THE VALUATION OF SOCIAL AND ECONOMIC COSTS OF MOSQUITO-TRANSMITTED ROSS RIVER VIRUS

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BSc MA MPhil

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STATEMENT OF ORIGINALITY

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JAYALATH TIKIRI BANDARA RATNAYAKE
ABSTRACT

Insect pests (such as mosquitoes) and their associated impacts have become important social, economic and environmental health issues. Mosquitoes transmit diseases, are widely perceived as a nuisance and are becoming a serious health concern for the public. The incidence of contracting mosquito-transmitted diseases has markedly increased in recent decades in Australia (Russell 1994). Currently, Ross River virus is the most prevalent mosquito-transmitted viral disease in Australia with up to 8,000 cases reported annually (Curran et al. 1996). The absence of documented evidence about the full social costs of mosquito-transmitted diseases is a critical issue as there is currently no economic rationale underlying existing resource allocation for intervention programs.

This study of the full social costs of Ross River virus was conducted between April and July 2002. Demographic, health-state and disease-related data were collected using survey questionnaires for 201 notified Ross River virus victims from across Queensland. Two self-administered surveys were conducted at the time approximately onset and six months from onset while a phone survey was conducted at 12 months after onset. Direct impacts such as the costs of health care (medical consultations, pathology services and medicines), non health care resources (treatment-related transport) and indirect impacts such as the opportunity cost of lost productivity (due to disability and treatment-related waiting times) of the viral illness were recorded in the questionnaires and were valued using market prices. A non-market valuation method (willingness-to-pay), in conjunction with a self-assessed standard health measure (Short Form 36) were used to quantify more intangible health-related quality of life effects such as change in physical, mental and social functioning. Estimated full social costs of the disease were analysed across age and gender groups. Based on the mean cost estimates for the study sample, the total disease costs have been extrapolated by local government areas as the appropriate administrative areas. A wide range of social and economic costs of the virus has been addressed in this thesis. However, the derived costs cannot be summed into a total estimate as several of these values overlap in terms of coverage. Therefore, only the major cost components, with a minimum of overlap, have been used to estimate the aggregate social cost of the disease. Given the methodological and empirical limitations of the study, the most accurate estimate of the average per
The estimate of the full social cost of Ross River virus disease can be a vital input for many relevant policy applications. For example, disease costs together with resource costs of current interventions, are essential inputs for ongoing economic evaluations of mosquito control programs at local level. In this thesis, the cost minimisation approach has been presented to evaluate mosquito control programs at the local level where the policy analyst’s task is to minimise the overall social costs (that is, disease costs plus control costs). These economic evaluations have substantial potential benefits to society in terms of the efficient allocation of scarce resources.

In addition, estimated disease cost is a significant input for economic impact assessment of regional disease outbreaks. It also can be used to highlight disease impact upon the economy and community and hence draw attention to the scale and scope of such problems to policy makers at all levels so that they can respond appropriately to the mosquito problem, and mosquito-transmitted diseases, as priority issues in the political agenda.
ACKNOWLEDGEMENTS

Most of all, my thanks go to the Ross River virus victims in Queensland who consented and took part in this study. Without you, there would be no research outcome to present in this thesis.

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<td>AB</td>
<td>Averting behaviour</td>
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<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<td>ACT</td>
<td>Australian Capital Territory</td>
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<td>ANOVA</td>
<td>Analysis of variance</td>
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<td>ANZIC</td>
<td>Australian New Zealand Industry Classification</td>
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<td>ARC</td>
<td>Australian Research Council</td>
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<td>ASCO</td>
<td>Australian Standard Classification of Occupations</td>
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<tr>
<td>AUD</td>
<td>Australian dollar</td>
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<tr>
<td>BTI</td>
<td><em>Bacillus thuringiensis israelensis</em></td>
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<tr>
<td>CBA</td>
<td>Cost-benefit analysis</td>
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<tr>
<td>CDI</td>
<td>Communicable Diseases Intelligence</td>
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<td>CDNA</td>
<td>Communicable Diseases Network Australia</td>
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<td>COI</td>
<td>Cost-of-illness</td>
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<td>COM</td>
<td>Co-morbidity</td>
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<td>CV</td>
<td>Contingent valuation</td>
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<td>DIS</td>
<td>Disabled period</td>
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<td>ELISA</td>
<td>Enzyme linked immunosorbent assay</td>
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<td>GEN</td>
<td>Gender</td>
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<td>GIS</td>
<td>Geographic Information System</td>
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<td>HCC</td>
<td>Health care costs</td>
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<td>IgG</td>
<td>Immunoglobulin G</td>
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<td>IgM</td>
<td>Immunoglobulin M</td>
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<td>INC</td>
<td>Income</td>
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<td>IOM</td>
<td>Institute of Medicine</td>
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<td>IPM</td>
<td>Integrated Pest Management</td>
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<td>IVM</td>
<td>Integrated Vector Management</td>
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<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>LEN</td>
<td>Disease duration</td>
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<td>LGA</td>
<td>Local government area</td>
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<td>LGAQ</td>
<td>Local Government Association of Queensland Inc.</td>
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<td>MCS</td>
<td>Mental Component Summary</td>
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<td>MST</td>
<td>Marital status</td>
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<td>NHMRC</td>
<td>National Health and Medical Research Council</td>
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<td>NNDSS</td>
<td>National Notifiable Diseases Surveillance System</td>
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<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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<tr>
<td>NSAIDs</td>
<td>Non-steroidal anti-inflammatory drugs</td>
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<td>NSW</td>
<td>New South Wales</td>
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<td>NT</td>
<td>Northern Territory</td>
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<td>PCS</td>
<td>Physical Component Summary</td>
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<td>QH</td>
<td>Queensland Health</td>
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<td>Qld</td>
<td>Queensland</td>
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<td>SA</td>
<td>South Australia</td>
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<tr>
<td>SD</td>
<td>Standard deviation</td>
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<td>SEV</td>
<td>Disease severity</td>
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<td>SF-36</td>
<td>Short-form 36</td>
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<td>Tas</td>
<td>Tasmania</td>
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<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>USEPA</td>
<td>United States Environmental Protection Agency</td>
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<td>US</td>
<td>United States of America</td>
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<td>Vic</td>
<td>Victoria</td>
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<td>WA</td>
<td>Western Australia</td>
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<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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<tr>
<td>WTA</td>
<td>Willingness-to-accept</td>
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<td>WTP</td>
<td>Willingness-to-pay</td>
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CHAPTER 1 INTRODUCTION

1.1 Introduction

Insect pests such as mosquitoes and biting midges are an important social, economic and environmental health issue. Mosquitoes transmit diseases, are widely perceived as a nuisance and are becoming a serious health concern for the public. Although the reasons are not clearly known, the incidence of contracting mosquito-transmitted diseases has markedly increased in recent decades in Australia (Russell 1994; Curran, Harvey, Crerar, Oliver, DiSouza, Myint, Rann and Andrews 1997). This has led to a marked growth in demand for more health care resources for the diagnosis and treatment of mosquito transmitted diseases at a national level. In addition, there is a growing demand for resources to be utilised for mosquito control and management programs at a local level (Local Government Association of Queensland 2000). Local governments in Queensland are responsible for providing a safe and healthy environment for the community living in their jurisdictions. Therefore, mosquito control is one of the prime issues being experienced by local governments in their efforts to maintain high residential quality of life and living standard. For example, local governments across Queensland spent over seven million dollars for mosquito control activities within their jurisdictions during the 1999/2000 period (LGAQ 2000).¹

Current mosquito control and management programs aim to reduce mosquito activity and hence reduce nuisance levels and mosquito-transmitted disease incidence. However, the allocation of appropriate resources for mosquito control and management programs at the local level is crucial due to: (1) increasing nuisance levels and disease risks (2) mounting pressure for

¹ 1999/2000 financial year.
environmentally-friendly control methods, and (3) competing demand for resources currently used to manage the problem.²

Local authorities are faced with a dilemma about whether mosquito control and management programs are cost-effective and whether allocation of additional resources is economically worthwhile. The absence of an appropriate methodology to assess the economic costs and social consequences of mosquito-transmitted diseases against the benefits of mosquito control and management programs appears to be a critical issue, as there is currently no established economic rationale for resource allocation. Because of the lack of reliable information on disease costs, authorities do not have a clear understanding about the magnitude of the disease burden, and this affects resource allocation priorities for mosquito control programs.

In addition, the economic impacts of sporadic disease outbreaks at a regional level are not taken into account due to their indirect nature.³ Therefore, in order to make socially optimal decisions about resource use, it is necessary to develop an efficient costing methodology to assess the whole range of social and economic impacts of mosquito-transmitted diseases including sporadic disease outbreaks.

This thesis presents findings of a comprehensive study conducted to assess the social and economic costs of Ross River virus, a mosquito-transmitted disease, within the Queensland context. This information is vital as disease cost information based on full social costs could be used to assess

² Several factors such as ramifications of global warming, unplanned property development (around mosquito breeding habitats) and increasing outdoor activities are attributed as the source of high disease risks (Russell 1994; Lindsay and MacKenzie 1996; Epstein 2000; McMichael and Woodruff 2002).

³ Social and economic impacts of sporadic disease outbreaks on regional economies could be substantial due to workforce absenteeism and restricted working hours. However, these impacts are not accounted for in disease costing methodology due to lack of information and complexity.
the effectiveness of current and new mosquito control programs implemented by local governments.\textsuperscript{4}

The primary aim of this research was to develop an efficient costing methodology to value a diverse range of social and economic impacts of mosquito-transmitted diseases by focussing on Ross River virus as a case study within the Queensland context.

1.2 Ross River virus

Ross River virus is currently the most prevalent arthropod-borne virus (arbovirus) disease in Australia with up to 8000 cases reported annually (MacKenzie and Smith 1996; Curran et al. 1997). It is generally increasing in Australia. The disease places social and economic burdens on Australian society and is one of the main contributors to morbidity in high disease incidence areas such as tropical and coastal Queensland. Prolonged morbidity and fatigue caused by Ross River virus may lead to a productivity loss within communities where the disease incidence is relatively high (Boughton, Hawkes, Lloyd and Naim 1989; Russell 2002). This loss appears to be substantial given that it is those in the work force (25 – 65 years of age) who are most at risk (Mudge and Aaskov 1983; Boughton 1994; Condon and Rouse 1995; Selden and Cameron 1996; Mackenzie and Smith 1996; Westley-Wise, Beard, Sladden, Dunn and Simpson 1996).

Although the disease does not cause mortality, people seek medical attention when they contract the disease thus increasing demands on health care resources for diagnosis and treatment of the disease. For example, the cost of serological tests of the Ross River virus outbreak in New South Wales in 1984 was estimated at around three million dollars (Boughton 1994). Harley, Sleigh and Ritchie (2001) estimated that diagnosis, treatment and lost

\textsuperscript{4} In general, resource allocation decisions are based on the economic evaluation of alternative programs for their net benefits. Disease cost information is a vital input for such evaluations.
earnings of Ross River virus could cost Australia around four million dollars every year while Mylonas, Brown, Carthew, McGrath, Purdie, Pandeya, Vecchio, Collins, Gardner, de Looze, Raymond and Suhrbier (2002) reported that the direct cost to the community could be around $AUD (1999) 1018 per patient. However, these cost estimations were well below those estimated by Boughton (1994).

The disease may take a long period of time for full recovery, thus having a significant impact upon productivity and efficiency of both paid and unpaid workers. The debilitating nature of Ross River virus has additional social costs from its negative quality of life impacts (Mudge and Berri 1977; Mudge and Aaskov 1983; Boughton 1994; Condon and Rouse 1995; Selden and Cameron 1996; Mackenzie and Smith 1996; Westley-Wise et al. 1996; Harley et al. 2001; Russell 2002). In addition, people take various actions to avoid contracting mosquito-transmitted diseases such as spending on personal protective methods. However, such costs were not taken into account in the previous studies mentioned above.

There are many other costs associated with Ross River virus, for example high disease incidence and severe mosquito infestation adjacent to breeding habitats could have significant impact upon the market value of residential properties. In addition, locations where the disease incidence or potential risk of contracting Ross River virus is relatively high could influence concerned visitors and tourists to change their travel plans and affect the number of tourist or visitor arrivals, occupancy rate and activities. Reduced visitation and expenditure in turn could have impact upon direct and indirect services associated with the tourism industry of the region.

Ross River virus is the most common mosquito-transmitted viral disease in Australia. The economic impact due to the disease or occasional disease outbreaks are rarely considered or quantified. Therefore, the valuation
of the social and economic costs of Ross River virus will have substantial benefits to State and local governments and will facilitate the evaluation of intervention programs to efficiently allocate resources and derive maximum net benefits to the community.

1.3 Context of the research

This section contextualises the research presented in this thesis. First, it distinguishes environmental health intervention from health care intervention. Then it outlines the historical developments in disease-cost valuation methodologies and their applications in economic evaluation studies in the health discipline. The main focus of the research is to select appropriate valuation methodologies and to modify and extend them as necessary to develop an efficient and effective disease-costing framework. Ideally, the modified approach should capture the whole range of costs associated with mosquito-transmitted diseases. It will help to close the current knowledge gap existing between conventional cost-of-illness applications and the costing of mosquito-transmitted diseases. In general, the cost-of-illness method has been used for the economic evaluation of health care services and interventions. However, its direct application in environmental health interventions such as mosquito control programs may not be appropriate.

The significant differences between health care interventions and environmental health interventions such as mosquito control programs are evident in the World Health Organisation (2000) publication on Considerations in Evaluating the Cost-Effectiveness of Environmental Health Interventions:

First, environmental health interventions are often regulatory in nature, acting on the fundamental cause of an injury or illness. Thus they are almost exclusively preventive, but their benefits may not be realised until the distant future. Second, environmental health interventions potentially convey considerable non-health benefits, such as saving time, increasing amenity, etc., which should be included when the viewpoint of the study is the societal one. Third, the primary responsibilities of funding and implementing environmental health interventions are often outside the
domain of health sector, and thus they require the collaboration or support of other sectors and/or ministries in their implementation. Fourth, the effectiveness of environmental health interventions is more difficult to evaluate than many core health services, as they are less amenable to controlled experiments due to the long time periods involved or they impact potentially large population groups but often in small amounts. Fifth, environmental health interventions also hold gains already achieved, and prevent ‘back-sliding’, which is often not taken into account in evaluation.

(World Health Organisation 2000 p.1)

Accordingly, it is apparent that economic evaluation of environmental health interventions such as mosquito control programs needs to be carried out from a much broader perspective than health care. Unlike health care evaluations, it is desirable that the economic evaluation of mosquito control programs be conducted from a societal perspective. Therefore, it is evident that full disease costs, as well as benefits associated with control and management programs need to be taken into account in the economic evaluation process to reflect the overall efficiency of the program. This necessitates a valuation methodology with a much broader perspective to capture disease costs including health and non-health impacts of mosquito-transmitted diseases.

1.3.1 Valuation of disease costs

Researchers have used a wide range of approaches to value disease impacts. Amongst them cost-of-illness is the most commonly used tool to value the economic burden of disease in healthcare. This method directly measures values using observed behaviour and is prevalent in the health economics literature. This estimate provides some notion of the overall cost savings achieved by reducing or removing the risk factor (Stephenson, Bauman, Armstrong, Smith and Bellew 2000).

