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**TRENDS AND ETHNIC DISPARITIES IN THE  
INCIDENCE AND OUTCOME OF STROKE IN  
AUCKLAND, NEW ZEALAND OVER 20  
YEARS.**

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**A thesis submitted in fulfilment of the  
requirements for the degree of Doctor of  
Philosophy, The University of Auckland, 2007.**

# ABSTRACT

*Aims:* The aims of this thesis were to investigate trends and ethnic disparities in the incidence and outcome of stroke in Auckland, New Zealand between 1981 and 2003.

*Methods:* Trends were assessed using information from the three Auckland Regional Community Stroke (ARCOS) studies, conducted in people (aged  $\geq 15$  years) in Auckland, during 12-month calendar periods in 1981-1982, 1991-1992, and 2001-2002. These studies used comparable definitions and case finding methods and have been shown to meet the stringent criteria for a population-based “ideal” stroke incidence study. Rates were calculated using Poisson distribution and are presented with 95% confidence intervals. Trends in survival were assessed using Cox Proportional hazards regression modelling.

*Results:* Overall trends in the incidence and event rates of stroke declined across the study period. These declines were significant in males and for the ages 65 to 74 years only. However, growing disparities in the rates of stroke between the major ethnic groups in New Zealand were found, with significant declines in New Zealand Europeans and increases in Māori and Pacific populations.

Dramatic improvements in survival over the study period were also found, with the greatest improvement in the acute period, within the first 28-days after stroke. Adjustments for patient or disease severity factors strengthened the survival model. However, adjustments for care/service factors nullified the survival model, thus explaining most of the improving trend.

*Conclusions:* The small declines in the incidence of stroke, improvements in survival and the ageing of the New Zealand population will lead to data dramatic increases in the number of people living with the effects of stroke. To maintain stable numbers of strokes occurring, more intensive prevention strategies need to target high-risk populations and population-wide health education strategies are needed to improve the health of the general population, hence reducing the risk of stroke.

To my parents  
Phil and Judy Carter,  
for their continued support and encouragement.

## ACKNOWLEDGEMENTS

I would like to thank the many people who were involved with this thesis. Firstly, I would like to thank Professor Craig Anderson for encouraging me to embark upon this thesis. Thank you for your support over the years, both in Auckland and Sydney. I would also like to thank Professor Anthony Rodgers and Dr Velandai Srikanth for their advice and encouragement. I would like to acknowledge the team at [www.betteredit.com](http://www.betteredit.com) who proof read the first four chapters of this PhD thesis.

To all of the people, patients, families and project staff, involved in the three ARCOS studies, a big thank you. Without all of the continued hard work over the past two decades this thesis along with its important messages would be lost. There have been a number of people who have provided statistical and epidemiological advice to me over the years: Professor Chris Wild, Dr Derrick Bennett, Dr John Huakau, Varsha Parag, Stephen Vander Hoorn and Julie Winstanley. Thanks a bunch to Dr Maree Hackett who was always there to bounce ideas off and walk down the PhD path with me.

I would like to say particular thanks to the Health Research Council (HRC) of New Zealand for their financial support during my PhD, providing me with a Pacific Health PhD scholarship. The HRC also provided funds for the conduct and completion of the three ARCOS studies. I would also like to thank the other funding bodies that have provided financial assistance with the research and writing of this thesis and for assistance with travel to conferences to present this work: The Clinical Trials Research Unit, The George Institute for International Health, The University of Auckland graduate research fund, and the Sir John Logan Campbell Medical Trust.

Finally, a big thank you to all of my family and friends who have kept me sane over the past four years. You have no idea how much I am indebted to you.

