1987)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>% High Scorers (&gt;5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployed (30–64 years)</td>
<td>6.17</td>
<td>49</td>
</tr>
<tr>
<td>Widowed (40–64 years)</td>
<td>6.17</td>
<td>48</td>
</tr>
<tr>
<td>Divorced/Separated (40–64 years)</td>
<td>5.47</td>
<td>36</td>
</tr>
</tbody>
</table>

(Adapted from Goldberg, 1988)

A second study of interest is from Brodaty and Andrews, 1983, again reported by Goldberg (1988). The GHQ 30 was administered to consecutive attenders at 10 family practices in Sydney. Forty-six percent scored above the threshold of four. Three further GHQs were completed at two-monthly intervals. They found that over a six-month period 64% of GP attenders can expect to have at least one episode of high scoring on the GHQ, but only 12% will be persistently high over the six-month period.
Appendix B
Comparison of Referent Group Results With Published Normative Data

An obvious question is whether the Wellington referent group may themselves be cognitively impaired if compared with the normal population. To attempt to answer this we can look at the results of the referent group compared to published normative data for each of the tests used. Details of normative studies are in Appendix A.

These comparisons are summarised in Appendix 5, Table 5.2 with the “expected” scores being on the basis of the published normative data for each subtest.

1. PASAT

The firefighters in both groups had a mean score of 3.2, which is also the mean for the NZ normative group reported by Gronwall, 1977. However, the standard deviation for the referent group was much greater.

2. WORD FLUENCY

The firefighters in Wellington had group mean and median better than those of the normative groups reported by the authors of the test, Borkowski et al, 1967.

It is probable that this New Zealand group would have a higher average intelligence level than the normative sample (mean IQ 93) and possibly the advantage of better education than the Iowa sample of young mothers.

We have not been able to locate any NZ normative data for the Word Fluency test.

3. REY FIGURE COPY AND MEMORY

Table 11: Rey figure copy and memory scores

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Copy 25</th>
<th>Copy 50</th>
<th>Memory 25</th>
<th>Memory 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand Students</td>
<td>33.0</td>
<td>34.5</td>
<td>21.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Lezak (1976)</td>
<td>31.0</td>
<td>32.0</td>
<td>18.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Wellington firefighters</td>
<td>26.0</td>
<td>28.0</td>
<td>14.5</td>
<td>18.0</td>
</tr>
</tbody>
</table>

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The group mean scores for the Rey figure tests were considerably lower for the firefighters than in the published norms generally used (Lezak, 1976). See Table 15.

The NZ norms produced by Ogden are higher again than those published in Lezak.

It should be noted that the data in Table 11 indicate that the difference between the Copy and Memory scores is about 10 points on average for the firefighters, as for both Lezak’s and Ogden’s standardisation groups, at the 50th percentile, suggesting that the problem relates more to the execution of the drawing than the memory component of the task.

Firefighters as an occupational group may have poor visuographic skills. This possibility would warrant further investigation because perceptual organisation and visual memory would presumably be important facilities for firefighters having to move through smoke-filled buildings.

However, it is also possible that the firefighters’ lower scores may be partly accounted for by the following factors:

(i) The norms published in Lezak predate the rigorous scoring criteria now recommended.

(ii) Ogden’s sample was composed of university students who probably have higher IQ and more experience in “exam technique” than the firefighters. The firefighters would differ from the New Zealand standardisation group on the variables of age, sex, and education level, each factors that may correlate with visuographic ability.

(iii) There are a number of different ways in which this test is administered as the instructions have never been standardised. Greater emphasis may be placed on the requirement for neatness and accuracy in some studies. A group administration may differ from an individual administration.

(iv) The use of coloured felt-tip pens may reduce the care with which the copy is executed, compared to coloured pencils, or lead pencil and eraser.
(v) The marker in this study may have applied the marking criteria more strictly. However, it must be stated that our marker, an experienced neuropsychologist felt the quality of some of the drawings was extremely poor.

4. PURDUE PEGBOARD

As may be seen from the data in Table 5.2, the performance of the referent group appears to be comparable to the population norms for male industrial applicants published by Tiffin, 1968.

5. COMPREACT REACTION TIME TEST

The mean reaction times for both central and peripheral visual fields were equivalent for the Wellington referent group and the New Zealand normative data submitted by Gronwall. The range of reaction times produced by the referent group was larger. This may be a function of the size of the referent group. (N = 217 compared with N = 60).

6. DIGIT SYMBOL

The mean score for the Wellington referent group of 55.4, was comfortably within the range of raw scores equated to a standard score of 10 on the WAIS, i.e. 51–56.

It is interesting that for this test, where very good population based norms are available, the standard deviation of Wellington scores (and incidentally Auckland scores) were very much smaller than expected from the published norms.

7. DIGIT SPAN

Wellington performed rather better on the Digit Span than would have been expected from the WAIS norms, and as, for Digit Symbol, the standard deviation was smaller than for the standardisation group.
Note:

As mentioned in the rationale for including Digit Span in the test battery, a difference of 3 or more between digits forward and backwards, is widely used as an indicator of concentration difficulties although we have not been able to locate any normative data showing what percentage of the population would be expected to suffer from such concentration difficulties.

24% of the referent group and 30% of the study group showed a difference of this degree. The significance of this remains unclear.

Summary

To summarise, although the standardisation groups on which the normative data is based for some of the tests in the battery are questionable in terms of their comparability to a group of New Zealand firefighters, the only test on which the referent group did less well than would have been expected was the Rey Figure test. Alternative reasons have been put forward for this discrepancy.

We conclude that the comparison of the results of the Wellington referent group with the published normative data would not support a contention that the Wellington firefighters are themselves cognitively impaired.
REFERENCES


Ogden, J.A., Lamdin, R., The effects on accuracy scores of different administrations of the Rey-Osterrieth complex figure. (Submitted)


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Appendix II

REPORT TO THE MINISTERIAL ADVISORY COMMITTEE ON THE ICI FIRE

Consultant Psychiatrist
Bexley Clinic
228 Great South Road
Remuera
Auckland 5
January 1990
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<th>Page</th>
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HISTORY OF THE ICI FIRE

"At 1645 hours on Friday, 21 December 1984 a serious fire occurred at the Riverview Store of ICI, New Zealand, at 28 Bowden Road, Mt Wellington, Auckland. Eighty-six officers and men attended, and following extinction of the fire some four hours later, a number of firefighters were involved in the clean-up operation the following week."

The fire itself produced a heavy dense black smoke, visible from many parts of Auckland kilometres away. At 1730 hours firefighters were complaining of burning sensations on their feet and legs, and three were transported to hospital. Thirty-four firefighters were treated on site by the ambulance staff, mainly for skin problems. On 23 December, one firefighter who had been examined at Auckland Hospital, reported he had been "treated for dioxin poisoning". Within a half-an-hour of arriving at the fire, certain firefighters were aware that the chemical paraquat was involved, immediately withdrew and decontaminated themselves.

Thus within hours of the firefighters’ attendance at the fire, there were physical effects of skin irritation, burning sensations and rashes. A comment about the presence of dioxin and paraquat was enough to engender initial legitimate anxiety and concern. The practice of the officer-in-charge, who came from another fire-fighting division, may have been at variance with some senior personnel, in the face of a complex fire and chemical hazard which contributed to some management dis-ease. Thus right at the beginning of the incident there was evidence of anxiety, uncertainty, and concern with the management of the fire.

Despite attempts to make factual statements about the chemical implications of the fire (by the then Medical Officer of Health), interviews on television and media reports involving a senior lecturer in environmental studies, and a Greenpeace spokesperson on chemical matters, emphasised concern about the possible presence of dioxin to the extent that on 3 January 1985, an Addendum to Fire Brigade Orders 77–84 stated

"Conflicting reports by people of various levels of expertise in the field of chemistry and toxicology as to the severity or otherwise of the chemicals involved. These comments covered the short and long-term effects, and possible danger to health of anyone contaminated by such chemicals."

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This uncertainty and these fears were heightened by a firefighter's admission to hospital and a media report on New Year's Eve stating that his condition was "deteriorating" though in fact his clinical state was an infected rash. Partly because of the holiday period, shortness of staff, anxiety in the absence of any authoritative statements, concerns about 2,4,5-T and dioxons continued. News features often quoted Greenpeace's concern with dioxins, linking this with Agent Orange and its reported long-term health effect when used in the Vietnam War. There were implied criticisms expressed during television interviews whether the ICI company had failed in its responsibility, and at times discussions were widened to include the Ivon Watkins Dow plant in New Plymouth, which manufactured 2,4,5-T. Photographs were shown of vegetation with spotted destruction, and references were made to dead mangroves and there were pictures of mud crabs and snails lying dead in parts of the Tamaki Estuary. A Greenpeace spokesperson expressed concern that the Fire Service may have handled the fire wrongly, treating it as a fire rather than as a chemical fire. Concern was elevated further when an MP called for an immediate inquiry, linking his concern with a recent chemical release in Bhopal, India, which killed and injured thousands. On 11 January 1985, news reports indicated that the Vietnam Veterans' Association renewed its call for a complete ban on 2,4,5-T production in New Zealand and the Vice President of an environmental group asked the Prime Minister to end its production. Professor Rappe, a world authority from Sweden on dioxin, was reported as saying that he planned to investigate the correlation that was reported in New Zealand between 2,4,5-T use and bowel cancer in sheep. Further, the Greenpeace spokesperson referring to dioxin, commented on the literature which had found the presence of this chemical in the breast milk of German and Swedish women, indicating that the substance passed through the food chain. A high profile of the ICI fire as a chemical event was maintained through the media, and tended to reinforce the firefighters' justifiable concern with their symptoms. Dioxin and paraquat were considered to be highly relevant to the firefighters' distress.

