Investigation into the possible health impacts of the M5 East Motorway Stack on theTurrella community

Phase 1 – a cross sectional clinical assessment of potentially affected residents

NSW HEALTH
Working as a Team

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SHPN (EHB) 030281
ISBN 0 7347 3624X

Further copies of this document can be downloaded from the NSW Health website: www.health.nsw.gov.au

November 2003

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Acknowledgments

The preliminary study into the possible health impacts of the M5 East exhaust stack was conducted on behalf on NSW Health by:

- Physicians from the Royal Prince Alfred Hospital; in association with
- The Environmental Health Branch, NSW Health

The following medical specialists conducted the clinical assessments of the affected residents in April and May 2003:

- Dr. Robert Loblay
- A/Professor. Guy Marks
- Dr. Janet Rimmer
- Professor Wai-On Phoon
- Dr. Kwok Yan
- Dr. Karl Baumgart
- Dr. Velencia Soutter.

The specialist nursing staff performing testing were Dorothy Callender, Catherine Broue, Carol Field, Susan Henderson, and Nuala Hanniffy.

Dr. Robert Loblay coordinated the clinics, which were held at the Royal Prince Alfred Hospital, Allergy Clinic. Clerical assistance was provided by Jenny Misa, Ann Martin, Carmen Hurley and Vicki Harrison.

Data were compiled and analysed by Adam Capon, Katy Emmett, Dr. Vicky Sheppeard and Dr. Alison Rutherford, Environmental Health, NSW Health.

Advice concerning study design and protocol was provided by Dr. Robert Loblay, A/Prof. Guy Marks, Dr. Steven Corbett,[5] Dr Michael Staff,[6] A/Prof Mark Ferson,[7] A/Prof. Bin Jalaludin,[8] Margo Eyeson Annan[5] and Gea de Meer.[9]

All other activities were coordinated by Dr. Vicky Sheppeard, Dr. Alison Rutherford, Adam Capon and Katy Emmett.

Funds were provided by NSW Health.

The research team wishes to thank all participants for their interest and willingness to be part of this exploratory study.

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Summary

The M5 East Motorway includes a 4 km long tunnel that is ventilated through a single exhaust stack system. The exhaust stack is located in Turrella and is designed to remove all motor vehicle exhaust emissions from the tunnel. In the first half of 2002, immediately after the opening of the tunnel, NSW Health received over 80 complaints from local residents who believed their health was being affected by the stack exhaust. Monitoring in the local area showed that pollutant levels had not changed, so there was no apparent cause for the symptoms. After consultation with key stakeholders and experts, NSW Health developed a multi phase investigation strategy to examine the health concerns and symptoms of the local residents. This report is of Phase 1 of that strategy.

Phase 1 investigation consisted of an exploratory, qualitative study to better define the nature of the symptoms being experienced by the residents. It involved a clinical examination by a medical specialist, allergy testing and a questionnaire on the residents' health status. The sample population was all residents within 700 metres of the exhaust stack and those who had made a previous complaint to NSW Health. By the nature of its design, the study was purposely biased toward those who believed their health had been affected by exposure to emissions from the M5 East exhaust stack.

Invitations for participation were sent to the 1,928 homes identified within the 700 metre zone and 88 invitations were sent to those who had previously complained to NSW Health.

Fifty-two residents from within the 700 metres and two residents from outside the 700 metres presented for examination. Their clinical histories were summarised to provide information on the perception of risk, initiating events, symptom triggers and temporal relationships of their symptoms. Once clinical information had been collected, symptoms were categorised by the specialists into three categories.

Category A: Person reported symptoms that were assessed by the physicians as having a likely relationship with the M5 East stack.

Category B: Person reported symptoms that were assessed by the physicians as having an uncertain relationship with the M5 East stack.

Category C: Person reported symptoms that were assessed by the physicians as having an unlikely relationship with the M5 East stack.

This classification provided the basis for the analysis of the information collected.

Thirty-four of the fifty-four participants had one or more symptoms that were assigned into 'Category A'. Sixteen participants' symptoms were assigned into 'Category B' while four participants' symptoms were classified as 'Category C'.

The symptoms most commonly reported and assessed by the medical specialists in 'Category A' were eye (29 participants), nose (14 participants) and throat (10 participants) symptoms. Other less commonly associated symptoms related to chest, skin, headache and feelings of depression.

'Category A' symptoms were generally noted as having an onset temporally related to the opening of the tunnel. These symptoms tended to not fluctuate hour to hour or day to day.

Allergy testing revealed a lower but not statistically significant prevalence of allergen reaction in those with 'Category A' symptoms when compared with the general population.

Quality of life was assessed using the Short Form – 36 questionnaire. Results showed participants reporting a poorer health status than the general Australian population in all criteria except for mental health. However these differences were not statistically significant.

This study can make no inference about the actual 'cause/s' of the symptoms being experienced. It remains for analytical studies to prove or disprove whether or not there is an association between 'Category A' symptoms and living close to the M5 East stack.

Recommendations for further investigation include:

1. An analytical study with the aim of determining whether or not there is a real association between residential location and 'Category A' symptoms.
2. Should an analytical study demonstrate an association, an environmental investigation to better characterise pollutant exposure levels.

Background

1

The M5 East Motorway is a 10 km long, 4-lane dual carriage motorway, which links central Sydney with Sydney's southwest. It consists of three major sections that include:

- **The western section**: This section covers 4 kilometres of open carriageway from the end of the existing M5 South-West Motorway at King Georges Road to the start of the tunnel section at Bexley Road, Earlwood.
- **The tunnel section**: From Bexley Road, Earlwood to Marsh Street, Arncliffe. The tunnel section consists of twin 2 lane tunnels, 4 kilometres in length. The tunnel is ventilated utilising a closed system (ie to avoid exhausting from portals) with fresh air supplied through an air intake at Duff Street Arncliffe. Jet fans operate against traffic flow at exit portals, and with traffic flow in the Marsh Street entry, to assist the movement of air to an exhaust location. Exhaust air is extracted without filtration through a single stack located approximately 900m north of the tunnel near Turrella railway station.
- **The eastern section**: From Marsh Street, Arncliffe to General Holmes Drive at Sydney Airport that includes the Eve Street viaduct, the Cooks River crossing and the freeway interchange with General Holmes Drive.

