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NSW GOVERNMENT | Transport Roads & Maritime Services

ROADS AND MARITIME SERVICES

TRIP GENERATION SURVEYS

MEDICAL CENTRES

ANALYSIS REPORT

Report Document Control	
Title	TRIP GENERATION SURVEYS MEDICAL CENTRES
Date	August 2015
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Client	ROADS AND MARITIME SERVICES
Job No.	15005
Quality Control Reviewer	L. Hawley
Keywords	Trip generation / medical centres / NSW Roads and Maritime Services
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1 INTRODUCTION

1.1 Study purpose

The former Roads and Traffic Authority (RTA) published its Guide to Traffic Generating Developments ("*Guide"*) in the mid-1990s. This document drew on the results of a number of trip generation and parking demand surveys covering a range of land uses. These surveys had been progressively conducted since 1978. The trip generation and parking requirement data in the Guide is becoming increasingly out-of-date. Several new business types are not adequately represented and there is evidence of ongoing industry rationalisation (e.g. larger medical centres, evolving medical practices, etc.). There is increasing awareness that public transport has not been adequately accounted for in previous trip and parking generation surveys.

TEF Consulting (The Consultant) was appointed to undertake a detailed trip generation analysis of medical centres. The study includes surveys of traffic characteristics relating to vehicle and person trips at 14 medical centres in the Greater Metropolitan Sydney area, and 6 medical centres in the Regional N.S.W. areas.

1.2 Approach

The approach to this trip generation study is described below:

- The Consultant initially compiled a list of over 40 prospective survey sites. A list of required attributes and other criteria for the area selection is provided in the Brief. These attributes and criteria are hereby acknowledged.
- The Consultant has assessed the suitability of the sites for the Study in consultation with the RMS Project.
- The Consultant then undertook site inspections and collection of site characteristics.
- The Consultant then arranged traffic counts on a weekday at all sites between 7:00 am and 7:00 pm. The surveys were mainly undertaken from Monday to Friday with a few sites being surveyed over the weekend. The survey data included vehicle counts entering and exiting each site (where off-street parking was available), number of people entering and exiting the site, modes of transport people used to get to the survey site (from questionnaire surveys), number of passengers in the vehicle as well as classification counts of traffic flows on the main road adjacent to the site.
- A count of vehicles parked on site in marked parking spaces as well as outside formal parking areas, where available, was also carried out, at 15 minute intervals.
- The Consultant studied the data using linear and non-linear regression analysis and considered the generated data as a function of a number of the key variables.
- The Consultant prepared a report to summarise the findings of the survey and data analysis.
- The reporting is presented in two documents. The first document (this report) contains the analysis covering all of the calculations and comparisons. The second report contains the raw data from the surveys and other data such as survey site plans and tabulated vehicle-trip and person-trip data.

1.3 Report structure

This analysis report has the following structure:

- **Chapter 1: Introduction** – This contains the background to the study, approach and report structure;
- **Chapter 2: Survey methodology** – This contains a description of the survey and survey area selection process;
- **Chapter 3: Survey analysis** – This section analyses the survey results using linear and non-linear regression;
- **Chapter 4: Summary**

2 SURVEY METHODOLOGY

2.1 Selection of survey sites

The survey areas were selected according to the specifications set out in the RMS Brief.

2.2 Survey site selection methodology

- Consultation with the RMS.
- Detailed examination of cadastral maps and aerial photographs.
- Identification of survey site characteristics:
    - Survey site location;
    - Identification of access points;
    - Identification of additional services.
- Initial survey planning to check suitability in terms of ease of observations.
- Confirmation of 20 survey sites including three sites for special 6-day or 7-day surveys and four sites for two-day surveys (one weekday and one weekend day):
    - Survey area visits and collection of specific details;
    - Questionnaire survey of staff and patients at all sites (to gauge the information about their travel characteristics);
    - Photographic and video records of access locations.

The details of the selected survey areas are summarised in **Table 2.1** (a full summary table, including trip and parking statistics is contained in the **Appendix**). The locations of the survey areas are shown on **Figure 2.1**.

Table 2.1 Details of the selected survey sites (continued on the next page).

	Sydney sites									
Site ID	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Site 9**	**Site 10**
Name of the development	The Mosman Practice	Crows Nest Medical Practice	Five Dock Medical Centre	Riverstone Family Medical Practice	Dural Medical Centre	Hunters Hill Medical Practice	Broadway General Practice	Sans Souci Medical Practice	Balmoral Street Medical Centre	Barwell Medical Centre
Site address	393 Military Road, Mosman NSW 2088	Suite 1a/375 Pacific Highway, Crows Nest NSW 2065	150 Great North Road, Five Dock NSW 2046	10 Pitt Street, Riverstone NSW 2765	535 Galston Road, Dural NSW 2158	6 Ryde Road, Hunters Hill NSW 2110	M105 Level 1 Broadway Shopping Centre, 1 Bay Street Broadway, Sydney NSW 2007	420/410/422 Rocky Point Road, Sans Souci NSW 2219	98 Balmoral Street, Hornsby NSW 2077	Suite 16, 7/9 Barwell Avenue, Castle Hill NSW 2154
Day and date of survey(s)	Mon, 01/06/15	Mon, 09/03/15	Thu, 19/03/15	Sat, 28/02/15 Mon, 02/03/15	Thu, 05/03/15 Sat, 07/03/15	Fri, 13/03/15	Wed, 04/03/15	Sat, 21/03/15 Mon-Fri, 23-27/03/15	Sun, 15/03/15 Mon, 16/03/15	Fri, 06/03/15 Sun-Tue, 8-12/03/15 Sat, 14/03/15 Wed-Thu, 25-26/03/2015
Duration of survey - frontage road	7:00-19:00	7:00-19:00	7:00-19:00	Sat 7:30-13:00 Mon 7:00-19:00	Thu 7:00-19:00 Sat 7:00-13:30	7:30-19:00	7:00-19:00	Sat 7:00-13:00 Mon-Fri 7:00-19:00	7:00-19:00	Mon-Thu 7:30-18:30 Fri 7:00-19:00 Sat-Sun 8:30-13:30
Duration of survey - site trip generation	7:00-19:00	7:00-19:00	7:00-19:00	Sat 8:00-13:00 Mon 7:00-19:00	Thu 7:00-19:00 Sat 7:00-13:30	8:00-18:00	8:00-19:00	Sat 8:00-13:00 Mon-Fri 8:00-18:00	7:00-19:00	Mon-Thu 8:00-18:00 Fri 8:00-17:00 Sat 8:00-13:00 Sun 9:00-13:00
Surrounding area characteristics	Town centre	Inner suburb	Inner suburb	Outer suburb	Outer suburb	Inner suburb	Town centre	Inner suburb	Town centre	Town centre
Surrounding land uses	Low-medium density residential, scattered commercial.	Low-medium density residential.	Low density residential.	Commercial / retail and low density residential.	Commercial / retail and low density residential.	Low density residential.	Commercial / retail. Located within a shopping centre.	Commercial / retail and low-medium residential.	Low density residential developments.	Commercial / retail and low-medium residential.
Frontage road - AM peak period (weekday)	7:00-8:00	8:00-9:00	8:15-9:15	10:00-11:00	7:45-8:45	8:45-09:45	9:15-10:15	multi-day[1]	7:45-8:45	multi-day
Frontage road - PM peak period (weekday)	16:15-17:15	17:15-18:15	17:30-18:30	15:15-16:15	16:00-17:00	15:30-16:30	12:15-13:15	multi-day	16:15-17:15	multi-day
Development details:										
Total site area (m^2)	876	1726	424	720	909	1069	1361	2215	400	4979
Total GFA (m^2)	1194	300	848	210	235	804	1361	475	800	980
No. of rooms	23	9	12	5	5	14	14	11	12	12
No. of doctors	15	6	6	5	5	12	12	10	5	9
No. of total staff	29	10	13	11	8	16	18	15	6	14

[1] For detailed information please refer to the Trip Generation Surveys Medical Centres Data Report.

	Sydney sites				Regional sites					
Site ID	**Site 11**	**Site 12**	**Site 13**	**Site 14**	**Site 15 (R1)**	**Site 16 (R2)**	**Site 17 (R3)**	**Site 18 (R4)**	**Site 19 (R5)**	**Site 20 (R6)**
Name of the development	Complete Medical Centre	Dee Why Family Practice	Medical Centre Bankstown	Kable Street General Practice	Umina Family Practice	Broadmeadow Medical Centre	Cardiff Medical Centre & Skin Cancer Clinic	Worrigee Medical Centre	Kelso Medical IPN	Wyong Family Practice
Site address	251 Queen Street, Campbelltown NSW 2560	7/9 Howard Avenue, Dee Why NSW 2099	Shop MM.014, The Appian Way, Bankstown NSW 2200	2 Kable Street, Windsor NSW 2756	297 West Street, Umina Beach NSW 2257	154 Lambton Road, Broadmeadow NSW 2292	321 Main Road, Cardiff NSW 2285	53 Isa Road, Worrigee NSW 2540	13 Marsden Lane, Kelso NSW 2795	152-156 Pacific Highway, Tuggerah 2259
Day and date of survey(s)	Wed, 10/06/15	Fri, 19/06/15	Thu, 25/06/15	Fri, 26/06/15	Fri, 13/03/15 Sat, 14/03/15	Wed, 25/03/15	Fri, 20/03/15 Sat, 21/03/15	Sat-Fri, 7-13/03/15	Thu, 12/03/15	Tue, 24/03/15
Duration of survey - frontage road	7:00-19:00	7:00-19:00	8:00-15:00	7:00-19:00	Fri 7:00-19:00 Sat 7:00-12:00	7:00-19:00	Fri 8:30-18:00 Sat 7:30-12:30	Mon 7:00-22:00 Tue-Fri 7:00-19:00 Sat 12:00-22:00 Sun 10:00-20:00	7:00-19:00	8:15-18:30
Duration of survey - site trip generation	7:00-18:00	7:00-19:00	8:30-14:30	8:00-19:00	Fri 8:00-18:00 Sat 8:00-12:00	8:00-18:00	Fri 7:00-18:00 Sat 7:30-12:30	Mon 7:00-22:00 Tue-Fri 7:00-19:00 Sat 12:00-22:00 Sun 10:00-20:00	8:00-19:00	8:00-18:00
Surrounding area characteristics	Outer suburb	Inner suburb	Town centre	Outer suburb	Inner rural	Inner rural	Inner rural	Outer rural	Outer suburb	Inner rural
Surrounding land uses	Commercial / retail.	Commercial / retail and recreational. Medium density residential.	Commercial / retail and recreational. Located within a shopping centre	Commercial / retail and low density residential.	Commercial / retail.	Commercial / retail and low density residential.	Commercial / retail and low density residential.	Low density residential.	Commercial / retail and low density residential.	Commercial / retail.
Frontage road - AM peak period (weekday)	10:00-11:00	11:00-12:00	8:30-9:30	8:15-9:15	11:00-12:00	7:45-8:45	07:30-08:30	multi-day	8:30-9:30	08:00-09:00
Frontage road - PM peak period (weekday)	16:00-17:00	15:00-16:00	13:45-14:45	15:15-16:15	15:15-16:15	16:45-17:45	12:15-13:15	multi-day	16:45-17:45	12:15-13:15
Development details:										
Total site area (m^2)	896	780	300	615	420	3183	710	1760	7366	300
Total GFA (m^2)	407	690	300	1000	420	966	310	722	742	300
No. of rooms	8	15	9	15	12	13	5	19	8	11
No. of doctors	6	12	6	13	9	11	6	8	9	6
No. of total staff	10	20	10	24	11	18	8	16	11	9

Figure 2.1 Greater Sydney survey site locations.