On 29 May 1985, a bulletin from the Trade Union Health and Safety Centre, indicated that out of a "number of questionnaires" that were circulated on 19 April 1985, only eighteen replies were received up to 24 May 1985. Possible central nervous system symptoms were: five answered "yes" indicating headache, seven for sleep disturbance,
four for co-ordination problems, six for depression, five for mood changes, and six for both loss of memory and inability to concentrate. It is unclear whether the numbers referred to persons or complaints, but at that stage the fact is that there did not seem to be many firefighters who were complaining to their Union of health problems.

On 18 June 1985, a further letter from the Director of the Trade Union Health and Safety Centre, indicated that blood samples collected in February 1985 from two members who attended the fire at the ICI warehouse, and a third blood sample taken from another union member who had not attended the fire were all sent to the laboratory of Professor Rappe at the University of Umea, Sweden. An analysis of dibenzofurans and dioxins revealed that the unexposed firefighter showed the highest levels of chemicals, compared with the firefighters attending the fire. Further, the Swedish laboratory spokesman stated that Swedish workers involved in sawmills exposed to timber treatment chemicals had average levels ten times as high as those reported in the New Zealand samples, and none of these sawmill workers had any symptoms of dioxin poisoning. That in view of the half-life of these chemicals, the blood level would not have decreased to any extent between their attendance at the fire and the time at which the samples were collected.

On 30 May 1985, an OPS communication 13–1–7 listed a number of firefighters and their symptoms. If it is accepted that CNS symptoms include headache, sleep disturbance, co-ordination problems, mood changes, and memory and concentration difficulties, then fourteen firefighters were reported as having these symptoms.

A bulletin of 28 June 1985 noted that Dr W Glass was appointed as a Consultant to the New Zealand Fire Service to consider the health and welfare of firefighters who attended that fire, and make appropriate recommendations. A bulletin on 30 August 1985 Brigade Routine Order No. 90/85 indicated that Dr Glass had completed three days of consultation and had seen “some thirty-six personnel”.

In his interview with P J Edwards(73) Dr Glass is quoted as saying

“After several weeks they complained of symptoms associated with central nervous system disorder. The symptoms grew and developed in people’s minds. April to May 1985 it started to build up to a major concern, yes they must have talked around
amongst themselves, compared notes and found they were similarly affected”.

A senior executive officer who was medically assessed and regarded as healthy and symptom-free by the Fire Brigade’s doctor on 21 January 1985, consulted the same practitioner with a three-day history of sore throat on 10 April 1985, enlarged cervical lymph glands, mild pyrexia, sweating, general malaise and an ill-defined set of symptoms which was diagnosed as glandular fever with a lymphocytosis and a positive Paul Bunnell laboratory test. This condition is normally a benign condition of viral origin (Epstein-Barr) but is often incapacitating with symptoms of general malaise and tiredness, and may take several weeks or months to resolve.

The officer, in association with the Director of Personnel, consulted Dr M Tizard. Dr Tizard diagnosed paraquat toxicity and residual 2,4,5-T. The officer was treated from 25 June 1985 to 26 July 1985. Since glandular fever is generally a benign condition which spontaneously remits, the officer’s symptomatic resolution coincided with Dr Tizard’s treatment programme.

The officer then wrote to the Principal Medical Officer of the Fire Service endorsing Dr Tizard’s treatment programme.

Dr Glass’s letter to the Regional Commander, New Zealand Fire Service, Auckland on 2 September 1985, stated that he, Dr Glass had observed Dr Tizard’s methods and

“Dr Tizard’s cure of the officer has raised the question of his ability to treat effectively the other members who have been seriously affected by this fire.”

Dr Glass chose three firefighters whom he considered were seriously affected by the fire as test cases. He was apparently impressed by the response of the two who were treated by Dr Tizard, and wrote to that effect to the Regional Commander on 11 October 1985. The enthusiasm of this Senior Officer and his Director of Personnel resulted in many firefighters seeking treatment with Dr Tizard. The fact was that senior personnel and an independent medical consultant had endorsed the treatment programme, a diagnosis had been made with a treatment strategy and an implied promise to resolve their symptoms was offered to the firefighters.
It is understandable that with the continuing anxiety, uncertainty and conflict, and the opportunity for firefighters to follow senior personnel in their leadership role, the opportunity was available for a resolution of the firefighters' anxieties.

The Director of Personnel efficiently organised a rostered attendance of those firefighters who wished to seek help from Dr Tizard, and firefighters were rostered at eight minute intervals, as listed in Brigade Routine Order 106–85, dated 18 October 1985. In fact on 25 November 1985, Bulletin OPS 13–1–7 stated fifty-six personnel were undergoing treatment with Dr Tizard, and a further twelve will have commenced treatment as from 25 November 1985. Dr Tizard had advised that there were a further sixty requiring treatment and a further seventy to examine and test prior to December 1985. This totalled 198 personnel.

The Director of Personnel stated

“There is no doubt that as time goes on, more and more firemen are suffering from the effects of attending the fire”.

Dr Tizard in his own submission stated that he was aware that an officer had a diagnosis of glandular fever, accompanied by lymphocytosis and a positive Paul Bunnell, but considered this a false-positive test result in the light of a positive EAV diagnosis of chemical poisoning. Of some “two hundred persons examined, all of whom had been involved in the fire or on standby duty, or cleaning gear, only two were found to be free of chemicals”. He referred to the “firefighters’ symptoms as being typical of ME”.

The above description shows the massive escalation of symptomatic firefighters from the numbers replying to the questionnaire, to the number seen by Dr Glass, and finally to those attending Dr Tizard.

Dr Tizard’s practice, diagnosis and approach may have afforded some firefighters relief, but may well have reaffirmed in others the notion of chemical disease.

The Department of Health’s Task Force(74) on chronic agricultural chemical poisoning notifications, and the subsequent report on the possible health effects of the manufacture of 2,4,5-T in New Plymouth(75) both adversely comment on the main diagnostic tool used by Dr Tizard, the electro-acupuncture according to Voll (EAV) which
was banned for diagnostic and treatment purposes by the FDA, USA, in 1973.

After the publication of the Brinkman Report, the Accident Compensation Corporation ceased all payments to Dr Tizard for treatment of the firefighters. The firefighters were left with a legacy of what they saw as betrayal. There was anger, demoralisation and a sense of helplessness. Although deficiencies and criticisms were levelled at Dr Tizard’s concept and practice, he offered a strategy for management and hope which had been withdrawn.

Though the Occupational Health Service was established as recommended by Dr Glass, there still seems to be no coherent programme which monitors the health of ICI firefighters as a long-term strategy.

A number of firefighters were medically boarded. A number may well have minimised their symptoms to avoid boarding. A number remained with a variety of symptoms, and it remains uncertain how many are involved, what supervision and monitoring is taking place, and by whom. Thus whether one takes an emotional or physical view of the symptomatology, there still seems to be an inadequate structure to care for those who perceive themselves as unwell following the ICI fire.

A REVIEW OF THE LITERATURE

The following review of the literature is concerned with psychiatric and psychological aspects of the health of the firefighters relevant to the ICI fire of the 21st December 1984.

Contained in this report is a recognition that:

(a) the firefighters were exposed to a major fire
(b) the fire involved a variety of chemicals
(c) the event was, and is, the focus of community and environmental groups’ concern
(d) the incident and its sequelae were of interest to the media, and
(e) compensation claims are still persisting some five years later.
The weather conditions at the time of the fire was a temperature of 24 degrees, humidity of 71 degrees, followed that evening by moderate to heavy rain. Heat stress and the physical demands of firefighting produce symptoms such as headache, fatigue, malaise, cramps and nausea, and facilitate the rapid skin absorption of any chemical contamination.

General literature references of those chemicals known to exist in the ICI warehouse, and having neurotoxic effects on humans, are listed.

Neurotoxic agents may effect the nervous system centrally via the brain or through the peripheral nervous system. The following comments apply to cerebral toxicity.

The clinical manifestations of cerebral neurotoxicity are presented in Table 5.1 by Johnson writing on the “Prevention of neurotoxic illness in working populations”. Apart from mild and severe forms of acute intoxication, the chronic toxic encephalopathies are categorised as Type (1), (2a), (2b) and (3). Type (1) CNS symptoms alone, involving irritability, depression, sleep disorders, concentration and memory problems which usually are reversible after withdrawal of exposure. Type (2a) is organic mood disorder which is similar to Type (1) but with greater severity and frequency; Type (2b) categorises neuro-behavioural impairment which again has similar symptoms but with neuro-psychological test abnormalities. Type (3) is a very severe chronic toxic encephalopathy akin to dementia. It is in the latter and rare group that neuro-diagnostic investigations are more appropriate in eliciting structural damage that may have taken place in the brain.