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# LIST OF ABBREVIATIONS

ACE Inhibitor	Angiotensin Converting Enzyme Inhibitor
AF	Atrial Fibrillation
AIC	Akaikes Information Criterion
ANOVA	Analysis of Variance
ARCOS	Auckland Regional Community Stroke studies
BMI	Body Mass Index
C	Community Case Ascertainment
CF	Case Fatality
CHD	Coronary Heart Disease
CI	Confidence Interval
CT	Computed Tomography
CTRU	Clinical Trials Research Unit
CVA	Cerebrovascular Disease
D	Death Certificate Case Ascertainment
DALY	Disability Adjusted Life Years
DRG	Diagnostic Related Grouping
FDA	Federal Drug Administration
FSP	Framingham Stroke Profile
GCNKS	Greater Cincinnati Northern Kentucky Stroke study
GCS	Glasgow Coma Score
GP	General Practitioner
H	Hospital Case Ascertainment
HR	Hazard Ratio
ICD	International Classification of Diseases
ICH	Intracerebral Haemorrhage
IPA	Independent Practitioners Associations
IQR	Inter-quartile Range
ISC	Ischaemic Stroke
ISEI	International Socioeconomic Index
LR	Likelihood Ratio
MONICA	Monitoring of Trends and Determinants in Cardiovascular Disease
MRA	Magnetic Resonance Angiography
MRI	Magnetic Resonance Imaging

N	Number of strokes
NHANES	National Health and Nutrition Examination Surveys
NIHSS	National Institute of Health Stroke Scale
NOMAS	Northern Manhattan Stroke study
NZ	New Zealand
NZ/European	New Zealand European
NZHIS	New Zealand Health Information System
NZSCO	New Zealand Occupational status
NZSEI	New Zealand Socioeconomic Index
OCSP	Oxford Community Stroke Project
OR	Odds Ratio
OXVASC	Oxford Vascular Study
PH	Proportional Hazards
PICH	Primary Intracerebral Haemorrhage
rFVIIa	recombinant activated factor VIIa
RR	Rate Ratio
rtPA	recombinant tissue plasminogen activator
SAH	Subarachnoid Haemorrhage
SD	Standard Deviation
SER	Standardised Event Ratio
SES	Socioeconomic Status
SF	Stroke Foundation
SLSR	South London Stroke Register
SMR	Standardised Mortality Ratio
TIA	Transient Ischaemic Attack
TOAST	Trial of Org 10172 in Acute Stroke Treatment
UK	United Kingdom
UND	Undetermined Stroke Type
US	United States
WHO	World Health Organization

## STATEMENT OF PARTICIPATION

The research presented in this thesis was based in part on data obtained from the third Auckland Regional Community Stroke (ARCOS) study conducted in Auckland between 2002 and 2003 by investigators of the University of Auckland. Professor Craig Anderson, formerly the co-director of the Clinical Trials Research Unit (CTRU) was the primary investigator of this study and the main supervisor of this PhD. Associate Professor Anthony Rodgers was maintained as the University of Auckland based supervisor after Professor Anderson moved to The George Institute for International Health in Sydney. Professor Ruth Bonita was responsible for the development, conduct and data from the two previous ARCOS studies conducted in 1981-1982 and 1991-1992.

Initially, I was brought into the study team to advise on statistical methodology and provide projections of potential sample size calculations. I was part of the Operations Committee that met weekly for the study, the Steering Committee that met monthly and the Qualitative and socio-economic analysis group that met bi-monthly to develop and conduct qualitative interviews of stroke victims and their informal caregivers of four ethnic groups. At these meetings I would provide updates of the notification and registration of cases to the study. I was involved in developing the Manual of Procedures for the study and the development of face to face and telephone questionnaires. It was through this process that Professor Anderson and I developed the proposal for this PhD.

As part of this study I was responsible for all statistical analyses and the supervision of a junior statistician who checked the results. I was also responsible for liaising with the New Zealand Health Information Service to sort through the notifications of all hospital discharges for stroke, match the names with the current ARCOS database and provide the study manager, Faith Mahoney, with a list of names of patients to be followed up in each hospital in the Auckland region. I worked closely with the data management and information technology teams at the CTRU to develop and validate the

data base with which the data would be entered by the data entry team of the data management team and the permanent Oracle 8i database. All data was then extracted into SAS 8.1 from the Oracle database.

As part of this thesis I spent a considerable amount of time sorting through a mass of SAS datasets from the previous studies conducted in 1981-1982 and 1991-1992. All of these data were reviewed and organised and copied into a permanent Oracle 8i database with the help of the data management and information technology teams at the CTRU. The data was organised into datasets by forms and follow up studies. As part of the continuation of the 1981-1982 and 1991-1992 ARCOS studies I developed a 21 year and 11 year follow up of all of the survivors, respectively. Ethical approval for this study was provided by the Auckland Ethics committee. Through this study I supervised third year medical student, who contacted all those cases who were not known to have died from these studies and completed a short telephone questionnaire about their current residence and health status and their health related quality of life using the Short Form 36 questionnaire (SF36).