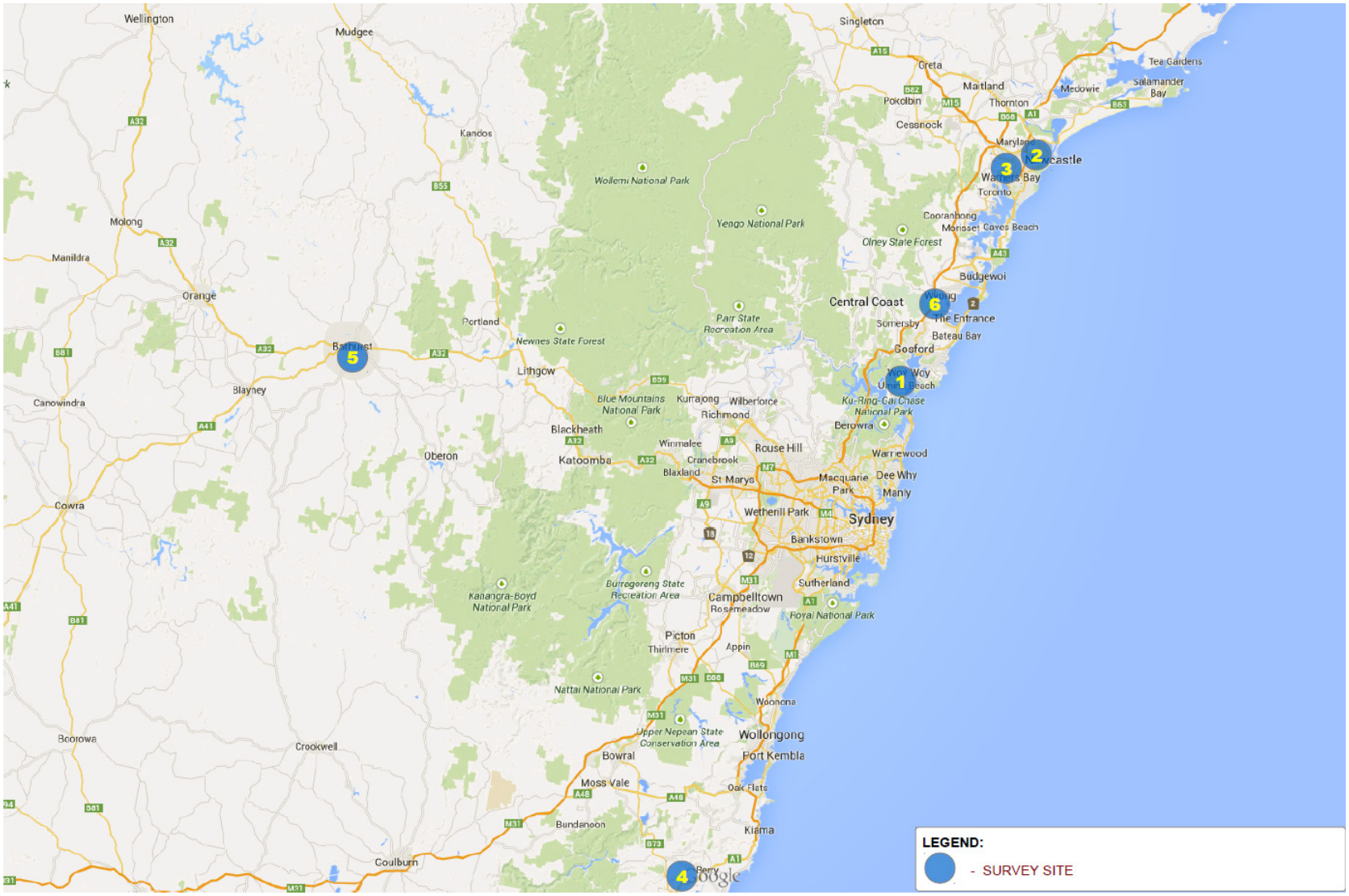

Figure 2.2 Regional N.S.W. Survey site locations.

2.2.1 Survey site selection and survey conduct issues

- There were no technical issues with the manual counts and video surveys, except obtaining permissions from the medical centres.
- Most medical centres could not provide information about the exact year when they were opened; available information was only approximate; however it was stated by the interviewed staff that all centres operated for longer than 5 years.

2.3 Survey Process

Conduct of surveys

Survey period	February – June 2015 Outside school holidays and public holidays
Day of the week	Any day ▪ 3 sites with surveys conducted on all operating days of one calendar week ▪ 4 sites with surveys conducted on one weekday and one weekend day ▪ 13 sites with surveys conducted on one weekday
Survey times	7:00 am to 7:00 pm, with minor variations depending on a particular medical centre having longer or shorter opening hours.

Data recorded by traffic surveyors

- A count of vehicles parked on-site in marked parking spaces at the commencement of the survey, where on-site parking existed;
- A count of vehicles entering and leaving the site, in 15-minute bands, where on-site parking existed;
- A count of the number of vehicles parked on-site in marked parking spaces taken at 15-minute intervals, where on-site parking existed;
- An hourly vehicle count on the frontage road, to establish the impact of the development on underlying hourly traffic patterns;
- For Sites 8, 10 and 17 (special survey over 6 or 7 days): count of all vehicles entering the development for each day over the full 7-day period (6 days if the site was closed on Sunday), to establish daily and hourly visitation patterns.
- Questionnaire surveys of staff and patients to obtain information about the mode of transport and number of passengers.
- Information about the site – opening times, number of staff, site area, building area, number of rooms and different types of services and facilities that are available on site.

3 SURVEY ANALYSIS

3.1 Survey Output Requirements

The survey data was analysed with the key parameters being:

- Daily Vehicle Trips (i.e. incoming trips + outgoing trips)
- Peak Vehicle Trips (i.e. the maximum number of vehicle trips to/from the site in any one-hour period)
- Peak Vehicle Trips during the AM and PM commuter peak hours (i.e. the number of vehicle trips to/from the site during the morning and afternoon peak hours on the frontage road)
- Peak parking demand (calculated from the maximum number of persons present on site and their responses to questionnaire surveys)

3.2 Average Trip Rates for Medical Centres

The trip generation calculation that was to be performed would depend upon the variable that was interrogated. Several variables were interrogated, as listed below.

- Total Gross Floor Area (GFA) of the medical centre
- Number of doctors present
- Total number of staff present
- Number of rooms

The summary of the survey data for each of the surveyed areas is shown in **Table 3.1**. Average trip generation rates are summarised in **Table 3.2**.

The detailed survey results are contained in a separate "Data Report".

A review of the data reveals a number of observations

- The surveys were undertaken at medical centres with the following ranges of independent variables
  - floor space varying from 210 m^2 to 1,380 m^2;
  - number of doctors varying from 5 to 15
  - number of staff varying from 5 to 29
  - number of rooms varying from 6 to 23
- The results of the analyses for both peak hour and daily trips rates and parking accumulation indicate high values of standard deviation in all cases, with somewhat lower standard deviation for the peak parking accumulation per doctor for all sites and Sydney sites. The base data is therefore regarded as wide-spread and average rates are not recommended to be used for predicting the trip generation because of wide prediction intervals around the mean estimated values.
- Peak trip generation at most centres occurred during the morning hours, typically after the commuter peak hour.
- Peak parking accumulation at most centres occurred during the morning hours, typically after the commuter peak hour.

Table 3.1 Traffic survey results summary (continued on the next page).

	Sydney sites									
Site ID	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Site 9**	**Site 10**
Name of the development	The Mosman Practice	Crows Nest Medical Practice	Five Dock Medical Centre	Riverstone Family Medical Practice	Dural Medical Centre	Hunters Hill Medical Practice	Broadway General Practice	Sans Souci Medical Practice	Balmoral Street Medical Centre	Barwell Medical Centre
Vehicle trips:										
Centre peak hour vehicle trips (in+out)	**69**	**22**	**44**	**22**	**40**	**40**	**46**	**42**	**35**	**48**
Time of centre peak hour vehicle trips	11:15-12:15	11:00-12:00	16:45-17:45	10:30-11:30	9:30-10:30	11:00-12:00	9:15-10:15	multi-day	8:30-9:45	multi-day
Centre peak hour vehicle trips per room	3.0	2.4	3.7	4.4	8.0	2.9	3.3	3.8	2.9	4.0
Centre peak hour vehicle trips per doctor	4.6	3.7	7.3	4.4	8.0	3.3	3.8	4.1	7.0	5.6
Centre peak hour vehicle trips per total staff	2.4	2.2	3.4	2.0	5.0	2.5	2.6	2.8	5.8	3.3
Centre peak hour vehicle trips per 100m^2 of total GFA	5.8	7.3	5.2	10.5	17.0	5.0	3.4	8.8	4.4	4.9
Total daily centre vehicle trips	**445**	**141**	**256**	**134**	**249**	**246**	**209**	**270**	**226**	**264**
Total daily centre vehicle trips per room	19.3	15.7	21.3	26.8	49.8	17.6	14.9	24.5	18.8	22.0
Total daily centre vehicle trips per doctor	29.7	23.5	42.7	26.8	49.8	20.5	17.4	26.5	45.2	30.7
Total daily centre vehicle trips per total staff	15.3	14.1	19.7	12.2	31.1	15.4	11.6	18.2	37.7	18.3
Total daily centre vehicle trips per 100m^2 of total GFA	37.3	47.0	30.2	63.8	106.0	30.6	15.4	56.8	28.3	26.9
Centre vehicle trips during adjacent road's peak hour (AM)	**10**	**9**	**31**	**17**	**18**	**29**	**1**	**27**	**20**	**29**
Centre vehicle trips per room during adjacent road's peak hour (AM)	0.4	1.0	2.6	3.4	3.6	2.1	0.1	2.5	1.7	2.4
Centre vehicle trips per doctor during adjacent road's peak hour (AM)	0.7	1.5	5.2	3.4	3.6	2.4	0.1	2.6	4.0	3.4
Centre vehicle trips per total staff during adjacent road's peak hour (AM)	0.3	0.9	2.4	1.5	2.3	1.8	0.1	1.8	3.3	2.0
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (AM)	0.8	3.0	3.7	8.1	7.7	3.6	0.1	5.7	2.5	3.0
Centre vehicle trips during adjacent road's peak hour (PM)	**50**	**8**	**35**	**12**	**29**	**35**	**19**	**23**	**17**	**17**
Centre vehicle trips per room during adjacent road's peak hour (PM)	2.2	0.9	2.9	2.4	5.8	2.5	1.4	2.1	1.4	1.4
Centre vehicle trips per doctor during adjacent road's peak hour (PM)	3.3	1.3	5.8	2.4	5.8	2.9	1.6	2.3	3.4	2.0
Centre vehicle trips per total staff during adjacent road's peak hour (PM)	1.7	0.8	2.7	1.1	3.6	2.2	1.1	1.6	2.8	1.2
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (PM)	4.2	2.7	4.1	5.7	12.3	4.4	1.4	4.8	2.1	1.7
Parking:										
No. of public car spaces	27	0	0	5	7	19	0	0	14	0
Peak parking accumulation	**41**	**15**	**22**	**15**	**23**	**27**	**24**	**20**	**20**	**24**
Peak parking accumulation per room	1.8	1.7	1.8	3.0	4.6	1.9	1.7	1.8	1.7	2.0
Peak parking accumulation per doctor	2.7	2.5	3.7	3.0	4.6	2.3	2.0	2.0	4.0	2.8
Peak parking accumulation per total staff	1.4	1.5	1.7	1.4	2.9	1.7	1.3	1.4	3.3	1.7
Peak parking accumulation per 100m^2 of total GFA	3.4	5.0	2.6	7.1	9.8	3.4	1.8	4.2	2.5	2.4
Time of peak parking accumulation	12:00-12:15	12:00-12:15	10:00-10:15	14:00-14:15	10:15-10:30	11:45-12:00	11:00-11:15	11:00-11:15	10:30-10:45 13:00-13:15	multi-day
Accessibilty score	227	167	75	70	31	62	337	34	29	176

[1] For detailed information please refer to the Trip Generation Surveys Medical Centres Data Report.

	Sydney sites				Regional sites					
Site ID	**Site 11**	**Site 12**	**Site 13**	**Site 14**	**Site 15 (R1)**	**Site 16 (R2)**	**Site 17 (R3)**	**Site 18 (R4)**	**Site 19 (R5)**	**Site 20 (R6)**
Name of the development	Complete Medical Centre	Dee Why Family Practice	Medical Centre Bankstown	Kable Street General Practice	Umina Family Practice	Broadmeadow Medical Centre	Cardiff Medical Centre & Skin Cancer Clinic	Worrigee Medical Centre	Kelso Medical IPN	Wyong Family Practice
Vehicle trips:										
Centre peak hour vehicle trips (in+out)	**29**	**52**	**25**	**81**	**52**	**70**	**28**	**89**	**42**	**58**
Time of centre peak hour vehicle trips	12:15-13:15 14:00-15:00	9:15-10:30	10:00-11:00	09:15-10:15	15:15-16:15	09:15-10:30	13:45-14:45	multi-day	10:15-11:15	10:00-11:00
Centre peak hour vehicle trips per room	3.6	3.5	2.8	5.4	4.3	5.4	5.6	4.7	5.3	5.3
Centre peak hour vehicle trips per doctor	4.8	4.3	4.2	6.2	5.8	6.4	4.7	11.7	4.7	9.7
Centre peak hour vehicle trips per total staff	2.9	2.6	2.5	3.4	4.7	3.9	3.5	5.6	3.8	6.4
Centre peak hour vehicle trips per 100m^2 of total GFA	7.1	7.5	8.3	8.1	12.4	7.2	9.0	12.3	5.7	19.3
Total daily centre vehicle trips	**178**	**380**	**70**	**589**	**205**	**379**	**147**	**606**	**189**	**294**
Total daily centre vehicle trips per room	22.3	25.3	7.8	39.3	17.1	29.2	29.4	31.9	23.6	26.7
Total daily centre vehicle trips per doctor	29.7	31.7	11.7	45.3	22.8	34.5	24.5	79.7	21.0	49.0
Total daily centre vehicle trips per total staff	17.8	19.0	7.0	24.5	18.6	21.1	18.4	38.4	17.2	32.7
Total daily centre vehicle trips per 100m^2 of total GFA	43.7	55.1	23.3	58.9	48.8	39.2	47.4	83.9	25.5	98.0
Centre vehicle trips during adjacent road's peak hour (AM)	**21**	**29**	**7**	**66**	**38**	**13**	**24**	**41**	**25**	**51**
Centre vehicle trips per room during adjacent road's peak hour (AM)	2.6	1.9	0.8	4.4	3.2	1.0	4.8	2.2	3.1	4.6
Centre vehicle trips per doctor during adjacent road's peak hour (AM)	3.5	2.4	1.2	5.1	4.2	1.2	4.0	5.4	2.8	8.5
Centre vehicle trips per total staff during adjacent road's peak hour (AM)	2.1	1.5	0.7	2.8	3.5	0.7	3.0	2.6	2.3	5.7
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (AM)	5.2	4.2	2.3	6.6	9.0	1.3	7.7	5.7	3.4	17.0
Centre vehicle trips during adjacent road's peak hour (PM)	**18**	**42**	**11**	**66**	**52**	**22**	**14**	**55**	**14**	**20**
Centre vehicle trips per room during adjacent road's peak hour (PM)	2.3	2.8	1.2	4.4	4.3	1.7	2.8	2.9	1.8	1.8
Centre vehicle trips per doctor during adjacent road's peak hour (PM)	3.0	3.5	1.8	5.1	5.8	2.0	2.3	7.2	1.6	3.3
Centre vehicle trips per total staff during adjacent road's peak hour (PM)	1.8	2.1	1.1	2.8	4.7	1.2	1.8	3.5	1.3	2.2
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (PM)	4.4	6.1	3.7	6.6	12.4	2.3	4.5	7.6	1.9	6.7
Parking:										
No. of public car spaces	0	0	0	0	0	0	0	19	0	0
Peak parking accumulation	**15**	**24**	**12**	**37**	**17**	**23**	**10**	**52**	**20**	**19**
Peak parking accumulation per room	1.9	1.6	1.3	2.5	1.4	1.8	2.0	2.7	2.5	1.7
Peak parking accumulation per doctor	2.5	2.0	2.0	2.8	1.9	2.1	1.7	6.8	2.2	3.2
Peak parking accumulation per total staff	1.5	1.2	1.2	1.5	1.5	1.3	1.3	3.3	1.8	2.1
Peak parking accumulation per 100m^2 of total GFA	3.7	3.5	4.0	3.7	4.0	2.4	3.2	7.2	2.7	6.3
Time of peak parking accumulation	12:00-12:15	11:00-11:15	11:00-11:15	15:00-15:15	15:15-15:30 15:30-15:45	15:45-16:00	11:45-12:00	multi-day	10:15-10:30	10:15-10:30
Accessibilty score	215	187	198	64	52	37	76	21	4	70