It is mainly Nordic countries that have pioneered the investigations of cerebral neurotoxicity and the WHO publication Environmental Health No 5 briefly summarises diagnostic criteria used in Denmark, Finland, Norway and Sweden. However, the Nordic countries make it very clear that they are dealing with a recognised and explicit long-term chemical exposure (of some ten years) usually with organic solvents, in these studies. Triebig and Valentin from the Federal Republic of Germany commented that their studies, failed to confirm the result of other studies particularly from Denmark. They caution that in assessing toxic risks there are a number of confounding factors all of which must be taken into account to avoid misclassification.
Errebo-Knudsen and Olsen\textsuperscript{(29)} comment that many studies, particularly in Denmark, reveal "hundreds" of false positive diagnoses of chronic cerebral "damage" due to neuro-psychological testing without adequate control data. They give this as a main reason for discrepant results often found between Danish and other countries workers in studies of organic solvent encephalopathy. Because of inadequate control data there is reluctant acceptance of the concept, and particularly its frequency, by many international reviewers.

The National Institute of Occupational Safety and Health (NIOSH)\textsuperscript{(35)} states that

"the effect of neurotoxic agents on the CNS present a wider range of disturbances than those on the peripheral nervous system. The most striking effects are changes in mood, in personality and manifestations of cognitive dysfunction. These may occur after exposure to many solvents and to asphyxiants such as carbon monoxide".

They further state that research into neuro-behavioural effects of industrial chemicals is relatively new but that occupational neurotoxicity may be a larger problem than previously suspected. F.S. He\textsuperscript{(36)} at the Asian Pacific Symposium on Environmental Occupational Toxicology supported psychological testing in neurotoxic studies. He, however, cautions that the selection of tests and interpretation is still open to question and the WHO core battery, though emphasising a positive trend to unification and standardisation of methods and instruments, has not yet been defined and commonly agreed upon.

The need to assess cognitive function is recognised in evaluating central nervous system symptoms whether they result from concussion, alcoholism, cerebral disease or industrial toxicity.

**CHRONIC ORGANO-PHOSPHATE (OP) TOXICITY**

1. Electro-encephalograph (EEG)\textsuperscript{(19)} studies in chronically exposed workers have shown "soft" EEG changes but in nine out of ten subjects' sleep records are comparable to those patients with narcolepsy.

2. Gershon and Shaw\textsuperscript{(20)} reported sixteen cases of mental illness following chronic exposure to OP compounds (Malathion spraying) and described schizophrenia, depression and impaired concentration. Their findings have never been replicated and a subsequent study\textsuperscript{(21)}.
failed to substantiate the findings. Polyneuropathy is described\(^\text{[16]}\) and Fisher\(^\text{[22]}\) reported a case of the Guillain-Barre syndrome four days after exposure with Merphos. The WHO report\(^\text{[15]}\) however, disputed his conclusion.

**CHLOROPHENOXY HERBICIDES**

Hayes\(^\text{[3]}\) quotes an industrial study in which nervous and mental symptoms occurred but the clinical picture was dominated by chloracne, hypertrichosis, hyperpigmentation and porphyria.

**COMBUSTION**

Incineration of public refuse is not dissimilar from aspects of the ICI fire and creates a variety of pollutants, such as hydrogen chloride, cyanide, nitrogen oxides, sulphur oxides, hydrocarbons, carbon dioxide, carbon monoxide and benzene. Combustion toxicology is discussed by Einhorn.\(^\text{[76,77]}\) Potentiation may take place when carbon monoxide and hydrogen sulphide occur together.\(^\text{[23]}\) References 24, 25, 26 and 27 relate to CNS dysfunction and exposure to carbon monoxide and organic solvents. Though neuro-psychiatric symptoms are well recognised following acute carbon monoxide poisoning, the literature is less clear on chronic or recurrent carbon monoxide toxicity at low exposure levels. Hartman\(^\text{[80]}\) states that auditory and visual vigilance tests are adversely affected.

The ability to monitor exposure may provide some data to this complex problem.\(^\text{[37,38,39,40,41]}\)

**ALUMINIUM**

The relationship between Aluminium and Alzheimers Disease (AD) is unproven and AD patients do not show differential levels of Aluminium in CSF, hair or serum. Patients with *chronic renal failure* may develop encephalopathy from chronic ingestion of Aluminium containing antacids or dialysate. Dialysis dementia is characterised by personality change to global intellectual impairment with seizures, gait problems, dysartrhia, apraxia and myoclonus after some three years’ dialysis. Subjects with *normal renal function* clear Aluminium effectively.\(^\text{[80]}\)
**ALCOHOL**

Chemical intoxicant studies on neuro-psychological assessment of non-Korsakoff alcoholic males reveal significant cerebral impairment, compared with controls. The literature is reviewed by Brandt and Butters.32)Lishman, Ron and Acker(33) in their computed tomography and psychometric assessment of “superficially intact alcoholics” demonstrated significant memory changes, impaired test responses to perceptual motor skills and abstracting tasks, compared with controls. Tarter,(34) in reviewing psychological evidence of brain damage in alcoholics, indicates that in general, overall intelligence quotient remains intact. However, cognitive testing reveals disturbance in non-verbal abstracting ability, although deficits involving visuo-spatial tasks were more pronounced.

**CONCUSSION**

McClelland(30) and Lishman(31) list the post-concussional symptoms as headache, fatigue, insomnia, concentration problems, irritability, subjective memory impairment and depression. Psychological assessments show impairment in visual perception and cognition, perceptual speed, memory and psycho-motor co-ordination impairment. Lishman’s paper is deserving of some detailed consideration, as he reflects on the symptomatology of acute and chronic post-concussional syndrome. The symptoms are similar and it is uncertain whether cerebral effects, psychological reactions, or admixtures of both can account for the symptomatology.

Lishman(31) in his analysis of the concussional syndrome, describes findings such as otological dysfunction, slowing of the cerebral circulation and auditory revoked responses delayed in the brain stem, concluding that the symptoms of acute underlying concussion appear to be organic in origin.

Lishman’s view of the chronic post-concussional syndrome comments on the relevance of pre-traumatic genetic vulnerability, personality and previous psychiatric illness, and present psycho-social problems in recent life events. He observes that the circumstances of the accidents which may contribute to persistence in symptoms include fear and anger, that patients at the time of trauma are highly suggestible about medical comments that may be made, anxious and uncertain about treatment. Compensation and litigation are also complicating
factors, with its recurrent and persistent repetition of symptoms that generate, reinforce and perpetuate the syndrome.

Lishman in discussing head trauma argues that these acute cerebral effects rapidly resolve over a matter of weeks, and the *chronic* post-concussional syndrome is mainly due to psycho-social factors.

**PSYCHO-SOCIAL DISCUSSION**

New Zealand society has a view of itself, rightly or wrongly, as a green country relatively pollution-free, and the development of its nuclear-free policy no doubt partly reflects some aspects of this viewpoint. The world has seen a growing concern with pollution caused by humans through car exhausts, industrial chemicals, radiation wastes and accidents, as well as growing concern with the use of pesticides and other chemicals in horticulture and farming. With this growing concern, special interest groups have developed and media publicity has maintained a high level of public awareness of these issues, some informed, some uncritical. It is against this background of social sensitivity about chemical issues that the ICI fire has to be seen.

In view of the considerable number of firefighters complaining of symptoms, the possibility of a psychological group response requires consideration. McLeod(42) reviewed the Parnell incident of 1973(43), in which an organophosphate was spilt from damaged drums, and concluded that fear, anxiety and exhaustion may have contributed to bodily symptoms of many subjects.

Colligan and Murphy(44) have written on mass psychogenic illness (M.P.I.). They recognise that environmental agents such as volatile hydrocarbons, organophosphate and other chemicals may produce psychiatric symptoms. “Mental epidemics” in industry have usually been diagnosed on the basis of excluding possible chemical causes. They indicate that it is never possible to be sure all agents are excluded, and therefore the diagnosis of mental epidemics is never definitive.

McEvedy and Beard(45) published a reconsideration of an epidemic at the Royal Free Hospital in 1955 in which 200 staff were admitted to this London hospital. The main symptoms referred to the CNS, and included headache, general weakness, dizziness, body pains, nausea and depression. Editorials(46,47) refer to the dissemination of “mental
infections”. The group sharing common emotions, insecurity or anxiety are generating factors; imitations are engendered, detailed public announcements take place and fresh outbreaks removed from the present epidemic may occur. Fearful anticipation and vague rumours of danger abound, anxiety and bodily symptoms predominate, emphasising headache, malaise, dizziness, and fearfulness, with little objective evidence of disease.

There are conflicting interpretations of the Royal Free incident but when assessing illness affecting a large number of people, a psychological viewpoint has to be maintained whilst physical assessments are concurrently being made.

Wessely, (48) in writing on collective psychogenic illness, refers to it as an outbreak of abnormal illness behaviour, or sick role that cannot be explained by physical illness, affecting people who would not otherwise normally behave in this way. He states that the link between participants is not coincidental, and that newspaper coverage increases tension and facilitates spread. He states the group reality replaces external reality, pressure to conform to this deviant behaviour and the desire to remain part of the group encourages participation.