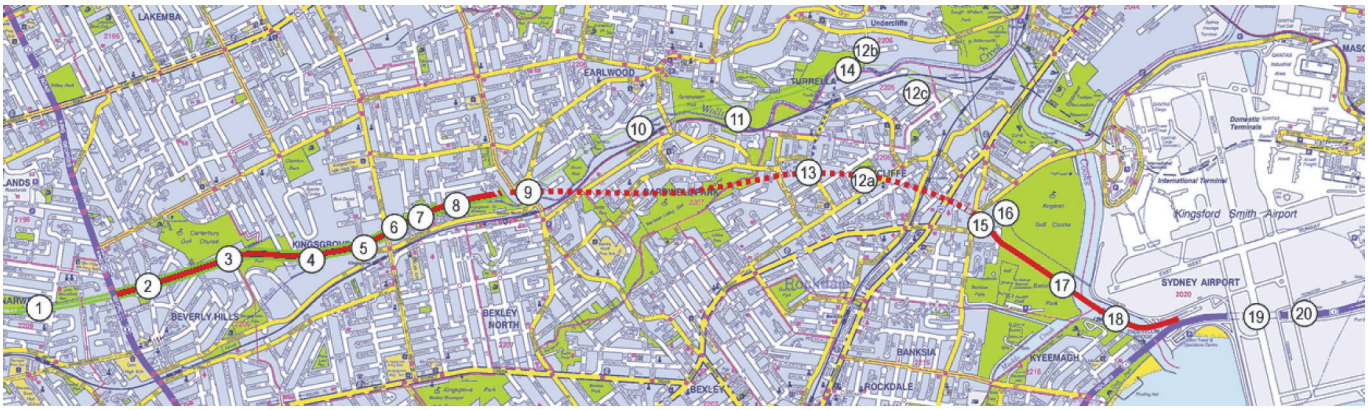
1.1 History

From its inception this development has been a controversial one. This report deals with the specific health concerns from the many local residents around the M5 East exhaust stack.

The concept of developing a motorway linking central Sydney to Sydney's southwest has existed since the late 1940's. However it was not until 1989 that an Environmental Impact Statement (EIS) for a 6-lane motorway between Beverly Hills and Alexandria was exhibited. In 1994 an alternative EIS was released. This 1994 EIS proposed a 4 lane tolled motorway. Following exhibition of the 1994 EIS key modifications were made and in 1996 yet another EIS was exhibited. This 1996 EIS originally proposed a three stack/three intake system of ventilation for the tunnel section of the motorway. However owing to 7951 representations of objection during its exhibition period, on 30 June 1997, the Roads and Traffic Authority (RTA) modified the 1996 EIS to a one stack / four air intake system. The stack was to be located near Henderson Street, Turrella.

On 9 December 1997, the RTA was given approval by the Minister of Urban Affairs and Planning, subject to 150 conditions, to proceed with the single ventilation stack M5 East Motorway development.

Figure 1. Location of M5 East Motorway*



12 a 12b, 12c.-Air Quality monitoring stations

13 – Air intake system

14 – M5 East exhaust stack, Turrella.

All other numbers do not relate to this report but are general features along the M5 East motorway.

* Figure taken from RTA website

On 16 January 1998 the Transport Action Group Against Motorways Inc. commenced proceedings in the Land and Environment Court to stop the current plan for development of the M5 East motorway, challenging the validity of some of the decisions taken by the RTA and the Minister for Urban Affairs and Planning. One key argument was the modification of the 1996 EIS from a three stack / three air intake system to a one stack / four air intake system. They unsuccessfully argued that this was a significant change to the development and as such another EIS and community consultation period should be undertaken. A subsequent appeal was also dismissed.

On 28 October 1999 a Parliamentary Committee was established to investigate the proposed development of the single ventilation stack at Turrella *(General Purpose Standing Committee No.5 (GPSC5))*. The Committee made 12 recommendations, which included:

Recommendation 6 – The need for an epidemiological health study of the community surrounding the ventilation stack.

Owing to the limitations of epidemiological studies in small populations, NSW Health advised resources to be directed to more effective measures such as monitoring pollutants.

Community outrage towards the ventilation stack increased, culminating in a rally and a sit down protest outside Parliament House in May and August 2000. On 12 December 2000 the Construction, Forestry, Mining and Energy Workers Union ('the CFMEU') issued a green ban on the ventilation construction site.

In August 2000, on advice from various government departments, the Department for Urban Affairs and Planning (DUAP) increased the construction height of the ventilation stack from 25 metres to 35 metres.

On 26 March 2001, the Parliamentary Committee (GPSC5) reformed to inquire into new areas of concern and report on the progress of its recommendations. At its conclusion, the Committee made 14 recommendations including:

Recommendation 2 – That Recommendation 6 from the previous Committee meeting be enacted.

Originally planned for opening on 4 June 2002, the Motorway construction was ahead of schedule and the opening was revised to 9 December 2001. This early opening meant some of the conditions of approval for the development of the M5 East Motorway would not be met. Therefore on 6 November 2001 Residents Against Polluting Stacks (RAPS) threatened to seek an injunction in the Land and Environment Court to prevent the opening of the tunnel until all the regulator's conditions had been met or a commitment to install electrostatic filtration equipment had been made. Three days prior to the opening an agreement between RAPS and RTA was reached and the temporary injunction adverted.

On 9 December 2001 the M5 East Motorway opened for traffic.

On 30 April 2002 NSW Health received, as part of a submission from RAPS, a petition with 72 signatures from residents around the Turrella ventilation stack who believed their health was being affected from stack exhaust. The predominant symptoms reported were eye irritation, headache and new or worsening asthma.

As part of the consent for development the RTA had installed air pollutant monitors around the M5 East exhaust stack. Five monitoring stations were installed, three operational since June 2000, with the other two operational since November 2001. These air pollutant monitors showed that air pollutant levels (carbon monoxide, nitrogen dioxide, fine particles and air toxics) did not change significantly once the stack opened. Further, the levels of measured pollutants remained below applicable standards before and after the stack opened, except for occasions of city-wide elevations as is found with bushfires.

Residents also reported significant odours associated with the opening of the stack. In December 2001 the RAPS group distributed odour diaries to residents. Katestone Environmental Consultants conducted preliminary analysis of diaries from 24 households and one workplace covering the period 10/12/01 to 30/6/02. The consultants reported that independent

complaints were often made on the same day, particularly during light winds.

In July 2002 NSW Health attended various committee and community group meetings to elicit more information about the health complaints and to determine the best way of addressing the concerns. The unique situation in this case was that people were reporting symptoms in the absence of any predictions of ill health. The epidemiological difficulties associated with assessing the reported symptoms in this circumstance were:

- The relatively small population affected
- Difficulty in quantifying exposure
- Presence of multiple potential confounders (cigarette smoking, home heating, traffic, annoyance)
- Lack of knowledge of mechanism of symptomatology (eg. which chemicals could be causing symptoms, whether or not symptoms are odour mediated)
- Likelihood of small physiological changes which would require a large study population over time to detect (eg changes in peak flows in asthmatic children)
- Difficulty in assessing cause

NSW Health prepared an internal discussion paper and convened a series of meetings with experts in epidemiology and environmental health inside and outside the Department to discuss possible research strategies to investigate the symptoms. A steering committee was appointed to guide the investigation.

Various strategies were considered, including a prevalence study of symptoms through the NSW Health Survey, a cohort study of children with asthma at nearby schools and a cohort study of adults with asthma at various 'exposure distances' from the stack. These options were limited by their relative insensitivity. Given the relatively small population affected, any form of population study has the potential for Type II errors (missing a true effect).