Table 3.2 Trips rate summary.

	Sites 1 to 20				Sydney sites (1-14)				Regional sites (15-20)			
	Min	Max	Avg	St Dev	Min	Max	Avg	St Dev	Min	Max	Avg	St Dev
Development details:												
Total site area (m^2)	300	7366	1550	1780	300	4979	1234	1199	300	7366	2290	2713
Gross floor area (m^2)	210	1361	503	279	300	1361	506	315	300	742	496	195
No. of rooms	5	23	12	5	8	23	12	5	5	19	11	5
No. of doctors	5	15	9	3	5	15	9	4	6	11	8	2
No. of total staff	6	29	14	6	6	29	15	6	8	18	12	4
Vehicle trips:												
Centre peak hour vehicle trips (in+out)	22	89	47	19	25	81	43	17	28	89	57	21
Centre peak hour vehicle trips per room	2.4	8.0	4.2	1.3	2.8	8.0	3.8	1.4	4.3	5.6	5.1	0.5
Centre peak hour vehicle trips per doctor	3.3	11.7	5.7	2.2	3.3	8.0	5.1	1.5	4.7	11.7	7.1	2.9
Centre peak hour vehicle trips per total staff	2.0	6.4	3.6	1.3	2.5	5.8	3.1	1.1	3.5	6.4	4.7	1.2
Centre peak hour vehicle trips per $100m^2$ of total GFA	3.4	19.3	8.5	4.1	3.4	17.0	7.4	3.4	5.7	19.3	11.0	4.9
Total daily centre vehicle trips	70	606	274	143	70	589	261	134	147	606	303	170
Total daily centre vehicle trips per room	7.8	49.8	24.2	9.2	7.8	49.8	23.2	10.4	17.1	31.9	26.3	5.3
Total daily centre vehicle trips per doctor	11.7	79.7	33.1	15.4	11.7	49.8	30.8	11.3	21.0	79.7	38.6	22.7
Total daily centre vehicle trips per total staff	15.4	106.0	48.3	24.6	15.4	106.0	44.5	23.1	25.5	98.0	57.1	27.8
Total daily centre vehicle trips per $100m^2$ of total GFA	1	66	25	15	1	66	22	16	13	51	32	14
Centre vehicle trips during adjacent road's peak hour (AM)	0.1	4.8	2.4	1.4	0.1	4.4	2.1	1.2	1.0	4.8	3.1	1.5
Centre vehicle trips per room during adjacent road's peak hour (AM)	0.1	8.5	3.3	1.9	0.1	5.2	2.8	1.5	1.2	8.5	4.3	2.5
Centre vehicle trips per doctor during adjacent road's peak hour (AM)	0.1	5.7	2.1	1.3	0.1	3.3	1.7	0.9	0.7	5.7	3.0	1.6
Centre vehicle trips per total staff during adjacent road's peak hour (AM)	0.1	17.0	5.0	3.8	0.1	8.1	4.0	2.4	1.3	17.0	7.4	5.5
Centre vehicle trips per $100m^2$ of total GFA during adjacent road's peak hour (AM)	8	66	28	17	11	66	27	17	14	55	30	19
Centre vehicle trips during adjacent road's peak hour (PM)	0.9	5.8	2.4	1.2	1.2	5.8	2.4	1.3	1.7	4.3	2.5	1.0
Centre vehicle trips per room during adjacent road's peak hour (PM)	1.3	7.2	3.3	1.7	1.6	5.8	3.2	1.5	1.6	7.2	3.7	2.3
Centre vehicle trips per doctor during adjacent road's peak hour (PM)	0.8	4.7	2.1	1.0	1.1	3.6	1.9	0.8	1.2	4.7	2.4	1.4
Centre vehicle trips per total staff during adjacent road's peak hour (PM)	1.4	12.4	5.0	3.1	1.4	12.3	4.6	2.7	1.9	12.4	5.9	3.9
Parking:												
No of public car spaces	0	27	5	8	0	27	5	9	0	19	3	8
Peak parking accumulation	10	52	23	10	12	41	23	8	10	52	24	15
Peak parking accumulation per room	1.3	4.6	2.1	0.7	1.3	4.6	2.1	0.8	1.4	2.7	2.0	0.5
Peak parking accumulation per doctor	1.7	6.8	2.8	1.2	2.0	4.6	2.8	0.8	1.7	6.8	3.0	2.0
Peak parking accumulation per total staff	1.2	3.3	1.7	0.7	1.2	3.3	1.7	0.6	1.3	3.3	1.9	0.8
Peak parking accumulation per $100m^2$ of total GFA	1.8	9.8	4.1	2.0	1.8	9.8	4.1	2.1	2.4	7.2	4.3	2.0

3.3 Regression analysis

As per the project brief, the data has been analysed to determine the most consistent measure of trip generation, using a simple linear regression approach.

The coefficient of determination (R^2) has been used to provide a measure of the usefulness of the regression equation. It measures the proportion of variation in Y (trip behaviour) that is explained by the independent variable X (such as gross floor area or the number of doctors) in the regression model. The values vary from 0 to 1 with higher values representing a higher degree of correlation. In this study, R^2 above 0.8 are considered to provide the desired level of correlation. In other words, at least 80% of the variation in trip behaviour can be explained by the variability in the independent variable in the acceptable level.

A number of simple linear regression models did not fit the data at an acceptable level, returning low R^2. For this reason, non-linear and multiple regression models were trialled as well.

3.3.1 Relationship between the number of trips and principal independent variables

The following key independent variables were used for this regression analysis:

- total building GFA;
- number of consulting rooms;
- number of doctors and other medical specialists;
- total number of staff.

The analysis was carried out for the following trip and parking characteristics:

- daily vehicle trips (i.e. inward trips + outgoing trips);
- peak vehicle trips (i.e. the maximum number of vehicle trips to/from the site in any one-hour period)
- vehicle trips during adjacent road's AM and PM peaks (i.e. the number of vehicle trips to/from the site during the morning and afternoon peak hours on the frontage road).
- peak car parking accumulation

3.3.1.1 Total building GFA

- R^2 for all trip characteristics for all medical centres is low and indicates little correlation between the number of trips and the overall gross floor area.
- The data points for trips during the adjacent road's AM peak are located close to the trend line, which may appear as if there was a correlation between the independent and dependant variables. However, the trend line does not show a slope against the X axis, with the first coefficient in the equation being very close to zero (0.0014). This means that the values of the dependant variable, calculated using the equation from the regression analysis, are all nearly the same regardless of the value of the independent variable. In other words, there is no correlation between the two, which is indicated by the low R^2.
-

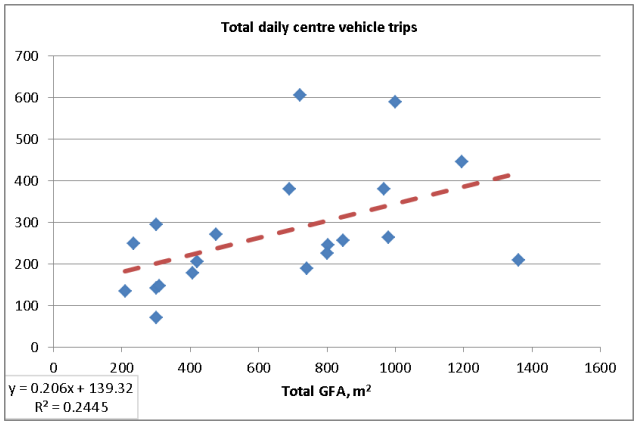

Figure 3.1 **Total daily centre vehicle trips vs. Total building GFA – Linear type**

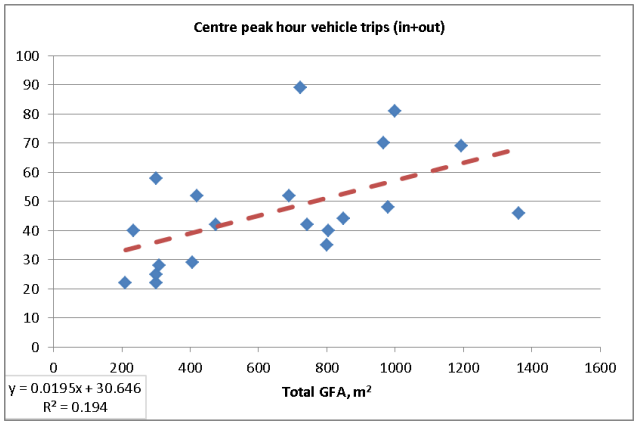

Figure 3.2 **Centre peak hour vehicle trips vs. Total building GFA – Linear type**

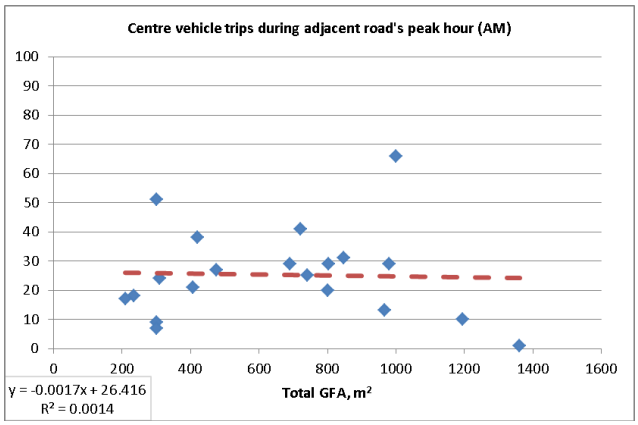

Figure 3.3 **Centre vehicle trips during Peak hour on adjacent road (AM) vs. Total building GFA – Linear type**

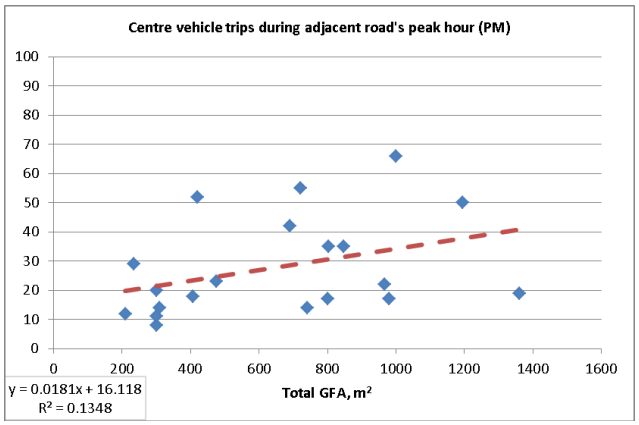

Figure 3.4 **Centre vehicle trips during Peak hour on adjacent road (PM) vs. Total building GFA – Linear type**

3.3.1.2 Number of consulting rooms

- R^2 for all trip characteristics for all medical centres is low and indicates little correlation between the number of trips and the number of consulting rooms.