Sirois(49) views the manifest group tension as a response to a threat which may be real or fantasised and that factors such as helplessness and powerlessness may exist and prevent a healthy adaptive response. Small and Borus(50) stated a threat of environmental pollution contributed to the psychological stress in their epidemiological study in which urine toxicology proved positive for a chemical and thirteen out of the eighteen students admitted to hospital. However, the same compound was found in healthy adults and when glass containers were substituted for plastic urine containers, no toxic substances were found, implicating contamination of the plastic containers. Controls and detailed analysis of the data is essential to guard against possible erroneous conclusions.

Hefez,(') in studying a group epidemic on the Jordan West Bank, emphasised the role of the media. With each sensationalised comment from the press, a new wave of subjects presented with bodily complaints to the local hospital. Media reports noted that “sudden partial blindness” occurred in thirty-four subjects who complained of “headaches, stomach-ache and cyanosis of the limbs”. Four days later newspapers referred to a mysterious “gas poisoning” in which
fifty-six subjects were poisoned. Two days later the articles refer to poisoning by “nerve gas” claiming three hundred people were affected, and now newspapers reported that the poison had been spread on “classroom curtains”. Some five days later on 2 April, newspapers further reported that gas was being used to sterilise the students. These press reports demonstrate the importance of the influence of mass media on such outbreaks, and he suggests that journalists “selectively filter available information, often phrased in an emotionally laden way”. The episode was only terminated when two foreign and independent committees of experts investigated the incident and made the authoritative statement that “there was no evidence that poisoning existed”.

EMOTIONAL/PSYCHOLOGICAL ISSUES

Post-traumatic stress disorder (PTSD) is a diagnosis recognised by the Australia and New Zealand College of Psychiatry, and is based on a number of specified criteria.

McFarlane\(^{52,53,54}\) administered psychological questionnaires to 469 volunteer firefighters four months after an Australian bush fire in South Australia on 16 February 1983. Psychological questionnaires assessing the impact of the disaster were followed by a structured interview of fifty high-risk subjects. Eleven subjects diagnosed as PTSD were compared with thirty-four controls. Accepting the small samples involved and the insufficient validation of the structured interview, it appeared that PTSD did not reflect the intensity of exposure, the perceived threat and losses involved in the disaster. An assessment of pre-morbid factors was significantly associated with the development of the chronic PTSD, relating to such factors as past and family history of psychiatric illness and personality traits. Thus the debate on the priority of the event versus pre-morbid elements in the personality and history in the aetiology of the PTSD syndrome is maintained.

Studies suggest that pre-morbid psycho-social factors may have more relevance particularly in the subsequent history of the PTSD syndrome. McFarlane, commenting on symptoms, discussed disturbed concentration, indicating that concentration problems can be very central to emotional responses and do not necessarily imply cerebral dysfunction.
This recalls Lishman’s comment that pre-morbid psycho-social factors were mainly contributory to the chronic post-concussional state.

*The concept of abnormal illness behaviour* is derived from sociological views of illness enunciated by Parsons.\(^{(55)}\) The “sick role” is accepted by members of society. The rights of that sick person are that the person is released from normal and usual obligations to society, is absolved from guilt concerning his or her condition, and it is recognised that the person will require care and treatment by others. However, in response, that person is obligated to seek help from those professionally competent, to co-operate with such advisors and to be motivated to establish health. A sick role is not necessarily a medical condition but a status in society. The notion is that something disabling has happened, entitling the person to special attention. The sick role fits into the notion of illness rather than disease. Illness is a subjective statement and refers to the way people differently experience symptoms. It is an altered state of self-perception— that is how a person experiences him or herself.

Disease on the other hand is that which is determined by a practitioner, and implies some objectively determined condition discussed by Scadding.\(^{(56)}\)

Mechanic\(^{(57)}\) and Pilowsky\(^{(58,59)}\) further develop these concepts which “in general shows different ways patients may emphasise or minimise their illness to a disproportionate degree” compared with the degree of objective disease. Bodily symptoms are often expressed and a chronic sick role is sought for a variety of personal reasons, e.g., disability payments or a way of solving family conflict.

Because the emphasis of bodily symptoms may accompany demonstrable physical disease, the pertinent question becomes how much is “disease”, and how much is illness. Ford\(^{(60,61)}\) described the “Humpty Dumpty Syndrome” as a particular example of a disability syndrome in which patients, previously hardworking have assumed responsibility prematurely in their lives and worked long hours. Following an accident their fundamental dependency needs, which have not been fulfilled throughout earlier years, have an opportunity to be gratified. A previous compensatory independence crumbles against those dependency needs. The patient becomes permanently dependent and disabled, often at a time when they are reaching an age in which work demands may be too excessive for the person’s resources. Ford underlines how refractory to treatment and how chronically disabling
the condition may be. There is often a collusive behaviour between the patient and his family who help to maintain that person in an invalid role, and relieve him of all responsibilities. Lishman in his discussion on the chronic post-concussional syndrome notes that a persistent and repeated repetition of symptoms to institutions, agencies and a variety of physicians all help to perpetuate the patient’s illness view of him or herself.

COMPENSATION ISSUES

Miller\(^{62}\) considered the disability following a working accident was primarily motivated by financial gain, and that following settlement, the condition resolved. However, Tarsh and Royston\(^{63}\) followed up thirty-five claimants diagnosed as accident neurosis one to seven years after compensation had been obtained. The patients had perplexing bodily symptoms without demonstrable organic pathology. Having seen thirty-five patients, Tarsh concluded that complete recovery was rare and return to work unusual, despite the resolution of their compensation. The authors noted that there was not a poor work record amongst the subjects involved, and they did not consider they had abnormal personalities or abnormal families. Raphael\(^{64}\) states the issue of compensation may in itself become a source of conflict, inter-personal difficulties, bitterness and stress, which can add to the patient’s original morbidity, and the apparent need “to maintain a disorder for compensation may both prolong and exacerbate the morbidity”. It is apparent that the changed social role of the person involved as a result of a dramatic incident or trauma, may be far more significant in determining their subsequent pathology than any financial settlement. Raphael elaborates that in general, people make reasonable claims and do not see money as the most important goal, or in any way real compensation for their impaired health. The financial claim symbolises recognition of suffering rather than offering full compensation for impaired health.

FIREFIGHTERS’ HEALTH LITERATURE

Although there is a growing literature and recognition of the toxicity of fires, particularly related to combustion products, the main emphasis on firefighters’ health appears to be on respiratory disorders, cardiovascular problems, hearing defects and stress. There is a paucity of literature on the neurotoxicity of firefighters.
Markowitz et al\textsuperscript{65} studied a sample of eighty firefighters compared with fifteen subjects and assessed psychological stress following a polyvinyl chloride fire. He refers to the toxic incident as an “event”, and his ten-year computer research of psychological abstracts “revealed no papers on the psychological effects of any toxic exposure event among firefighters”. The fire study involved a building containing scrap PVC. The firefighters experienced eye irritation and skin rashes. Of 125 firefighters, ninety-five (76\%) volunteered for his study, carried out forty-two days from the event. Eighty of the ninety-five were deemed to have been directly involved with the fire, and fifteen non-involved firefighters were a comparative group. Questionnaires were self-administered, and measures such as demoralisation, emotional distress specific to exposure, and perception of threat to physical health, were the tests administered. The distress level of the involved firefighters was higher than the comparative group, although the two groups were not strictly comparable on baseline characteristics nor were they a random sample.

Markowitz in a follow-up study\textsuperscript{66} twenty-two months later revealed a persistent state of distress.

Dyer and Esch\textsuperscript{67} reported a study of 175 firefighters from 1970 to 1975, who experienced toxicity when attending a plastic teflon office copy machine fire (PVC) during a twenty minute attendance, when no masks were initially used. The main symptoms again were respiratory, with tightness of the chest, dyspnoea, accompanied by headache, dizziness and nausea. Apparently twenty-five hours after the fire, a thirty-three-year-old male fainted, had an epileptic-like seizure and died. Post-mortem noted pulmonary haemorrhages, chemical pneumonitis and coronary atherosclerosis. It was considered that hydrogen chloride had been inhaled and caused significant irritation to the mucous membranes of the lung.

Melius and Schulte\textsuperscript{68} in their article on “Occupational Neurotoxicity” state two main variables “hopefully correlated, exposure and response”. However, “measuring exposure is often difficult, several neurotoxic agents may occur together, the separation of individual effects is difficult”. They discuss the problems of epidemiological studies and exemplify this by quoting three studies of exposed groups.