To refine the study options, NSW Health consulted with experts in immunology and respiratory medicine at Royal Prince Alfred Hospital. After a number of meetings NSW Health determined that the best methodology was to use a multi phase investigation, with the first phase being an exploratory, qualitative study to better define the nature of the symptoms being experienced. A similar methodology was successfully used in 1996 to explore symptoms reported by people who believed they had been exposed to pesticides in Gunnedah.[1] The initial objectives were to define a group of residents who could be experiencing symptoms attributable to the M5 East stack, and then to monitor symptoms and signs in this population to determine if there was a plausible, temporal relationship between pollutant and/or odourous emissions from the M5 East and clinical effects. If indicated by these first 2 phases, NSW Health planned to conduct a cross sectional household survey of the prevalence of identified symptoms in the community.

On 21 October 2002 the Parliamentary Committee (GPSC5) presided for a third time on the M5 East tunnel and stack. During this Inquiry, on 18 November 2002, the Chief Health Officer, Dr. Greg Stewart advised the committee that NSW Health was committed to investigating the symptoms reported.

In December 2002 community meetings were held to discuss the study protocol with local residents, after which several revisions were made to the study protocol. The protocol for the first phase was submitted to the Ethics Review Committee of the Central Sydney Area Health Service in January 2003. Approval to proceed with the study was granted in March 2003.

1.2 Health effects of traffic emissions

Motor vehicles emit a variety of pollutants, many of which are known to be associated with adverse health effects. The pollutants of concern can generally be classified as particulate or gaseous, and the gaseous pollutants of concern include the commonly measured oxides of nitrogen and carbon monoxide, and air toxics, a diverse group of more complex chemicals including volatile organic compounds and polycyclic aromatic hydrocarbons. These pollutants have been investigated as individual chemicals and as part of the typical urban pollutant mix to assess their effect on human health.

Particulate air pollution has mainly been investigated in ecological studies, where health effects are attributed to the variability in particulate levels over time. Established health effects include increased respiratory and cardiovascular morbidity and mortality, although irritative effects to the mucous membranes are also reported.[2 3 19]

An oxide of nitrogen, nitrogen dioxide, has been demonstrated in chamber and ecological studies to produce irritative effects on the eye and respiratory tract, as well as associations with increased respiratory morbidity and mortality.[2 3 4]

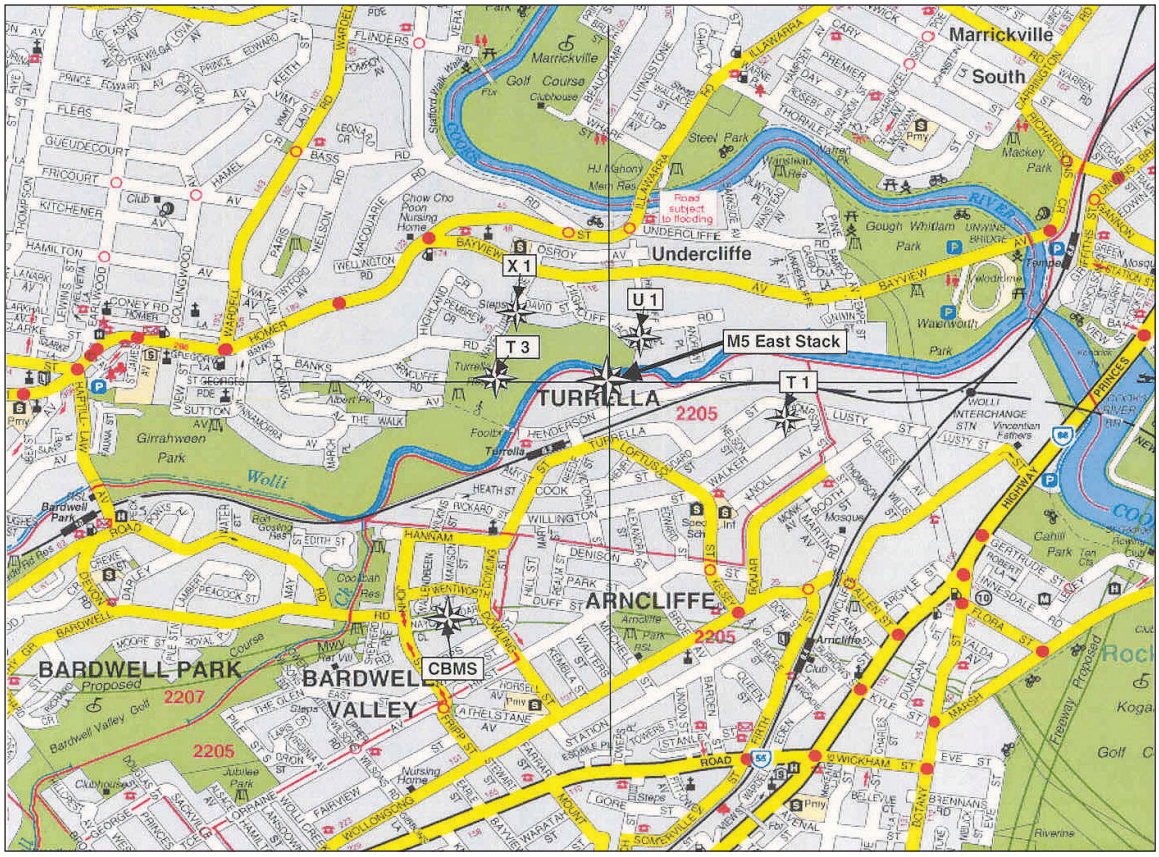
The effects of carbon monoxide relate to its preferential binding with haemoglobin to reduce oxygen supply to the tissues

Australia has developed ambient air quality standards for nitrogen dioxide, carbon monoxide and particulate matter as part of the Ambient Air Quality National Environment Protection Measure (Air NEPM). While these standards are based on health effects, the standards do not provide a threshold below which effects do not occur. Particles especially are recognised as having a dose response effect on health outcomes, even in settings with levels well below the NEPM standard.[5]

The general population is not typically exposed to levels of air toxics associated with immediate adverse health impacts, and there are no applicable population exposure standards for these compounds in Australia. The World Health Organization has established low or no observed effect levels for many, and occupational standards are also available. Air toxics have a range of effects, reflecting the wide range of chemicals in this group, however many cause irritative effects to the mucous membranes and nervous system. Several air toxics are known or probable carcinogens.[5]

The four air monitoring stations around the M5 East stack do not demonstrate that there has been any change in the level of common air pollutants since the tunnel opened. The two monitoring sites for air toxics (T1 and T3 – sixth daily sampling) indicate that those air toxics that are measured (benzene, 1,3 butadiene, acetaldehyde and formaldehyde) are at the typical low levels found in Sydney, and well below levels thought to cause irritative effects.

Figure 2 Location of monitoring stations.



T1 - Cnr Walker Street and Thompson Street, Turrella.

U1 - Cnr Jackson Place and Highcliff Road, Undercliffe.