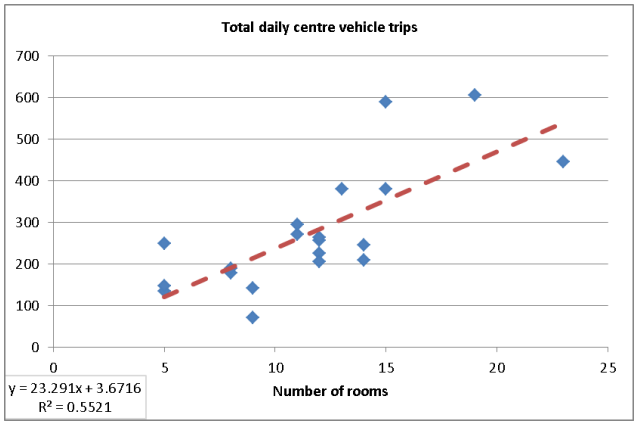

Figure 3.5 **Total daily centre vehicle trips vs. Number of consulting rooms – Linear type**

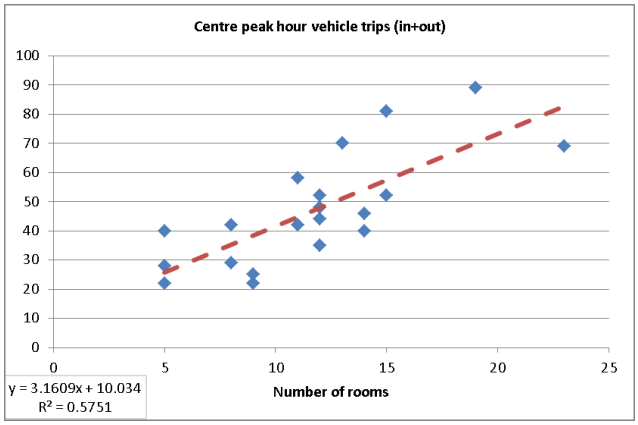

Figure 3.6 **Centre peak hour vehicle trips vs. Number of consulting rooms – Linear type**

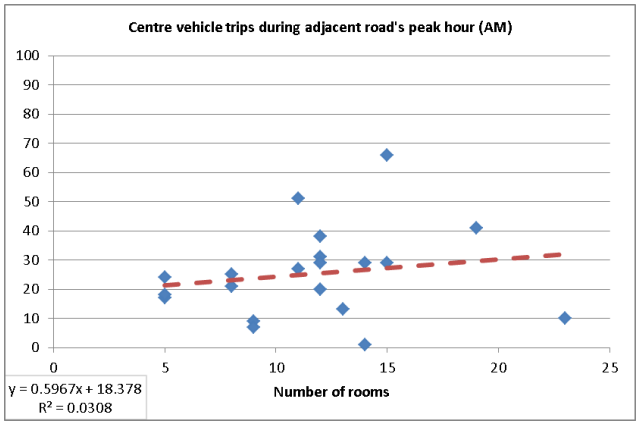

Figure 3.7 **Centre vehicle trips during Peak hour on adjacent road (AM) vs. Number of consulting rooms – Linear type**

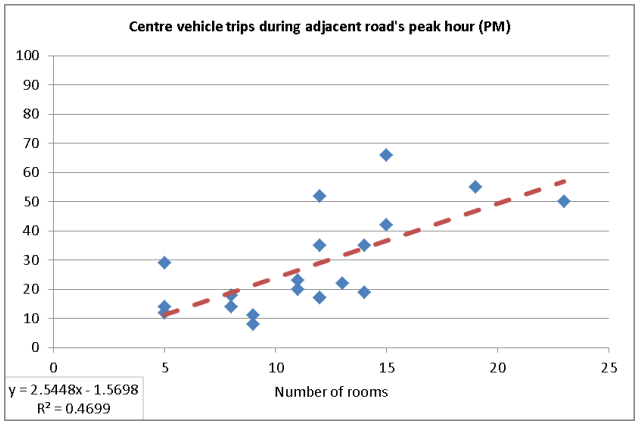

Figure .3.8 **Centre vehicle trips during Peak hour on adjacent road (PM) vs. Number of consulting rooms – Linear type**

3.3.1.3 Number of doctors

- R^2 for all trip characteristics for all medical centres is low and indicates little correlation between the number of trips and the number of doctors.

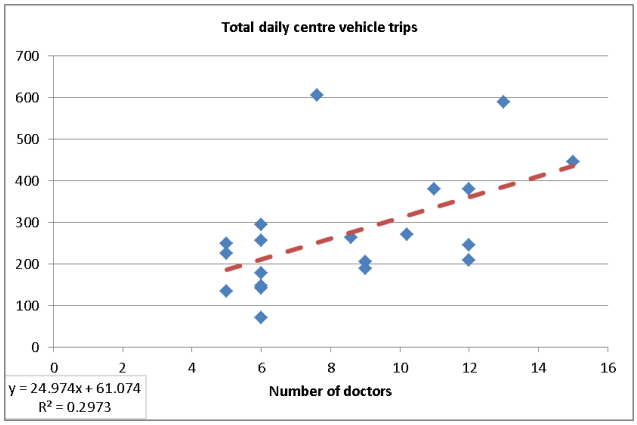

Figure 3.9 Total daily centre vehicle trips vs. Number of doctors – Linear type

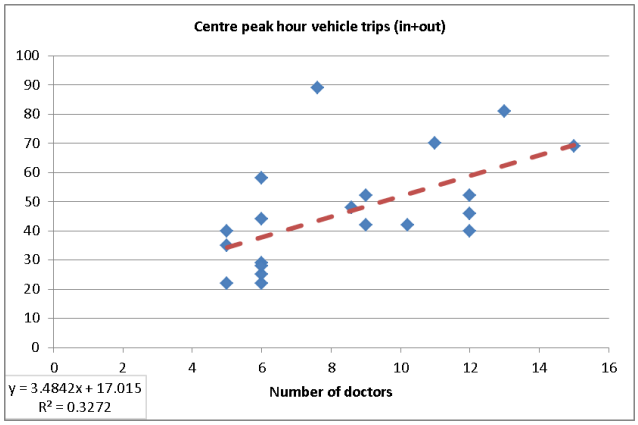

Figure 3.10 Centre peak hour vehicle trips vs. Number of doctors – Linear type

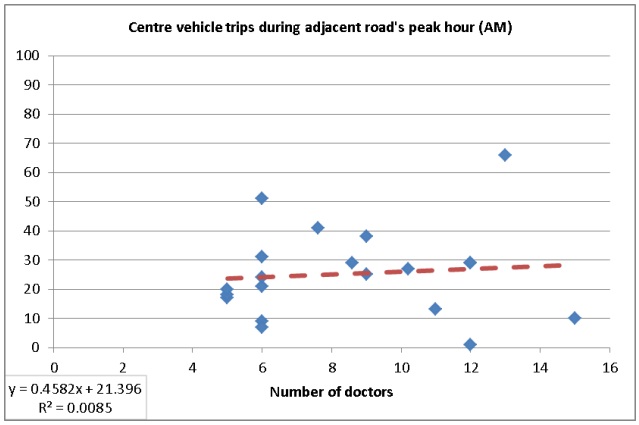

Figure 3.11 Centre vehicle trips during Peak hour on adjacent road (AM) vs. Number of doctors – Linear type

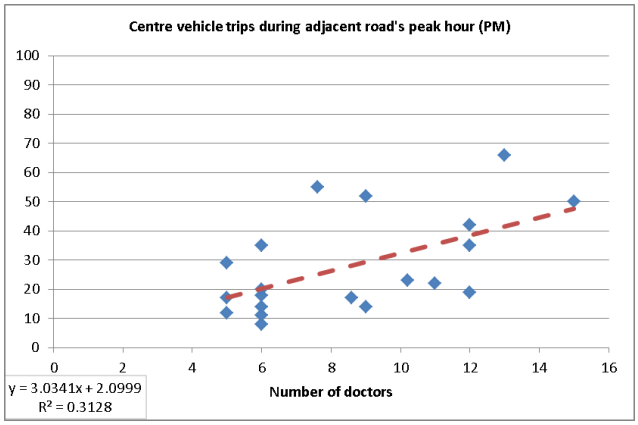

Figure 3.12 Centre vehicle trips during Peak hour on adjacent road (PM) vs. Number of doctors – Linear type

3.3.1.4 Total number of staff

- R^2 for all trip characteristics for all medical centres is low and indicates little correlation between the number of trips and total number of staff.

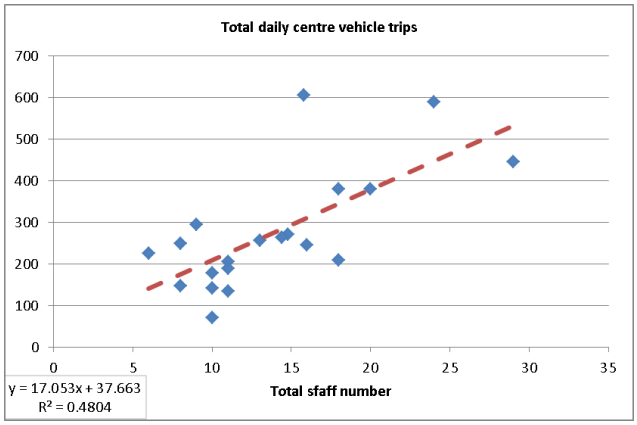

Figure 3.13 Total daily centre vehicle trips vs. Total number of staff – Linear type

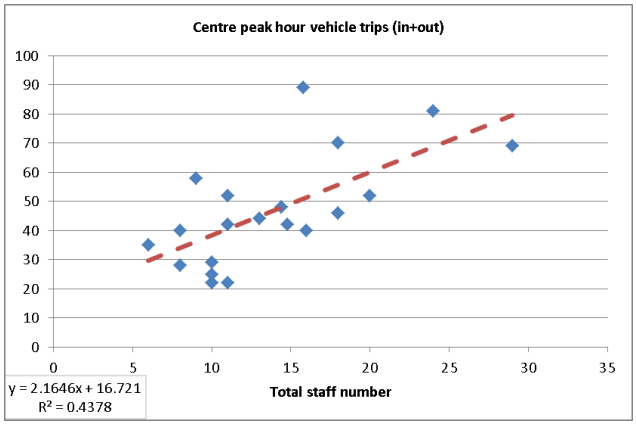

Figure 3.14 Centre peak hour vehicle trips vs. Total number of staff – Linear type

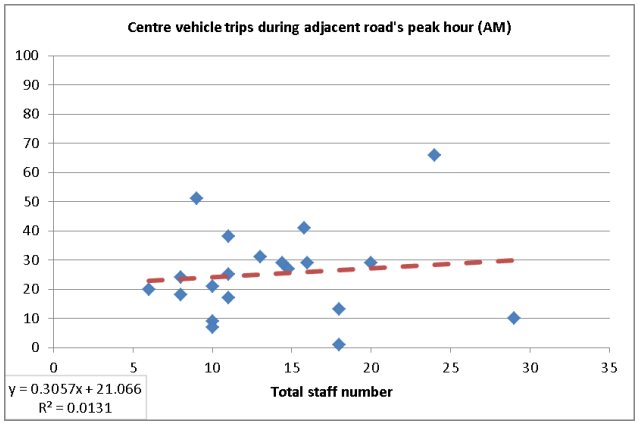

Figure 3.15 Centre vehicle trips during Peak hour on adjacent road (AM) vs. Total number of staff – Linear type

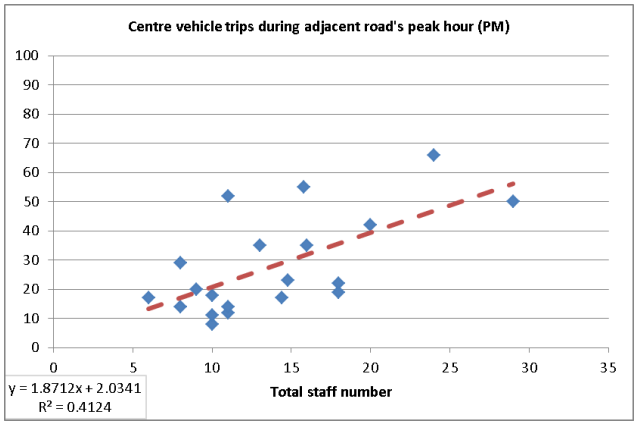

Figure 3.16 Centre vehicle trips during Peak hour on adjacent road (PM) vs. Total number of staff – Linear type

- The results of linear regression analysis indicated no significant correlation between the number of vehicular trips of any type and the independent variables.
- It was, therefore, considered worthwhile analysing whether application of non-linear relationships would improve the goodness of fit.

3.3.1.5 Non-linear regression analysis

- Non-linear regression analysis was carried out for all combinations of independent and dependent variables analysed in Sections 3.3.1.1 to 3.3.1.4 of the present report.
- Similarly to the linear regression analysis, the results of the non-linear regression analysis revealed no significant improvement in any of the relationships examined.
- The highest R^2 (0.5758) value that was found came from the relationship between the number of rooms and the peak 1-hour vehicle trips (in-out) (refer to Figure 3.19). All other non-linear graphs for the same combinations of independent and dependent variables as those analysed in Sections 3.3.1.1 to 3.3.1.4 were not included in this report because they displayed even lower R^2.
- Given that the single variable analysis, both linear and non-linear, did not produce any useful results, a multiple regression analysis has been undertaken.