Jannerfeldt\textsuperscript{69} was requested to evaluate the possibility that a fire may have led to lasting adverse health effects among the 400 firefighters at
a Las Vegas hotel in 1980. A questionnaire for health effects and the profile of mood states (POMS) was completed by 356 firefighters. Symptoms included a high prevalence of upper respiratory tract symptoms, increased irritability and sleep disturbance. The fire contained extensive plastics and other synthetic building and decorative material, and presumably produced toxic air contaminants. Eighty-four persons, mainly guests and employees of the hotel died. The authors comment that many firefighters may be exposed to toxic substances which can cause haematological, neurological and liver function disturbances. They state toxins such as benzene and toluene can be produced by pyrolysis but may have been present prior to the fire, for example in chemical waste dumps and pesticide warehouses. They also state that in the latter situation, the fire may cause destruction of containers and thus subsequent toxic contamination of the environment in which the firefighters work. The paper emphasises the stress aspect, stating that firefighters are often the first to have contact with survivors of fires. Firefighters have to maintain emotional stability when exposed to serious physical hazards, and are involved with the stress not only of victims but rescue workers and survivors. Jannerfeldt states that thirty-five firefighters sought medical care, fifteen were admitted to hospital mainly due to smoke inhalation. Three firefighters were still receiving medical care at the time of the survey, two months after the fire. The firefighters were all male with a median age of 27, and 36% reported cigarette smoking. Increased irritability and sleeping difficulties were reported by 28% of the firefighters and 8% continued to complain at the time of the interview. A group of firefighters who in 1974 had been exposed to a pesticide fire and assessed, were compared as was a non-exposed group of firefighters. The groups, however, were small and not matched on demographic variables. The findings were such that though an association between exposure to the fire and acute symptoms during the days following the fire was evident, it was more difficult to determine whether the association persisted two months after the time of the interview.

The author concludes that there was a high prevalence of respiratory symptoms as well as signs of psychological disturbance, such as mood effects, irritability and sleeping problems in the surveyed population but no apparent association between health effects reported at the time of the interview and exposure to the fire. They conclude, that health problems both physical and psychological reflect the high degree of stress experienced by professional firefighters.
Schulte(70) surveyed seventy of seventy-nine personnel who had attended a pesticide warehouse fire in July 1974 in Ohio, USA, the survey being done in December 1979 and 1980, using health questionnaires. The study had been requested by the Association of Firefighters to ascertain if symptoms experienced by its members were related to exposures to various pesticides and other chemicals. The warehouse included pesticides, herbicides and grain fumigants. Several large explosions occurred, smoke and flame were extensive. The fire was extinguished in six hours. Immediately after smoke came to ground level, firefighters complained of nausea, dizziness, burning of the eyes, nose and throat, headaches and chest pain. Respirators were not available until two hours after the fire began, and in insufficient numbers. Seventeen firefighters were taken to a local hospital for treatment of smoke inhalation and some apparently received atropine injections for “possible organophosphorous pesticide poisoning”. Symptoms complained of in 1979 some five years later, were mental distress, depression, anger, violence, suicide and memory dysfunction, tightness in the chest and shortness of breath. The medical survey contained two parts of a self-administered health questionnaire and the POMS, in addition to a personal interview on health matters and data concerning attendance at the fire. The study included twenty-five of the thirty-one career firefighters who were present. A referent group of twenty-four firefighters from a similar sized city in the same region were chosen as controls.

Twenty-five of thirty-one Alliance career firefighters reported a statistically significant history of memory and concentration loss, and nervousness compared with unexposed career firefighters. The Alliance firefighters were found to be significantly different from the referent group for variables describing tension, vigour, fatigue, confusion and for all the mood variables taken together. It appeared that those who had health effects at the fire also showed significantly more symptoms at the time of the assessment. Thus the investigator concluded that those people who became ill or affected at the scene of the fire were either more heavily exposed to toxic gases, or initially more susceptible, or both. He concluded that in those who had health effects at the scene of the fire, chemical exposure could account for their current symptoms and adverse health conditions. The investigator also referred to the fact that the data did not support the existence in the three groups of what he calls a “talk-up” effect, that is a group discussion, reinforcement and augmentation of emotions or feelings, due to
concern about previous exposure to toxic materials. The pattern is more supported by a hypothesis of "common effect from exposure". Cautiously he states that the exposure that occurred at the fire may be linked to the high prevalence of mood disturbance and abnormal health conditions compared with the referent group of firefighters who were not exposed. The study indicated that concentration and memory problems were significant symptoms.

A further NIOSH Report by Anderson and Melius\(^{(71)}\) was at the request of the Detroit Firefighters' Association for a health hazard evaluation of respiratory symptoms and skin irritation in a group of tw hundred firefighters. The incident was a chemical fire and explosion in 1984 at a warehouse in a Detroit suburb. The warehouse company was involved in the blending and distribution of pesticides and a supply of chemical solutions used in the blue print industry. Chemicals mentioned included ammonia, phosphoric acid, methyl alcohol, Malathion and various amounts of other pesticides and chemicals. The fire "raged" for over four hours and ammonia-laced smoke along with heavy black smoke could be seen for miles around. Few of the firefighters wore a respirator for any appreciable time during the fire. The investigation was carried out some ten weeks after the incident. It consisted of a baseline pulmonary function test, a self-administered medical questionnaire and profile of mood states scale. A large number of respiratory, nose and throat irritation symptoms were complained of lasting several hours after the fire, and were reported by nearly half of the survey participants. Cough and shortness of breath was also reported by some 38% and 26% respectively. Questioning revealed that the time spent at the fire and in heavy smoke seemed significantly associated with recurrence of those symptoms, and those firefighters who had spent more than six hours at the scene of the fire were more than twice as likely to develop persistent cough. The study included some 136 firefighters, and the emphasis was on respiratory function. Irritability and sleeping difficulties were reported in 80% two months after the fire, though the mood scale test results were lower than student norms.

Sandoz manufactures chemicals for textiles and agro-chemical industries in Schweizerhalle, which is located on the border of France and Switzerland, and in 1986 a building in the plant was destroyed by fire. The chemicals were classified under the general headings of pesticides, herbicides and insecticides. Some 200 firefighters were in action and the fire took some four hours to come under control. It is
of interest that the report\(^{(72)}\) herein quoted states "no firemen had been hurt".

CLINICAL COMMENT ON THE CNS PROBLEMS OF THE ICI FIREFIGHTERS

- Firefighters in Auckland were exposed to a fire involving chemicals and combustion products. As indicated in the literature review, the "fire as an event" became a focus of considerable social concern. It gave rise to legitimate anxieties as to the health of those involved and contributed to financial hardship and compensation problems.

This highly stressful situation must have made the firefighters feel a beleaguered and uncared for group despite their high standing in New Zealand society.

- Of primary concern is the effect of chemicals on the central nervous system which is being increasingly recognised world-wide as a relatively important new development both in industrial medicine and in sequelae from accidents. This relatively new subject lacks unequivocal descriptions of neuropathological changes, and because of species specific differences, animal studies may not necessarily have relevance to human problems.

The monitoring and assessment of exposure and dosage is also problematic.

In an attempt to enhance knowledge of some of the problems of what is now described as neurotoxicity, both the World Health Organisation and the National Institute of Occupational Safety and Health (NIOSH) of the United States have developed psychological tests to assess possible central nervous system effects resulting from chemical exposure.

The World Health Organisation has indicated a number of neuropsychological tests which they describe as a core battery, the principles which have been followed during the present investigation. The WHO state that there is not yet international agreement on the selection of appropriate tests, their reproductibility, standardisation and the distinction between normal and abnormal performance results.

As a general statement with respect to a study some five years after the event, a number of biases may affect test results. These include
motivation to participate in the study which may well be different between the Auckland and the Wellington group and give some sample bias, problems of recall and observer variation in testing despite the attempt to use the same personnel with the same equipment. Other factors such as alcohol and its effect on the central nervous system, disorders of the nervous system, age, educational level, sleep disturbance on the night prior to testing, drinks with stimulant effects such as coffee, tea, and soft drinks, smoking, personal motivational factors, anxiety, fatigue and medical disorders as well as drugs may all influence a person's performance on a specific time on a specific day.

Thus both epidemiological study and individual assessment is a very complex and difficult exercise which is recognised in international writings and can only allow a statement of probabilities in the light of all the data available from which reasonable conclusions can be drawn. There can be no absolute certainties and perhaps living with some degree of uncertainty has to be accepted.

**Establishment of Clinical Categories**

Ongoing central nervous system symptoms, reported in the health status questionnaire, were grouped and are reported below.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Memory, concentration problems</td>
<td>103</td>
<td>42.0</td>
</tr>
<tr>
<td>2. Insomnia</td>
<td>29</td>
<td>11.8</td>
</tr>
<tr>
<td>3. Loss of interest, motivation,</td>
<td>58</td>
<td>23.7</td>
</tr>
<tr>
<td>fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Mood disturbance</td>
<td>97</td>
<td>39.6</td>
</tr>
<tr>
<td>5. Inco-ordination, balance problems</td>
<td>8</td>
<td>3.3</td>
</tr>
<tr>
<td>6. Paraesthesiae</td>
<td>4</td>
<td>1.6</td>
</tr>
<tr>
<td>7. Headache</td>
<td>29</td>
<td>11.8</td>
</tr>
<tr>
<td>8. Dizziness</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>9. Visual disturbance</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>10. Eye irritation</td>
<td>5</td>
<td>2.0</td>
</tr>
<tr>
<td>11. Tinnitus, hearing loss</td>
<td>4</td>
<td>1.6</td>
</tr>
<tr>
<td>12. Speech, writing impediment</td>
<td>4</td>
<td>1.6</td>
</tr>
<tr>
<td>13. Sex difficulties</td>
<td>4</td>
<td>1.6</td>
</tr>
</tbody>
</table>

The above list shows a number of self-reported CNS symptoms many of which do not fit into any special clinical syndrome. They may
commonly occur and are a small percentage of the total CNS symptom group.