In the cost-of-illness method, the analyst first attempts to identify cost-generating elements of an illness and then imputes market values to those elements. These market values reflect the opportunity cost of resources such as health and non-health services used or lost due to the illness (Hodgson and
Meiners 1982). The cost-of-illness valuation method has been extensively used in the health care sector to evaluate the cost-effectiveness of alternative health interventions (Drummond 1992).

Two major cost components, namely direct and indirect costs, are taken into consideration in the cost-of-illness valuation. Direct costs include health and non-health care expenditure occasioned by illness or disease. For example, health care expenditure includes health professional consultation, pathology services, medicines, hospitalisation, nursing care, home health care and counselling. Furthermore, diseases could also affect production of goods and services. Conceptually, all these costs should be accounted as indirect costs resulting from the disease. However, some indirect costs are often overlooked or disregarded due to lack of data and conceptual difficulties (Hodgson and Meiners 1982). In general, productivity loss due to morbidity and mortality are accounted as the only indirect cost of the disease. The usual components of productivity loss are earnings and the imputed market value of unperformed housekeeping services. In addition, illness produces a wide variety of impacts upon a victim’s physical, mental and social functioning that lead to deterioration of health-related quality of life. These are frequently referred to as the psychosocial costs of a disease (Hodgson 1994). These intangible impacts are, however, not accounted for in the cost-of-illness method. Victims of illness, their spouses, children, co-workers and those who provide care may all be affected. Illness may also bring personal disasters that are not reflected in direct or indirect costs. However, such impacts are very difficult to measure.

1.3.2 Historical developments

The origins of disease burden studies can be traced back to the late 1600s when attempts were made to measure the economic benefits of health care investments. These investments aimed to address common issues such as malaria and mental illness and hence to improve the health and living
conditions of the public (Fein 1958). The first formal cost-of-illness study was carried out by Malzberg (1950) to estimate the indirect impacts of mental illness. Reynolds (1956) made a further contribution with his attempt to estimate the economic burden of road accidents on the British community. The analyses of mental illness by Fein (1958), cancer, tuberculosis and poliomyelitis by Weisbrod (1961), health as an investment by Mushkin (1962), and syphilis by Klarman (1965), further facilitated the establishment of an effective conceptual approach to estimate the economic costs of disease.

A methodological framework with procedures to estimate the economic costs due to illness was effectively developed and presented by Rice in 1966. In the late 1970s, the United States health authorities formed a special task force to establish formal guidelines to ensure conformity and comparability in disease costing studies. It reflected the increased recognition by policy makers and program managers that cost-of-illness estimates are an essential component in the evaluation of alternative demands on scarce health care resources. It also acknowledged the concern that the usefulness of cost-of-illness studies has suffered from a lack of consistent methodologies (Hodgson and Meiners 1982).

1.3.3 Current applications

Initial applications of the cost-of-illness method were mainly aimed at quantifying the economic burden of various illnesses and injuries and subsequent demand for more resources. In more recent times, the method has been extensively used by the pharmaceutical industry and health professionals to highlight the economic burden of certain diseases such as asthma and rheumatoid arthritis (Drummond 1992). These cost estimates have been used as baselines to evaluate alternative intervention strategies and hence to select the most suitable intervention with maximum net social benefits. In addition, cost-of-illness information has been used to determine resource allocation priorities for medical research (Black and Pole 1975).
There are two approaches to the application of cost-of-illness methodology (Hartunian, Smart and Thompson 1980) – (1) the prevalence-based approach estimates the total cost of a disease in a given period, usually a year, while (2) the incidence-based approach estimates the life time costs of an illness from the first diagnosis. Each method has its own merits and is useful for different purposes. For example, the prevalence approach estimates indicate the current costs of a disease or an illness and can serve as the basis for various policy decisions. On the other hand, cost estimates of the incidence approach are more useful for estimating benefits which can be derived from preventing or reducing the incidence of specific disease or illness (Scitovsky 1982). However, this approach requires ongoing monitoring of disease condition and related spending to estimate disease costs per case. Although it demands more time and resources, results are more useful compared to the prevalence-based approach.

1.3.4 Major weaknesses in the cost-of-illness method

In the cost-of-illness method, two categories of costs are estimated direct and indirect costs. In general, almost all studies estimate indirect costs of disease using the human capital approach (Koopmanschap and van Ineveld 1992). This method estimates the value of lost production as a consequence of disease by considering total number of disability days and average daily earnings (in the case of a paid worker) and the imputed market value of unperformed housekeeping services (in the case of an unpaid worker). However, some researchers are of the view that the human capital approach tends to overestimate productivity loss and hence to inflate net social costs of a disease (Shiell, Gerard and Donaldson 1987, Drummond 1992; Koopmanschap and van Ineveld 1992; Glied 1996).

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5 Prevalence represents the number of existing cases of disease at a certain time period. It focuses on whether a disease is present or not, rather than whether the disease is a new case. Prevalence is less precise than incidence.
This led to the introduction of an alternative approach known as the “friction cost” method to estimate indirect costs. According to this method, production losses may be confined to the period needed to replace a sick worker - the friction period. The length of this period and the resulting indirect costs depend on the situation in the labour market (Koopmanschap, Rutten, van Ineveld and van Roijen 1995).

Another major criticism of using the cost-of-illness method to value costs associated with diseases is its inability to value intangible costs such as costs incurred in terms of pain, suffering and deterioration in health (Drummond 1992). Therefore, the method understates actual disease costs. The analysis may also be complicated by the current system of payment for health care. Furthermore, morbidity often compels an individual to seek external help or assistance (paid or unpaid) to maintain daily tasks. These costs are unaccounted for in the cost-of-illness analysis. However, in order to value disease costs from a societal perspective, it is necessary to take into account these costs as well. In addition, the cost-of-illness method does not take into account various costs incurred in preventive actions against disease. For example, in the case of mosquito-transmitted diseases, the cost-of-illness approach does not consider private costs incurred on account of mosquito control, prevention and personal protection.

1.3.5 Alternative disease costing methods

An alternative approach to value disease costs is the contingent valuation method. It is prevalent in the environmental economics literature. The contingent valuation method (the most commonly used stated preference method) measures respondent’s willingness-to-pay for a hypothetical environment/health improvement. Willingness-to-pay is becoming popular in

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6 In other words, the cost-of-illness analysis may not reveal the severity of the illness.
7 Prices for health care vary depending on individual entitlements such as Medicare and Pharmaceutical Benefits.
health care because the approach gives rise to monetary estimates and has some conceptual grounding in welfare economic theory (Hodgson and Meiners 1982). Contingent valuation offers the potential to trace out the willingness-to-pay distribution for a population of economic agents for a proposed change in a good (Carson, Flores and Meade 2001). On the other hand, the averting behaviour method (a revealed preference approach) estimates willingness-to-pay from observed behavioural responses to real situations. This method infers willingness-to-pay from the cost and effectiveness of actions taken to defend against injury or illness (Jones-Lee, Hammerton and Phillips 1985). Instead of estimating components of disease costs, the willingness-to-pay method proposes that the value of health or the avoidance of illness and disease can be deduced from the amount people would be willing to pay to reduce the disease risk (Schelling 1968; Mishan 1971).

The contingent valuation method also shares some weaknesses with the cost-of-illness method (Hodgson and Meiners 1982). For example, because of the hypothetical nature of the contingent valuation method and the fact that there is no actual transaction, there are various biases that may be associated with the estimate (Mitchell and Carson 1989). Furthermore, willingness-to-pay largely depends on the respondent’s ability to pay and hence is affected by personal income and wealth. Therefore, labour market conditions and many other economic factors may influence the willingness-to-pay amount and derived disease costs. Several other methods have been used less frequently to value disease impacts including hedonic pricing, travel cost methods and risk-risk-tradeoff (Clarke 1996; Kuchler and Golan 1999). Jury awards data methods may also be a potentially useful approach, however they have not been fully evaluated by economists for their usefulness in the valuation of health effects (Cohen 1988).

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8 Willingness-to-pay approach appears to capture the full disease impacts.
1.3.6 Valuation of disease costs within the current research context

Both cost-of-illness and contingent valuation methods aim to quantify disease costs. Although the cost-of-illness method estimates direct and indirect components of disease costs, the contingent valuation method produces a composite, total monetary estimate influenced by other factors such as personal income. Both methods have developed to a stage where a well-recognised disease-costing framework exists to facilitate the assessment of costs of diseases in a reasonably systematic manner. However, capturing psychosocial costs appears to be a challenging task and efforts need to be made to examine the relationship between willingness-to-pay estimates and standard health measures such as those covered using the “Short Form - 36” survey. Also known as SF-36, Short Form – 36 is a self-administered questionnaire which generates a profile of scores across eight dimensions of individual’s health (Ware and Sherbourne 1992). Presumably, this relationship could be revealed by conducting a comprehensive analysis of the main determinants of willingness-to-pay such as gender, age, marital status, personal income, disease severity and standard health measure. This approach could be used to explain the magnitude of health-related quality of life impacts of diseases such as the Ross River virus. According to the Institute of Medicine (1981), it appears that neither the cost-of-illness nor the contingent valuation method can measure the whole range of costs arising from a disease and hence it recommends a combined approach be applied to estimate the overall costs of a disease.

1.4 Contribution of the research

This research will contribute to the expansion of existing knowledge in economics, environmental health and disease epidemiology regarding the assessment of social and economic impacts of environmental health issues such as mosquito-transmitted diseases. The information presented will have immense benefits for environmental health, health care and micro-economic
policy workers. In particular, it will enable the valuation of the full spectrum of costs of mosquito-transmitted diseases and hence the evaluation of the net social benefits associated with control programs. Cost information could be used to highlight the economic impact of mosquito-transmitted diseases in general, and to assess regional economic impacts in the case of disease outbreaks. Furthermore, disease cost information could be vital to capture the attention of policy makers and incorporate disease-control programs into the current environmental management policy agenda.

This research applies economic valuation and disease costing methods by developing and applying significant innovations. These include:

- The development of a conceptual model to assess the social and economic impacts specifically associated with mosquito-transmitted diseases
- The valuation of costs of health care, non-health care resources, lost productivity and health-related quality of life impacts of Ross River virus
- The investigation of bivariate correlation and independence between major explanatory variables such as health care costs, willingness-to-pay, age, gender, marital status, income, co-morbidity (coexistence of two or more disorders), standard health measure, disease severity, disease duration and disability period
- The estimation of the economic value of major costs of Ross River virus from a societal perspective
- The application of disease cost estimates to evaluate cost-effectiveness of current mosquito control programs

1.5 Thesis structure

The remainder of this introductory chapter gives an overview of the structure and content of this thesis. The dissertation presents the findings of a comprehensive study carried out on Ross River virus, a mosquito-transmitted
disease, in Queensland, Australia from 2002 - 2003. Chapter two presents an overview of Ross River virus, its debilitating symptoms, post-illness effects and highlights its social and economic implications. In chapter three, a thorough literature survey presents a critical review of the existing social and economic impact valuation theory and research in health care and environmental health disciplines. A major focus is upon the emerging role and importance of valuing the whole range of costs associated with mosquito-transmitted diseases from a societal perspective and the potential use of this information to evaluate the effectiveness of current mosquito control programs.

The fourth chapter presents an overview of the research methodology and the case study disease, Ross River virus within the Queensland context. It gives a detailed account of the approach used to contact Ross River virus victims, the survey schedule and time line, disease-related data collection, data processing and analytical procedures. It also highlights how survey data can be used as the primary data source to value the opportunity cost of health and non-health care resources, lost productivity and health-related quality of life impacts.

Chapter five is the main focal point of this thesis as it gives a detailed account of the disease-costing exercise. It is in two parts. The first part of the chapter gives an overall view of the direct and indirect costs of Ross River virus. It provides a detailed account of resources and opportunity costs associated with Ross River virus including health and non-health care resources, costs of disease preventive actions and the opportunity costs of lost productivity and caregiver’s time. In addition, the section includes a comprehensive analysis of victim’s disability data (due to Ross River virus) by occupational category and industry. Comparable statistics for the general Queensland population are also presented. This information is analysed to provide insight into the impact of Ross River virus on productivity.
Part two of chapter five presents information on the major descriptors of the study participants including demographic data, health care costs, standard health measures, disease severity, disease duration and disability period. These study variables are used for the next phase of analysis of health care costs of Ross River virus. Correlation analyses including chi-square tests of independence were conducted to examine variable independence and their associations including strength, direction and statistical significance. Results of the analyses are used to assess the quality of survey data so that cost estimates are reliable. Health care costs of Ross River virus were analysed by demographic variables such as victim’s age and gender. The mean cost was applied to extrapolate disease costs by local government area based on number of disease notifications in 2002. Cumulative disease costs of Ross River virus for 1994 – 2003 period also presented in 2002 Australian dollars.

Chapter six presents contingent valuation of health-related quality of life impacts of Ross River virus. A standard health measure (SF-36) was used to assess the victim’s state of health so that survey data can be used to establish statistical evidence to show the impact of Ross River virus on the state of health in terms of physical, mental and social functioning. In parallel, hypothetical willingness-to-pay questions were used to elicit individual maximum willingness-to-pay to avoid deterioration in health (as experienced by contracting the virus).

The above approach is consistent with the economic theory of health valuation as it generates a condition similar to that of an actual market where buyers makes decisions within their budget constraints. If respondents understand the commodity to be valued (that is, deterioration in health due to Ross River virus) and answer the valuation question truthfully, the approach yields estimates of individual willingness-to-pay. The first part of chapter six describes measuring of victim’s health in terms of standard health survey and applying willingness-to-pay to value victim’s deteriorated health. The
outcome of chi-square tests of independence, correlation analyses and age-gender analyses (analyses of willingness-to-pay by victim’s age and gender) are discussed in the second part of the chapter. The mean willingness-to-pay was applied to extrapolate intangible costs of Ross River virus by local government area. Cumulative costs by local government area were also estimated based on 1994 – 2003 disease notifications (in 2002 Australian dollars).

Chapter seven discusses policy aspects of the research findings. It discusses the current approach and highlights the importance of environmental health interventions such as mosquito control programs as an effective risk management strategy. The chapter gives an overview of the economics of mosquito control and economic rationale behind program evaluation. The chapter also describes how disease cost and control cost information can be effectively applied to minimise the overall costs to the society. This information is vital to policy analysts and facilitates a reliable, robust estimate of optimal allocation as an aggregate of research findings. In addition, the chapter highlights some constraints for economic evaluation and issues that could improve future research.

In light of the above, chapter eight summarises and concludes the research findings. It gives a snapshot view of the research outcome by highlighting significant attributes of this research made to current prevention and control of mosquito-transmitted Ross River virus disease.
CHAPTER 2  SOCIAL AND ECONOMIC COSTS OF MOSQUITO-TRANSMITTED ROSS RIVER VIRUS

2.1 Introduction

Insect pests such as mosquitoes are a major health concern for the public. Apart from causing a nuisance, mosquitoes transmit a wide range of diseases including Dengue, Ross River and Barmah Forest viruses and cause mortality and morbidity problems. Currently, Ross River virus is the most prevalent mosquito-transmitted viral disease in Australia with up to 8,000 cases reported annually (Curran et al. 1997). Studies have shown that the incidence of Ross River virus is closely linked to climatic factors such as rainfall, tide, temperature and humidity (Tong, Bi, Hayes, Donald and MacKenzie 2001). High disease incidence is a major concern for policy makers since a significant proportion of national healthcare resources are being utilised for the diagnosis and treatment of mosquito-transmitted diseases. Moreover, the social and economic burden of mosquitoes and mosquito-transmitted diseases, in terms of resource costs, productivity loss and health-related quality of life appears to be substantial. Current policy is reliant on quite crude approximations of these costs and not robust analysis and evaluation.

