Understanding Gastroenteritis and Foodborne Diseases in Elderly Australians

by

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A thesis submitted for the degree of

Doctor of Philosophy

The Australian National University

May 2011
Declaration

I declare that the work contained in this thesis is the result of original research and has not been submitted to any other University or Institution.

The research I conducted used data from three research studies and two surveillance systems that were collaborative in nature and included the input of epidemiological colleagues. For the research studies, I was either a principal researcher or co-researcher and was centrally involved in design of the studies, collection of data, quality assurance, analysis of data, and reporting of the studies. I conceived a plan and analyzed data from the two surveillance systems. Specifically, I initiated the assessment of the association of age on disease outcomes in the different datasets. Therefore, I facilitated involvement of epidemiologist colleagues in the collection of data and interpretation of findings. I was solely responsible for overall project management, data management and analysis.

In this thesis I analyze data from these studies to address specific objectives. These analyses are my own work, except where indicated by references or acknowledgements in the text.

Signed: ________________________________
Acknowledgments

There are many people to thank for their assistance during my candidature. I have had a huge amount of help from many people.

The Australian Government Department of Health and Ageing approved my PhD studies and supported me by providing funding for some of the studies and datasets. From the Department I thank Dr Ian McKay, Ms Raelene Thompson, Ms Margaret Curran, Ms Sally Goodspeed and Dr Leslee Roberts for approving my studies and manuscripts, and providing support for this work. A big thanks to Drs Jenny Firman and Susan Hunt, who encouraged me and regularly provided advice during my studies.

During my PhD candidature, the National Health & Medical Research Council provided a public health postgraduate scholarship for the years 2008–11.

Members of the OzFoodNet network—Australia’s system of enhanced surveillance of foodborne disease—formed a vital network of friends, colleagues and co-authors during my studies. In particular, I thank, Dr Barry Combs, Ms Robyn Gibbs, Ms Joy Gregory, Ms Karin Lalor, Ms Charlotte McKercher, Mr Cameron Moffatt, Ms Jennie Musto, Dr Jane Raupach, Dr Russell Stafford, Ms Nicola Stephens, Dr Leanne Unicomb, for their help and support. A big thanks to Ms Katie Fullerton, Dr Katrina Roper and Ms Katrina Knope for taking on the role of Coordinating Epidemiologist of OzFoodNet while I was working part-time and studying. Each of you did a fantastic job and I couldn’t have done this PhD without your support and help.

I thank the many public health officers in State and Territory health departments and public health laboratory staff who contributed surveillance data to the studies presented in this thesis. Similarly, I thank the many clinicians and facilities who provided information on gastroenteritis and outbreaks as part of surveillance that I analyzed for this thesis.
I thank my three academic advisors for this degree—Dr Hassan Vally (The Australian National University), Dr Mark Veitch (The University of Melbourne) and Dr Fred Angulo (Centers for Disease Control and Prevention, United States of America). I really appreciated your encouragement and advice during the three years.

I thank my two academic supervisors Professor Niels Becker and Associate Professor Gillian Hall, both from the National Centre for Epidemiology and Population Health (NCEPH) at the Australian National University. In particular, Gill has been a great friend and mentor over the last ten years. Both Niels and Gill were extremely approachable and a source of wise advice and ideas. I am grateful for all your hard work and hope it has been an enjoyable experience for both of you. I have learnt so much from you!

I thank my wife—Roslyn—and three children—Lucy, Alexander and Samuel. Thanks for putting up with me! Roslyn, thanks for all your great advice, support and help. I really appreciate your sacrifice and hard work for my studies and career. I feel very blessed. I hope my studies will encourage each of you to continue learning throughout your life.