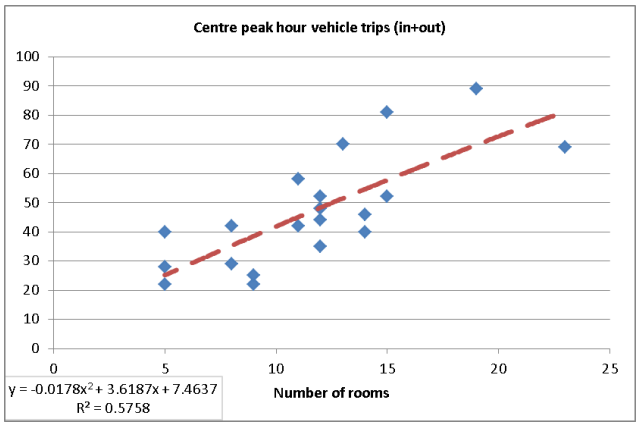

Figure 3.17 Centre peak hour vehicle trips (in+out) vs. Number of rooms – Non-linear type

3.3.1.6 Multiple regression analysis

- Further analysis has been undertaken to determine whether multiple regression based on two independent variables yields a more reliable estimate of peak and/or daily trip behaviour.
- Pairs of independent variables under examination were (Total GFA & No. of staff), (Total GFA & No. of doctors), (No. of rooms & No. of staff), (No. of rooms & No. of doctors) and (No. of rooms & Total GFA).
- For all of the above multiple regression interrogations the highest values of adjusted R^2 were in the order of 0.4-0.5, with the highest value of 0.5288 for the relationship between the total daily number of trips and (No. of rooms & No. of staff).

Table 3.3 Total daily centre vehicle trips vs. (Number of rooms & Total number of staff)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.7605
R Square	0.5784
Adjusted R Square	0.5288
Standard Error	97.832
Observations	20

ANOVA

	df	*SS*	*MS*	*F*
Regression	2	223254.3279	111627.164	11.66283079
Residual	17	162710.2221	9571.189533	
Total	19	385964.55		

	Coefficient	*Standard Error*	*t Stat*	*P-value*
Intercept	-9.6476	62.64442652	-0.154006234	0.879418301
No. of rooms	16.449	8.272978145	1.988236856	0.063133458
Total number of staff	6.6927	6.493470444	1.030676102	0.317134315

- Adjusted R^2 of 0.5288 is less than the 0.80 benchmark. It is also less than R^2 for the single variable relationship with the number of rooms (0.5521).
- All of the relationships were well below the 0.80 benchmark and thus cannot be used for reliable estimates.

3.3.2 Relationship between the Accessibility Score and car travel modes.

- The survey sites differed from each other in terms of both the Accessibility Score and the travel mode splits of staff and visitors. Table 3.4 and Figure 3.18 show the travel mode splits and Accessibility Scores for comparison.

Table 3.4 Modes of travel.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20
Driver	55%	40%	54%	57%	72%	59%	41%	59%	60%	56%	54%	46%	39%	66%	47%	69%	63%	54%	65%	71%
Passenger	25%	19%	23%	34%	24%	36%	2%	27%	28%	36%	15%	23%	35%	26%	26%	19%	29%	37%	27%	22%
Dropped off	1%	2%	7%	7%	4%	1%	1%	1%	2%	2%	11%	1%	9%	3%	0%	3%	0%	7%	0%	2%
Taxi	1%	1%	0%	0%	0%	0%	2%	1%	1%	0%	3%	1%	0%	2%	5%	3%	0%	0%	0%	0%
Bus	5%	5%	4%	0%	0%	2%	19%	2%	0%	2%	9%	5%	4%	1%	11%	2%	2%	0%	4%	6%
Train	1%	1%	0%	1%	0%	0%	6%	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%
Walk	11%	33%	12%	2%	0%	2%	28%	10%	9%	3%	9%	24%	9%	2%	11%	0%	4%	2%	4%	0%
Other*	1%	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	3%	2%	0%	0%	0%
Accessibility Score	227	167	75	70	31	62	337	34	29	176	215	187	198	64	52	37	76	21	4	70

* Other includes Tram, Cycle and Motorbike.

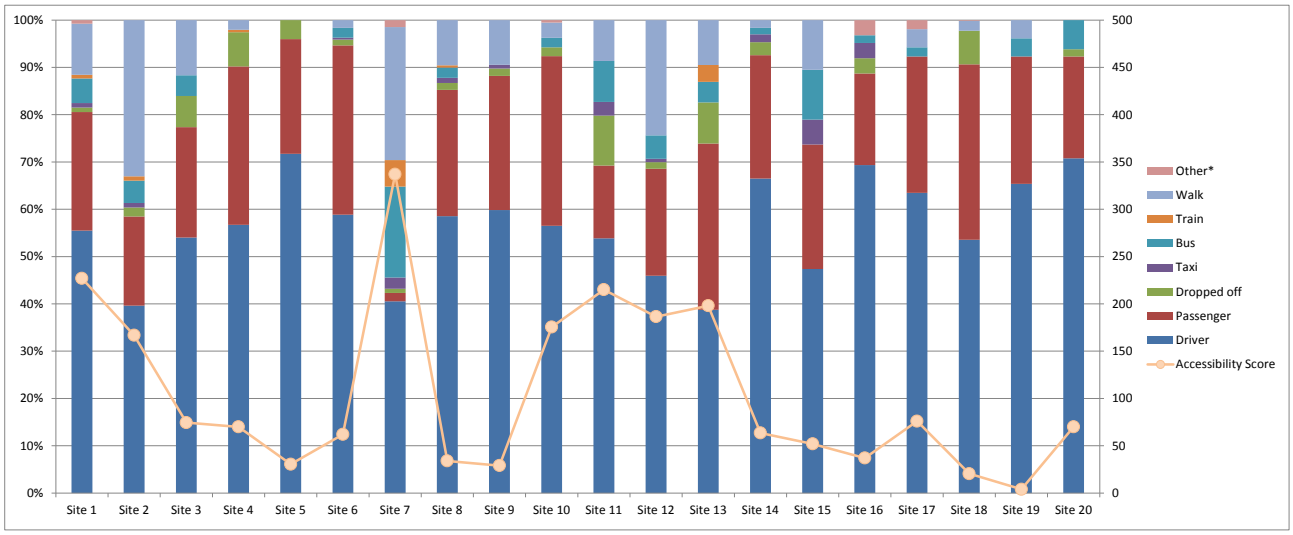

Figure 3.18 Travel modes and Accessibility Scores.

- The above data was used to analyse the travel mode relationship with the Accessibility Score.
- The graph included in Figure 3.19 overleaf shows levels of car use (per cent of car drivers plus passengers plus drop offs plus taxis) plotted as a dependant variable for various Accessibility Score values.
- It is evident from the graph below that a substantial level of correlation exists between the per cent of car travel mode and the Accessibility Score.
- It was felt that variations in car travel mode shares between the sites could be a reason for low correlation between the number of vehicular trips and the independent variables. It was therefore decided to examine the relationship between the number of person trips and the independent variables.
- The relationships between person trips and the AM & PM peak traffic on adjacent roads returned R^2 values under 0.2 and for this reason the respective graphs were excluded from the following Sections of the report.

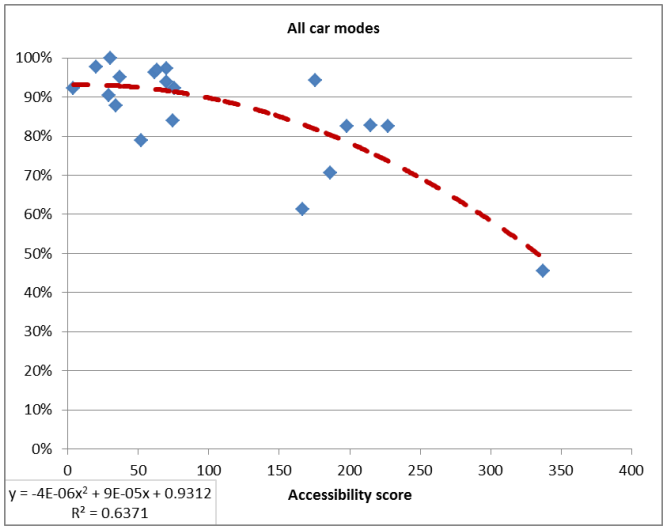

Figure 3.19 Per cent of car as a mode of travel vs. Accessibility score – Non-linear type

3.3.3 Relationship between the number of person trips and independent variables.

3.3.3.1 Total building GFA

- R^2 for all trip characteristics for all medical centres is low and indicates little correlation between the number of trips and total GFA.

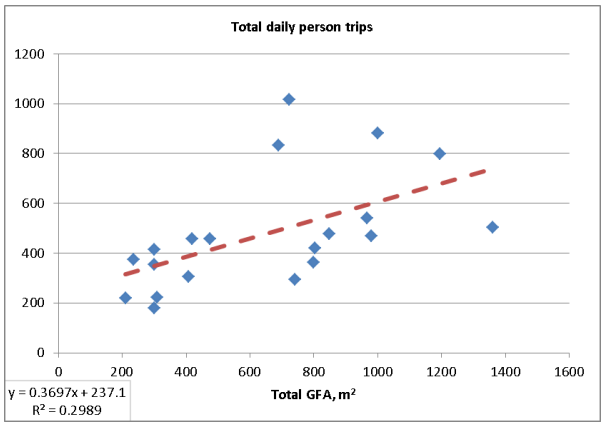

Figure 3.20 Total daily person trips vs. Total GFA – Linear type

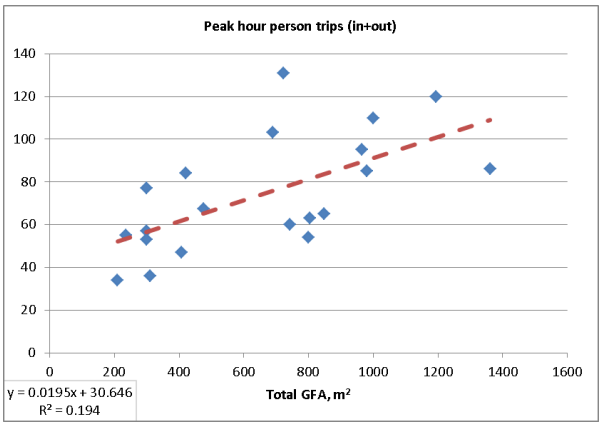

Figure 3.21 Peak hour person trips vs. Total GFA – Linear type

3.3.3.2 Number of consulting rooms

- R^2 for the daily and peak 1-hour trips in relation to the number of consulting rooms is much higher than R^2 for other independent variables.
- The result of $R^2 = 0.7889$ indicates a good correlation between the number of Peak 1-hour person-trips and the number of rooms.
- The result of $R^2 = 0.6952$ for the total daily trips is also quite high, although not as close to the 0.8 benchmark.

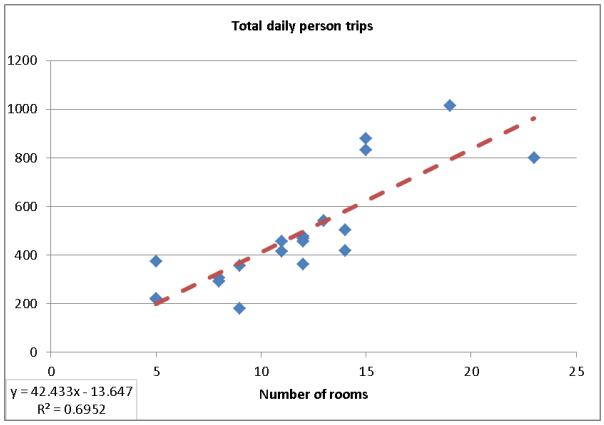

Figure 3.22 Total daily person trips vs. Number of rooms – Linear type

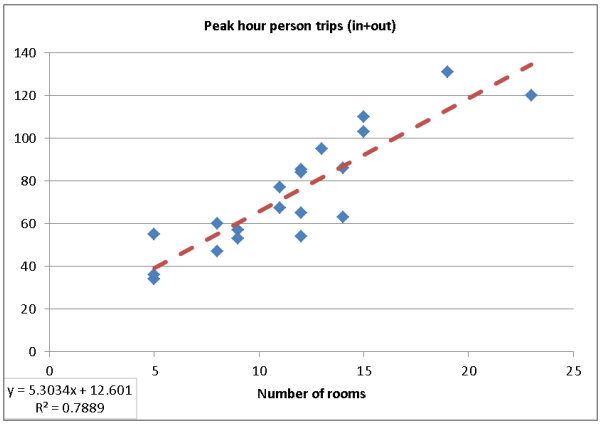

Figure 3.23 Peak hour person trips vs. Number of rooms – Linear type

3.3.3.3 Number of doctors

- R^2 for the daily and peak 1-hour trips is low and indicates little correlation between the number of trips and total GFA.