X1 - Cnr of Wavell Parade and David Street, Earlwood.

CBMS - Gipps Street Lookout, Bardwell Valley.

T3 - Finlays Avenue, Earlwood

Objectives

2

This is an exploratory descriptive study involving 54 individuals who have presented as a result of symptoms they believe are related to their close proximity to the M5 East exhaust stack. While responsibility for the overall study rests with NSW Health, specialist physicians from the Royal Prince Alfred Hospital were given full independence to conduct the clinical investigation.

The objectives of this study were:-

To determine the range of symptoms experienced by individuals in relation to their atopic status and environmental exposure in order –

1 *To identify and categorise the range of clinical phenomena which may be related to environmental exposure from the M5 East stack*

2 *To provide baseline information for further epidemiological investigation of the possible health impact of the M5 East stack*

3 *To attempt to determine criteria by which causal relationships could be established*

3 Study Methods

NSW Health had received over eighty complaints from concerned residents regarding their health. The majority of these complainants lived within 700 metres of the M5 East stack. We therefore defined our initial study population as all residents living within 700 metres of the stack. However, residents who had submitted a complaint with NSW Health but who lived outside the 700-metre study area were also invited to take part.

Participants were recruited through the following means:

- De-identified addresses of all premises within 700 metres of the stack were provided by Rockdale and Canterbury Councils. A letter inviting participation in the investigation was sent to each of these addresses. To ensure adequate opportunity for non – English speaking residents to participate, information on access to interpreter services was provided in the 5 dominant ethnic languages of the area (as defined by local census data)
- Advertisements of clinic times and contact details were placed in local and ethnic newspapers and local pharmacies and with active community groups in the area
- A community meeting was held to discuss the investigation. Here community members had the opportunity to comment on the study plan and register for the investigation
- Interviews with local radio were held.

General practitioners were informed of the investigation through the newsletters of the local Divisions of General Practice.

The inclusion criteria for participation was an adult or child who:

- Believed that their, or their child's, physical health had been affected by emissions from the M5 East stack;
- Lived within 700m of the stack or have previously complained to NSW Health; and
- Was able to attend a clinic at Royal Prince Alfred Hospital.

Participants were required to undertake:

1. A questionnaire / smell and symptom diary and
2. Specialist assessment.

All participants were provided with an information sheet about the investigation and were required to sign a consent form. Confidentiality was maintained by each participant being allocated a unique number, and all investigations and questionnaires being coded and identified only by this number. No link was made with participant's previous medical records at Royal Prince Alfred Hospital. The master list of participants' names and unique numbers, with their consent forms but without any clinical information, was maintained by the chief investigator. A summary of results was mailed to each participant or their parent, and to their general practitioner if requested.

3.1 Questionnaire/smell and symptom diary

Individuals who volunteered to participate in the study were asked to fill out the questionnaire and odour diary up to two weeks before attending their appointment. The questionnaire was broken into four parts.

3.1.1 General health

This section consisted of 36 possible symptoms that the participant may have experienced. Each participant was required to categorise any symptom they may have experienced into a scale of severity (0 = none, 1 = mild, 2 = moderate, 3 = severe). Symptoms were then further categorised into the participant's perception of when they first experienced the symptoms (At present – within the year; In the past – more than a year; Only since the M5 tunnel was opened; Present in the past, but worse since the M5 East tunnel opened).

3.1.2 Short Form Health Survey (SF-36)/ Child Health Questionnaire

The SF–36 is an instrument that has been developed to incorporate self-assessment of well being and normal functioning, for physical and mental health indices. Generic health concepts are measured across age, disease and treatment groups.

The eight scales contained in the SF-36 assess health status, in the following areas of functioning; physical functioning, physical role limitations, bodily pain, general health, vitality, social functioning, emotional role limitations and mental health. In addition, there is a single item measure of perceived health status transition that is not used to score any of the eight multi item scales. For this investigation, the questions regarding bodily pain were removed.

The SF- 36 survey data was processed using the approved Basic Scoring Algorithms. Results obtained from the participants in the study were compared with standardised Australian Norms for the SF–36. These norms were developed by the Australian Bureau of Statistics.

For children (<10 years) and teenagers (10 – 15 years) the comparable Child Health Questionnaire (CHQ) was administered. The CHQ is based on the criteria of the SF–36 but is specifically designed for use on children and teenagers. In our investigation the CHQ PF50 Australian Adaptation[6] was administered. This version has been developed in two forms, a parent/proxy form for the children and an adolescent form for the teenagers. Like the SF-36, the CHQ PF50 Australian Adaptation contains 50 questions aimed at measuring the functional health status and well being of the child.

Data from the CHQ PF50 Australian Adaptation was processed using the approved Basic Scoring Algorithms from the 'Child Health Questionnaire (CHQ) – A users manual'. The results were then compared with Australian norms produced by Walters et al.[7]

3.1.3 Local environment

This section enquired into the participants' perception of their local environment. It dealt with a range of issues including air, noise, visual and odour pollution. Participants were invited to rate the most important environmental issue within their community. They were then asked a series of questions reflecting how this environmental issue had affected their lifestyle and wellbeing. Participants were then asked to rank three environmental issues (noise, soot/haze and odour) separately. Finally, perceptions of the benefits of the motorway were explored.

3.1.4 Demographics and lifestyle

In order to accurately reflect the demographic profile of our clinics, participants were asked general questions about themselves and their lifestyle. These were broken into a number of parts so that a comparison against local census data could be made. The questions included age, sex, address, length of residency, language spoken at home, employment status and education level. In addition two questions on possible indoor pollution generation through smoking and home heating were included.

3.1.5 Smell and symptom diary

For up to 2 weeks before the clinics, participants were invited to maintain an odour diary for any smells they felt could be ascribed to the stack. They were requested to note the date, time and duration of the incident, the symptoms they experienced, what (if any) treatment was required to mitigate these symptoms, weather conditions and any general comments. Results for the questionnaires and odour diaries were entered and analysed on an Excel spreadsheet.

Demographic information

All background demographic data was sourced from the Australian Bureau of Statistics 2001 census[8] for the 3 collector districts that were partially located in the 700 metre radius of the M5 East stack.

3.2 Specialist assessment

Dr Robert Loblay coordinated the clinical assessment. Specialist clinics were held over two weekends in April and May 2003. Seven specialist medical physicians, including a paediatrician, were chosen as investigators because of their experience in immunology and respiratory medicine. Examinations of all participants were conducted by one of the seven specialists and two specialist nursing staff. The examinations included:

- Clinical consultation with the specialist, incorporating history and physical examination.
- Skin prick test with standard allergen extracts
- Spirometry – where indicated
- Asthma challenge test – where indicated

At the conclusion of each examination session the specialists conducted a case conference. The clinical history and findings of each case were presented and discussed, following which the symptoms of each case were categorised according to their likely relationship with the stack. This was a qualitative decision, based on the temporal pattern of symptoms and the best clinical judgement of the examining physicians. Symptoms were categorised as:

Category A - Person reported symptoms that were assessed by the physicians as having a likely relationship with the M5 East stack.