Current challenges posed by the spread of mosquito-transmitted diseases in tropical and sub-tropical regions illustrates the importance of co-operation and partnership at all levels of government (including Commonwealth, State/Territory and local) in order to effectively protect public health. To combat mosquitoes and the public health hazards they present, local authorities, in collaboration with State and Territory public health services, have established mosquito control and management programs in problem areas. This chapter is divided into two main sections. The first part is a concise case study of the mosquito-transmitted disease Ross River virus within the Australian context, including its social and economic significance. The second part discusses disease control, prevention strategies and their cost-effectiveness. The prevention of
Ross River virus is directly linked to current mosquito control programs. However, the true cost-effectiveness of these programs is unknown because economic evaluations are undermined by the absence of disease cost information.

### 2.2 Ross River virus in Australia

Within the Australian context, mosquito-transmitted viral diseases such as Ross River (also known as Epidemic Polyarthritis), Barmah Forest, Dengue, Sindbis, Kunjin and Australian Encephalitis have significant importance (Dale 1993). Among these, Ross River is the most common mosquito-transmitted viral disease in Australia (MacKenzie, Broom, Hall, Johansen, Lindsay, Phillips, Ritchie, Russell and Smith 1998). It has existed for a long period of time, with several major outbreaks being reported over the last few decades. The disease is characterised by arthritis, fever, rash and fatigue. Thus, it is also identified as “Acute Polyarthritis”, “Polyarthritis with Rash”, “Epidemic Exanthema”, “Exanthematous Disease” and “Epidemic Polyarthralgia” (Russell 1994). However, the disease is most commonly referred to as “Ross River Fever or Virus” or “Epidemic Polyarthritis” (Russell 1994; MacKenzie et al. 1998).

Ross River virus has never been known to be fatal to its victims. However, its debilitating nature and persistent symptoms have raised serious concerns about the social and economic implications of the disease on Australian society (Russell 2002). Early research studies have mainly focused on biological, epidemiological and immunological aspects of Ross River virus and have recommended thorough investigations into social and economic consequences of the disease (Condon and Rouse 1995; Westley-Wise et al. 1996; Harley et al. 2001). However, few studies have addressed economic costs of the disease (Geelhoed 1995; Harley et al. 2001; Mylonas et al. 2002).

#### 2.2.1 Main characteristics

Ross River virus was first recognised in the late 1920s. However, the virus and its association with the manifest disease were not identified until the early 1960s. The first successful isolation of Ross River virus was reported in
the early 1960s (Doherty, Whitehead, Gorman and O’Gower 1963). The virus was given this name as it was isolated from *Aedes vigilax* mosquitoes trapped at the Ross River near Townsville in Queensland. Since then, several outbreaks of the disease have been reported in Queensland, New South Wales, Victoria and Western Australia. Figure 2.1 presents the number of Ross River virus notifications (Australia as a total) and disease incidence on population at risk (in Queensland). Around 4,000 Ross River virus notifications are reported every year across Australia. Major disease outbreaks appear to occur roughly in three to four year cycles. For example, total Ross River virus notifications reported in 1992/93, 1996/97 and 1999/2000 periods were higher than that of the average number of notifications from 1991 to 2004.

**Figure 2.1** Ross River virus notifications in Australia and disease incidence in Queensland (1991-2003)

The virus has been isolated from a large number of mosquito species (Russell 1994; Ritchie, Fanning, Phillips, Standfast, McGinn and Kay 1997; Ryan, Do and Kay 1999; Harley et al. 2001). The major vectors of the virus are *Ochlerotatus vigilax* and *Ochlerotatus camptorhynchus* in coastal areas, *Culex annulirostris* in inland areas and *Ochlerotatus notoscriptus* in semi-rural and urban areas. *Ochlerotatus vigilax* and *Ochlerotatus camptorhynchus* breed in

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9. Renamed as *Ochlerotatus vigilax* since 2001; earlier *Ochlerotatus* was a group within *Aedes* but have been elevated to genus level because of different physical characteristics (Foley 2001).

10. Number of new cases reported per population at risk over a specified time period, usually a year.
saltwater pools in mangroves and salt marshes after flooding by spring tides and heavy rains.

In contrast, *Culex annulirostris* breeds primarily in fresh water swamps and water ponding following heavy rain or irrigation, while *Ochlerotatus notoscriptus* breeds close to homes and populated areas in artificial containers such as old tyres, empty containers, bird baths, pot plant saucers and backyard rubbish holding water.

It has been reported that native marsupials, such as wallabies and kangaroos, act as hosts of Ross River virus (Kay and Aaskov 1989; MacKenzie et al. 1998). Antibodies of the virus have been detected in these animals and hence support the view that marsupials are the most likely reservoir host of Ross River virus (Russell 1994). As a result, major vectors could transmit the disease provided that favourable environmental conditions prevail throughout the year. In addition, there is growing evidence to suggest that mammals – such as horses, dogs, cats and bats – may act as vertebrate hosts in some areas thus providing further means of virus dispersal (MacKenzie et al. 1998). The fact that Ross River virus outbreaks may occur in geographically separate areas, almost simultaneously, suggests the persistence of the virus in the environment.

### 2.2.2 Geographical distribution and seasonality

Ross River virus is endemic to Australia, Papua New Guinea, and adjacent parts of Indonesia and the Solomon Islands (Fraser and Marshall 1989; MacKenzie et al. 1998). Furthermore, the incidence of Ross River virus has been reported in all States and Territories of Australia (Fraser and Marshall 1989; MacKenzie et al. 1998). There is evidence that the geographical distribution of Ross River virus in Australia has been expanding (Selden and Cameron 1996; Tong et al. 2001). However, on average, Queensland accounts for more than 50% of the total Ross River virus notifications every year (see Table 2.1). Most cases of Ross River virus infection occur in coastal regions, which have salt-marsh habitats of the principal mosquito vector species. The geographic
distribution of Ross River virus is also affected by many other factors: climate, land use pattern, population growth and density, human activity and behaviour, and ecological conditions. It appears most of these factors are favourable in Queensland hence it has a high disease incidence.

The transmission cycle of Ross River virus seems complex (Kay and Aaskov 1989) and the occurrence of the disease is related to the presence of vectors and hosts. For example, heavy rainfall, high tide, and, in some areas, irrigation and water management practices provide favourable breeding habitats for the dominant vectors thus increasing vector population and disease incidence. Therefore, it appears the incidence of Ross River virus infection largely fluctuates with climatic factors such as rainfall, tide, temperature and humidity (Tong and Hu 2001). Disease outbreaks occur mainly in the wet seasons in the northern parts of Australia, while in the south they may begin as early as November but usually reach a peak from February to May. Sporadic cases caused by endemic infection can occur at any time of the year in southern as well as northern parts of Australia. A recent study has shown the possibility of predicting Ross River virus outbreaks based on regional weather data (Woodruff, Guest, Garner, Becker, Lindsay, Carvan and Ebi 2002).

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<td>312</td>
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<td>28</td>
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<td>1995</td>
<td>2</td>
<td>236</td>
<td>369</td>
<td>1,650</td>
<td>21</td>
<td>28</td>
<td>35</td>
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<td>2,644</td>
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<td>1996</td>
<td>1</td>
<td>1,032</td>
<td>137</td>
<td>4,885</td>
<td>55</td>
<td>76</td>
<td>152</td>
<td>1,445</td>
<td>7,783</td>
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<tr>
<td>1997</td>
<td>9</td>
<td>1,597</td>
<td>218</td>
<td>2,366</td>
<td>635</td>
<td>12</td>
<td>1,042</td>
<td>717</td>
<td>6,596</td>
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<tr>
<td>1998</td>
<td>6</td>
<td>581</td>
<td>127</td>
<td>1,946</td>
<td>66</td>
<td>9</td>
<td>128</td>
<td>288</td>
<td>3,151</td>
</tr>
<tr>
<td>1999</td>
<td>8</td>
<td>951</td>
<td>170</td>
<td>2,306</td>
<td>40</td>
<td>67</td>
<td>250</td>
<td>625</td>
<td>4,417</td>
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<td>2000</td>
<td>16</td>
<td>751</td>
<td>145</td>
<td>1,447</td>
<td>416</td>
<td>8</td>
<td>326</td>
<td>1,087</td>
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<td>343</td>
<td>203</td>
<td>3,199</td>
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<tr>
<td>2002</td>
<td>0</td>
<td>181</td>
<td>55</td>
<td>883</td>
<td>42</td>
<td>117</td>
<td>38</td>
<td>127</td>
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<td>2,511</td>
<td>23</td>
<td>8</td>
<td>12</td>
<td>459</td>
<td>3,631</td>
</tr>
</tbody>
</table>


Note: ACT – Australian Capital Territory
      NT – Northern Territory
      SA – South Australia
      Vic – Victoria
      NSW – New South Wales
      Qld – Queensland
      Tas – Tasmania
      WA – Western Australia
Table 2.1 presents Ross River virus notifications by State and Territory from 1991 to 2003, as compiled by the National Notifiable Diseases Surveillance System administered by the Communicable Diseases Network of Australia. These numbers show the newly diagnosed Ross River virus infections that are notified through the State and Territory health authorities. Fluctuation in the number of notifications across the period may be largely attributed to the factors discussed above.

Ross River virus infections have been widespread in south-eastern Australia and in recent years there have been major outbreaks coinciding with heavy rainfall and/or high tides. In general, epidemic activity is more often observed in temperate areas with heavy rainfall, flooding or high tides (Weinstein 1997). For example, major outbreaks of the disease have occurred when these conditions have been prevalent in Western Australia (1991/92 and 1996/96), Victoria and South Australia (1993 and 1997), New South Wales (1996/97) and Queensland (1996). The single largest outbreak of the disease so far was reported in the South Pacific islands in 1979-80 where more than 50,000 people were affected (Fraser and Marshall 1989). It is believed that an infected traveller from Australia carried the virus to these islands (Wolstenholme 1992).

### 2.2.3 Common symptoms, diagnosis and management

The incubation period for Ross River virus is seven to nine days on average but may range between three and 21 days (Mudge 1993; Hills 1996). Normally, during this period symptoms become evident in people who get exposed to mosquito bites of a virus carrying species. People with mild cases of the disease may recover in less than one month but the symptoms may persist for months or years. About three-quarters of patients suffer pain and tenderness in muscles and joints while more than 80% of patients experience rash and associated joint symptoms (Boughton, Hawkes, Lloyd and Naim 1989; Fraser and Marshall 1989). In addition, symptoms that are common to most viral illnesses – such as fever, chills, headache, loss of appetite and nausea – are also observed in many instances. Over 95% of patients experience joint symptoms of
pain and stiffness. Though it is possible that any joint of the body may be affected, the ankles, fingers, knees and wrists are most common.

Diagnosis of Ross River virus infection largely depends on recognition of clinical symptoms and pathology test results. Often typical symptoms of viral illness with rheumatoid arthritis lead to suspicion about possible Ross River virus infection. However, only positive test results showing the presence of Ross River virus antibodies in the patient’s blood confirms Ross River virus infection. There is no prescribed medical treatment or vaccine aimed directly at Ross River virus. Instead, disease symptoms are treated with appropriate medication such as analgesics (to reduce the pain and fever) and anti-inflammatory agents (for arthritic symptoms).

In general, it is considered that infection with Ross River virus results in long-term immunity to the disease. However, it has been shown that two distinct genetic types of Ross River virus exist. One is predominant in eastern Australia and the other in Western Australia. Both types exist in north and north-western Australia (MacKenzie et al. 1998). A third genetic type has been identified but has not been detected since 1977. This identification of distinct types of Ross River virus raises the question of whether a relationship exists between particular genetic types, disease severity and reinfection risk (MacKenzie et al. 1998). The illness tends to subside over time with occasional relapses of arthritis and fatigue. Symptoms sometimes reappear after several months.

2.2.4 Post-illness effects

Several studies have investigated the persistence of symptoms and morbidity associated with Ross River virus (Mudge and Aaskov 1983; Boughton et al. 1989; Condon and Rouse 1995; Selden et al. 1996; Westley-Wise et al. 1996).

\[^{11}\] No clinical assessment was conducted in this study, therefore, sub clinical effects will not appear in the data.
These studies suggest that on average, people are able to resume normal work within six weeks (53% by four weeks and almost 80% within eight weeks) of symptoms developing while full recovery may take two or more months. However, it is now being argued that previous studies such as Condon and Rouse (1995), Selden and Cameron (1996) and Westley-Wise et al. (1996) overstated post-illness impacts of the Ross River virus as they did not take into account the presence of co-morbid conditions in study subjects. \(^{12}\) Recent studies by Harley et al. (2001) and Mylonas et al. (2002) suggest that those without co-morbidity have reported an early disease recovery while those with co-morbidity have not.

In addition, Ross River virus infection may have induced chronic conditions such as arthritis among non co-morbid patients on the way to recovery. Therefore, some Ross River virus symptoms can persist for longer periods of time even though the person is able to return to work or other activities. These complications may have contributed to the persistent symptoms and longer recovery periods reported in previous studies. For example, it is reported that symptoms may persist after six months in about 50 to 80% of cases and in about 30 to 65% of cases after twelve months (Fraser and Marshall 1989; Condon and Rouse 1995; Selden and Cameron 1996). Symptoms that commonly continue up to twelve months after infection include joint pain (arthralgia), muscle pain (myalgia), tiredness and depression. Some of these studies, for example Selden and Cameron (1996), report that symptoms may continue in certain subjects for several years.

2.2.5 Disease burden

Mosquito-transmitted diseases such as Ross River virus are a social and economic burden. People contract these diseases when they are exposed to virus-carrying mosquitoes. Their initial exposure to the vector can be in a domestic environment, in the workplace or in leisure time. People take a variety of protection measures to avoid mosquito bites and hence minimise the disease risk.

\(^{12}\) It appears to be an important contributory factor for disease symptoms and recovery. The presence of other disorder/s may be known (diagnosed) or unknown (undiagnosed) to the subject.
Some of these measures, such as the purchase of fly screens or mosquito nets for beds, appear to be a long-term strategy of minimising the disease risk while expenditure on mosquito coils, insect sprays and repellents is a shorter-term strategy. Long-term and short-term strategies, both require financial resources. In addition, when people become ill, disease severity and poor health force them to seek medical attention to reduce the time and degree of negative impacts. This increases the demand for health care resources. The magnitude of negative impacts and hence disease burden depend on disease severity, duration and post-illness effects. In the case of malaria and dengue, this impact could be substantial as such diseases may result in death. However, diseases such as Ross River virus are rarely fatal, though debilitating and persistent disease symptoms may result in increased morbidity and multiple health problems affecting the productivity levels and quality of work output of victims. Thus, in areas where disease incidence is relatively high, disease impact may be significant.

Ross River virus is one of the main causes of morbidity in high disease incidence areas such as tropical and coastal Queensland. Therefore, Ross River virus illness can lead to significant productivity losses in these regions. There is not sufficient evidence to suggest that a particular gender or age group is more susceptible to the disease (see Table 2.2).