The symptoms of memory, concentration, loss of interest, motivation, fatigue and mood disturbance constitute a large percentage of complaints. These symptoms may be seen in both emotional states and those organically caused.

The psychiatric categories of I-IV defined below arise from a clinical judgment which attempts to imply a hierarchy of neurotoxicity from I-IV respectively. Thus Category I is mood disturbance alone; Category II suggests a greater degree of distress whilst the inclusion of concentration and memory in Categories III and IV suggests a possible organic factor may be causative.

If neurotoxicity was relevant to the production of these symptoms, then some correlation could be expected with neuro-psychological test abnormalities and exposure to toxins.

Categories I, II, III, and IV are defined as follows:

(1) Category I
the presence of mood disturbance in the absence of fatigue, loss of interest or motivation, memory and/or concentration impairment.

(2) Category II
the presence of fatigue, loss of interest or motivation, and mood disturbance in the absence of memory and/or concentration impairment.

(3) Category III
the presence of memory and/or concentration impairment and either mood disturbance and/or fatigue, loss of interest or motivation.

(4) Category IV
the presence of memory and/or concentration impairment in the absence of fatigue, loss of interest or motivation, and mood disturbance.
Testing consisted of a neuropsychological (NP) battery and the General Health Questionnaire (GHQ) (Goldberg). The symptoms described by the firefighters are non-specific and are clinically seen in both emotional states and in conditions of brain dysfunction irrespective of the latter's cause.

Neuropsychological testing is an attempt to provide an objective and standardised method of assessing brain function. One of its goals is to determine whether the subject's symptoms have an emotional basis or neurotoxic basis.

An overall risk ratio of 1.32 comparing the two groups is regarded as a small relative risk in epidemiological terms. This ratio may have resulted from a variety of unavoidable methodological issues and biases.

Brain impaired subjects show both poor responses to psychomotor and memory testing. However, the psychologists suggested that tests involving time and speed (as with psychomotor tests) would be more likely to be adversely affected by anxiety. The subcategories of psychomotor tests compared with memory tests and timed compared with non-timed tests show a relative risk of 1.51 compared to 1.05 and 1.58 compared to 0.91 between Auckland and Wellington subjects respectively.

This suggests that the relative risk of 1.32 in favour of the referent group may well have an important element of anxiety that contributed to the difference between Auckland and Wellington groups.

The results support the contention that anxiety and stress as discussed later in this section is more likely to be an explanation of symptoms than cerebral toxicity.

There is no statistical significance in distribution of the NPI index for the study group for all four clinical categories combined or for Category IV alone. The latter category contains the most "neurotoxic" symptoms of concentration and memory and the failure to show significance would argue against a physical or toxic causation.

The Investigator's report indicates that for all the four combined clinical categories there is no significant association for a number of variables including age, years of service, alcohol intake and exposure.
to the fire or clean-up in either the respiratory or dermatological mode.

In the results presented by the psychologists, they indicate that the Wellington group appear to have test results comparable to a normal population with the exception of the Rey Osterrieth Figure test. However this latter test as discussed in the psychologists' report does present problems in presentation, methodology and marking, apart from the presence of appropriate normative data. In the light of these factors, it would be clinically wise to put aside this single test difference in assessing the overall test responses of the Wellington group.

In view of the present status of neuropsychological testing and the factors influencing the results, abnormal NP results in the absence of clinical symptoms cannot be taken as indicative of brain dysfunction.

For group comparison, psychological procedure would suggest cut-off points at the 10th (or 90th) percentile and in this group 11 out of 20 firefighters in Auckland have a NPI index of more than three and come within a psychiatric category.

The Investigator's report suggested a percentile of 2.5 (97.5) cut-off is usual with biological tests. This identified 13 out of 25 Auckland firefighters who had considerably poorer test results (than the 10th percentile group) though only in more than one test response.

In view of the possible biases already commented upon previously, it cannot be assumed at this stage that those firefighters in this specified group have cerebral impairment. However, it is recommended that these 13 firefighters warrant further clinical and psychological reassessment to clarify their health status.

Of the Wellington group there is only one firefighter coming into the above category.

The General Health Questionnaire is a measure of the emotional symptoms of ill health. The results show a significant difference with the Wellington group and indicate that there is a considerable level of emotional distress amongst the Auckland firefighters. The psychologists point out that as the test enquires how the subject compares feelings in recent weeks with the usual state, rather than prior to the ICI fire, there is concern that the General Health Questionnaire may not have been a wholly appropriate instrument. Nevertheless the
results do reflect the large number of Auckland firefighters who continue to experience distressing, ongoing symptoms.

Of the 245 Auckland firefighters assessed, 138 indicate that they experience ongoing symptoms which include mood disturbance, loss of interest, motivation and fatigue and problems with memory and concentration. They do not necessarily each share all the symptoms and with a lack of quantitative assessment, varying severities cannot be commented upon from the group data. That a large number of firefighters in Auckland have varying degrees of distressing emotional symptoms is of considerable concern.

This study primarily applies itself to the firefighters but it is recognised that families and partners have also been adversely affected by the symptomatology with its effect on relationships irrespective of the causation of the symptoms.

In group response it is not implied that the group's experience is not real, or that it is illusory. There is sufficient literature on the physiological effects of stress to recognise that the symptoms experienced are as distressing as any recognised medical disorder. It simply represents a subject's conflict between his/her coping mechanisms and the demands environmentally made on the subject.

The literature contained in the report and review of the toxicology of the fire as a chemical event fails to indicate a level of toxicity comparable to the studies of Nordic investigators who in their description of organic solvent encephalopathy, demand prolonged and explicit exposure to solvents over many years as a prerequisite for the diagnosis of chronic CNS dysfunction.

The possibility of known and unknown chemicals resulting from the fire and the contribution of carbon monoxide are legitimate concerns but the degree and severity of toxic exposure is both uncertain and debatable.

On the other hand, in relation to an emotional basis for the present symptomatology, this report indicates that at the time of the fire there was evidence of some mismanagement of the fire and firefighters inevitably experienced anger. There was and still is legitimate concern due to the failure of adequate medical help, uncertainty about chemical exposure exacerbated by conflicting statements and public concern. Feelings of insecurity and abandonment were experienced
following certain decisions made by the Accident Compensation Corporation. That this committee enquiry was found to be necessary is indicative of the chronic and unfortunate stress placed on the Auckland firefighters.

RECOMMENDATION

Reassessment and monitoring of firefighters who have abnormal test results indicated above is required to clarify their CNS function.

It is suggested that those firefighters whose symptomatic state still affords them distress should be given the opportunity of debriefing and counselling for their stress symptoms, and to receive factual information on toxicology, as there has been considerable confusion and conflicting statements.

The study did not have measures of previous levels of test functioning of firefighters prior to the ICI fire. There may be a number of firefighters whose prior cognitive functioning was of such a high order that despite impairment they would still come within the normal level on testing in a group study. Those individuals who consider themselves to have symptoms and believe they fall into this category should be given the opportunity for reassessment if they so choose.

The high level of stress encountered by firefighters particularly in motor vehicle accidents is a neglected area and stress management and debriefing opportunities need to be made available.

At the time of entry and selection to the service, a brief neuropsychological profile should be obtained, and would provide a useful baseline for subsequent assessment should traumatic experiences necessitate further reassessment.

Hopefully a fully established occupational health service with access to specialist facilities, will be established to expedite these needs for those firefighters wishing to take advantage of them.
REFERENCES


295


71. Anderson, K.E., Melius, Jun. H.E.T.A. No. 84.4841574. NIOSH. Cincinnati, Ohio, U.S.A.

73. Edwards, P.J. Homeopathy Patient Controlled Paradox. dissert. BA (Hons) Univ. of Otago 1986.


Appendix III

PRINCIPAL TYPES OF HORTICULTURAL AND AGRICULTURAL CHEMICALS DESTROYED BY FIRE OR WASHED TO WASTE OR SPILLED AND RETAINED ON SITE, OR NOT SPILLED (Total Stocks Held in Store)

<table>
<thead>
<tr>
<th>Product</th>
<th>Ingredient</th>
<th>Quantity</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organophosphates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actellic Dust 2% Pirimiphosmethyl</td>
<td>230 kg</td>
<td>'Selvesso 150'-aromatic (hydrocarbon mix (petroleum)</td>
<td></td>
</tr>
<tr>
<td>Actellic 50 50% Pirimiphosmethyl</td>
<td>708 l.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actellic Smoke 20% Pirimiphosmethyl</td>
<td>29 kg</td>
<td>'Solvesso 150'</td>
<td></td>
</tr>
<tr>
<td>Attack 47.5 Pirimiphosmethyl 2.5% Permethrin</td>
<td>2256 l.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diazinon 20P 20% Diazinon</td>
<td>774 l.</td>
<td>Pegasol R150-aromatic hydrocarbon mix</td>
<td></td>
</tr>
<tr>
<td>Dibrom EC 90% Naled</td>
<td>351 l.</td>
<td>Hydrocarbon</td>
<td></td>
</tr>
<tr>
<td>Malathion 50 50% Maldison</td>
<td>1437 l.</td>
<td>Pegasol R150</td>
<td></td>
</tr>
<tr>
<td>Orthene Acephate 75%</td>
<td>126 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>358 kg</td>
<td>+ 5526 l.</td>
<td></td>
</tr>
</tbody>
</table>