Category B - Person reported symptoms that were assessed by the physicians as having an uncertain relationship with the M5 East stack.

Category C - Person reported symptoms that were assessed by the physicians as having an unlikely relationship with the M5 East stack.

Most participants described multiple symptoms, of which one or more may have been classified into different categories.

The assessing physicians did not attempt to make a diagnosis as to the underlying condition that the participants were experiencing. The purpose of the assessment was to classify symptoms for use in further phases of the investigation.

Analysis was undertaken using an Excel spreadsheet.

Results

4

4.1 Profile of participants

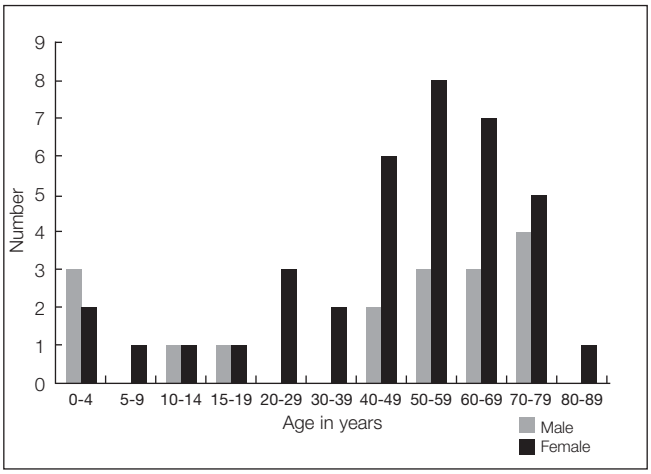
Fifty-two residents from within 700 metres presented for clinical examination. Two residents from outside the 700-metre radius also participated in the study. These fifty-four residents resided in thirty-six households.

4.1.1 Demographics

The age and sex distribution is shown in Figure 3.

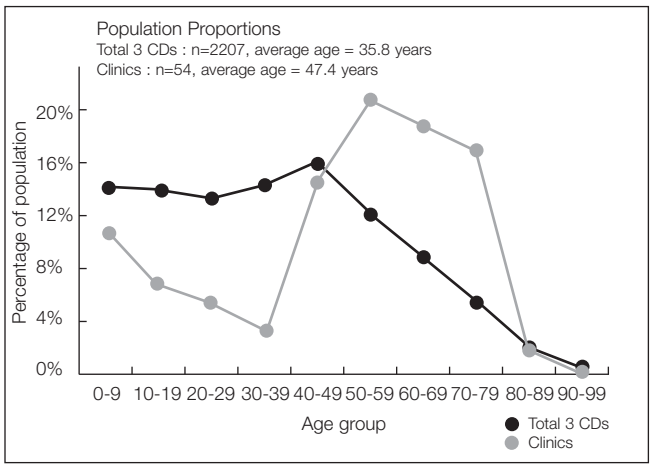
The majority of participants were females in the 40 to 70 year age bracket.

Figure 3. Age and Sex of participants



When comparing this to the local population around the stack, the female older section of the community was over-represented at our clinics (Figure 4) and some non-English speaking background groups were under-represented (Figure 6).

Figure 4. Comparison of clinic age group with the surrounding community

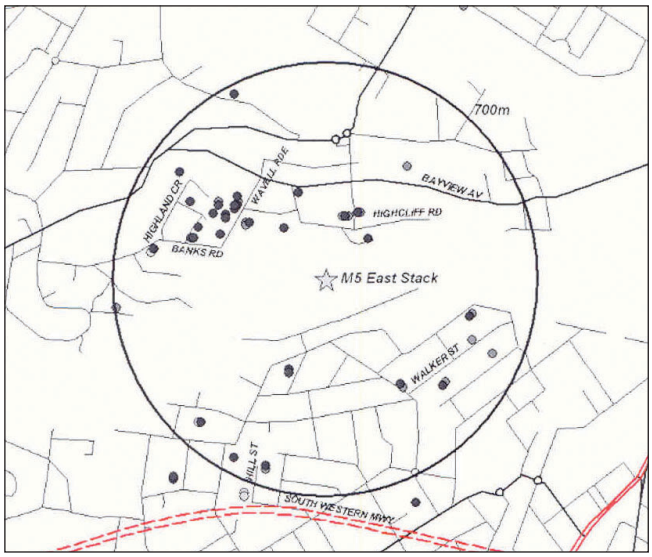


Total 3CDs include collector districts 1351802, 1362501 and 1362511

4.1.2 Location of participants

Participants were asked for their addresses so that residential patterns could be obtained. The majority of participants were located on the ridgeline to the north west of the stack. Figure 5 presents the location of the participants.

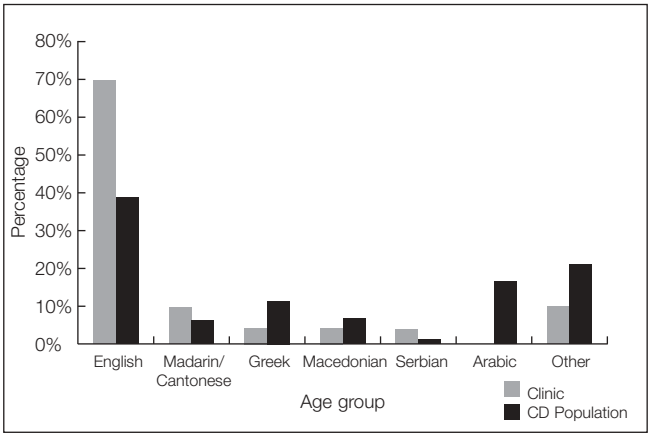
Figure 5. Participant residential locations



4.1.3 Ethnicity

Comparison to Australian Bureau of Statistics data demonstrated that people attending the clinics were more likely to be English speaking than the local population. In particular, few Arabic-speaking residents attended the clinics. The information shown in Figure 6 provides a breakdown of ethnicities of clinic participants versus the general community based on language spoken at home.

Figure 6. Analysis of languages of the M5 East clinic participants



4.1.4 Employment status and education level

The employment status is described in Table 1. Of those employed participants who gave job descriptions only one participant's job had the potential of heightened exposure to vehicle emissions. There was a range of education attainment levels among the participants.

Table 1. Employment status of participants

Employment Status	Percentage*
Located at residence (retirees, home duties, young children)	43%
Full/Part time employment	37%
Student	16%
Miscellaneous	6%

* Actual Percentage adds to 102% owing to rounding error.

Table 2. Education profile of participants

Maximum education level	Percentage
School Certificate or below	45%
Higher School Certificate	11%
Tertiary	44%

4.1.5 Smoking and home heating status

Smoking and home heating were analysed both at an individual and household level. Individually, only six percent of all participants smoked. Seventy eight percent had never smoked while seventeen percent had smoked in the past but now had given it up. Of the thirty-six households represented, two had smokers within them.