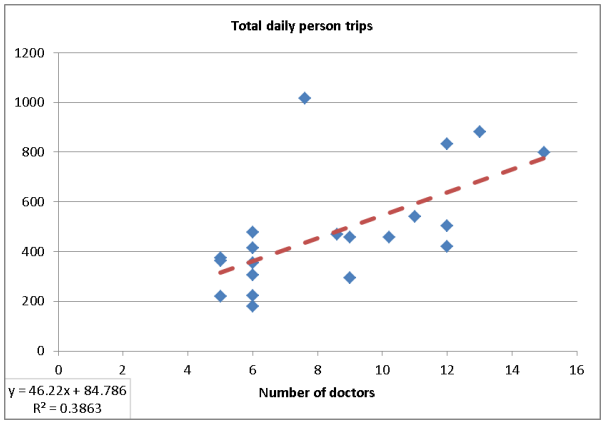

Figure 3.24 Total daily person trips vs. Number of doctors – Linear type

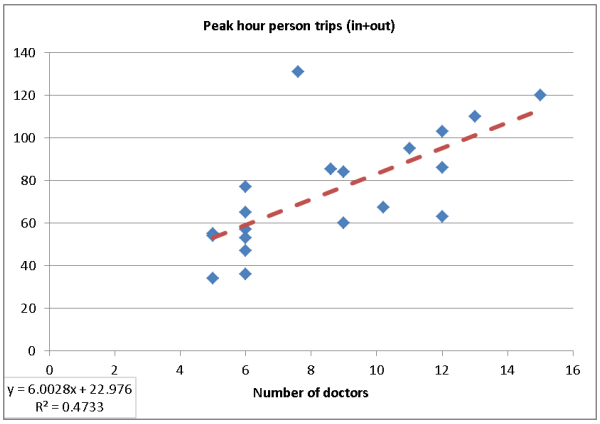

Figure 3.25 Peak hour person trips vs. Number of doctors – Linear type

3.3.3.4 Total number of staff

- The results of $R^2 = 0.5747$ and $R^2 = 0.6048$ indicate some correlation with the independent variable, although not sufficiently close to the 0.8 benchmark.

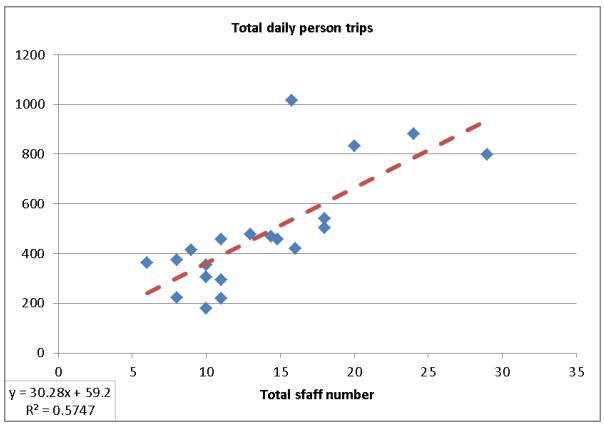

Figure 3.26 Total daily person trips vs. Total staff number – Linear type

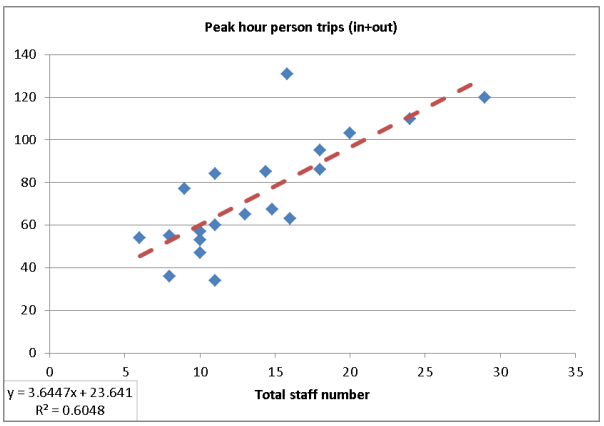

Figure 3.27 Peak hour person trips vs. Total staff number – Linear type

- Based on the results of the linear analysis it was decided to carry out a non-linear regression analysis in order to determine whether a better goodness-of-fit relationship could be found between the variables.

3.3.3.5 Non-linear regression analysis

- Non-linear regression analysis was carried out for the same combinations of variables as for the linear analysis. No significant improvements have been found in the majority of the examined relationships, compared with the linear regression results. However, it was found that the R^2 for the relationships between Peak 1-hour trips and Number of rooms and Total daily trips and number of rooms had slightly increased.
- The highest R^2 (0.79) value that was found came from the relationship between Number of rooms and the Peak 1-hour person trips (in & out). Whilst R^2 of 0.79 still remains below 0.8, this marginal difference is considered acceptable and the number of rooms van thus be regarded as a good predictor for the 1-hour person trips.
- Based on all the other results from the non-linear regression analysis it was considered worthwhile carrying out a multiple regression analysis to determine whether any additional improvements could be found.

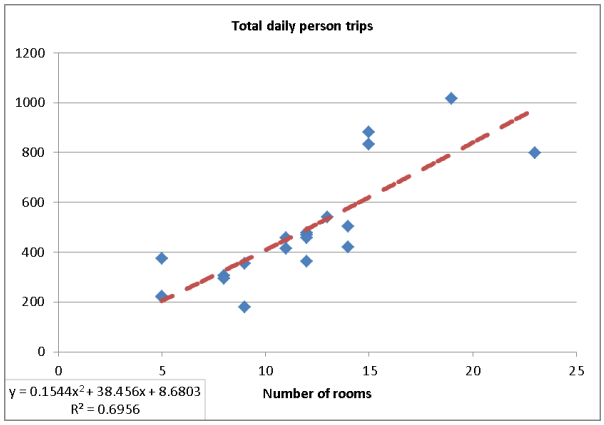

Figure 3.28 Total daily person trips vs. Number of rooms – Non-linear type

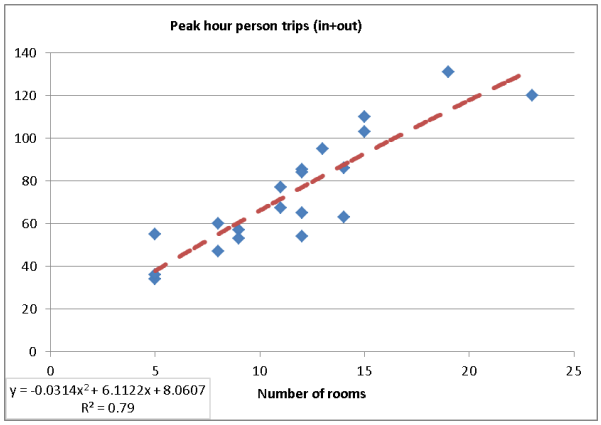

Figure 3.29 Peak hour person trips vs. Number of rooms – Non-linear type

3.3.3.6 Multiple regression analysis

- Further analysis has been undertaken to determine whether multiple regression based on two independent variables yields a more reliable estimate of peak and/or daily trip behaviour.
- Pairs of independent variables under examination were (Total GFA & No. of staff), (Total GFA & No. of doctors), (No. of rooms & No. of staff), (No. of rooms & No. of doctors) and (No. of rooms & Total GFA).
- For all but one of the above multiple regression interrogations the highest values of adjusted R^2 were in the order of 0.5-0.6.
- The highest adjusted R^2 values were the same as for the single variable regression analysis, that is for the total daily trips and peak 1-hour trips as a function of (No. of rooms & No. of staff). The resulting values of R^2 (0.6842 and 0.78 respectively) are lower than those from the single variable analysis. The single variable analysis thus produced more reliable relationships.

3.3.4 Relationship between parking demand and independent variables.

- As per the project brief, the data has been analysed to determine the most consistent measure of peak parking accumulation, using a simple linear regression approach.

3.3.4.1 Total building GFA

- R^2 is low and indicates little correlation between the peak parking accumulation and total GFA.

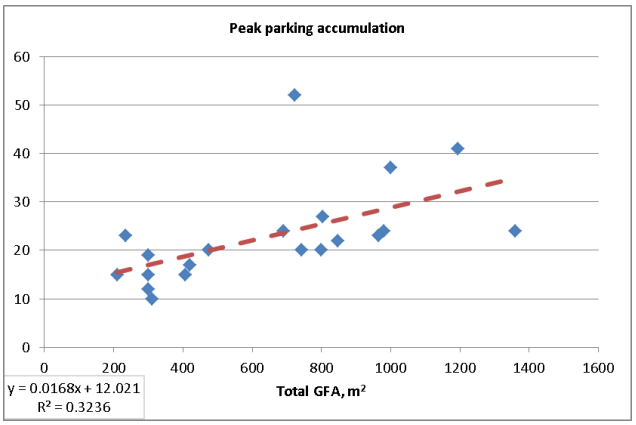

Figure 3.30 Peak parking accumulation vs. Total GFA – Linear type

3.3.4.2 Number of consulting rooms

- R^2 is much higher when compared to other variables and indicates some correlation between the peak parking accumulation and the number of rooms, although, at 0.6627, it is not sufficiently high to indicate good reliability of the relationship between the variables.

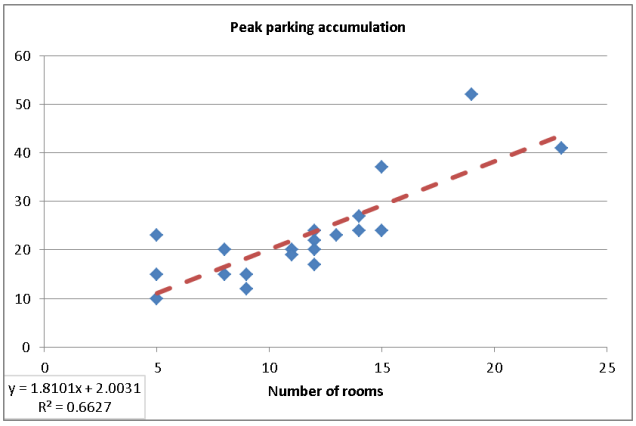

Figure 3.31 Peak parking accumulation vs. Number of doctors – Linear type

3.3.4.3 Number of doctors

- R^2 is low and indicates little correlation between the peak parking accumulation and the number of doctors.

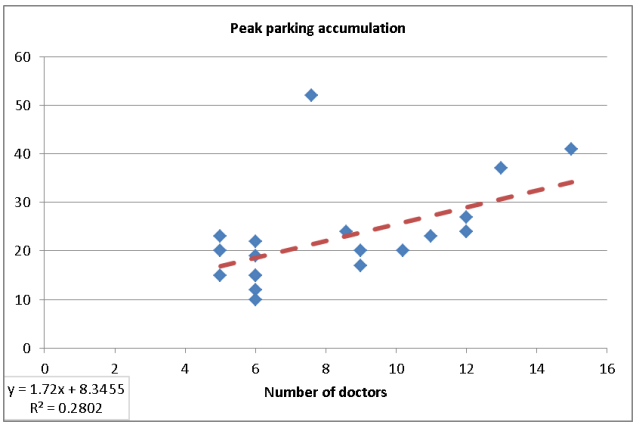

Figure 3.32 Peak parking accumulation vs. Number of doctors – Linear type

3.3.4.4 Total number of staff

- R^2 is low and indicates little correlation between the peak parking accumulation and the number of staff.

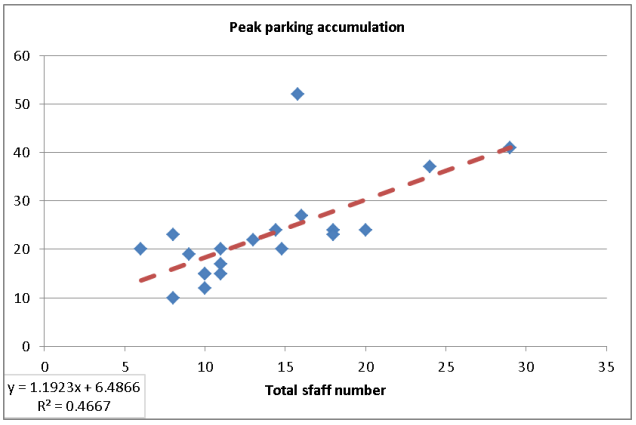

Figure 3.33 Peak parking accumulation vs. Total staff number – Linear type

- A non-linear regression analysis was carried out in order to determine if there is a more reliable relationship between the variables.

3.3.4.5 Non-linear and multiple regression analysis

- Possible relationship between the car parking demand and all independent variables were examined using non-linear and multiple (for all combinations of variables) regression analysis.
- No significant improvements have been found in the majority of the examined relationships, compared with the linear regression results. However, it was found that the R^2 for the relationships between the peak parking accumulation and Number of rooms had slightly increased, from 0.6627 to 0.703 (refer to Figure 3.35).
- R^2 of 0.703 still remains below the 0.8 benchmark, although it comes reasonably close to it and the graph indicates better fit for centres with 8 to 15 rooms.
- Graphs and tables for other combinations of variables were not included in this report due to their low R^2 values.