299
<table>
<thead>
<tr>
<th>Product</th>
<th>Ingredient</th>
<th>Quantity</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated Hydrocarbons</td>
<td>Gammexane L20 19.8% Lindane</td>
<td>2960 l.</td>
<td>MEK (Methylethylketone)</td>
</tr>
<tr>
<td>Paraquat/ Diquat/ Group</td>
<td>Gramoxone 20% Paraquat</td>
<td>44702 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Preeglone 12% Paraquat/ 6% Diquat</td>
<td>12980 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Peglone 20% Diquat</td>
<td>3485 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Spraygrow 15% Paraquat/ 2.5% Diquat</td>
<td>16930 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Torpedo 10% Diquat</td>
<td>1160 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>79257 l.</td>
</tr>
<tr>
<td>Carbamates</td>
<td>Furadan 10G 10% Carbofuran</td>
<td>9660 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Furadan 5G 5% Carbofuran</td>
<td>773 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saturn 50 EC 50% Thiobencarb</td>
<td>590 l.</td>
<td>Hydrocarbon</td>
</tr>
<tr>
<td></td>
<td>Pirimor 50 50T Pirimicarb</td>
<td>176 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>10609 kg</td>
</tr>
<tr>
<td></td>
<td>+ 590 l.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenoxy and Other Herbicides</td>
<td>Atraflow Atrazine (residual herbicide)</td>
<td>130 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Agral 27% Nonyl-Phenyl Ethoxylate</td>
<td>6340 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Amine 2,4-D 5.5lb active 2,4-D per gallon</td>
<td>600 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Butoxone 2,4,5-T 5.1lb active 2,4,5-T per gallon</td>
<td>730 l.</td>
<td>Diesel</td>
</tr>
<tr>
<td></td>
<td>Caneclean Dust 40% Atrazine, 40% 2,4-D</td>
<td>330 kg</td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>Ingredient</td>
<td>Quantity</td>
<td>Solvent</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Canespray 333</td>
<td>2,4-D and 2,4,5-T at 2.25 per gallon</td>
<td>13796 l.</td>
<td>Diesel</td>
</tr>
<tr>
<td>Contact</td>
<td>27% Nonyl-Phenyl Ethoxylate</td>
<td>1239 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Dicambone 5G</td>
<td>50g/kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dimethylamine Salt Dicamba</td>
<td>3056 kg</td>
<td></td>
</tr>
<tr>
<td>Dicambone 75-D</td>
<td>7.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dimethylamine Salt Dicamba + 30% 2,4-D</td>
<td>3570 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Dicamba</td>
<td>Dimethylamine Sale 20% Dicamba</td>
<td>3540 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Dicidex</td>
<td>60% Triclorphon</td>
<td>1021 l.</td>
<td>Xylene</td>
</tr>
<tr>
<td>Embark 2-S</td>
<td>24% Melfluidide</td>
<td>302 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Ethone 2,4-D</td>
<td>36% 2,4-D</td>
<td>20 l.</td>
<td>Diesel</td>
</tr>
<tr>
<td>Fusilade</td>
<td>25% Fluazifop-Butyl</td>
<td></td>
<td>2529 l.</td>
</tr>
<tr>
<td></td>
<td>'Solvesso 2001–hydrocarbon mix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gesaprim 80</td>
<td>80% Atrazine</td>
<td>408 kg</td>
<td></td>
</tr>
<tr>
<td>Ricespray 70</td>
<td>Methyl Chlorophenoxy acetic acid MCPA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4,5lb per gallon</td>
<td>290 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Trident</td>
<td>60% dichlorprop, 15% MCPA, 1.87% Dicamba</td>
<td>420 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Icipon</td>
<td>74% Dalapon</td>
<td>2020 kg</td>
<td></td>
</tr>
<tr>
<td>Nortron 50EC</td>
<td>50% Ethofumesate (sulphonate)</td>
<td>8 l.</td>
<td>Cyclohexanone/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>xylene</td>
</tr>
<tr>
<td>Norton SC</td>
<td>20% Ethofumesate</td>
<td>255 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Totals</td>
<td>5824 kg</td>
<td>+ 34790 l.</td>
</tr>
</tbody>
</table>

301
<table>
<thead>
<tr>
<th>Product</th>
<th>Ingredient</th>
<th>Quantity</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Remedies, Pesticides, Fungicides and Other Chemicals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nilverm</td>
<td>4% Levamisole</td>
<td>2676 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Formaldehyde 37%</td>
<td>37% Formalin</td>
<td>120 l.</td>
<td>Formaldehyde</td>
</tr>
<tr>
<td>Perenox</td>
<td>50% Cuprous Oxide</td>
<td>495 kg</td>
<td></td>
</tr>
<tr>
<td>Talon 50 WB</td>
<td>0.005% Brodifacoum</td>
<td>5464 kg</td>
<td></td>
</tr>
<tr>
<td>Talon 20P</td>
<td>0.002% Brodifacoum</td>
<td>15 kg</td>
<td></td>
</tr>
<tr>
<td>Triton X-45</td>
<td>Surfactant, alkyl aryl polyester alcohol</td>
<td>2500 l.</td>
<td></td>
</tr>
<tr>
<td>Ambush 10 EC</td>
<td>10% Permethrin</td>
<td>964 l.</td>
<td>Pegasol 150</td>
</tr>
<tr>
<td>Ambush 50 EC</td>
<td>50% Permethrin</td>
<td>332 l.</td>
<td>Pegasol 150</td>
</tr>
<tr>
<td>Goal</td>
<td>24% Oxyfluorfen, 35% Xylene</td>
<td>282 l.</td>
<td>Dimethylformamide</td>
</tr>
<tr>
<td>Milcurb</td>
<td>12.5% Dimethirimol</td>
<td>490 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Nimrod</td>
<td>25% Bupiramate</td>
<td>60 kg</td>
<td></td>
</tr>
<tr>
<td>Diuron 80</td>
<td>80% Diuron</td>
<td>4080 kg</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>10114 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ 7354 l.</td>
<td></td>
</tr>
<tr>
<td>Pool Care Products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algaeshock</td>
<td>Active ingredient</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-chloro 6 bis (ethylamino)-S-triazine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>618 l.</td>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Baqucil</td>
<td>20% w/w solution of poly</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(hexamethylene biquanide) hydrochloride</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8175 l.</td>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>Ingredient</td>
<td>Quantity</td>
<td>Solvent</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------</td>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Pool Care Products—continued</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granular Pool Chlorine</td>
<td>650 grams per kilogram of calcium hypochlorite</td>
<td>2172 kg</td>
<td></td>
</tr>
<tr>
<td>Phenol Red Tabs PH</td>
<td>Phenol Red Tabs</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td>Pool Stabilisers</td>
<td>98% isocyanuric acid in powder form</td>
<td>569 kg</td>
<td></td>
</tr>
<tr>
<td>Pool Testers Chlorine T Kit</td>
<td></td>
<td>453 kits</td>
<td></td>
</tr>
<tr>
<td>Stabilised Pool Chlorine Tablets</td>
<td>900 grams trichloroisocyanuric acid per kilogram</td>
<td>933 kg</td>
<td></td>
</tr>
<tr>
<td>Pool Floc</td>
<td>Preparation of Aluminium sulphate</td>
<td>558 kg</td>
<td></td>
</tr>
<tr>
<td>pH Buffer</td>
<td>pH buffer is a preparation of sodium bicarbonate</td>
<td>2196 kg</td>
<td></td>
</tr>
<tr>
<td>pH Decrease</td>
<td>Preparation containing sodium bisulphate</td>
<td>490 kg</td>
<td></td>
</tr>
<tr>
<td>pH Increase</td>
<td>Preparation of soda ash</td>
<td>2664 kg</td>
<td></td>
</tr>
<tr>
<td><strong>Healthcare Products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amolin Crea</td>
<td>13,00 x 50 g</td>
<td>650 kg</td>
<td></td>
</tr>
<tr>
<td>Amolin Lotion</td>
<td>3,516 x 200 ml</td>
<td>703 l. Water</td>
<td></td>
</tr>
<tr>
<td>Amolin Powder</td>
<td>2,856 x 300 g</td>
<td>857 kg</td>
<td></td>
</tr>
<tr>
<td>Amolin Shampoo</td>
<td>36 x 200 ml</td>
<td>7 l. Water</td>
<td></td>
</tr>
<tr>
<td>Alka Seltzer Tabs</td>
<td></td>
<td>72000 tabs</td>
<td></td>
</tr>
<tr>
<td>Buccaline Berna</td>
<td>100 x packs 7 tabs</td>
<td>700 tabs</td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>Ingredient</td>
<td>Quantity</td>
<td>Solvent</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------</td>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Habitane</td>
<td>61,116 x 500 ml</td>
<td>30558 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Disinfectant</td>
<td>972 x 200 ml</td>
<td>194 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Reef Oil</td>
<td>1,452 x 200 ml</td>
<td>290 l.</td>
<td></td>
</tr>
<tr>
<td>Sanitaire Spray</td>
<td>72 x 75 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cream</td>
<td>800 x 30 g</td>
<td>24 kg</td>
<td></td>
</tr>
<tr>
<td>Savlon Cream</td>
<td>4,560 x 75 g</td>
<td>342 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>350 x 500 g</td>
<td>175 kg</td>
<td></td>
</tr>
<tr>
<td>Burn Dressings</td>
<td>1,840 x pack 5</td>
<td>1840</td>
<td></td>
</tr>
<tr>
<td>Savlon Dry</td>
<td>705 x 75 g</td>
<td>52 kg</td>
<td></td>
</tr>
<tr>
<td>Skin Food</td>
<td>58536 x 200 ml</td>
<td>11707 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Savlon Liquid</td>
<td>12345 x 125 ml</td>
<td>1543 l.</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>1710 x 1 litre</td>
<td>1710 l.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1424 x 2 litres</td>
<td>2848 l.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17655 x 500 ml</td>
<td>8828 l.</td>
<td></td>
</tr>
<tr>
<td>Savlon Shampoo</td>
<td>612 x 150 ml</td>
<td>92 l.</td>
<td>Water</td>
</tr>
<tr>
<td>Talc T.S.</td>
<td>194 x 25 kg</td>
<td>4850 kg</td>
<td></td>
</tr>
</tbody>
</table>