<table>
<thead>
<tr>
<th>Ross River virus study</th>
<th>Male:Female (No of cases)</th>
<th>Mean age (years)</th>
<th>Standard deviation (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condon and Rouse (1995)</td>
<td>1:4:1(330)</td>
<td>43.1</td>
<td>14.4</td>
</tr>
<tr>
<td>Selden and Cameron (1996)</td>
<td>1:1.3(814)</td>
<td>38.8</td>
<td>13.6</td>
</tr>
<tr>
<td>Westley-Wise et al. (1996)</td>
<td>1:7:1(129)</td>
<td>42.5</td>
<td>13.4</td>
</tr>
<tr>
<td>Mylonas et al. (2002)</td>
<td>1:1.3(67)</td>
<td>41.6</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Note: n.a. - not available

However, studies have shown that severity and longevity of disease symptoms could be higher for those in 35 – 55 years age group. Therefore, the productivity loss due to Ross River virus could be considerable given that the majority of people in this age group are active in the labour force.
It appears that those at younger ages experience milder symptoms following Ross River virus infection. In general, the mean age of Ross River virus cases varies between 38 and 43 years (Condon and Rouse 1995; Selden and Cameron 1996; Westley-Wise et al. 1996; Mylonas et al. 2002).

2.2.6 Social and economic costs

On account of prolonged illnesses and morbidity, the full social and economic impacts of the Ross River virus are likely to be substantial. It has been estimated that the economic cost of healthcare resources and productivity loss associated with Ross River virus infection could be around $1,000 to 2,500 per person (Boughton 1996; Harley et al. 2001; Mylonas et al. 2002). These are approximate estimates since none of the studies looked at the whole range of costs associated with Ross River virus.

For example, in order to value social and economic costs of a disease it is necessary to look at the whole spectrum of impacts from both a private and societal perspective. Such an approach would thus account for all health care, non-health care and indirect costs attributed for the disease. These costs include private costs such as spending for disease prevention, alternate health care and treatment-related transport while social costs comprise lost production time and costs associated with help and assistance received from formal/informal sources.

Physical disability throughout the duration of the illness may require infected persons to stay away from the workplace (in the case of paid workers) and/or to avoid routine household activities (in the case of unpaid workers). In addition, stress, fatigue and depression conditions inherent to the disease could reduce the quality of work. Hence, there is an overall decline in quality and quantity of output. Apart from these indirect costs of Ross River virus, large amounts of resources are used for medical treatment, mosquito control, research and public health programs. As a result, Ross River virus could have produced significant losses for the Australian economy.
In addition, regional disease outbreaks could produce unfavourable implications for tourism and real estate development projects. Therefore, in valuing of the social and economic costs of Ross River virus the whole range of negative impacts including post-illness effects associated with the disease must be identified, enumerated and measured.

2.2.7 Disease outlook

In the recent past, considerable attention has been drawn to the possible effects of global warming on human health. Of the infectious diseases, those most likely to be affected by global warming are diseases that are transmitted by insect vectors such as mosquito-borne arboviruses. It is predicted that mosquito-borne diseases such as Ross River virus will become increasingly prevalent because their insect carriers (vectors) are very sensitive to meteorological conditions (Tong et al. 2001; Woodruff et al. 2002). Rainfall and temperature have the potential to enhance vector abundance and extend distribution, increase vector development, reproductive and biting rates, shorten incubation period, and extended adult life-span. These factors are important as they promote potential disease infection by producing more effective and more frequent disease transmission. In addition, wind (direction, speed and frequency) has an impact on mosquito population survival and dispersal. Conversely, cold conditions can limit mosquito activity to seasons and regions where temperatures stay above certain minimum levels.

The important influence of weather conditions on outbreaks of human arboviral disease in Australia has been widely recognised (Russell 2002). In particular, unusual weather conditions, such as heavy rainfall and flooding, may result in outbreaks of mosquito-transmitted diseases. In addition, other environmental factors, such as rising sea levels, may lead to greater tidal penetration along coastlines and an increased incidence of Ross River virus in the future. Within this context, mosquito control programs at the local level appear to have paramount importance for the local community.
2.3 Benefits of mosquito control programs

In general, mosquito control and management programs aim to minimise the risks of mosquito-transmitted diseases to humans by reducing mosquito populations. Such measures appear to be the most effective, feasible and economical means of disease prevention and control. In the absence of a vaccine and prescribed treatment for Ross River virus, control and prevention of virus-transmitting mosquito species are the most effective options for managing the disease. State-assisted programs that undertake mosquito monitoring and virus surveillance systems facilitate these prevention and control strategies by providing early warnings about virus activity. This enables timely interventions to lower the mosquito numbers and reduce the risk of contracting Ross River virus.

The overall benefits associated with mosquito-control programs cannot be underestimated. Mosquito control programs help to save valuable healthcare resources and allow allocation for high priority areas. The subsequent reduced disease incidence also prevents productivity losses (of paid and unpaid workers) while improving the overall quality of life and well-being of the general public. In addition, reduced nuisance levels and disease risks may have positive impacts upon some industries such as real estate and tourism.

2.3.1 Role of State and local governments

Having recognised the overall benefits of lowering mosquito numbers, the State government has imposed regulatory requirements to curtail mosquito breeding and habitat formation. In 1916 the “Rat and Mosquito Prevention and Destruction Regulations” was gazetted. It was amended in 1927 and became known as the “Mosquito Prevention and Destruction Regulations 1927”. These regulations were revised in 1942, 1973, 1982 and 1991 to correct legal deficiencies and to increase penalties for listed offences. In mid 1990s, a number of health regulations were combined and the existing “Mosquito Prevention and Destruction Regulations” became Part 8 of the Health Regulation 1996 under the Health Act (1937).
The associated Mosquito Prevention and Destruction Regulations declare all species of mosquitoes to be noxious. It requires that local governments supervise the regulation and execution of detailed measures to destroy mosquitoes and prevent their breeding. Accordingly, local governments in Queensland undertake mosquito control programs in their respective areas. The State health authority facilitates these programs by providing some technical, research and development support. Every year, on average, State and local government authorities in Queensland spend over seven million dollars on mosquito control and research programs (LGAQ 2000).

2.3.2 Disease management strategies

The breeding and biting behaviour of the mosquito is a vital factor in determining effective management strategies. These strategies aim to reduce the disease risk by lowering human exposure to mosquitoes.\(^{13}\) This can be achieved either through undertaking active mosquito control or through personal protective measures.

For instance, mosquito control may be directed at controlling breeding and thus reducing the mosquito population. It can be achieved by applying chemicals, such as larvicides and adulticides; by introducing biological agents such as fish into the breeding habitats; or by modifying mosquito breeding sites (WHO 1982). Habitat modification such as runnelling was introduced later on (Hulsman, Dale and Kay 1989). Personal protective methods – such as fly screens, nets for bed, repellents and mosquito coils – may also be used to lower the probability of mosquito-human contact. In addition, lowering or vaccinating wild reservoirs (hosts) has been considered as another option of controlling mosquito-transmitted diseases (Ginsberg 2001).

\(^{13}\) The overall aim of insect pest control is to reduce the levels of nuisance and disease risks.
2.3.3 Integrated management

Mosquito control measures are mainly directed at larval and adult stages by applying appropriate techniques. These measures are dependent on specific needs determined by reports of alerts and complaints, larval surveys, mosquito trap data, routine surveys, forecasts, and the proximity of breeding areas to places of human activity such as residential, occupational and recreational precincts. Some of these functions are facilitated by relatively new technologies, such as Geographic Information Systems (GIS), which are used to maintain mosquito control data for operational and management purposes.

In general, mosquito control programs are applied in combination. A balanced mix of control methods is integrated to suit local conditions, needs and available resources. This integrated approach usually includes mosquito breeding habitat modifications (runnelling), chemical sprays (larvicides) and biological control agents (native fish). Spray of adulticides to control mosquito numbers is limited and used only occasionally, at critical times such as after heavy rainfall, floods, high tides and disease outbreaks.

Control programs are designed to have minimal impact upon the non-target species and the physical environment while protecting the health and safety of the general public (Russell 1994).

Public education and extension programs are also included as an integral part of mosquito control. Education and extension programs aim to enhance public awareness and alert householders to ensure their backyard and neighbourhood does not contain water-holding containers, which can provide suitable mosquito larval habitats (for example, old tyres, empty bottles and containers, undrained pot plants and blocked gutters). Education programs also promote personal protective measures, which include avoiding known mosquito-infested areas; avoiding direct mosquito exposure at maximum biting times (often pre-dawn and late afternoon/evening depending on mosquito species); ensuring that houses are adequately screened; wearing appropriate clothing (that
is, loose fitting, long-sleeved clothing) and using repellents when outside for work or recreation.

2.3.4 Social and economic benefits

Environmental health interventions such as mosquito control programs at the local level reduce mosquito numbers and therefore nuisance levels and disease risks. This saves health care resources, reduces social and economic impacts, and improves the quality of life and well-being of the affected community. In general, surveillance programs track disease risks by monitoring adult and larval mosquitoes and larval habitats. When established mosquito larval and adult threshold populations are exceeded, control programs are initiated. However, there is no information to substantiate the effectiveness of control programs from an economic point of view. Available information is insufficient to establish any claims against the number of potential cases avoided and resources saved by these programs.

2.3.5 Cost-effectiveness and efficiency

Integrated Vector Management (IVM) is a recently developed concept for disease control aimed at achieving the desired levels of management while reducing the overall use of chemicals. It is a evidence-based decision-making procedure aimed to plan, deliver, monitor and evaluate targeted, cost-effective and sustainable combinations of regulatory and operational vector control measures with a measurable impact on transmission risks, adhering to the principles of subsidiarity, intersectorality and partnership (WHO 2001). IVM has benefited from experience with integrated pest management (IPM) systems used in agriculture (Ginsberg 2001). Although chemical control has proved effective in protecting increased crop yields, their adverse environmental and health effects and the development of chemical resistance have required the introduction of pest management systems encompassing all methods that have an impact on the pest problem. Such integrated approaches help to preserve ecosystem

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14 This includes using aerial photographs, topographic maps, seasonal records and weather data.
integrity and encourage the propagation of natural enemies of pest species, such as pathogens and predators. Making better use of environmental, biological and other measures can extend the useful life of chemicals so that they are available when and where the need is great. The success of IPM is due, in part, to the fact that farmers see direct results in the form of increased crop yields and better management of irrigation water and are able to enjoy the economic benefits. In contrast, the improvements in health resulting from control of vectors-borne disease such as Ross River virus can be difficult to measure and the associated economic benefits for the community are less obvious.

Furthermore, it is difficult to assign a dollar value to preventing cases of human disease. The absence of full disease cost information for mosquito-transmitted diseases appears to be one of the major constraints. However, in the case of vector-borne diseases, some argue that cost-effectiveness analysis would be preferable to cost-benefit analysis (WHO 1993; Ginsberg 2001). Because it is very difficult to quantify associated program benefits in monetary terms. In general, budgetary layout for vector control programs is often pre-determined. Hence, program managers try to ensure maximum benefits from allocated provisions by keeping the number of mosquitoes hence, hopefully, human cases of disease at a minimum level (Mills and Drummond 1987; Mills 1994). However, this raises some moral, ethical and equity concerns regarding the prioritisation and allocation of available resources. In this context, the selection of appropriate economic evaluation method to assess the effectiveness and efficiency of control programs can be considered vital.

Very few studies have evaluated the effectiveness of mosquito control programs and their associated economic benefits (Sharma 1991). In order to assess the effectiveness and efficiency of control programs, it is necessary to value related costs. A vital input for this analysis would be the total costs of mosquito-transmitted diseases. However, the absence of appropriate disease costing methodology is a major impediment to calculating the total costs of mosquito-transmitted diseases.
2.4 Summary and conclusion

Ross River virus has never been known to kill its victims. However, its debilitating nature and persistent symptoms have raised serious concerns about the social and economic implications of the disease for Australian society. The full social and economic impacts of the Ross River virus are likely to be substantial. In the absence of a vaccine (to prevent the infection) or prescribed treatment (to manage the illness) for Ross River virus control strategies are mainly directed at reducing the disease transmission risks, especially the control of virus-transmitting mosquito species.

In general, these control programs aim to reduce mosquito numbers and hence overall disease incidence. Such preventive actions help to save valuable resources and allow them to be allocated to high priority areas. In addition, reduced disease incidence would prevent productivity losses associated with both paid and unpaid workers. Lower mosquito numbers and reduced disease risk improves the overall quality of life and living standards of the general public.

However, allocation of resources for mosquito control programs is a formidable task as there is no precise indication of the economic dimensions of the costs and benefits of intervention. Lack of disease cost data is a major constraint in the evaluation of the efficacy and efficiency of related programs.
CHAPTER 3 VALUATION OF DISEASE IMPACT: EXISTING THEORY AND RESEARCH

3.1 Introduction

Environmental health interventions such as local mosquito control programs aim to reduce the risks of contracting mosquito-transmitted diseases whilst improving residential quality of life. However, the net benefit of these programs to the broader community is not well known. One major constraint evaluating these programs in economic terms is that disease impacts across society are typically not measured. Current valuation methods such as the cost-of-illness method mainly focus upon private costs and ignore the external costs associated with the disease. For example, while the cost-of-illness method accounts for health care expenditure and the monetary value of lost productivity due to workplace absenteeism, it does not consider spillover effects of the disease such as the costs of deteriorated health, lost leisure, reduced social activities and interaction. In order to assess the full disease impact, it is vital to include the whole range of private and social costs of the disease. Therefore, the proposed valuation methodology used in this study covers a comprehensive set of private and spillover impacts associated with mosquito-transmitted diseases. This facilitates the assessment of overall societal benefits of current mosquito control programs across whole local communities and the comparison of these benefits gained with the costs of alternative program options. Failure to apprehend these private and social costs understates the net welfare effects of existing mosquito control and management programs.

This chapter presents an overview of valuation of disease impacts and a critical review of the valuation literature. It describes three common valuation methods, their historical development, conceptual issues and practical applications in health care and environmental health disciplines. The chapter finally examines the feasibility of formulating an appropriate valuation

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15 Social costs are comprised of private and external costs. Most often external costs are ignored (as they are difficult to capture and quantify) and only private costs are accounted for.
methodology that captures the full social and economic impacts of mosquito-transmitted diseases.

3.2 Valuation of disease impact

Researchers have used a wide range of approaches to value the social and economic impact of health issues. Some methods are based on observing market behaviour while others use non-market approaches. Although these methods differ in their approach, they both aim to value the loss of welfare due to a particular health issue (Hodgson and Meiners 1982). In order to value the welfare loss caused by a disease it is necessary to identify and capture the whole range of associated health and non-health impacts. This requires that the conventional disease costing approach is extended to encompass relevant non-health impacts such as reduced health-related quality of life, lost leisure time and increased spending on disease risk reduction, by the population at risk.

In general, conventional disease costing has focused upon quantifying the value of health care resources and the opportunity cost of lost production due to disability linked to the disease. For example, Hartunian et al. (1980) estimated the economic costs of motor vehicle injuries, cancer, heart disease and stroke by considering the whole range of costs associated with health care resources and lost production. These conventional costing approaches quantify the opportunity cost of lost production by estimating the value of the work loss as a result of work place absenteeism due to illness. Some studies extend this estimation further by valuing diminished productivity at work while recovering from the illness.