Ninety three percent of all participants (34 out of the 36 households) had some form of home heating. The predominant form of heating was electric.

Table 3. Comparison of home heating on an individual level

Type Of Heating	Primary Source (No. of participants)	Secondary Source (No. of participants)
Wood fire	2	2 (Electric)
Flued gas	3	
Unflued gas	9	2 (Electric)
Electric	36	

Table 4. Comparison of home heating by household

Type Of Heating	Primary Source (No. of households)	Secondary Source (No. of households)
Wood fire	1	1 (Electric)
Flued gas	2	
Unflued gas	4	1 (Electric)
Electric	27	

4.1.6 Local environmental profile

Participants were given a choice of seven possible environmental issues that their local community might face. Each participant was asked to note the single environmental issue they felt affected their community the most. Some participants nominated two environmental issues. To adjust for this, we randomly assigned one nominated issue per participant.

Eighty one percent of all participants identified air pollution as the single most important environmental issue facing their community. Fifteen percent identified motor vehicle emissions as the most important issue, while two percent thought odours were the most important issue. The other two percent identified other miscellaneous issues. This is in contrast to the NSW Environmental Protection Authority report 'Who Cares about the Environment - 1994'[9] which identified noise pollution as the most important local environmental issue. The Rockdale City Council State of the Environment Report 2001-2002[10] and Canterbury City Council State of the Environment Report 2001[11] also identifies noise as the main cause of local community environmental complaints.

Of the above environmental issues identified, the majority of participants believed that these issues had caused them to worry about their health, seek medical attention, sleep with their windows closed and worry about the value of their house.

When the issues of noise, soot/haze and odour were considered separately, soot and haze was identified as being the most prominent and annoying by most participants. Most participants attributed this soot/haze to the M5 East stack. Odour was also an issue of major concern. Most participants did notice odours and found them quite disturbing. Once again the M5 East stack was identified as the main source of these odours. A large proportion of participants did notice noise, however they found this less of a disturbance than soot and odour. Sources of the local noise identified included traffic and aircraft.

When asked if they believed the M5 East Motorway had brought any benefits to their community, the responses varied with most believing there were disadvantages. (Table 5)

Table 5. Participant responses to community benefits from the M5 East Motorway

Responses	Number and percentage of participants*
Many benefits	5 (9%)
Some benefits and some disadvantages	19 (35%)
Few benefits but mostly disadvantages	12 (22%)
No benefits	18 (33%)

* Actual Percentage adds to 99% owing to rounding error.

4.2 Profile of symptom exposure relationship

Of the fifty-four participants who attended the clinics thirty-four were assessed as having 'Category A' symptoms. Sixteen participants were assessed as having symptoms classified as 'Category B', while four had symptoms that were assessed as 'Category C'. Each participant's symptoms were coded and graphed by the following categories and sub categories (Table 6).

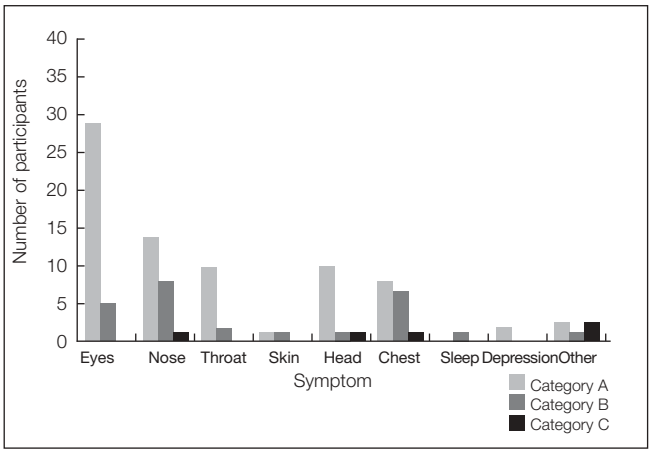
Table 6. Categorisation of symptoms

Eye	
E1	Eye Irritation
E2	Eye Burning
E3	Conjunctivitis
E4	Dry Eyes
Nose	
N1	Rhinitis
N2	Congestion
N3	Sneezing
N4	Nose Irritation
N5	Nose / Other
Throat	
T1	Throat Irritation / Dry Throat
T2	Pharyngitis
Skin	
S1	Burning
S2	Eczema
S3	Rash
S4	Dry / Itchy

Table 6. Categorisation of symptoms (cont'd)

Headache	
H1	Headache
H2	Migraine
Chest	
C1	Cough
C2	Asthma
C3	Shortness Of Breath
C4	Bronchitis
C5	Other Respiratory
Sleep Problems	
A1	Sleep Problems
A2	Fatigue
Depression (D)	
Other (O)	

Figure 7. Symptom by participant categorisation

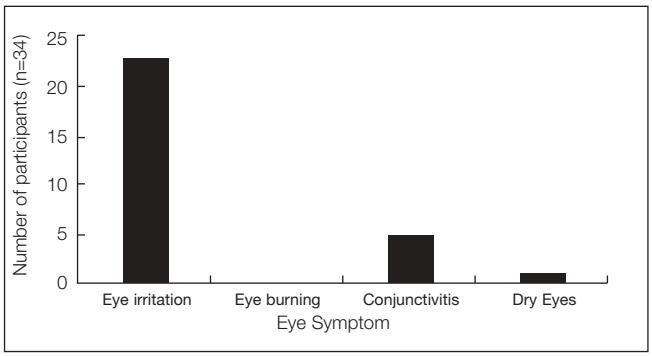


The predominant symptom observed in over half of all participants related to eyes (Figure 7). When analysed at a category level, twenty-nine of the thirty-four participants in 'Category A' presented with eye symptoms.

The 'Category A' symptoms were temporally related to the commencement of operation of the M5 East motorway. The symptoms tended to not fluctuate, except for a noticeable reduction during holidays away from the area. Participants who worked away from the area reported relief from the symptoms when working.

All participants with 'Category A' nasal symptoms also had eye symptoms. Women were 1.5 times more likely to have symptoms assigned to 'Category A' as men. Eye irritation was the predominant eye symptom (Figure 8).

Figure 8. Breakdown of 'Category A' eye conditions



The predominant symptoms in 'Category B' were nasal and chest conditions, while the four participants classified with only symptoms in 'Category C' presented with a range of symptoms.

4.2.1 Reporting of symptoms and sensitivity

While symptoms did not appear to vary temporally, many participants reported relief upon sleeping with their windows closed. Of those participants who had resided for a period of time away from their primary residence, symptoms were reported to be reduced in intensity and in most cases disappear.

In many cases only one member of a household reported adverse symptoms, the other members appearing not to be affected, raising the issue of variation in sensitivity within the household and community.

4.3 Smell and symptom diary

Twenty-five of the fifty-four participants had completed their smell and symptom diaries. Symptoms noted from these diaries were assessed by and assisted in the physician's diagnosis. Symptoms were observed to appear worse on still days and between peak hour morning and afternoon periods. Days of the week when symptoms appeared worse were from Tuesday to Saturday, although this may be an artefact from the day of the week the participant received the diary.

