# Nitrogen Dioxide Exposure Inside and Outside of Primary Schools

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## Introduction

Nitrogen Dioxide ($NO_2$) has been linked to a variety of adverse health conditions. Spatial studies of air pollution and health often assign an average ambient air pollutant concentration monitored at a central outdoor site to individuals as a surrogate for personal exposure, yet these estimations may be inaccurate as they fail to consider heterogeneity of concentrations across micro environments (Monn, 2001; Wilson *et al*, 2005, Wilson *et al*, 2006), resulting in inaccurate identification of dose-response relationships. For children, time spent in the school environment may significantly contribute to personal $NO_2$ exposure levels as schools are often located near busy roads. In recognising the adverse health effects associated with personal exposure to $NO_2$ a social responsibility exists to ensure the standard of air quality in the school environment.

International research has identified relationships between $NO_2$ exposure for children attending schools near motorways and traffic density, percentage of time downwind and distance of schools from motorways (Janssen *et al*., 2001). Recently in New Zealand confusion has arisen over acceptable in school limits, including the delayed opening of an Auckland day-care centre and the deferred realignment of a Wellington bypass adjacent to a primary school.

**Toxic Auckland childcare centre closed**

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An Auckland daycare centre, The Jump & Jive Childcare Centre, has not been allowed to open as the Auckland Regional Public Health Service has deemed it too toxic.

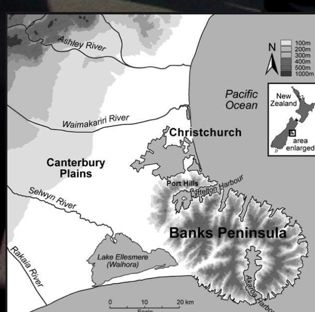
Child care facilities near busy roads are under scrutiny because of concerns about air pollution.

## Research Aim

Therefore, the aim of this research was to identify the impact of changing traffic density on exposure to Nitrogen Dioxide in and around schools.

## Study Area and Rationale

Christchurch, with a population of over 350,000, is situated on the East Coast of the South Island of New Zealand (43º 33'S, 172º 47'E). Topographic features of the region include the Canterbury Plains to the north and west, the Pacific Ocean to the east and the Port Hills to the south. It has severe wintertime particulate matter air pollution episodes. However, limited studies have researched $NO_2$ as a significant indoor or outdoor pollutant in Christchurch and none in relation to schools.

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## Method

To compare school ground concentrations of $NO_2$ in relation to traffic density sampling was carried out as follows:

- In and around 10 Christchurch Schools (1 central city, 7 suburban and 2 rural) all within 400 metres of a major roadway
- Classrooms used heating sources other than gas and were single glazed
- Sampling was conducted utilising Palmes diffusion tubes (Palmes *et al*, 1976)

Sampling was conducted:

- in school classrooms
- on school grounds
- on surrounding roads

Schools were monitored in two 2-week phases:

- Term time (children attending school) - 11/09/07 to 25/09/07
- Holiday period (children off school) - 25/09/07 to 09/10/07

Additional data was collected:

- meteorological data (wind speed, wind direction, relative humidity)
- traffic volume
- distance of monitors from main road
- percentage of time down wind (as defined in Janssen *et al*, 2001 & van Roosbroeck *et al*, 2007)

## Findings

Weather conditions were similar in both time periods. No significant correlations were observed between roadside traffic density and roadside $NO_2$ concentrations or between traffic density and either indoor or outdoor $NO_2$ concentrations in either study period (Table 1). Traffic counts weighted for percentage of time downwind correlated with indoor $NO_2$ during both term time and the holiday period (Table 2). The $r^2$ indicates that 92% of the variance in indoor $NO_2$ is related to weighted road counts during term time and 42% during the holiday period. Weighted traffic counts are an effective predictor of indoor $NO_2$ concentrations.

| | Term time | | | | Holiday | | | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **Road side** | **School Grounds** | **Front door** | **Indoor** | **Road side** | **School Grounds** | **Front door** | **Indoor** |
| **City centre** | 15.98 | 10.33 | 11.14 | 12.07 | 11.38 | 11.38 | 11.87 | 9.05 |
| **Suburban** | 13.52 | 11.79 | 13.51 | 16.26 | 8.47 | 8.83 | 11.63 | 10.46 |
| **Suburban** | 13.63 | 8.72 | 8.88 | 8.55 | 9.88 | 9.88 | 7.85 | 7.7 |
| **Suburban** | 11.66 | 8.97 | 15.86 | 8.97 | 7.12 | 4.88 | 10.66 | 4.88 |
| **Suburban** | 13.49 | 9.52 | 7.82 | 7.05 | 8.28 | 8.28 | 9.69 | 6.54 |
| **Suburban** | 13.13 | 7.55 | 14.43 | 9.79 | 4.07 | 4.07 | 13.84 | 7.17 |
| **Suburban** | 12.92 | 13.12 | 17.89 | 7.86 | 9.22 | 9.22 | 11.1 | 6.27 |
| **Suburban** | 9.94 | 9.35 | 10.74 | 11.91 | 7.7 | 7.7 | 5.38 | 9.44 |
| **Rural** | 6.8 | 7.17 | 5.35 | 4.06 | 6.1 | 6.1 | 4.06 | 9.4 |
| **Rural** | 10.43 | 6.25 | 5.76 | 5.25 | 3.86 | 3.86 | 5.57 | 2.43 |
| **Mean** | **12.12** | **9.28** | **11.14** | **9.06** | **9.45** | **7.42** | **9.16** | **7.48** |

Table 1: $NO_2$ measurements in and out of schools (µg $m_{-3}$)

| **Term Time** | | | | |
|---|---|---|---|---|
| **Variable 1** | **Variable 2** | **r** | **p** | **$r^2$** |
| Roadside $NO_2$ | Traffic count | .36 | .09 | .13 |
| Average grounds $NO_2$ | Weighted traffic count | .31 | .40 | .10 |
| Indoor $NO_2$ | Weighted traffic count | .96 | .001 | .92 |
| **Holiday Period** | | | | |
| Roadside $NO_2$ | Traffic count | .42 | .10 | .18 |
| Average grounds $NO_2$ | Weighted traffic count | .60 | .08 | .36 |
| Indoor $NO_2$ | Weighted traffic count | .65 | .05 | .42 |

Table 2: Correlation and variances for $NO_2$ (roadside, average on grounds and indoor) and road traffic count and weighted road count. (Significance $p<0.05$).

## Discussion and Further Research

This pilot study found that :

- Average school ground concentrations were not significantly associated with weighted traffic density or percentage of time downwind; however,
- Indoor $NO_2$ concentrations were significantly associated with weighted traffic density and percentage of time downwind of a major roadway for term time.

This indicates pupils and staff in school classrooms that are exposed to a high percentage of time downwind of a high traffic density road are more likely to have increased exposure to $NO_2$ concentrations.

This is similar to that found for schools near main roads in the Netherlands (Janssen *et al*, 2001; Roorda-Knappe *et al*, 1998), although the findings for outdoor $NO_2$ concentrations are consistent with Van Roosbroeck *et al*, (2007) but contrary to Janssen et al., (2001). The difference in outcomes may be attributed to a smaller dataset, reduced monitoring time frame and lower density of traffic on main roads within this study.

There is a social responsibility to further research school ground exposure to $NO_2$ to ensure a safe, non-polluted environment for children and school staff. Further research should include a larger monitoring time frame utilising smaller temporal and similar spatial scales to more accurately assess variations in concentrations.

## References

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