## PUBLICATIONS AND PRESENTATIONS

*To date the following publications have resulted from this PhD thesis:*

1. Tobias M, Cheung J, **Carter K**, Feigin F. Stroke surveillance: Population-based estimates and projections. *Australia and New Zealand Journal of Public Health*. 2007 (In press):
2. **Carter KN**, Anderson CS, Hackett ML, Barber PA, Bonita R. Improved survival after stroke is admission to hospital the major explanation? Trends analyses of the Auckland Regional Community Stroke (ARCOS) studies. *Cerebrovascular Diseases*. 2007; 23: 162–168.
3. Dyllal L, **Carter K**, Bonita R, Anderson C, Feigin V, Kerse N, Brown P. Incidence of Stroke in Women in Auckland, New Zealand. Ethnic Trends Over Two Decades. *NZ Med J*. 2006;19:1245
4. **Carter KN**, Anderson CS, Hackett ML, Feigin V, Barber PA, Broad JB, Bonita R, on behalf of the Auckland Regional Community Stroke (ARCOS) Study Group. Trends in Ethnic Disparities in Stroke Incidence in Auckland, New Zealand, During 1981 to 2003. *Stroke*. 2006;37:56-62.
5. Feigin V, **Carter K**, Hackett M, Barber PA, McNaughton H, Dyllal L, Chen M-h, Anderson C. Ethnic disparities in incidence of stroke subtypes: Auckland Regional Community Stroke Study, 2002-2003. *The Lancet Neurology*. 2006;5:130-139
6. Anderson CS, **Carter KN**, Hackett ML, Feigin V, Barber PA, Broad JB, Bonita R, on behalf of the Auckland Regional Community Stroke (ARCOS) Study Group. Trends in Stroke Incidence in Auckland, New Zealand, During 1981 to 2003. *Stroke*. 2005;36:2087-2093
7. **Carter KN**, Hackett ML, Anderson CS. Disparities in the incidence of stroke in Asian populations in Auckland, New Zealand. Inaugural International Asian Health Conference. Conference Proceedings. 2004.
8. Feigin VL, **Carter K**. Editorial Comment--Stroke Incidence Studies One Step Closer to the Elusive Gold Standard? *Stroke*. 2004;35(9):2045-2047.
9. Anderson CS, **Carter KN**, Brownlee WJ, Hackett ML, Broad JB, Bonita R. Very Long-Term Outcome After Stroke in Auckland, New Zealand. *Stroke*. 2004;35(8):1920-1924.

*To date the following presentations have resulted from this PhD thesis:*

1. Stroke Society of Australasia. Adelaide, October 2006. Oral Presentation. How preventable is stroke? Projecting the future burden of stroke from the Auckland Regional Community Stroke (ARCOS) study data.
2. New Zealand Rehabilitation Association. Auckland, November 2005. Oral Presentation. Trends in ethnic disparities of stroke in Auckland New Zealand, 1981-2003.
3. School of Public Health seminar series, University of Sydney, October 2005. Invited lecture. Ethnic variation in Stroke.



4. Stroke Society of Australasia. Melbourne, September 2005. Oral Presentation. Can we explain any improvement in stroke survival?: Results from population-based incidence studies in Auckland, New Zealand over 20 years
5. European Stroke Conference. Bologna, Italy, May 2005. Oral Presentation. Continued improvements in short-term survival after stroke: Experience from population-based studies in Auckland, New Zealand.
6. Inaugural Asian health and Wellbeing Conference, Auckland, November 2004. Oral Presentation. Ethnic disparities and trends in stroke in Auckland over 20 years.
7. Stroke Society of Australasia. Hobart, October 2004. Key-note presentation. Ethnic variation in Stroke.
8. Stroke Society of Australasia. Hobart, October 2004. Oral Presentation. Complex trends in stroke incidence in Auckland, New Zealand during 1981-2003.
9. World Stroke Congress. Vancouver, Canada, June 2004. Poster presentation. Ethnic disparities in trends in stroke rates in Auckland, New Zealand during 1981-2003.