Finally, I thank God who ‘makes all things possible’ and is my reason for being!
Abstract

Elderly people are potentially at higher risk of gastroenteritis and foodborne diseases due to declining immunity, co-morbid illnesses and poorer food handling. In particular, residents of Long-Term Care Facilities (LTCF) have been highlighted as an ‘at-risk’ group, as outbreaks often occur in these facilities. The objectives of my research were to estimate the incidence of gastroenteritis and foodborne diseases in elderly Australians compared with other age groups, and elderly Australians living in LTCFs compared to elderly people in the community. I also examined the occurrence of outbreaks and causes of foodborne diseases in elderly people. To achieve these objectives I analyzed five different datasets: (1) a systematic review of gastroenteritis in LTCF residents, (2) 12-months longitudinal surveillance for gastroenteritis in residents of 16 LTCF in New South Wales, (3) two national surveys of gastroenteritis in the Australian community, (4) food- and waterborne infections in elderly people from Victorian public health surveillance, and (5) national surveillance of outbreaks of gastroenteritis and foodborne disease in Australian LTCF. I defined elderly people as 65 years or older. I analyzed datasets using meta-analysis, and negative binomial and logistic regression, depending on the nature of the data. In a meta-analysis of 15 international studies included in the systematic review, I estimated LTCF residents experience 0.15 episodes of gastroenteritis per person per year. Incidence was higher for studies conducted outside the United States at 0.27 episodes per person per year, which was similar to my findings of 0.23 episodes of diarrhea per person per year from longitudinal surveillance of 16 Australian LTCF. I estimated from national surveys that elderly people living in the community experienced 0.15 episodes of diarrhea per year, which was lower than any other age group. From Victorian surveillance data, the rate of Campylobacter infection in LTCF residents was 37% lower than in community residents, after adjusting for age, gender and reporting period. However, Victorian LTCF residents were at higher risk of Salmonella infections, particularly in association with outbreaks. From longitudinal surveillance, 96% (245/254) of gastroenteritis episodes in LTCF residents were outbreak-associated. Analysis of 3,257 outbreaks of gastroenteritis that occurred in Australian LTCF over six years identified that 84,769 people were affected and facilities could expect one outbreak every three years.
Outbreaks were predominantly transmitted from one infected person to another, with norovirus causing 35% (1,136/3,257) of outbreaks. Foodborne outbreaks were extremely rare and a food-vehicle was only identified in 27% (14/52) of outbreaks, where the main causes were meals that were pureed or contained eggs. In outbreaks of foodborne salmonellosis, 6.1% (15/244) of affected LTCF residents died. It was surprising to find that elderly people do not experience more gastroenteritis than younger people. Elderly people living in LTCF had a lower incidence of many foodborne infections than those living in the community, with the exception of salmonellosis. Gastroenteritis in LTCF residents was often associated with outbreaks, which were mainly spread from person-to-person. From these studies, health agencies should focus on identifying interventions to contain outbreaks of viral gastroenteritis in LTCF.
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Chapter 1

Introduction
Emergence of a national problem

Health departments and food safety agencies that provide consumer education to prevent foodborne disease often quote the phrase that ‘the very young, elderly, pregnant women and those who are immunocompromised are at greater risk of foodborne diseases’ [1-2]. Despite this, very little information existed in the literature to verify this statement by quantifying the risk or identifying if certain sub-groups of the elderly were more vulnerable.

In 2006, there was a dramatic 150% increase in the number of gastroenteritis outbreaks reported to OzFoodNet compared to the previous year [3-4]. OzFoodNet is an Australian network of foodborne disease epidemiologists working in State, Territory and federal health departments [5]. The increase was most notable in Long-Term Care Facilities (LTCF), where over 1,000 outbreaks occurred in 2007 and the case fatality ratio was highest [6]. The increased number of outbreaks has been sustained in subsequent years in all Australian States and Territories [7].

In addition, in 2007 an outbreak of foodborne Salmonella Typhimurium 44 in a Victorian LTCF resulted in the deaths of five residents, leading to widespread concern in the community and the media [6, 8]. This outbreak highlighted the consequences of foodborne disease in these facilities, and was followed by other severe outbreaks of foodborne disease in LTCF in other States. It became apparent that while serious foodborne outbreaks occurred in LTCF, there was little information available to indicate if this was due to better ascertainment in these closed living environments, or whether residents were truly at higher risk of infection when compared to elderly people living in the community.