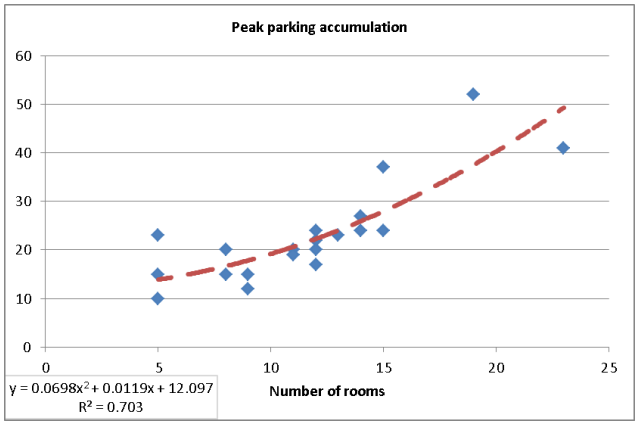

Figure 3.34 Peak parking accumulation vs. Number of rooms – Non-linear type

3.3.4.6 Exclusion of Site 18 from the analysis

- Worrigee Medical Centre (Site 18) is a large medical centre serving an unusually wide regional area. It attracts a remarkably large volume of patients and operates the longest hours compared with the rest of the survey sites. It is believed that the reason for this situation is a lack of medical consulting services in the area.
- Observation of the parking accumulation graphs reveals that values associated with Site 18 stand out substantially.
- Based on this observation it was considered worthwhile investigating whether exclusion of Site 18 from the analysis would improve the goodness of fit.
- Indeed, after the exclusion of Site 18 from the data set, R^2 for all relationships have increased. The highest R^2 value (0.7805) that was calculated for the relationship between total staff number and the peak parking accumulation. Whilst 0.78 still remains below the 0.8 benchmark, the relationship between the variables can be considered acceptable for forecasting of the parking demand.
- The second highest R^2 value (0.7038) came from the relationship between the number of rooms and the peak parking accumulation.

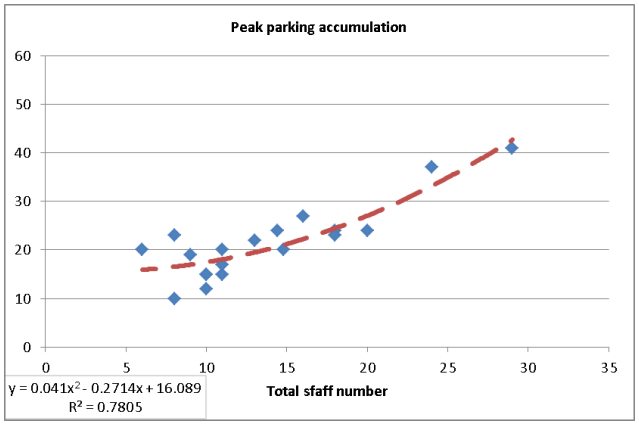

Figure 3.35 Peak parking accumulation vs. Total staff number (excl. site 18) – Non-linear type

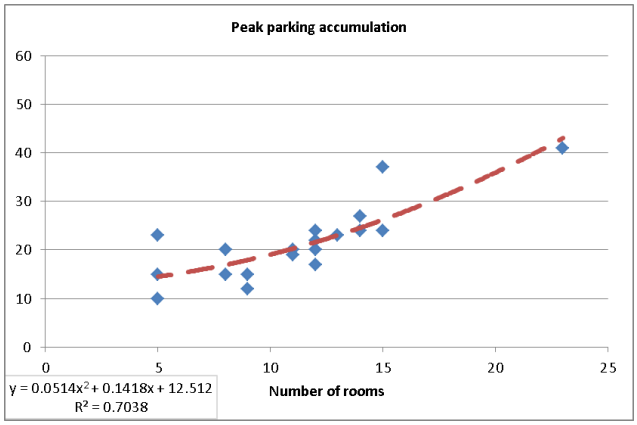

Figure 3.36 Peak parking accumulation vs. Number of rooms (excl. site 18) – Non-linear type

3.4 Operational parameters.

- It is a rather common situation that planning for the likely parking demand and trip generation of a new medical centre needs to be carried out when no detailed plans exist. Such a situation, for example, can occur when a development application is prepared for a shell space and the final medical centre layout, number of rooms or staff are not yet known.
- The data contained in Table 3.5 shows operational parameters of the surveyed medical centres. It can be used to estimate the operational parameters when only the floor spaces is known.

Table 3.5 Operational parameters.

	Sites 1 to 20				Sydney sites (1-14)				Regional sites (15-20)			
	Min	Max	Avg	St Dev	Min	Max	Avg	St Dev	Min	Max	Avg	St Dev
Development details:												
GFA per consulting room (m^2)	17.3	97.2	45.7	21.6	28.7	97.2	44.5	21.1	27.3	92.8	48.7	24.5
No. of doctors per room	0.40	1.20	0.78	0.22	0.42	1.00	0.76	0.17	0.40	1.20	0.81	0.31
GFA per doctor (m^2)	26.5	114.0	60.4	25.0	33.5	114.0	59.8	27.0	43.9	95.0	61.6	21.5
No. of staff per room	0.50	2.20	1.25	0.36	0.50	2.20	1.29	0.37	0.82	1.60	1.15	0.34
GFA per staff member (m^2)	13.7	75.6	38.4	17.6	20.8	75.6	37.0	19.3	26.8	67.5	41.7	14.1
Number of support staff per doctor	0.20	1.20	0.63	0.30	0.20	1.20	0.68	0.28	0.22	1.08	0.50	0.33

Note: the average GFA per consulting room includes all ancillary areas and was determined by dividing the total GFA of a centre by the number of rooms.

4 SUMMARY

The former Roads and Traffic Authority (RTA, now Roads and Maritime Services) published its Guide to Traffic Generating Developments ("Guide") in the mid-1990s. The trip generation and parking requirement data in the Guide is becoming increasingly out-of-date. The Guide contains trip generation and parking demand information derived from a 1992 survey of 19 Medical centres across greater Sydney. A number of changes have occurred since then in terms of medical centres' mode of operation, services offered and size. Given these changes, there is now a need to collect and analyse trip generation and parking demand data for Medical centres, to assist with traffic impact assessment and planning of future developments.

Fourteen (14) sites within the Sydney Metropolitan Area (SMA) and six (6) sites in regional NSW were selected in consultation with RMS Project Manager.

There were no technical issues with the conduct of the surveys, except obtaining permissions from the medical centre operators and collecting information about the year when the station was opened.

Surveys of trips generation were carried out in March-June 2015, outside school holidays. Classification counts of vehicles entering and leaving the sites, where off-street parking was available, were undertaken at each site generally between 7 am and 7 pm on weekdays. All people entering and leaving the sites were also counted. Interview surveys of staff and patients were undertaken as well, to determine travel modes, parking locations and length of stay. Three sites were chosen for a special survey where observations were conducted over all operating days of a week, to establish daily, as well as hourly visitation patterns. Surveys over two days, one weekday and one weekend day, were conducted at five sites. Surveys at the remaining 12 sites were carried out on a single weekday.

4.1 Average rates

A review of the data revealed a number of observations.

- The surveys were undertaken at medical centres with the floor space varying from 210 m^2 to 1,380 m^2 and with the number of rooms varying from 6 to 23.
- The results of the analyses for both peak hour and daily trips rates and parking accumulation indicate high values of standard deviation in all cases, with somewhat lower standard deviation for the peak parking accumulation per doctor for all sites and Sydney sites. The base data is therefore regarded as wide-spread and average rates are not recommended to be used for predicting the trip generation because of wide prediction intervals around the mean estimated values.

4.2 Regression analysis

The trip generation rates were then analysed in terms of their dependency on a number of variables, using linear and non-linear regression analysis. The interrogated variables are listed below.

- total building GFA;
- number of consulting rooms;
- number of doctors and other medical specialists;
- total number of staff.

The analysis was carried out for the following trip and parking characteristics:

- daily vehicle and person trips (i.e. inward trips + outgoing trips);
- peak vehicle and person trips (i.e. the maximum number of vehicle and person trips to/from the site in any one-hour period)

- vehicle and person trips during adjacent road's AM and PM peaks (i.e. the number of vehicle and person trips going to/from the site during the morning and afternoon peak hours on the frontage road).

- peak car parking accumulation

The regression analysis showed low levels of correlation between the number of vehicular and person trips and the independent variables. However, acceptable levels of correlation have been found for person trips and peak car parking accumulation with some independent variables, as summarised in **Table 4.1**. For estimating vehicular trips, it is recommended that person trips be estimated firstly and then the car travel mode share for the particular location be applied to the person trips.

Table 4.1 Trip generation relationships

	Variable	
	X_1 = Number of consulting rooms	**X_2 = Number of staff**
Variable range	6 to 23	5 to 29
Y = Total daily person trips	$Y = 0.1544X_1^2 + 38.456X_1 + 8.6803$ **R^2=0.70**	
Y = Peak 1-hour person trips (in+out)	$Y = -0.0314X_1^2 + 6.1122X_1 + 8.0607$ **R^2=0.79**	
Y = Vehicle or person trips (in+out) during AM peak hour on adjacent road	No reliable relationship has been found	
Y = Vehicle or person trips (in+out) during PM peak hour on adjacent road	No reliable relationship has been found	
Y = Peak car parking accumulation		$Y = 0.041X_2^2 + 0.2714X_2 + 16.089$ **R^2=0.78**

In summary, the analysis of data highlighted the following facts:

- Average trip rates should not be utilised for planning purposes.
- Satisfactory non-linear relationships were established between the number of total daily and peak 1-hour person trips and the number of consulting rooms. For peak parking accumulation, the best predictor was the number of staff on site.

Appendix

A summary of collected site data

Table A.1 Details of the selected survey sites and traffic survey results summary (continued on the next page)