In the case of mosquito-transmitted diseases such as Ross River virus, it is critical to account for both private and external costs that are attributed to the illness because economic evaluation of mosquito control programs aim to assess the net benefits from society’s point of view. Private costs are covered mainly by treatment-related health care and non-health care spending such as treatment-related transport. In addition, expenditure on disease prevention and risk
reduction strategies such as personal protection must also be included. On the other hand, indirect impacts of the disease can be seen as external costs. For example, severe cases of Ross River virus may involve pain, fear, fatigue and depression. These conditions cause the victims’ health to decline and their leisure, family and social activities to be reduced or limited. In addition, severe disease conditions often compel sick persons to be absent from work and to obtain help or assistance from others. For example, when sufferers become incapable of performing personal or household tasks, they may require assistance from private sources such as caregivers, childcare and housekeeping services. In general, these costs are not included in current cost estimations of disease impacts (Koopmanschap and Brouwer 2001). When these services are received from unpaid sources such as family and friends, they tend to be omitted in disease cost valuations since the collection of non-market data involves new, often quite complex and contentious techniques that can require considerable resources.

3.3 Common impact valuation approaches

Three general impact valuation methods, the cost-of-illness method, the contingent valuation method and the averting behaviour method, are commonly applied to estimate the economic value of health impacts (Hodgson 1983; Rice, Hodgson and Kopstein 1985; Harrington, Krupnick and Spofford 1989; Bresnahan and Dickie 1995; Chestnut, Keller, Lambert and Rowe 1996).

Among these approaches, the cost-of-illness method is the most extensively used in healthcare cost valuations (Shiell, Gerard and Donaldson 1987; Hodgson 1989; Drummond 1992). The cost-of-illness method directly values health care costs using observed market behaviour. It measures the costs incurred as a result of illness including direct costs (such as medical expenses) and indirect costs (such as forgone earnings from days absent from work due to ill-health). The cost-of-illness method employs the human capital approach to estimate indirect costs of the illness. Because of this the cost-of-illness approach
is sometimes also referred to as the human capital approach (Hodgson and Meiners 1982; Scitovsky 1982).  

The application of non-market valuation methods, such as the contingent valuation method (stated willingness-to-pay) and the averting behaviour method (revealed willingness-to-pay), are receiving increased attention as alternative approaches of deriving proxy disease costs (Smith 2000).  

In general, these methods are more prevalent in environmental and transport economics and are applied to measure individual willingness-to-pay amounts when no market information is available (Diener, O’Brien and Gafni 1998). The principal idea underlying stated willingness-to-pay method is that people have true, but hidden preferences for all kinds of goods and are capable of transforming them into monetary measures. Accordingly, a theoretical situation can be developed to elicit the monetary measure. For example, willingness-to-pay is the maximum amount of money that one would pay for an improvement in well-being while willingness-to-accept is the minimum amount of money one would wish to accept for a deterioration in well-being. The contingent valuation method, the most commonly used stated preference method, measures individual willingness-to-pay or willingness-to-accept amounts by constructing a hypothetical market situation. In this survey-based approach, the respondent is being asked to consider the contingency of a market’s existing for the thing being valued and state his or her willingness-to-pay or willingness-to-accept.  

Conversely, the averting behaviour method, a revealed preference method, estimates the willingness-to-pay amount from observed behavioural responses to real situations. This method infers willingness-to-pay from the cost and effectiveness of actions taken to defend against disease conditions. Several other non-market methods such as the travel cost method have been used less frequently to value health impacts (see Clarke 1996). The travel cost method,  

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16 The human capital approach is the value of individual’s loss of production of goods and services due to their illness or disease.
hypotheses that the costs in money and time spent travelling to a free or nominally priced amenity/service could be used to approximate respondents’ willingness-to-pay for the amenity/service

In addition, studies of jury awards appear to be potentially useful source of data for health impact valuations. Generally, jury awards intend to cover compensatory damages and are meant to represent the closest possible financial equivalent of the harm suffered by the plaintiff, and to restore the plaintiff to the position he or she occupied before (Cohen 1988). Compensation includes special (for example, medical costs and lost earnings) and general (for example, pain, suffering, inconvenience and humiliation) damages. However, the validity of these awards for use in disease impact studies is questionable given that they were neither supported by economic theory nor evaluated by economists (Rodgers 1993; Chase 1995).

3.3.1 The cost-of-illness method

The cost-of-illness method is commonly used to estimate the overall burden of a disease on society and to highlight the economic consequences of letting a disease take its course (Drummond 1992). In this method, the first step is to identify cost-generating aspects of an illness and then impute market values to those elements. These market values reflect the opportunity cost of resources used or lost due to the illness (Hodgson and Meiners 1982).\footnote{Costs to society occur when resources are directed away from uses to which they would have otherwise been put.}

According to the methodology outlined by Rice (1966), the cost-of-illness approach consists of three major cost components: direct, indirect and intangible costs. Direct costs are mainly borne by the healthcare system responsible for treating the disease, while indirect costs account for lost production owing to morbidity or premature death caused by the disease. The third cost component, intangible costs, are linked mainly to pain, suffering and the reduction in quality of life experienced by those who have contracted the disease. However, as there
is no accepted methodology to quantify disease impacts upon quality of life, intangible costs are often not accounted for in cost-of-illness studies (Drummond, O’Brien and Stoddart 1997).  

3.3.1.1 **Historical developments**

The origins of disease burden studies can be traced back to the late 1600s when attempts were made to measure the economic benefits of control programs aimed at mitigating disease outbreaks (Fein 1958).  In 1950, the most influential study at that time was carried out by Malzberg to estimate the indirect costs of mental illness. Reynolds (1956) made a further contribution with his attempt to estimate the economic burden of road accidents on the British community. The analyses of mental illness by Fein (1958), the study of cancer, tuberculosis and poliomyelitis by Weisbrod (1961), health expenditure as an investment (Mushkin 1962), and costs of syphilis by Klarman (1965), furthered the development of an effective conceptual approach for estimating the economic costs of disease and other health-related problems. Most of these studies have been based on annual or periodical data, and have assessed the aggregate economic burden of illness in terms of hospital resources and lost work time for a particular period of time (usually a year). However, it was not until the mid-1960s that a systematic framework with procedures to estimate the economic costs due to illness and disease were effectively developed and presented by Rice (1966).

3.3.1.2 **Setting formal guidelines**

In the late 1970s, a task force was formed by the United States Public Health Service to address methodological concerns related to the estimation and measurement of the costs of illness and disease. The task force was assigned the task of compiling methodological guidelines so that the results of disease cost studies could be better compared (Hodgson and Meiners 1982). The appointment of this task force reflected the increased recognition of cost-of-illness estimates

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18 It is one of the major weaknesses of this approach.
19 These diseases included black plague, dysentery and malaria.
as a vital source of information to evaluate alternative demands for scarce health care resources. The recommendations were designed to be sufficiently flexible so that the objectives of individual cost-of-illness studies could be achieved, while still promoting conformity to enhance the comparability of studies. For example, the guidelines encouraged users to employ consistent assumptions, methods (for example, human capital approach to estimate indirect costs) and data to value disease costs such as the costs of health care resources and lost production due to specific disease or illness. In addition, the task force highlighted areas for further improvement and encouraged development and expansion of estimation methods and procedures (Hodgson and Meiners 1982).

3.3.1.3 Applying the technique

The cost-of-illness methodology has been used extensively by health economists and health professionals (Rice et al. 1990; Drummond 1992). The methodology has been applied to derive cost estimates for different types of illnesses and for specific health issues such as smoking and substance abuse. These estimates have helped and facilitated healthcare decision makers to assess their resource allocation priorities. However, questions have recently been raised regarding the validity of the cost-of-illness methodology and the reliability of cost estimates. In particular, many have had concerns regarding the validity of considering productivity losses as an economic consequence of an illness and their inclusion in cost estimates (Drummond 1992). Because the method used to estimate indirect costs (that is, the human capital approach) in cost-of-illness tends to give greater weight to working-age men compared to women, as well as to the young and older persons. This has forced researchers to scrutinise existing methods and adopt alternative techniques and methods to improve disease cost estimations.

Currently, there is a large collection of literature utilising the cost-of-illness method. In general, this literature can be broadly grouped into two categories according to the study objectives. The first category includes
publications that address conceptual and methodological issues relating to the
cost-of-illness method while the second category includes publications that report
results of cost-of-illness applications. Among these, Rice (1966), Hartunian et al.
have made significant contributions by refining disease costing methodology in
general. Other researchers have critically examined specific aspects of the
costing methodology, such as the valuation of indirect costs of disease, and have
proposed alternative approaches (Koopmanschap and Van Inveld 1992). The
debate continues over the valuation of indirect costs and their inclusion in cost-
of-illness estimates (Koopmanschap and Brouwer 2001).

While the debate over methodological issues continues, recent literature
has focused on the strengths and weaknesses of cost-of-illness estimates and their
effective usage in healthcare policy analysis (Shiell, Gerard and Donaldson 1987;
Hodgson 1989; Drummond 1992; Koopmanschap 1999). Table 3.1 is a summary
of selected key studies that have addressed conceptual and methodological issues
relating to the cost-of-illness method.

The role of cost-of-illness estimates in healthcare decision making is still
contentious. In the past, cost-of-illness estimates have been used to highlight the
social costs of health issues such as mental illness, substance abuse, motor
vehicle injuries, cancer and heart disease and to seek or justify the use of more
resources in relevant management programs. More recently, these estimates have
been used by clinicians and pharmaceutical industries to highlight the impact of
specific illnesses or diseases, often to encourage the allocation of more resources
for research and development programs (Drummond 1992). Consequently, a
large body of literature concerning the application of the cost-of-illness method
has developed. A summary of selected cost-of-illness applications is given in
Table 3.2. In general, the majority of these applied studies have used the
prevalence-based approach to value disease costs.

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20 This debate centres upon whether to use the human capital approach or the friction cost method to value
indirect costs and whether indirect costs should be accounted for in assessing disease costs.
21 A detailed discussion of this approach is presented in Section 3.3.1.4 (Methodological issues).
Table 3.1   Key literature addressing conceptual and methodological issues of the cost-of-illness method

<table>
<thead>
<tr>
<th>Title of the paper</th>
<th>Aim of the study</th>
<th>Author(s)</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Estimating the cost of illness</em></td>
<td>Formalise disease costs valuation</td>
<td>Rice</td>
<td>US</td>
<td>1966</td>
</tr>
<tr>
<td><em>The economic cost of illness revisited</em></td>
<td>Review disease cost valuation method</td>
<td>Cooper and Rice</td>
<td>US</td>
<td>1976</td>
</tr>
<tr>
<td><em>Estimating the direct cost of illness</em></td>
<td>Evaluate direct cost estimation methods</td>
<td>Scitovsky</td>
<td>US</td>
<td>1982</td>
</tr>
<tr>
<td><em>Cost-of-illness methodology: a guide to current practices and procedures</em></td>
<td>Guidelines for current practices and procedures</td>
<td>Hodgson and Meiners</td>
<td>US</td>
<td>1982</td>
</tr>
<tr>
<td><em>Theoretical considerations on the cost-of-illness</em></td>
<td>Measurement of the cost of illness from a theoretical perspective</td>
<td>Goddeeres</td>
<td>US</td>
<td>1983</td>
</tr>
<tr>
<td><em>The state of the art of cost-of-illness estimates</em></td>
<td>Describe the methodology in detail</td>
<td>Hodgson</td>
<td>US</td>
<td>1983</td>
</tr>
<tr>
<td><em>The economic costs of illness: a replication and update</em></td>
<td>Replicate and update the method</td>
<td>Rice, Hodgson and Kopsten</td>
<td>US</td>
<td>1985</td>
</tr>
<tr>
<td><em>Cost-of-illness studies: no aid to decision-making</em></td>
<td>Application in health care policy analysis</td>
<td>Hodgson</td>
<td>US</td>
<td>1989</td>
</tr>
<tr>
<td><em>Cost-of-illness studies: a major headache?</em></td>
<td>Applications in health care policy analysis</td>
<td>Drummond</td>
<td>UK</td>
<td>1992</td>
</tr>
<tr>
<td>Title of the paper</td>
<td>Aim of the study</td>
<td>Author(s)</td>
<td>Country</td>
<td>Year</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>--------------------------------</td>
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<td>------</td>
</tr>
<tr>
<td><em>Towards a new approach for estimating indirect cost of disease</em></td>
<td>Propose a new approach for indirect cost valuation</td>
<td>Koopmanschap and van Ineveld</td>
<td>Netherlands</td>
<td>1992</td>
</tr>
<tr>
<td><em>The friction cost method for measuring indirect costs of disease</em></td>
<td>Describe the new approach of valuing indirect costs</td>
<td>Koopmanschap, Rutten, van Inveld and van Roijen</td>
<td>Netherlands</td>
<td>1995</td>
</tr>
<tr>
<td><em>A practical guide for calculating indirect costs of disease</em></td>
<td>Guidelines for indirect costs estimation</td>
<td>Koopmanschap and Rutten</td>
<td>Netherlands</td>
<td>1996</td>
</tr>
<tr>
<td><em>Estimating the indirect costs of illness: an assessment of the forgone earning approach</em></td>
<td>Describe and assess the valuation approach</td>
<td>Glied</td>
<td>US</td>
<td>1996</td>
</tr>
<tr>
<td><em>How to calculate indirect costs in economic evaluations</em></td>
<td>Describe indirect costs calculations</td>
<td>Liljas</td>
<td>Sweden</td>
<td>1998</td>
</tr>
<tr>
<td><em>Cost-of-illness studies: useful for health policy</em></td>
<td>Applications in health care policy analysis</td>
<td>Koopmanschap</td>
<td>Netherlands</td>
<td>1999</td>
</tr>
</tbody>
</table>
Table 3.2  Selected literature applying the cost-of-illness method to value economic costs of specific health problem/s

<table>
<thead>
<tr>
<th>Title of the paper</th>
<th>Aim of the study</th>
<th>Author(s)</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>The incidence and economic costs of cancer, motor vehicle injuries, coronary heart disease, stroke: a comparative analysis</td>
<td>Estimate direct and indirect costs including sensitivity analysis</td>
<td>Hartunian, Smart and Thompson</td>
<td>US</td>
<td>1980</td>
</tr>
<tr>
<td>Economic costs of alcohol, drug abuse and mental illness</td>
<td>Estimate costs of health care resources and lost production</td>
<td>Rice, Kelman, Miller and Dunmey</td>
<td>US</td>
<td>1990</td>
</tr>
<tr>
<td>The lifetime cost of injury</td>
<td>Estimate costs of health care resources and lost production</td>
<td>Max, Rice and MacKenzie</td>
<td>US</td>
<td>1990</td>
</tr>
<tr>
<td>Health care resource and lost labour costs of migraine headache in the US</td>
<td>Estimate economic costs of migraine headache</td>
<td>Osterhaus, Gutterman and Plachetka</td>
<td>US</td>
<td>1992</td>
</tr>
<tr>
<td>The economic impact of chronic fatigue syndrome</td>
<td>Estimate economic costs of chronic fatigue syndrome</td>
<td>Lloyd and Pender</td>
<td>Australia</td>
<td>1992</td>
</tr>
<tr>
<td>Persons with chronic condition: their prevalence and costs</td>
<td>Estimate economic costs of chronic illness</td>
<td>Hoffman, Rice and Sung</td>
<td>US</td>
<td>1996</td>
</tr>
<tr>
<td>Direct and indirect costs of asthma in Canada</td>
<td>Estimate direct and indirect costs of asthma</td>
<td>Krahn, Berka, Langlois and Detsky</td>
<td>Canada</td>
<td>1996</td>
</tr>
</tbody>
</table>
Table 3.2  Selected literature applying the cost-of-illness method to value economic costs of specific health problem/s (contd.)