4.4 Allergy profile

Fifty of the fifty-four participants received allergy testing. Four participants did not receive testing at the physician's discretion.

Looking at the prevalence rate in those with 'Category A' symptoms, we found that twelve of the thirty-two participants showed a reaction to the allergens tested (38% prevalence rate, CI 31% - 54%) and were defined as atopic. The definition of atopy used in this study was a greater than 4mm reaction to the Skin Prick Test. Similar allergy testing in Wagga and Lismore in 1991 and 1992 found prevalence in these communities of 44%.[12] Testing performed by the Woolcock Institute, Sydney on the population around Belmont, Newcastle (unpublished data) found a similar prevalence rate.

While not statistically significant, the prevalence rate of atopy found in 'Category A' participants was lower than that of the general community. This may be explained by the physicians tendency to not allocate participants in this category when allergy was a likely cause of the symptoms.

The results of the allergy testing were divided into three broad categories – allergy to grasses, animals and dust (Table 7).

Table 7. Results of Allergy Testing in 'Category A'.

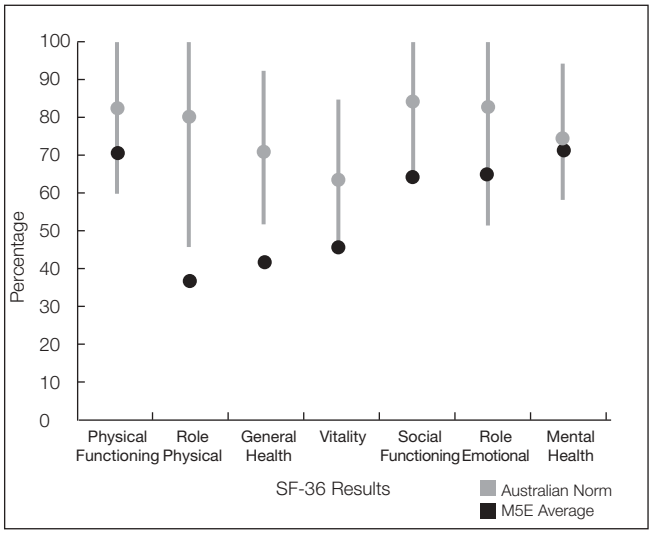
'Category A' Allergy Tests (N = 32)			
	Allergic	**Not Allergic**	**Prevalence**
Grasses	7	25	22%
Animals	1	31	3%
Dust	7	25	22%

In all statistical tests performed there was no statistical significance between allergy type and symptom categorisation.

4.5 SF-36/Child Health Questionnaire

Compared to published norms the responses to most scales tended to be lower than normal (Figure 9). The exception was the mental health scale that was close to normal. The trend to lower than expected health status could be biased by the age of participants, which was significantly older than a standard population*. The participant numbers were too few to allow adjustment for meaningful age comparison.

Figure 9. Comparison of participants mean score on the SF-36 (unstandardised) to the Australian mean and standard deviation



Although there were too few child participants to make a meaningful comparison, responses on the Child Health Questionnaire tended to score lower than normal.

* When compared to the Australian Female 55 – 64 age group norms, there was no statistical significance in any category.

5 Discussion

This preliminary investigation has attempted to identify and categorise the range of clinical phenomena that may be related to environmental exposure from the M5 East stack. These phenomena are predominantly eye irritation, and to a lesser extent nose, throat, headache and chest symptoms. It has provided NSW Health with baseline information for further epidemiological investigation (Phase 2). While this phase is of a preliminary nature, it was found that:

- A large proportion of participants presented with eye symptoms with an onset temporally related to the opening of the tunnel, and constant nature, varying only when the participants left the area.
- Many of the participants had others members in their household that did not appear to be affected, raising the issue of variation in individual sensitivity to the possible environmental exposures.
- The participant's allergy status was not related to their assessment category, with the atopy prevalence of those in 'Category A' appearing lower than normal.
- The participants were generally older, female, English speaking, from a range of education levels, and resided predominately to the north west of the M5 East stack. There did not appear to be significant indoor sources of air pollutants to explain the symptoms in most participants.
- The general health of the participants tended to be lower than the expected norms as measured by the SF-36, except for mental health which was almost average.
- Women were one and half times more likely to have 'Category A' symptoms as men.

This study can make no inference about the actual 'cause' of the symptoms being experienced. It remains for an analytical study to prove or disprove whether or not there is an association between eye and respiratory irritation and living close the M5 East stack.

The sampled group was not randomly selected, and was deliberately biased towards those people who were most likely to be affected. Whilst the recruitment strategy was broad and we attempted to minimise reasons people would be unable to participate, it is likely that people who were ill, elderly or non-English speaking were less likely to participate. There may therefore be people in this population that are more symptomatic than the sampled group. People living in the area may also have been either more or less likely to participate in an investigation run by a government department depending upon their past experiences and belief systems.

It is interesting to note that the symptoms reported by the participants have similarities to those of 'Sick Building Syndrome' (SBS). In the current World Health Organisation Air Quality Guidelines SBS is defined as the occurrence of specific symptoms with unspecified aetiology, which are experienced by people while working or living in a particular building, but which disappear after they leave it. Symptoms include mucous membrane, skin and eye irritation, chest tightness, fatigue, headache, malaise, lethargy, lack of concentration, odour annoyance and influenza symptoms. Volatile organic compounds (VOCs) were identified as a possible important cause of SBS. It was however conceded that SBS is probably an interaction of several factors, involving different reaction mechanisms. The causes of this syndrome may be as varied as environmental tobacco smoke, formaldehyde, VOCs, pesticides, odorous compounds, carbon monoxide, carbon dioxide, nitrogen dioxide, ozone, the surrounding temperature, relative humidity, ventilation rate, artificial light, noise, vibration, biological and psychological factors.[13]

Little is known about whether there are any health effects on eyes associated with the cumulative effects of low levels of pollutants. While individual compounds at this site do not exceed (or approach) recognised threshold levels for irritative effects, the cumulative impact of several subthreshold pollutants has been associated with eye irritation. Studies by Hempel – Jorgensen et al on VOCs and the eye have noted a clear association between the cumulative impact of mixtures of VOCs and increased eye irritation.[14] Suggested mechanisms for this irritation included chemical stimulation of the trigeminal nerve

ending in the mucosal tissue of the eye, nose and throat stimulating sensations of stinging, burning tickling and pain.[15] Hempel – Jorgensen et al also explored the time course of sensory eye irritation. Evidence suggests that sensory eye irritation increases exponentially during the first 20 to 40 minutes of VOC exposure, after which a period of equilibrium is established. This equilibrium is believed to be brought about by a possible chemical balance in tear film and air concentrations of VOCs. It was noted that prolonged irritation persisted long after exposure ended and that stimulation of one eye would elicit a response in the contralateral eye.[16 17] In their review of three research papers, Okawada et al[18] established links between threshold levels of photochemical air pollutants and eye irritation, defined by the appearance of superficial keratitis. They recognised that tear lysozyme levels were reduced by photochemical air pollution with the main offender being ozone. A tentative link between photochemical air pollutants and reduced pH levels in tears was also established.