To address these questions, I conducted several research studies, the results of which are presented in this thesis.
Aim & scope

The aim of this thesis was to assess the burden and causes of gastroenteritis and foodborne disease in elderly Australians.

There are many ways to assess the burden of infection, such as the incidence, costs, or using standardized metrics, such as disability adjusted life years [9]. One of the most important of these measures is incidence, or the number of ‘persons falling ill during a given period in a specified population’ [10]. In this thesis, I assess the incidence of gastroenteritis and specific infections in elderly people using data collected from surveillance and epidemiological studies. In particular, I use data on the number of bed-days occupied by Australian LTCF residents and the number of Australian residents aged ≥65 years old as denominator data for calculations of incidence.

Similarly, in assessing the causes of disease, I document the causes of illness in elderly Australians in terms of etiological agents and a limited number of food-based risk factors identified from investigation of outbreaks and cross-sectional surveys.

To address this aim, I constructed a series of research questions and conducted several research studies that are detailed in Chapter 3 on ‘Research design’.

Thesis structure

This thesis is a series of published papers that address research questions related to gastroenteritis and foodborne diseases in the elderly, along with chapters providing background, discussion and conclusions that are unpublished. At the beginning of each chapter, I have documented the publication status, co-authors, and the contribution of the paper to this thesis.

In the background in Chapter 2, I provide information on the aging population of Australia and gastroenteritis in elderly people, and define some of the terms used in the thesis. I then document the research questions I address and methods used to study gastroenteritis and foodborne disease in the elderly in Chapter 3. In the first paper in
Introduction

Chapter 4, I highlight the public health importance of gastroenteritis in the elderly to provide context for serious outbreaks. In the paper presented in Chapter 5, I review the literature regarding foodborne infections in elderly people, with a particular focus on those living in institutions.

In Chapter 6, I include a paper where I systematically review the literature and conduct a meta-analysis of the incidence of gastroenteritis in published infection control studies in LTCF. This serves as a useful means of comparing the incidence from a similar longitudinal study I conducted in 16 Australian LTCF that is reported as a paper in Chapter 7.

In Chapters 8 and 9, I present two papers comparing the incidence of gastroenteritis and specific food- and waterborne infections affecting elderly people living in LTCF and the community. In Chapter 8, I estimate the incidence of gastroenteritis of elderly people living in the community and examine risk factors from two national cross-sectional surveys. Chapter 9 is an analysis of reported rates of diseases potentially transmitted by contaminated food or water in people \( \geq 65 \) years old who were resident in one Australian State—Victoria—to examine if LTCF residents were at higher risk of infection.

This is followed by a paper where I analyze gastroenteritis outbreaks in LTCF reported to Australian State and Territory health departments over a six-year period in Chapter 10. In the paper in Chapter 11, I analyse a sub-set of LTCF outbreaks from surveillance that were confirmed or suspected to be due to contaminated food or water to identify potential means of prevention.

Chapter 12 contains a general discussion and conclusions in arising from the papers presented in this thesis.

In Appendix 1, I have included a published editorial from the journal *Clinical Infectious Diseases* that is a commentary on my paper reproduced in Chapter 10.
Introduction

All papers here are reproduced with the permission of the publishing company and co-authors. All papers included in the thesis were prepared during my doctoral candidature.

Student contribution

For each paper included in this thesis, I was the lead author and took primary responsibility for overall management of the drafting process. As each paper included contributions from several other co-authors, I have estimated my specific contribution to each paper in terms of a percentage in Table 1. I used guidance on contributorship from the British Medical Journal\(^a\) to estimate my contribution to (1) conception & drafting, (2) analysis & interpretation, and (3) drafting and revising. For each published article, I approved and submitted the final version of the manuscript, responded to comments from journal editors and reviewers, and was the corresponding author.

References


\(^a\) http://resources.bmj.com/bmj/authors/article-submission/authorship-contributorship Accessed on 19 April 2011.


Table 1. Estimate of student (Martyn Kirk) contribution to different aspects of publications included in this thesis as discrete chapters.

<table>
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<tr>
<th>Chapter Number</th>
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<th>Journal</th>
<th>Status</th>
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<td>Medical Journal of Australia</td>
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