<table>
<thead>
<tr>
<th>Title of the paper</th>
<th>Aim of the study</th>
<th>Author(s)</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>The burden of illness and the Economic costs of osteoporosis</td>
<td>Estimate cost of health care resources</td>
<td>Harris, Cumming, Watts Ebeling and Crowley</td>
<td>Australia</td>
<td>1998</td>
</tr>
<tr>
<td>Economic costs of substance abuse</td>
<td>Estimate economic costs of alcohol, illicit drugs and smoking</td>
<td>Rice</td>
<td>US</td>
<td>1999</td>
</tr>
<tr>
<td>Cost of chickenpox in Canada</td>
<td>Estimate direct and indirect costs and overall burden</td>
<td>Law, Fitzsimon, Jones McCormick and Riviere</td>
<td>Canada</td>
<td>1999</td>
</tr>
<tr>
<td>Cost of illness of neck pain in the Netherlands</td>
<td>Estimate economic costs of neck pain</td>
<td>Borghouts, Koes, Vondeling and Bouter</td>
<td>Netherlands</td>
<td>1999</td>
</tr>
<tr>
<td>Cost of smoking to the Medicare program</td>
<td>Estimate economic costs of smoking related diseases</td>
<td>Zhang, Miller, Max and Rice</td>
<td>US</td>
<td>1999</td>
</tr>
<tr>
<td>The costs of rheumatoid arthritis: an international long-term view</td>
<td>Estimate direct and indirect costs of rheumatoid arthritis from societal point</td>
<td>Pugner, Scott, Holmes and Hieke</td>
<td>UK</td>
<td>2000</td>
</tr>
<tr>
<td>The costs of illness attributable to physical inactivity in Australia</td>
<td>Estimate economic costs of heart disease, diabetes and colon cancer</td>
<td>Stephenson, Bauman Armstrong and Smith</td>
<td>Australia</td>
<td>2000</td>
</tr>
<tr>
<td>Economic burden of back pain in UK</td>
<td>Estimate costs of health care resources, lost production and informal care</td>
<td>Maniadakis and Gray</td>
<td>UK</td>
<td>2000</td>
</tr>
</tbody>
</table>
3.3.1.4 Methodological issues

The cost-of-illness method can be employed using either a prevalence-based approach or an incidence based approach (Hodgson and Meiners 1982; Scitovsky 1982; Drummond 1992). The *prevalence-based approach* assigns the costs of an illness to the year in which they are incurred. In contrast, the *incidence-based approach* calculates the lifetime costs of an illness from onset to recovery. Although there is little difference between these two approaches in the case of short-term illnesses, the difference increases with illness duration. The lack of adequate data is a more serious problem in the case of incidence-based than that of prevalence-based estimates. In addition, the difference between the costs calculated using these two approaches is larger when estimating indirect costs rather than just direct costs (Hartunian *et al.* 1980).

The prevalence and incidence-based approaches have different data requirements and degrees of data aggregation. Prevalence costs are often estimated using macro-level data such as aggregate health care expenditure while incidence costs tend to be built up from costs of individual cases. Prevalence costs are often estimated for broad disease categories such as heart disease, respiratory system-related diseases or injuries while incidence costs usually focus on more specific diseases or health issues such as rheumatoid arthritis, asthma, smoking or cancer.

3.3.1.4a Using the prevalence-based approach

The prevalence-based approach to estimating cost-of-illness typically follows a similar methodology to that set out by Rice (1966). In this approach, direct costs of the disease are measured during a specified period regardless of the time of disease onset. It gives a snapshot view of a disease at a particular point in time. Although the methodology was still being developed, Fein (1958), Weisbrod (1961), and Klarman (1965) adopted the prevalence-based approach in their disease costing work. A review of the literature reveals that the majority of cost-of-illness studies employ this approach to estimate total disease costs.
The prevalence-based approach apportions (that is, often distributed) health care expenditure to relevant cost categories such as hospital care, health professional consultations, medicines and other medical supplies. Expenditures in each category are identified for specific disease or illness and the direct cost of a disease or illness is found by summing expenditure categories.

Although the prevalence-based approach to estimating cost-of-illness produces appealing results it has a number of potential weaknesses (Tolley, Kenkel and Fabian 1994). For instance, the approach assigns total expenditures to direct cost categories such as medical costs and the method used to disaggregate data may influence final disease cost estimates. Furthermore, in the prevalence-based approach it is often incorrectly assumed that records of health care expenditure such as hospital admissions and treatment data are properly maintained and easily accessible. In addition, the prevalence-based approach takes into account annual expenditure and hence is best suited for illnesses of short duration (Hodgson 1994).

In spite of these weaknesses, the approach has several advantages. For example, the costs of a diverse range of diseases can be estimated by a single methodology thus making cost comparisons less expensive, simpler and more consistent (Cooper and Rice 1976). In addition, prevalence-based measures of indirect costs typically apply a fixed dollar value to the estimated duration of restricted activity. For example, Cooper and Rice (1976) used the mean value of earnings (by age and gender) to estimate the lost production for employed individuals and market prices in order to value the disability period of those who perform home duties (for example, unpaid work such as house work).

3.3.1.4b Using the incidence-based approach

The incidence-based approach to estimating cost-of-illness often follows a methodology similar to that described by Hartunian et al. (1980). The approach

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22 The approach helps to come out with a dollar amount.
23 For example, less than one year.
involves estimating the direct and indirect costs of illness from exact time of disease onset to near or full recovery. The costs are weighted using the average survival rate and assumes that natural history of the disease and medical care used and costs remain constant over time (Hodgson 1994).24

In the incidence-based approach, it is important to compute the present value of the discounted stream of costs if the disease or illness has a long recovery period (that is, more than one year). In this approach, estimates of direct costs are often based on actual costs incurred by patients. Cost information is based on health surveys, published documents, or inputs from health professionals. The incidence-based approach involves estimating the costs of each component of treatment and multiplying the costs by the probability of a patient receiving that treatment (Hartunian et al. 1980).

Thus, the incidence-based approach is more demanding than the prevalence-based approach in terms of data and analysis since it requires estimates to be made of the various costs through disease progression. Although the incidence-based approach demands more resources, it provides more precise and accurate results thus facilitating more efficient resource allocation decisions. In addition, cost-of-illness estimates derived using this approach give a baseline against which new interventions can be assessed in terms of their effectiveness. Estimates derived using the prevalence-based approach do not have this capability (Scitovsky 1982; Drummond 1992). In general, the incidence-based approach will include an estimate of all sources of lost earnings among employed individuals including days absent and shorter work hours resulting from disease impairment. An example of how the incidence-based approach does this is shown in a study by Hartunian et al. (1980) where they estimated the indirect costs of long-term illnesses among the employed using estimates of the duration of impairment and the earnings differential that can be attributed to disability from the disease.

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24 Average survival rate is the proportion of survivors in a group of patients studied over a period.
3.3.1.5 Estimating indirect costs

There is no controversy over the valuation of direct costs since cost estimation in this part of the process is consistent and transparent. However, some health economists are expressing concern over the valuation and inclusion of indirect costs in the cost-of-illness method (Drummond 1992; Johnson, Fries and Banzhaf 1997). Indirect costs are the value of all other tangible and intangible effects due to illness but largely focused upon the value of production lost to society due to disability and death. The justification for this emphasis on lost production is proposed in human capital theory. Human capital theory assumes that investments in health improvement are comparable to investments in physical assets, with the benefits able to be measured through increased output in the economy (Mushkin 1978). Since indirect costs are not directly linked to expenditure on disease treatment, they are not easily measurable. However, indirect costs strongly influence the result of economic evaluations of health care programs (Van Roijen et al. 1996). A review of several cost-of-illness studies has revealed that, in general, indirect costs constitute around 52% of total disease costs (Koopmanschap and Rutten 1995; Van Roijen et al. 1996).

Disagreement over the inclusion of indirect costs into cost-of-illness estimates are reflected in national healthcare program evaluation policy guidelines in different countries (Koopmanschap and Brouwer 2001). Some have ethical or philosophical objections. For example, if the relative economic burden of diseases includes productivity losses, and if these data are used in setting priorities, then more resources will be devoted to the care of people of working age or in certain occupations (Koopmanschap and Rutten 1995). It does not fit well with the social welfare and equity orientation of most health care systems. This controversy could be settled by excluding indirect costs from disease cost valuations. However, it would deny a substantial part of economic reality, since production losses do contribute to the scarcity of resources and hence decrease the wealth or output available to society.

25 For example, the Canadian and Dutch guidelines for pharmaco-economic evaluations accept the inclusion of indirect costs provided they are clearly separated from direct costs, whereas the Australian guidelines for the same discourage the inclusion of indirect costs.
Criticisms of including indirect costs in cost-of-illness analyses have encouraged health economists to examine other possibilities to measure indirect costs reliably. As a result, the “friction cost” method was proposed as an alternative to the human capital approach (Koopmanschap and Rutten 1992). The following section compares the concepts behind valuing indirect costs of diseases using the human capital approach and the friction cost method. Furthermore, it discusses the strengths and weaknesses of these two methods and thus facilitates the selection of an appropriate technique for the valuation of the indirect costs of mosquito-transmitted diseases.

In general, it seems preferable to estimate indirect costs as realistically as possible and present them separately from other costs. However, it is the responsibility of policy analysts to decide on what relative weights should be assigned to indirect costs.

3.3.1.5a Human capital approach

The human capital approach is the most commonly used method to value lost production in health care studies (Rice et al. 1985). It assumes a social perspective and has the important advantage of relying on data that is readily available. The approach assumes that the economic value of a person to society is revealed in his or her production potential (Hodgson and Meiners 1982). If markets are functioning efficiently, wages are determined by labour supply and demand. Labour demand, in turn, reflects the marginal productivity of labour.26 When the market is at equilibrium, each person seems to be paid the value of his or her marginal contribution to the economy’s production of goods and services. Thus the value of a person, to society, can be measured by his or her earning capacity and the value of life would then be the summation of a discounted future earnings stream.

The human capital approach is conceptually simple, easy to apply and is useful for answering questions regarding the economic burden of an illness for a

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26 Marginal productivity of labour is the increase in the amount of output from an additional unit of labour.
given time period, or for the economic evaluation of disease intervention programs. For these reasons most studies that estimate the indirect costs of illness use the human capital approach (Koopmanschap and Rutten 1992). However, the approach is subject to criticism. One major area is its discriminatory treatment of different socio-economic groups (Rice et al. 1990). For example, people outside the labour force (such as students, house workers and retirees) are discriminated against as indirect costs are estimated only for employed and unemployed victims. In addition, indirect cost estimates based on the human capital approach are often higher than the real indirect costs because of the extra labour available within firms and replacement of sick employees by “unemployees” since full employment in the labour market is not a realistic assumption (Johannesson and Karlsson 1997; Liljas 1998).

### 3.3.1.5b Friction cost method

The basic concept behind the friction cost method is that the amount of production lost due to disease depends on the time firms need to restore the initial level of production. This interval is called the “friction period” (Koopmanschap et al. 1995). It is assumed that if unemployment is beyond the level of frictional unemployment sick workers can be replaced after a necessary period of adaptation (either from internal or external labour reserves). However, some qualitative discrepancies between labour demand and supply always prevail since filling of vacancies takes time. Accordingly, production losses are assumed to be limited to the period needed to replace a sick worker, the friction period. Indirect costs that would be included in this approach are the “friction costs”, such as the costs of searching for and training new workers, and the loss of production during the interim or “friction” period.

To understand the theoretical flaws in the friction cost method, it is important to understand the economic theory that underpins the human capital approach. It is rests on two key assumptions of the economic theory of marginal productivity – the human capital approach assumes that labour markets are

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27 Frictional unemployment occurs when people moving between jobs, careers and locations.
perfectly competitive and that every firm’s main objective is profit maximisation. Under the human capital approach, the main aim is to identify per capita gross earnings and argue that these reflect the value of forgone production when an individual is absent from work or unable to work at full capacity due to illness (Weisbrod 1961; Cooper and Rice 1976).

However, Koopmanschap et al. (1995) suggest that sick employees often make up for lost work when they return after a period of absence and this leads to the argument that the human capital approach tends to overestimate indirect costs. However, the extent of overestimation would be less than the overestimation suggested by Koopmanschap et al. (1995). If employees make up for lost work by doing extra hours of work, this means that they reduce their leisure time. Otherwise, the extra hours would have been used for leisure, social activities or interaction. The opportunity cost of this leisure time would be the appropriate proxy for indirect costs. It is possible that the opportunity cost of leisure time falls short of the gross income (due to taxes on labour). In such a case, the human capital approach would overestimate indirect costs, but not by the full amount of the gross income as suggested by Koopmanschap et al. (1995).

Johannesson and Karlsson (1997) suggest that even if there are diminishing returns to labour within a firm (as assumed in the friction cost method), the internal labour reserve within a firm does not seem to be a fully convincing statement. A firm would not hire additional workers unless the value of their production exceeds or equals the gross income of the workers.28 An increase in the short-term absence of workers would then mean that the firm either loses production during the absence or has to hire additional workers that are withdrawn from other sectors in the economy. If the firm does not hire any additional workers and the production of the firm is unaffected by an increase in the absence, this would imply the firm is not maximising profits (Varian 1992).

28 This assumes that all firms aim to maximise their profits.
Although conceptually appealing, the friction cost method is not well supported by economic theory. In addition, when compared with the human capital approach, the friction cost method requires more detailed information such as firm-wise data to estimate indirect costs demanding more resources for data collection. Because of this, the majority of health economists use the human capital approach to estimate indirect costs. For example, all of the cost-of-illness studies listed in Table 3.2 have used the human capital approach to estimate indirect costs. Thus, it can be concluded that the human capital approach is more appropriate to estimate indirect costs associated with mosquito-transmitted diseases such as Ross River virus.

3.3.1.6 Strengths and weaknesses

There are both strengths and weaknesses associated with the use of the cost-of-illness method in valuing the social and economic impacts of illnesses. On the positive side, cost-of-illness estimates provide insight about health care resource use and production loss due to a particular illness, thus highlighting the economic importance of one health issue or disease (Drummond 1992; Hodgson 1994). The disease burden can then be ranked against the overall economic impact, facilitating the prioritisation of resources for disease control. For example, the majority of prevalence-based cost-of-illness studies estimate the economic burden of health issues at a national level – information that is used by policy analysts to allocate resources to priority areas to curtail disease incidence.

Another advantage associated with the cost-of-illness method is that estimated disease costs can be considered as a reference scenario to evaluate the effectiveness of new interventions (Hodgson 1994). In addition, cost-of-illness estimates are beneficial for the prioritisation of medical research, so that resources can be effectively allocated (Black and Pole 1975). However, to perform this type of analysis the cost-of-illness method should use an incidence-based approach (Drummond et al. 1997).

29 In particular, when a new treatment or medication is compared with an old treatment or medication.
It is often argued that the cost-of-illness method underestimates disease costs by not capturing the full spectrum of disease-related costs. For example, cost estimates do not include intangible costs such as pain, fatigue and reduced quality of life (Drummond 1992; Osterhaus 1992). This is particularly relevant in the case of diseases that are debilitating and have persistent symptoms. For example, a major concern with Ross River virus is that symptoms including severe pain, fatigue and discomfort persist for a long period of time (Russell 2002). The intangible costs associated with such diseases could be relatively large. However, the fact that existing disease-costing methodologies do not quantify these costs is a major barrier to assessing their effectiveness. A more suitable methodology that includes intangible costs is required.