	Sydney sites									
Site ID	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Site 9**	**Site 10**
Name of the development	The Mosman Practice	Crows Nest Medical Practice	Five Dock Medical Centre	Riverstone Family Medical Practice	Dural Medical Centre	Hunters Hill Medical Practice	Broadway General Practice	Sans Souci Medical Practice	Balmoral Street Medical Centre	Barwell Medical Centre
Site address	393 Military Road, Mosman NSW 2088	Suite 1a/375 Pacific Highway, Crows Nest NSW 2065	150 Great North Road, Five Dock NSW 2046	10 Pitt Street, Riverstone NSW 2765	535 Galston Road, Dural NSW 2158	6 Ryde Road, Hunters Hill NSW 2110	M105 Level 1 Broadway Shopping Centre, 1 Bay Street Broadway, Sydney NSW 2007	420/410/422 Rocky Point Road, Sans Souci NSW 2219	98 Balmoral Street, Hornsby NSW 2077	Suite 16, 7/9 Barwell Avenue, Castle Hill NSW 2154
Day and date of survey(s)	Mon, 01/06/15	Mon, 09/03/15	Thu, 19/03/15	Sat, 28/02/15 Mon, 02/03/15	Thu, 05/03/15 Sat, 07/03/15	Fri, 13/03/15	Wed, 04/03/15	Sat, 21/03/15 Mon-Fri, 23-27/03/15	Sun, 15/03/15 Mon, 16/03/15	Fri, 06/03/15 Sun-Tue, 8-12/03/15 Sat, 14/03/15 Wed-Thu, 25-26/03/2015
Duration of survey - frontage road	7:00-19:00	7:00-19:00	7:00-19:00	Sat 7:30-13:00 Mon 7:00-19:00	Thu 7:00-19:00 Sat 7:00-13:30	7:30-19:00	7:00-19:00	Sat 7:00-13:00 Mon-Fri 7:00-19:00	7:00-19:00	Mon-Thu 7:30-18:30 Fri 7:00-19:00 Sat-Sun 8:30-13:30
Duration of survey - site trip generation	7:00-19:00	7:00-19:00	7:00-19:00	Sat 8:00-13:00 Mon 7:00-19:00	Thu 7:00-19:00 Sat 7:00-13:30	8:00-18:00	8:00-19:00	Sat 8:00-13:00 Mon-Fri 8:00-18:00	7:00-19:00	Mon-Thu 8:00-18:00 Fri 8:00-17:00 Sat 8:00-13:00 Sun 9:00-13:00
Surrounding area characteristics	Town centre	Inner suburb	Inner suburb	Outer suburb	Outer suburb	Inner suburb	Town centre	Inner suburb	Town centre	Town centre
Surrounding land uses	Low-medium density residential, scattered commercial.	Low-medium density residential.	Low density residential.	Commercial / retail and low density residential.	Commercial / retail and low density residential.	Low density residential.	Commercial / retail. Located within a shopping centre.	Commercial / retail and low-medium residential.	Low density residential developments.	Commercial / retail and low-medium residential.
Frontage road - AM peak period (weekday)	7:00-8:00	8:00-9:00	8:15-9:15	10:00-11:00	7:45-8:45	8:45-09:45	9:15-10:15	multi-day[1]	7:45-8:45	multi-day
Frontage road - PM peak period (weekday)	16:15-17:15	17:15-18:15	17:30-18:30	15:15-16:15	16:00-17:00	15:30-16:30	12:15-13:15	multi-day	16:15-17:15	multi-day
Development details:										
Year opened						pre-2005	pre-2002	pre-2002		
Total site area (m^2)	876	1726	424	720	909	1069	1361	2215	400	4979
Gross floor area (m^2):	398	300	424	210	235	402	1361	475	400	980
Total GFA (m^2)	1194	300	848	210	235	804	1361	475	800	980
No. of rooms	23	9	12	5	5	14	14	11	12	12
No. of doctors	15	6	6	5	5	12	12	10	5	9
No. of total staff	29	10	13	11	8	16	18	15	6	14
Vehicle trips:										
Centre peak hour vehicle trips (in+out)	**69**	**22**	**44**	**22**	**40**	**40**	**46**	**42**	**35**	**48**
Time of centre peak hour vehicle trips	11:15-12:15	11:00-12:00	16:45-17:45	10:30-11:30	9:30-10:30	11:00-12:00	9:15-10:15	multi-day	8:30-9:45	multi-day
Centre peak hour vehicle trips per room	3.0	2.4	3.7	4.4	8.0	2.9	3.3	3.8	2.9	4.0
Centre peak hour vehicle trips per doctor	4.6	3.7	7.3	4.4	8.0	3.3	3.8	4.1	7.0	5.6
Centre peak hour vehicle trips per total staff	2.4	2.2	3.4	2.0	5.0	2.5	2.6	2.8	5.8	3.3
Centre peak hour vehicle trips per 100m^2 of total GFA	5.8	7.3	5.2	10.5	17.0	5.0	3.4	8.8	4.4	4.9
Total daily centre vehicle trips	**445**	**141**	**256**	**134**	**249**	**246**	**209**	**270**	**226**	**264**
Total daily centre vehicle trips per room	19.3	15.7	21.3	26.8	49.8	17.6	14.9	24.5	18.8	22.0
Total daily centre vehicle trips per doctor	29.7	23.5	42.7	26.8	49.8	20.5	17.4	26.5	45.2	30.7
Total daily centre vehicle trips per total staff	15.3	14.1	19.7	12.2	31.1	15.4	11.6	18.2	37.7	18.3
Total daily centre vehicle trips per 100m^2 of total GFA	37.3	47.0	30.2	63.8	106.0	30.6	15.4	56.8	28.3	26.9
Centre vehicle trips during adjacent road's peak hour (AM)	**10**	**9**	**31**	**17**	**18**	**29**	**1**	**27**	**20**	**29**
Centre vehicle trips per room during adjacent road's peak hour (AM)	0.4	1.0	2.6	3.4	3.6	2.1	0.1	2.5	1.7	2.4
Centre vehicle trips per doctor during adjacent road's peak hour (AM)	0.7	1.5	5.2	3.4	3.6	2.4	0.1	2.6	4.0	3.4
Centre vehicle trips per total staff during adjacent road's peak hour (AM)	0.3	0.9	2.4	1.5	2.3	1.8	0.1	1.8	3.3	2.0
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (AM)	0.8	3.0	3.7	8.1	7.7	3.6	0.1	5.7	2.5	3.0
Centre vehicle trips during adjacent road's peak hour (PM)	**50**	**8**	**35**	**12**	**29**	**35**	**19**	**23**	**17**	**17**
Centre vehicle trips per room during adjacent road's peak hour (PM)	2.2	0.9	2.9	2.4	5.8	2.5	1.4	2.1	1.4	1.4
Centre vehicle trips per doctor during adjacent road's peak hour (PM)	3.3	1.3	5.8	2.4	5.8	2.9	1.6	2.3	3.4	2.0
Centre vehicle trips per total staff during adjacent road's peak hour (PM)	1.7	0.8	2.7	1.1	3.6	2.2	1.1	1.6	2.8	1.2
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (PM)	4.2	2.7	4.1	5.7	12.3	4.4	1.4	4.8	2.1	1.7
Parking:										
No. of public car spaces	27	0	0	5	7	19	0	0	14	0
Peak parking accumulation	**41**	**15**	**22**	**15**	**23**	**27**	**24**	**20**	**20**	**24**
Peak parking accumulation per room	1.8	1.7	1.8	3.0	4.6	1.9	1.7	1.8	1.7	2.0
Peak parking accumulation per doctor	2.7	2.5	3.7	3.0	4.6	2.3	2.0	2.0	4.0	2.8
Peak parking accumulation per total staff	1.4	1.5	1.7	1.4	2.9	1.7	1.3	1.4	3.3	1.7
Peak parking accumulation per 100m^2 of total GFA	3.4	5.0	2.6	7.1	9.8	3.4	1.8	4.2	2.5	2.4
Time of peak parking accumulation	12:00-12:15	12:00-12:15	10:00-10:15	14:00-14:15	10:15-10:30	11:45-12:00	11:00-11:15	11:00-11:15	10:30-10:45 13:00-13:15	multi-day
Accessibilty score	227	167	75	70	31	62	337	34	29	176

	Sydney sites				Regional sites					
Site ID	**Site 11**	**Site 12**	**Site 13**	**Site 14**	**Site 15 (R1)**	**Site 16 (R2)**	**Site 17 (R3)**	**Site 18 (R4)**	**Site 19 (R5)**	**Site 20 (R6)**
Name of the development	Complete Medical Centre	Dee Why Family Practice	Medical Centre Bankstown	Kable Street General Practice	Umina Family Practice	Broadmeadow Medical Centre	Cardiff Medical Centre & Skin Cancer Clinic	Worrigee Medical Centre	Kelso Medical IPN	Wyong Family Practice
Site address	251 Queen Street, Campbelltown NSW 2560	7/9 Howard Avenue, Dee Why NSW 2099	Shop MM.014, The Appian Way, Bankstown NSW 2200	2 Kable Street, Windsor NSW 2756	297 West Street, Umina Beach NSW 2257	154 Lambton Road, Broadmeadow NSW 2292	321 Main Road, Cardiff NSW 2285	53 Isa Road, Worrigee NSW 2540	13 Marsden Lane, Kelso NSW 2795	152-156 Pacific Highway, Tuggerah 2259
Day and date of survey(s)	Wed, 10/06/15	Fri, 19/06/15	Thu, 25/06/15	Fri, 26/06/15	Fri, 13/03/15 Sat, 14/03/15	Wed, 25/03/15	Fri, 20/03/15 Sat, 21/03/15	Sat-Fri, 7-13/03/15	Thu, 12/03/15	Tue, 24/03/15
Duration of survey - frontage road	7:00-19:00	7:00-19:00	8:00-15:00	7:00-19:00	Fri 7:00-19:00 Sat 7:00-12:00	7:00-19:00	Fri 8:30-18:00 Sat 7:30-12:30	Mon 7:00-22:00 Tue-Fri 7:00-19:00 Sat 12:00-22:00 Sun 10:00-20:00	7:00-19:00	8:15-18:30
Duration of survey - site trip generation	7:00-18:00	7:00-19:00	8:30-14:30	8:00-19:00	Fri 8:00-18:00 Sat 8:00-12:00	8:00-18:00	Fri 7:00-18:00 Sat 7:30-12:30	Mon 7:00-22:00 Tue-Fri 7:00-19:00 Sat 12:00-22:00 Sun 10:00-20:00	8:00-19:00	8:00-18:00
Surrounding area characteristics	Outer suburb	Inner suburb	Town centre	Outer suburb	Inner rural	Inner rural	Inner rural	Outer rural	Outer suburb	Inner rural
Surrounding land uses	Commercial / retail.	Commercial / retail and recreational. Medium density residential.	Commercial / retail and recreational. Located within a shopping centre	Commercial / retail and low density residential.	Commercial / retail.	Commercial / retail and low density residential.	Commercial / retail and low density residential.	Low density residential.	Commercial / retail and low density residential.	Commercial / retail.
Frontage road - AM peak period (weekday)	10:00-11:00	11:00-12:00	8:30-9:30	8:15-9:15	11:00-12:00	7:45-8:45	07:30-08:30	multi-day	8:30-9:30	08:00-09:00
Frontage road - PM peak period (weekday)	16:00-17:00	15:00-16:00	13:45-14:45	15:15-16:15	15:15-16:15	16:45-17:45	12:15-13:15	multi-day	16:45-17:45	12:15-13:15
Development details:										
Year opened							pre-2003			pre-2005
Total site area (m^2)	896	780	300	615	420	3183	710	1760	7366	300
Gross floor area (m^2):	407	690	300	500	420	483	310	722	742	300
Total GFA (m^2)	407	690	300	1000	420	966	310	722	742	300
No. of rooms	8	15	9	15	12	13	5	19	8	11
No. of doctors	6	12	6	13	9	11	6	8	9	6
No. of total staff	10	20	10	24	11	18	8	16	11	9
Vehicle trips:										
Centre peak hour vehicle trips (in+out)	**29**	**52**	**25**	**81**	**52**	**70**	**28**	**89**	**42**	**58**
Time of centre peak hour vehicle trips	12:15-13:15 14:00-15:00	9:15-10:30	10:00-11:00	09:15-10:15	15:15-16:15	09:15-10:30	13:45-14:45	multi-day	10:15-11:15	10:00-11:00
Centre peak hour vehicle trips per room	3.6	3.5	2.8	5.4	4.3	5.4	5.6	4.7	5.3	5.3
Centre peak hour vehicle trips per doctor	4.8	4.3	4.2	6.2	5.8	6.4	4.7	11.7	4.7	9.7
Centre peak hour vehicle trips per total staff	2.9	2.6	2.5	3.4	4.7	3.9	3.5	5.6	3.8	6.4
Centre peak hour vehicle trips per 100m^2 of total GFA	7.1	7.5	8.3	8.1	12.4	7.2	9.0	12.3	5.7	19.3
Total daily centre vehicle trips	**178**	**380**	**70**	**589**	**205**	**379**	**147**	**606**	**189**	**294**
Total daily centre vehicle trips per room	22.3	25.3	7.8	39.3	17.1	29.2	29.4	31.9	23.6	26.7
Total daily centre vehicle trips per doctor	29.7	31.7	11.7	45.3	22.8	34.5	24.5	79.7	21.0	49.0
Total daily centre vehicle trips per total staff	17.8	19.0	7.0	24.5	18.6	21.1	18.4	38.4	17.2	32.7
Total daily centre vehicle trips per 100m^2 of total GFA	43.7	55.1	23.3	58.9	48.8	39.2	47.4	83.9	25.5	98.0
Centre vehicle trips during adjacent road's peak hour (AM)	**21**	**29**	**7**	**66**	**38**	**13**	**24**	**41**	**25**	**51**
Centre vehicle trips per room during adjacent road's peak hour (AM)	2.6	1.9	0.8	4.4	3.2	1.0	4.8	2.2	3.1	4.6
Centre vehicle trips per doctor during adjacent road's peak hour (AM)	3.5	2.4	1.2	5.1	4.2	1.2	4.0	5.4	2.8	8.5
Centre vehicle trips per total staff during adjacent road's peak hour (AM)	2.1	1.5	0.7	2.8	3.5	0.7	3.0	2.6	2.3	5.7
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (AM)	5.2	4.2	2.3	6.6	9.0	1.3	7.7	5.7	3.4	17.0
Centre vehicle trips during adjacent road's peak hour (PM)	**18**	**42**	**11**	**66**	**52**	**22**	**14**	**55**	**14**	**20**
Centre vehicle trips per room during adjacent road's peak hour (PM)	2.3	2.8	1.2	4.4	4.3	1.7	2.8	2.9	1.8	1.8
Centre vehicle trips per doctor during adjacent road's peak hour (PM)	3.0	3.5	1.8	5.1	5.8	2.0	2.3	7.2	1.6	3.3
Centre vehicle trips per total staff during adjacent road's peak hour (PM)	1.8	2.1	1.1	2.8	4.7	1.2	1.8	3.5	1.3	2.2
Centre vehicle trips per 100m^2 of total GFA during adjacent road's peak hour (PM)	4.4	6.1	3.7	6.6	12.4	2.3	4.5	7.6	1.9	6.7
Parking:										
No. of public car spaces	0	0	0	0	0	0	0	19	0	0
Peak parking accumulation	**15**	**24**	**12**	**37**	**17**	**23**	**10**	**52**	**20**	**19**
Peak parking accumulation per room	1.9	1.6	1.3	2.5	1.4	1.8	2.0	2.7	2.5	1.7
Peak parking accumulation per doctor	2.5	2.0	2.0	2.8	1.9	2.1	1.7	6.8	2.2	3.2
Peak parking accumulation per total staff	1.5	1.2	1.2	1.5	1.5	1.3	1.3	3.3	1.8	2.1
Peak parking accumulation per 100m^2 of total GFA	3.7	3.5	4.0	3.7	4.0	2.4	3.2	7.2	2.7	6.3
Time of peak parking accumulation	12:00-12:15	11:00-11:15	11:00-11:15	15:00-15:15	15:15-15:30 15:30-15:45	15:45-16:00	11:45-12:00	multi-day	10:15-10:30	10:15-10:30
Accessibilty score	215	187	198	64	52	37	76	21	4	70