Increase in pollutant levels has been associated with increased rates of eye conditions.[19] Defined as Discomfort Eye Syndrome (DES), Versura et al undertook an investigative study of 100 DES patients, to estimate whether a relationship existed between subjective symptoms of discomfort, the intensity of possible subclinical eye inflammation and/or dryness and the degree of air pollution in relation to the subjects' living zone. They undertook this process by the objective testing of the tear film and ocular surface. Testing included Schirmer-I, Ferning test, Tear Break Up Time, Impression Cytology and Scraping Cytology. (Other testing may include Eye Redness, Epithelium Damage and Foam Formation.)[20] Living zones were classified into 3 areas – downtown, town suburbs and countryside. The investigative group found no correlation between tear instability and location of residence. A correlation was found between inflammatory responses, measured by cytology, and living zone. This was not affected by age or sex. A significant positive correlation was found between dryness and pollution, according to different living zones. Women were found to be twice as likely to suffer from DES as men. It was however conceded that the participants may have been susceptible to dry eye conditions with the pollutants aggravating rather than causing the eye irritation/dry eye.[19]

In her literature review on livestock odours, Shiffman identified four ways that odours (mainly from VOCs) could affect human health. These included:[21]

1. Direct toxicological effects, such as acute poisoning;
2. Odourous compounds causing sensory irritation of the eye, nose and throat. This was mainly believed to occur through direct stimulation of the trigeminal nerve.
3. VOCs stimulating sensory nerves to cause neurological changes. It has been hypothesised that neurological changes occur so that a person develops a chemically learned response.
4. Cognitive and emotional factors such as stored mental experience may stimulate a response. People perceive the odour as irritating based on past experiences.

While all four mechanisms were reviewed, the overwhelming health symptoms in all four cases were of eye, nose, throat irritation, headache and drowsiness.

Dust particles may also have a significant effect on eye and nose irritation. In their experiments on human exposure to airborne office dust Pan et al[22] showed a significant reduction in tear break up time owing to dust exposure. The results showed a significant correlation between perceived air quality and the reported symptoms of dry eyes, eye irritation, facial skin irritation, nose irritation and feeling stressed. At an acute level there was a significant correlation between perceived air quality and odour intensity, leading to the hypothesis that odour was a major indicator of air quality. However, no significant change was found between dust exposure and, nasal volume, epithelial damage and foam formation.

Environmental concern or worry has been associated with adverse health symptom reporting in communities exposed to sub threshold levels of pollutants.[23 24 25] In their review of three surveys around hazardous waste sites Libscomb et al[26] found a significant association between environmental worry and eye/skin irritation. Brender et al[27] adjusted for environmental worry in their survey of a community surrounding a wood treatment facility contaminated with polycyclic aromatic hydrocarbons (PAH). This adjustment reduced the relative risks of the three health outcomes measured (skin rashes, chronic bronchitis and difficulties becoming pregnant) with only skin irritation still remaining significantly associated with the exposure to PAH.

The prevalence of eye, nose and throat irritation in the community is difficult to quantify. Hempel-Jorgensen et al[28] noted in a study of 2060 Danes by Volbjorn et al, that the prevalence of work related mucous membrane irritation (irritation of the eyes, nose and throat) was 16% whereas 7% of the subjects reported having mucosal irritation at home. In a separate study, Skov et al[29] found that 20% of men and 32% of women had work-related irritation of the mucous membranes with 8% of the men and 15% of the women having work related eye irritation and 12% of men and 20% of women having work related nasal irritation. In Queensland, a cross sectional prevalence study was undertaken near the hazardous chemical waste site at Kingston and a control site at Beenleigh in order to identify possible health impacts. The following eye, nose and throat prevalence were established:[30]

	Kingston	Beenleigh
Percentage experiencing the symptom in the last 6 months		
Chronic eye irritation	34%	11%
Irritated throat / husky voice	49%	38%
Itchy nose	42%	32%
Percentage noting an increase since moving to….		
Eye irritation	36%	11%
Eye tearing	27%	4%
Eye grittiness	28%	4%

Finally, the South Australian Department of Human Services established a community prevalence rate of 40.9% for itchy eyes whilst investigating community health complaints around the Castalloy Manufacturing plant.[31]

Dry eye can be an underlying factor to a perception of eye irritation. The documentation available on and classification of the prevalence of dry eye symptoms in Australia is better than eye irritation. Even so, differences in diagnostic tests and their results, definitions of dry eye, age, gender and environment, make establishing the prevalence of dry eye in Australia difficult. In her analysis of 1584 subjects in Mackay, Queensland, Albietz established an overall prevalence of dry eye of 10.8%. The prevalence of marginal dry eye conditions accounted for another 7.3% bringing the total subject population with dry eye symptoms to 18.1%. She noted a marked difference in prevalence with age.[32] A separate cross sectional prevalence study undertaken by McCarty et al on the Melbourne population identified varying prevalence rates for the various diagnostic tools of dry eye[33]. In this study, the percentage of participants who self-diagnosed with a severe symptom of dry eye that could not be attributable to hay fever was 5.5%. In an American study on the elderly, Schein et al concluded that for a population over 65 years the dry eye prevalence was 14.6%[34] (as defined by the reporting of one or more dry eye symptoms as 'often' or 'all of the time'). When repeating this American study on a Taiwanese Chinese population Lin et al determined a prevalence rate of 23.5%.[35]

The tests used in the diagnosis of dry eye are similar to those for eye irritation. These include the Schirmer test, Tear Break Up Time, Impression Cytology, Epithelium Damage, Tear Assay and general slit lamp observation. At a subjective level the use of a questionnaire is standard procedure. Currently in Australia, the most commonly used questionnaire is the McMonnies dry eye questionnaire.

This suite of objective and subjective eye irritation investigations, along with the previous prevalence studies, opens the possibility of quantifying any effect of pollution in this area. It would be advantageous for future studies to also include environmental monitoring of volatile organic compounds, particulates and odours.

Conclusion

6

This study has provided a description of the health status of a group of 54 people residing in the Turrella area who have reported health effects they believe are related to the M5 East exhaust stack. The information collected is based largely on their perceived health status, symptoms and limited clinical tests.

While it is acknowledged that the classification of reported symptoms into categories of relatedness to exposure has been based upon reports of perception by each individual to the examining medical officers, the description of symptoms, likely contributing and triggering factors, and initiating events, have provided a base from which it should be possible to further our investigations to determine any relationship between the M5 East exhaust stack emissions and the health status of the local population.

Some options for further investigation include:

1. An analytical study with the aim of determining whether or not there is a real association between residential location and symptoms.
2. Should an analytical study demonstrate an association, an environmental investigation to better characterise pollutant exposure levels.

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SHP (EHB) 030281