With acknowledgment to Mr W.C.C. Birch, Safety Manager, Chemical Group ICI New Zealand Limited, who checked and revised the list.
Appendix IV

REPORT FROM THE SWEDISH POISON INFORMATION CENTRE
HEALTH EFFECTS OF CHEMICAL FIRE ON FIREFIGHTERS, AUCKLAND, NEW ZEALAND (1984)

The fire at the ICI Mt Wellington store, Auckland on Friday, 21 December 1984 involved a great number of chemicals (listed in different reports on the fire) and the warehouse itself.

During a fire of this magnitude people might be exposed to the parent product, combustion products from the chemicals as well as combustion products from packaging and from the warehouse.

Combustion toxicology is a complex matter and a number of substances may be formed. One chemical may give different combustion products depending on for example temperature i.e. some combustion substances may be formed at low temperature while others are formed at high temperature.

Dr W I Glass has listed some of the combustion substances that might have been formed at this fire. You have to take into account all substances possibly formed, but at some stages of the fire the effects of the chemical itself also have to be considered.

Due to the extensive skin exposure many firefighters received local skin symptoms from the chemicals. Most of these symptoms resolved within a couple of weeks according to medical reports from the fire. Skin absorption of all chemicals involved may occur in cases of skin damage. Once skin damage has occurred, chemicals that normally do not penetrate skin also may be absorbed, as the natural protective skin barrier is destroyed.

Inhalation of fumes, particulates or aerosols of different substances, some of which are listed by Dr W J Glass, may give rise to local irritant effects of the respiratory tract. In severe cases advanced respiratory distress symptoms may occur. In the ICI fire symptoms
from the respiratory tract were present in a number of firefighters. Some of them presented advanced symptoms but only two had symptoms lasting more than a couple of days.

Initially many firefighters did not wear protective breathing apparatus and the fact that local symptoms from the respiratory tract were present indicates that the firefighters were exposed to and inhaled fumes while fire fighting.

Apart from local effects from skin and respiratory tract also symptoms as headache, nausea and discomfort occurred in the acute phase indicating systemic involvement. In a number of firefighters also diffuse neuropsychiatric symptoms appeared after one or two weeks. These symptoms have persisted in some of the firefighters.

Symptoms as excess tiredness, irritability, forgetfulness, mood change without reason, sleeping disturbances etc are neuropsychiatric symptoms that can be seen after exposure to some toxicants. The onset of these symptoms may be delayed for some time. In carbon monoxide poisoning for example, these symptoms described may appear up to two to three weeks after an acute exposure to high levels of carbon monoxide or repeated or prolonged exposure to low concentrations. In chronic exposure to many hydrocarbons neuropsychiatric symptoms are typical signs.

The fact that the firefighters were exposed to chemicals and combustion fumes without wearing protective clothing or breathing apparatus together with the fact that diffuse symptoms from CNS are present indicates that there might be a relationship between the exposure and the symptoms. However, it is impossible to exclude this relationship, but other possible aetiological factors to the CNS symptoms as leaking heating systems, repeated or prolonged solvent exposure, heavy ethanol consumption etc, should be excluded. Furthermore psychometric testing would be of value to decide whether symptoms are organic or psychogenic.

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Appendix V

REPORT FROM R M LAING ON PROTECTIVE CLOTHING FOR FIREFIGHTERS
I have read with interest the report from the Protective Clothing Sub-Committee on Turnout Clothing (undated) supplied by you. The committee has obviously put a great deal of effort into this project, and seem to be making progress. The approach of different levels seems sensible. However there is still more work to be carried out before the proposals are adopted.

The following points are either not clear from the present report or have yet to be addressed:

1  The precis states the project examines reliability, comfort and safety of the finished garments to be used in the assembly.

1.1 There is no information provided on the changes to performance of fabrics following cleaning procedures, hence to any suggestion of reliability of "fabrics". (The extrapolation from fabric results to the garment form is common and often misleading.)

1.2 The comfort of the proposed clothing assembly has only been partially evaluated and/or reported:

* Human testing at the Footscray Laboratory included a Zirpro treated wool overall yet the recommendation is for a Proban treated cotton overall. What difference is this likely to have?

* Garment trials to date have been carried out on 9 volunteers who might be considered a-typical, and incomplete results and analysis from the testing have been provided.

* The sensory comfort scale used at Footscray is not one which is recognised and I wonder if it has been standardized.

* Extrapolation of findings obtained on a homogeneous sample to a wider group needs to be viewed with caution.
1.3 The safety of finished garments has not yet been evaluated although I assume the field trial will achieve this. Further discussion is needed on field trial procedures.

2 The report contains many assumptions about garment design effects (e.g., bellows front and pockets, air movement between layers for cooling) which do not seem to have been validated. Total garment mass is known to be critical to generation of metabolic heat and yet this does not seem to have been mentioned at all. If one needs to minimize mass is there justification for adding items such as epaulettes, shoulder patches, design stripes?

Differences in effects of garment assemblies evaluated at Footscray are attributed largely to fabrics (excluding fabric mass) but results must be attributable also to garment design. Only two of the three assemblies were of the same design.

3 Fabric Properties

3.1 One table including all fabric properties tested at WRONZ would make identification of the preferred fabrics simpler.

3.2 A second table comparing results of fabric performance before and after cleaning and/or simulated use would also be helpful. This information is potentially very important because performance characteristics change over time.

4 No information is provided on the testing of helmets. The report states that the new helmets are weaker, but does not propose a routine for testing during the life of the product. At what point has the helmet failed?

5 No information is provided on the testing and performance of gloves.

6 No information is provided on the testing and performance of boots.

7 Labelling - What is a cleansing paste? How effective are the care routines proposed (cold water)? Have they been evaluated?

8 Government Stores Board Clothing and Footwear Advisory Service
   Does this service still exist?

I trust these comments are helpful to you. Please phone me if you need any clarification.

Yours sincerely

Raechel M Laing
Head of Departmental Group
Appendix VI

TOXICOLOGICAL BIBLIOGRAPHY


Appendix VII

ACKNOWLEDGEMENTS

We greatly appreciate the assistance we have had in preparing this report.

We owe a special debt of gratitude to the firefighters, both from Wellington and Auckland, who participated in our study at no small personal cost.

We received a great deal of assistance from the Fire Service Commission, the Professional Firefighters' Union, ICI (New Zealand) Limited, the Accident Compensation Corporation and the Department of Health. People who gave generously of their time to help us included Dr Fetherston, Dr Stephenson, Assistant Commander Radovan, Fire Commissioner Armstrong, Mr Clyde Stewart and Chief Fire Commander Woodward.

We interviewed more than 50 firefighters and officers and received a number of further written communications from them. We also interviewed a number of wives of firefighters, and appreciate very much the perspective they were able to give us. We have not recorded their names here because a number asked for assurances of confidentiality.

Those who supplied written submissions to us were:

   Accident Compensation Corporation, Mrs S Deverell, Royal New Zealand College of General Practitioners, Dr J Hanley, Ministry for the Environment, Order of St John, Tamaki City
A number of those who supplied us with written submissions, also attended meetings of the Committee either to expand upon their written submissions or in response to inquiries from the Committee.

We express our appreciation to those who provided information to us in this way.

We were extremely fortunate to have the assistance of Dr Major Eilenberg, Stuart Parkinson, Dr Deborah Read, Olina Carter, Clare Salmond and Coral Duggan. It was a privilege to work with them.
The health consequences of the ICI fire