Indirect costs estimated in the cost-of-illness method include only lost productivity due to absenteeism. However, there exists a broader range of costs (such as loss of productive time while waiting for medical treatment). In general, these costs are not included in disease costing due to the absence of relevant information (and their apparently trivial nature). Certain non-health care costs, such as expenditure on disease prevention actions and costs of disease-related transport are also not accounted for in disease-costing. Disease or illness can also force a family to incur extra expenses while caring for a sick member of the family, including household help (cleaning, cooking) child care, rehabilitation and comfort. These non-health care costs are not considered in cost-of-illness analysis. However, these costs do need to be accounted for when a cost-benefit analysis is conducted to evaluate the effectiveness of intervention programs from a societal perspective (Rice et al. 1985). Therefore, a much broader disease-costing paradigm that values the full costs of illness needs to be established. This is particularly important in the case of mosquito-transmitted diseases such as Ross River virus.

3.3.2 The contingent valuation method in health care

The importance of valuing disease impact in monetary terms and the weaknesses of the cost-of-illness method to do so accurately have prompted
health economists to examine alternative strategies. To properly evaluate disease control and management programs in terms of economic efficiency, accurate monetary measures of the full economic costs of disease are essential. These measures reflect changes in well-being due to disease and can attempt to include intangible costs such as pain, fatigue and depression. According to economic theory, an individual’s well-being depends on the consumption of marketed goods and services, health and characteristics of the environment. In general, changes in well-being, which are often intangible; are measured by using the contingent valuation method (CV) – the most commonly used stated preference valuation method. The CV method measures respondent’s willingness-to-pay (WTP) or willingness-to-accept (WTA) to avoid or compensate for a hypothetical degradation of welfare. Thus, the CV can be used to value changes in an individual’s health state. In a health context, WTP represents the largest amount of money an individual would voluntarily pay to avoid a deterioration in health, while WTA shows the smallest amount of money the individual would voluntarily accept as compensation to endure a detriment in health (O’Brien and Gafni 1996).

Contingent valuation is a survey-based approach and is consistent with the economic theory of health valuation (Klose 1999). For example, the CV method assumes that the monetary equivalent of changed welfare level reflects the disease’s impact upon individual’s health state. When respondents understand the commodity to be valued and answer valuation questions truthfully, CV yields estimates of individual WTP or WTA. Arguably, it appears to be the only method capable of capturing the full impact of disease on individual well-being. Furthermore, the method could be useful in indicating how individuals value health and life, and how differing valuations affect social preferences regarding public policy and the burden of disease. The approach takes the individual perspective and incorporates all aspects of well-being, including labour and non-

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30 The essence of the CV method is to use money to adjust a consumer’s changed utility (due to proposed intervention) to its original level. Monetary measure of the utility change could be either compensation or an equivalent variation. These values can be measured by willingness-to-pay or willingness-to-accept techniques (for more information see Hicks 1941).
labour income, and the value of leisure, pain and suffering. It has been suggested that this approach is particularly well suited to capturing the intangible aspects of illness and has the benefit that the respondents have nothing to gain or lose from their assessment and so could be used to complement the human capital approach (Rice et al. 1990). However, the absence of procedural guidelines for the CV method has resulted in an enormous variety of CV studies in healthcare (O’Brien and Gafni 1996).

3.3.2.1 Setting general guidelines

Initial applications of CV were largely confined to transport and environmental studies (Jones-Lee, Hammerton and Phillips 1985; Mitchell and Carson 1989). However, the absence of general guidelines in designing and implementing CV studies resulted in a large diversity of methodologies to elicit WTP/WTA values. Although a survey approach was common, the use of different elicitation and payment methods raised concerns over the validity and reliability of outcomes (Gafni 1991). Within this context, the US National Oceanic and Atmospheric Administration (NOAA) published a set of general guidelines on the design and implementation of CV studies for environmental damage assessment (NOAA 1993).

These guidelines were not designed for application in health care valuations so are in need of further examination to assess their applicability (O’Brien and Gafni 1996). One of the difficulties in implementing CV studies in health care is the diverse nature of the outcomes to be valued. As a result, the focus is often on improvements in health-related quality of life (O’Brien and Gafni 1996). Despite the growth in the application of CV in healthcare valuations, there appears to be large differences between study approaches. Therefore, a coherent conceptual framework is needed that connects the theoretical rationale for measurement with practical applications.

Some of the original NOAA recommendations are useful in this context to ensure the validity and reliability of CV estimates (Smith 2000). NOAA
recommends using WTP instead of WTA to elicit valuations, as WTP produces a more conservative estimate. From a theoretical perspective, WTP and WTA should be very close in price in a perfectly competitive private market. However, empirical studies reveal that WTA estimates usually exceed WTP estimates (Willig 1976; Hanemann, Loomis and Kanninen 1991). With respect to the elicitation method, NOAA recommends valuation questions in the take-it-or-leave-it format. It appears that this format is becoming popular in health care valuations since it approximates actual market conditions. Difficulties associated with this approach include sample size requirements and computation tasks involved (Boyle and Bishop 1988).

Furthermore, NOAA recommends that in-person interviews should be employed instead of mail surveys because of the latter’s inability to elicit reliable estimates. However, it could be costly to adopt this recommendation in case of CV studies that involve large samples. Another important recommendation from NOAA is that CV should remind the respondent about their budget constraints and other types of consumption goods that might need to be sacrificed when they are asked to state their WTP.

3.3.2.2 Conceptual framework for health care

The growing interest in the application of cost-benefit analysis as a technique for the economic evaluation of health care programs prompted O’Brien and Gafni (1996) to develop a conceptual framework for CV in health care. In cost-benefit analysis, both costs and benefits are expressed in the same unit of value typically money. A popular method for estimating money values for health care programs is the use of contingent valuation technique. Table 3.3 presents the conceptual framework developed by O’Brien and Gafni (1996) to facilitate design and interpretation of CV studies in health care, which is consistent with the theory of cost-benefit analysis.

31 WTP and WTA can be used as alternative approaches to estimate overall impacts of disease on welfare. However, WTA amounts are difficult to measure since the value an individual states is not bound by personal income. Therefore, such measures tend to be biased upward.

32 In general, WTP cannot exceed a respondent’s disposable income. In addition, the respondent needs to be aware that WTP will limit spending in other areas such as leisure and entertainment.
<table>
<thead>
<tr>
<th>Question</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What question do we want to answer?</td>
<td>Problem definition</td>
</tr>
<tr>
<td></td>
<td>Pricing and demand studies</td>
</tr>
<tr>
<td></td>
<td>Project appraisal for resource allocation</td>
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<td></td>
<td>Current status of program</td>
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<td></td>
<td>Program currently exists</td>
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<td></td>
<td>Program does not currently exist</td>
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<td></td>
<td>Utility and disutility of program to respondent</td>
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<td></td>
<td>Gain in utility from program</td>
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<tr>
<td></td>
<td>Loss in utility from program</td>
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<tr>
<td>2. What type of measure can we use?</td>
<td>Money measure of utility change</td>
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<tr>
<td></td>
<td>Compensating variation (CV)</td>
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<tr>
<td></td>
<td>Equivalent variation (EV)</td>
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<td></td>
<td>Direction of measurement</td>
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<tr>
<td></td>
<td>Willingness-to-pay (WTP)</td>
</tr>
<tr>
<td></td>
<td>Willingness-to-accept (WTA)</td>
</tr>
<tr>
<td>3. What to ask of whom?</td>
<td>Externality and option value</td>
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<tr>
<td></td>
<td>Currently diseased</td>
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<tr>
<td></td>
<td>Currently non-diseased; at future risk</td>
</tr>
<tr>
<td></td>
<td>Currently non- diseased; not at future risk</td>
</tr>
<tr>
<td></td>
<td>Framing of program consumption and payment</td>
</tr>
<tr>
<td></td>
<td>Ex-post user-based question</td>
</tr>
<tr>
<td></td>
<td>Ex-ante insurance-based question</td>
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<tr>
<td>4. What characteristics of the program are important for determining</td>
<td>Program outcome description</td>
</tr>
<tr>
<td>how it is valued?</td>
<td>Certain outcomes</td>
</tr>
<tr>
<td></td>
<td>Uncertain outcomes</td>
</tr>
<tr>
<td></td>
<td>Nature of the market for valuation scenario</td>
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<tr>
<td></td>
<td>Private goods market</td>
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<td></td>
<td>Political market</td>
</tr>
<tr>
<td>5. What question formats minimise bias and increase precision?</td>
<td>Valuation scenario</td>
</tr>
<tr>
<td></td>
<td>Holistic versus decomposed</td>
</tr>
<tr>
<td></td>
<td>Degree of realism</td>
</tr>
<tr>
<td></td>
<td>Value elicitation method</td>
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<tr>
<td></td>
<td>Open-ended question</td>
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<td></td>
<td>Bidding games</td>
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<tr>
<td></td>
<td>Payment cards</td>
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<tr>
<td></td>
<td>Take-it-or-leave-it</td>
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<tr>
<td></td>
<td>Take-it-or-leave-it (with follow up)</td>
</tr>
</tbody>
</table>

(O’Brien and Gafni 1996 p.290)

O’Brien and Gafni (1996) concluded that studies undertaking CV should distinguish between compensating variation, and equivalent variation, and recognise that respondents can be either gainers or losers of utility and therefore
should be asked WTP or WTA questions as appropriate. According to Mishan (1971 pp 9 and 11), compensating variation is the “sum of money received by or from the individual which, following a welfare change, leaves him at his original level of welfare” and equivalent variation is the “sum received by or from an individual which (if he denied the change in question) leaves him as well off as if he had the welfare change”. O’Brien and Gafni (1996) also suggested that more work needs to be conducted to assess the applicability of NOAA guidelines to health care studies.

3.3.2.3 Using the CV method

In contingent valuation, guidelines should be used in such a way that a satisfactory transaction can be established. A “satisfactory transaction” is defined as a transaction in which respondents are fully informed, not intimidated and are able to identify their own best interests (Fischhoff and Furby 1988). A satisfactory transaction will only take place if the good or change in welfare, method of payment and market are all well defined and understood by the respondent. Accordingly, CV consists of three key elements: (1) a description of the commodity or change in welfare to be valued, such as the symptoms to be avoided or the health risk to be reduced; (2) a hypothetical payment method; (3) a method of eliciting a respondent’s WTP or WTA for the commodity or change in welfare. In addition, it is recommended to include a fourth element in the survey regarding the respondent’s attitude and financial ability to pay (for example, personal income, wealth, desire for health and personal characteristics). This information is then used for internal validation of the elicited WTP values (Fischhoff and Furby 1988).

3.3.2.4 Applying the CV method to health care issues

In recent times, there has been a rapid increase in the number of CV studies conducted in the health care sector (Drummond et al. 1997; Johannesson et al. 1997). Several factors have contributed to this growth. Firstly, the increasing use of cost-benefit analysis (CBA) in the economic evaluation of the
societal optimality of health care interventions has required measurement of the benefits and costs of intervention programs in monetary terms (Johannesson and Jonsson, 1991). Secondly, CV offers greater potential for capturing the complete range of values associated with health issues than the conventional approach (O’Brien and Gafni 1996). Finally, considerable progress has been made in CV elicitation methodology and estimation techniques over time thus resulting in more accurate estimates (Smith 2000). A large number of CV studies have appeared in the health care literature with valuations over a range of health issues and treatments. Table 3.4 presents a list of selected publications that have used CV to value a wide range of health impacts ranging from diseases to health care interventions.

The majority of CV studies have used the WTP approach (rather than the WTA) to elicit monetary valuations. Unlike cost-of-illness valuations, there is wide variation in CV estimates. The variations can be attributed to methodological issues, such as sampling procedure, survey approach, question type format, elicitation procedure and mode of payment (Diener, O’Brien and Gafni 1998). Despite advancements in CV methodology in the environmental and transport disciplines, considerable work needs to be done in establishing the CV approach as a valid and reliable method in the health care sector (Bala, Mauskopf and Wood 1999). As a result, researchers have become critical of CV applications in health care and have conducted extensive reviews of the existing literature.

Diener et al. (1998) conducted a comprehensive review of the published literature available on both WTP and WTA applications in health care from 1984 to 1996. According to their investigations, around 88% of existing studies undertook CV in the context of CBA.
<table>
<thead>
<tr>
<th>Title of the paper</th>
<th>Aim of the study</th>
<th>Author(s)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Feasibility of WTP measurement in chronic arthritis</em></td>
<td>Measuring WTP for a new arthritis drug</td>
<td>Thompson, Read and Liang</td>
<td>1984</td>
</tr>
<tr>
<td><em>WTP for reduction in fatality risk: an exploratory survey</em></td>
<td>Measuring WTP for a risk reduction</td>
<td>Muller and Reutzel</td>
<td>1984</td>
</tr>
<tr>
<td><em>WTP for publicly provided goods: a possible measure of benefit</em></td>
<td>Measuring WTP for continuing care in hospital or nursing homes</td>
<td>Donaldson</td>
<td>1990</td>
</tr>
<tr>
<td><em>Valuation of the benefits of risk-free blood: WTP for haemoglobin solution</em></td>
<td>Measuring WTP for risk free haemoglobin</td>
<td>Eastaugh</td>
<td>1991</td>
</tr>
<tr>
<td><em>WTP for antihypertensive therapy - results of a Swedish pilot study</em></td>
<td>Measuring WTP for antihypertensive therapy</td>
<td>Johannesson, Jonsson and Borgquist</td>
<td>1991</td>
</tr>
<tr>
<td><em>WTP for public sector health care programmes in Northern Norway</em></td>
<td>Measuring WTP for public health programmes</td>
<td>Olsen and Donaldson</td>
<td>1993</td>
</tr>
<tr>
<td>Title of the paper</td>
<td>Aim of the study</td>
<td>Author(s)</td>
<td>Year</td>
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<tr>
<td><em>WTP for antenatal carrier screening for cystic fibrosis</em></td>
<td>Measuring WTP for clinical screening</td>
<td>Donaldson, Shackley, Abdalla and Miedzybrodzka</td>
<td>1995</td>
</tr>
<tr>
<td><em>Assessing the economic value of a new antidepressant: a WTP approach</em></td>
<td>Measuring WTP for an antidepressant drug</td>
<td>O'Brien, Novosel, Torrance and Streiner</td>
<td>1995</td>
</tr>
<tr>
<td><em>Measuring heart patients’ WTP for changes in angina symptoms</em></td>
<td>Measuring WTP changing symptoms</td>
<td>Chestnut, Keller, Lambert and Rowe</td>
<td>1996</td>
</tr>
<tr>
<td><em>Mother’s WTP for her own and her child’s health: a CV study in Taiwan</em></td>
<td>Measuring WTP for own and child’s health</td>
<td>Liu, Hammitt, and Wang</td>
<td>2000</td>
</tr>
<tr>
<td><em>WTP for colorectal cancer screening</em></td>
<td>Measuring WTP for cancer screening</td>
<td>Frew, Wolstenholme and Whynes</td>
<td>2001</td>
</tr>
<tr>
<td><em>WTP for a reduction of the risk of fracture</em></td>
<td>Measuring WTP for risk reduction</td>
<td>Telser and Zweifel</td>
<td>2002</td>
</tr>
</tbody>
</table>
The majority of them (95%) used the WTP approach. Despite that in-person surveys are better, most studies were mail surveys (52%). The studies used a wide range of value elicitation techniques such as open-ended questions (38%), payment cards (19%), discrete choice (26%) and/or bidding games (29%). In addition, around half of the studies (50%) conducted some form of construct validation. Unlike other non-market valuation approaches the CV method carries with it the advantage that specific validity and reliability checks can be included (such as associations between income and WTP). In contrast, valuation methods that rely on data from situations where people make actual market choices, such as the hedonic price method, must assume that the underlying theory is valid in order to generate results (Pearce and Turner 1990).

Klose (1999) conducted a similar comprehensive review of CV studies in health care. However, the aim was to examine methodological and conceptual aspects of CV studies and examine the relationships between WTP estimates and other valuations. Table 3.5 lists selected key literature that addresses conceptual and methodological issues of CV relating to health care.

3.3.2.5 Conceptual issues related to CV

There is no standard approach to the design of CV surveys (Pearce, Markandya and Barbier 1989). However, CV necessarily involves an interview with the survey respondent that can be conducted face-to-face, by mail or by telephone. CV questionnaires typically include three major stages. The first stage describes the good being valued (such as health change, health intervention) and the hypothetical circumstances under which it will be available to the respondent. The next stage provides details about the hypothetical scenario and the way it would work. A precise market characterisation of the good being valued is

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This review included CV studies that used original data. Klose (1999) reported on the widespread variation between studies due to different elicitation formats. In addition, diverse validity and reliability criteria made comparison of these studies problematic.
<table>
<thead>
<tr>
<th>Title of the paper</th>
<th>Aim of the study</th>
<th>Author(s)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>When do the “dollars” make sense? towards a conceptual framework for CV studies in health care</em></td>
<td>Proposing a conceptual framework for CV applications in health care</td>
<td>O’Brien and Gafni</td>
<td>1996</td>
</tr>
<tr>
<td><em>A note on the relationship between ex ante and expected WTP for health care</em></td>
<td>Describing relationship between ex ante and expected WTP</td>
<td>Johannesson</td>
<td>1996</td>
</tr>
<tr>
<td><em>Health care CV studies: a review and classification of the literature</em></td>
<td>Classifying and appraising of health care CV studies</td>
<td>Diener, O’Brien and Gafni</td>
<td>1998</td>
</tr>
<tr>
<td><em>WTP as a measure of health benefits for changes in angina symptoms</em></td>
<td>Presenting the theoretical foundation of WTP measures</td>
<td>Bala, Mauskopf and Wood</td>
<td>1999</td>
</tr>
<tr>
<td><em>The CV method in health care child’s health: a CV study in Taiwan</em></td>
<td>Highlighting conceptual and methodological issues of CV method</td>
<td>Klose</td>
<td>1999</td>
</tr>
<tr>
<td><em>WTP for reduced morbidity</em></td>
<td>Critically reviewing estimation methods and suggesting future directions</td>
<td>Dickie and Gerking</td>
<td>2002</td>
</tr>
</tbody>
</table>
important because CV studies attempt to simulate a market for a non-marketed good. The third stage of CV is the value elicitation process where the respondent is urged to express his or her WTP/WTA amount for the proposed good (Fischhoff and Furby 1988).

In general, CV surveys attempt to find the maximum dollar amount for a hypothetical good a person would pay before preferring to go without that good. Therefore, a major challenge is to construct a meaningful, unbiased, hypothetical market. According to Smith (2000), there is growing concern within CV literature – mainly within environmental economics but with important implications for applications in health care – about the appropriate questionnaire format for eliciting WTP values.

3.3.2.5a Questionnaire format (elicitation method)

The questionnaire format refers to the manner in which the WTP questions are presented. Formats include the use of direct or open-ended questions, the use of payment cards, bidding games and close-ended questions or take-it-or-leave-it options. The following section briefly discusses question formats and associated positive and negative features.

When using an open-ended or a direct question, the researcher attempts to measure the respondent’s maximum WTP amount. This is the simplest elicitation method. However, it represents a large task for the respondent and is likely to produce many non-responses and protest bids (Desvouges, Smith and Fisher 1987; Mitchell and Carson 1989). It has been argued that this approach produces fewer reliable responses since the question fails to motivate the respondent.

34 The main emphasis here is to construct a private goods market, where rivalry and excludability of private goods are clearly distinguished. For example, a private good, such as food is rival in consumption (what one consumes others cannot) and the benefits are excludable in the sense that others are excluded from the benefits of one’s consumption of the food. Public goods, however, such as national defence, are both non-rival and non-excludable.
In addition, it produces a large number of lower values when compared with other elicitation methods (Cummings, Brookshire and Schultz 1986). To overcome this problem, some guidance can be given to respondents to present them with a range of possible amounts.

Using the payment card system, the respondent is offered a card consisting of several WTP values, and asked to indicate his or her maximum WTP from a range of specified amounts either directly by marking the amount closest to the preferred WTP, or by indicating maximum and minimum amounts (Mitchell and Carson 1989). In the last case the centre of the resulting interval then gives the monetary valuation (Ryan, Ratcliffe and Tucker 1997). However, payment cards may lead to ‘range bias’ since the respondent is compelled to use values given on the payment card (Hoevenagel 1994).

The bidding game method is a simulated auction process used to derive the WTP amount (Brookshire, Eubanks and Randall 1983). This method works well in replicating market conditions. Respondents are asked whether they are willing to pay a specified amount for a distinct change that improves their welfare level. Depending on their answer, the bid is either lowered or raised by asking a series of iterated questions. The process goes on until the maximum WTP is found. A clear advantage of the bidding game is that it helps respondents to consider their preferences carefully (Hoehn and Randall 1987). The iterative process offers respondents time and learning experience, thus providing opportunity to state accurately their maximum WTP (Cummings et al. 1986). However, maximum WTP can be influenced by the first bid of the auction process. This is also known as the ‘starting point bias’. Another disadvantage of the bidding game is the presence of extremely high bidders (Hoevenagel 1994).35 In addition, the bidding game method is most appropriate in face-to-face interview and hence is more costly than other methods.

35 Around 1 to 2% of bidders present extremely high bidding amounts.
The closed-ended questionnaire format (also referred to as ‘take-it-or-leave-it’ or ‘referendum’) presents respondents with a single WTP amount, which they either accept or reject (Bishop and Heberelin 1979). One advantage of this technique is that respondents may find it easier to determine whether their WTP is above or below the amount rather than giving a precise value of their maximum WTP. Furthermore, it encourages respondents to reveal their true preference based on their best interests (Hoehn and Randall 1987). However, a major disadvantage of this method is the large number of observations it requires since different sub samples are offered different bids (Carson, Flores and Meade 2001). In addition, there may be many biased answers due to a tendency to say “yes” among survey respondents.  

3.3.2.6 Strengths and weaknesses

The CV method and the cost-of-illness method are unique approaches to estimating the economic cost of disease. When compared with CV, cost-of-illness is not very comprehensive and misses out many disease impacts. Both methods have the potential to contribute to a greater understanding of the total social and economic impact of disease (Rice et al. 1990). Unlike the cost-of-illness method, disease cost estimation using CV is still at an experimental stage in healthcare applications and does not have well-developed procedural guidelines (O’Brien and Gafni 1996). An exhaustive discussion of critical issues associated with CV and its application in health care are given by Donaldson (1990); O’Brien and Viramontes (1994) and Chestnut et al. (1996).

In addition, the following general problems have been encountered in CV studies:
- cost estimate is based on data collected from a sample survey so that the survey approach, question format, payment vehicle and estimation techniques may all affect the study outcome (Mitchell and Carson 1989). Researchers have to accept respondents stated behaviour as it is not possible to measure actual behaviour (perhaps the respondent may strategically provide a biased answer to produce a particular outcome).

36 When “yes” or “no” are the only response alternatives to a vague question, respondents tend to choose either one of the answers, hence biasing the survey outcome (Markus and Zajonc 1985).
- the CV method asks respondents to make an unfamiliar and hypothetical spending decision. In general, this decision may be influenced by several other factors such as respondent’s income.

- the CV method assumes the creation of an understandable, clear and meaningful hypothetical scenario. If this does not exist, respondents will give unreliable and invalid responses. One indication of the difficulty of answering WTP/WTA questions is the relatively high rate of protest answers. When the respondents do not understand hypothetical scenario and/or do not have clear understanding about their WTP/WTA, they are likely to skip these questions and/or provide unrealistic answers (for example, extremely high or low dollar amounts). According to Opschoor (1989) the non-response rate on the valuation question in WTP settings can be around 20% – 30% and even higher in WTA settings.

In spite of such drawbacks, the CV approach appears to be a versatile and flexible valuation technique. Most of the biases (such as range bias, starting point bias and strategic bias) and their associated problems can be overcome by placing more emphasis on the design and pre-testing of CV questions (Schuman and Kalton 1985). Although pre-testing of CV questions involve extra cost and time, it enhances the meaningfulness of a CV scenario and minimises possible biases. CV can be used to estimate the economic value of tangibles or intangibles in monetary terms. However, it is best able to estimate monetary values for goods and services that are easily identified and understood by users. CV is probably the most widely-accepted method for estimating total economic value and a great deal of research has been conducted to improve the CV methodology and the validity and reliability of its results (For example, the CV method can estimate use values, existence values, option values and bequest values).\(^{37}\)

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\(^{37}\) Total value includes all types of non-use or passive use values.
3.3.3 The averting behaviour method

The averting behaviour method is another approach to the valuation of health effects in monetary terms, though it is less frequently used than cost-of-illness or CV. The method uses a revealed preference approach to measure WTP and is well grounded in accepted economic theory. It is assumed that the approach accounts for all effects of health on individual well-being since it measures individual WTP. The averting behaviour method values health effects using expenditure made to avert or mitigate an adverse effect. For example, in the case of skin cancer risk due to exposure to sun, averting expenditure would include spending on sunscreens, hats and long-sleeved clothes (Dickie et al. 1987). The theory of averting behaviour assumes that a person will take protective action as long as the perceived benefits of the action exceed the perceived cost. If there is a continuous relationship between defensive action and health improvement, according to economic theory, the individual will continue to avert until the cost equals their WTP for the health improvement or avoidance of adverse health effects.38

3.3.3.1 Applying the averting behaviour method

The averting behaviour method considered as an alternative approach of revealing individual WTP. The theory linking averting behaviour to WTP originated in the late 1970s and has continued to develop in recent years (Courant and Porter 1981; Bresnahan and Dickie 1995). In general, most averting behaviour applications attempt to value health impacts due to hazardous waste contamination, air and water pollution and food poisoning (see Table 3.6). No studies currently exist that attempt to value health impacts due to vector-borne diseases. It may be due to difficulty in linking vector problem solely to a specific disease.

38 That is, marginal WTP, or the WTP for a small change in health or health risk, which is inferred from: (a) the cost of the averting good and (b) its effectiveness as perceived by the individual in reducing risk or improving health.
<table>
<thead>
<tr>
<th>Title of the paper</th>
<th>Aim of the study</th>
<th>Author(s)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Value of symptoms of ozone exposure: an application of AB method</em></td>
<td>Valuing benefits of reduced symptoms of ozone exposure</td>
<td>Dickie, Gerking, Schulze, Coulson and tashkin</td>
<td>1986</td>
</tr>
<tr>
<td><em>Evaluating the benefits of non-marginal reductions in pollution using information on defensive expenditure</em></td>
<td>Assessing the benefits of pollution reductions</td>
<td>Bartik</td>
<td>1988</td>
</tr>
<tr>
<td><em>The benefits of reducing the incidence of nonmelanoma skin cancers: a defensive expenditure approach</em></td>
<td>Valuing benefits of reduced rates of skin cancer</td>
<td>Murdoch and Thayer</td>
<td>1990</td>
</tr>
<tr>
<td><em>Protective responses to household risk: a case study of radon mitigation</em></td>
<td>Valuing the costs of radon risk</td>
<td>Doyle, McClelland, Schulze, Elliot and Russell</td>
<td>1991</td>
</tr>
<tr>
<td><em>Valuing environmental quality changes using AB expenditures: an application of groundwater contamination</em></td>
<td>Valuing the costs of ground water contamination</td>
<td>Abdalla, Roach and Epp</td>
<td>1992</td>
</tr>
<tr>
<td><em>Averting behaviour and urban air pollution</em></td>
<td>Explaining defensive responses to air pollution</td>
<td>Breshnahan, Dickie and Gerking</td>
<td>1997</td>
</tr>
</tbody>
</table>
3.3.3.2 Strengths and weaknesses

Although the averting behaviour method produces a value for health effects that is based on observed market information, it has several methodological weaknesses. Firstly, it is difficult to isolate WTP for health from the other impacts averting behaviour has on well-being. For example, the use of air conditioning may reduce health effects from exposure to polluted air. However, it is also increases welfare through cooling air and decreases it by increased probability of other diseases such as legionnaires.

In addition, individual perception about health risks may vary from person to person. Therefore, the method requires detailed surveys to elicit perceptions about the effects of behaviour on health. Finally, averting behaviour often involves a discrete choice about whether to take an action. In general, such discrete choice data does not directly reveal WTP and sophisticated techniques need to be applied to estimate WTP accurately (Dickie and Gerking 1991).

3.4 Appropriate disease impact valuation paradigm

The main aim of this chapter was to formulate an appropriate paradigm for valuing the social, economic and environmental health impacts of mosquito-transmitted diseases. The literature review has addressed this by compiling and critically evaluating the existing literature on social and economic impact valuation theory and research in the fields of health care and environmental health.

The cost-of-illness method has commonly been used to value disease impacts in health care, however, it needs further modification to accurately value the full costs of disease. For example, in valuing the costs of mosquito-transmitted diseases, the cost-of-illness method needs to be broadened to capture disease prevention expenditure and health-related quality of life impacts. However, as the total economic value of health contains many intangible aspects, it is difficult to quantify precisely using market based measures. For these
reasons, the literature suggests it would be appropriate to use more than one method to value the impact of disease. For example, the cost-of-illness method could be used in conjunction with a non-market valuation method such as contingent valuation or averting behaviour in order to more accurately measure the health impact of disease.

The cost-of-illness method, the most widely used of the three approaches, values direct and indirect costs of disease. The contingent valuation method attempts to captures full disease impact including intangible costs. As a result, the CV method is regarded as a promising method to value total disease impact. However, its hypothetical nature, survey approach and diverse elicitation methods have caused concerns about the validity and reliability of its cost estimations. In contrast, the averting behaviour method assumes WTP can be revealed by just observing disease prevention spending. Table 3.7 presents a summary comparison of the three valuation methods discussed in this chapter in terms of their strengths and weaknesses.

<table>
<thead>
<tr>
<th>Table 3.7</th>
<th>A comparison of common disease impact valuation methods (cost-of-illness, contingent valuation and averting behaviour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Valuation approach</td>
</tr>
<tr>
<td>Cost-of-illness</td>
<td>Based on observed market prices <em>(ex post application)</em></td>
</tr>
<tr>
<td>Contingent valuation</td>
<td>Based on survey to elicit WTP/WTA for a hypothetical change <em>(ex ante or ex post application)</em></td>
</tr>
<tr>
<td>Averting Behaviour</td>
<td>Based on observed defensive expenditure to infer WTP <em>(ex post application)</em></td>
</tr>
</tbody>
</table>
3.5 Summary and conclusion

Mosquito control programs are an environmental health intervention that is undertaken to mitigate mosquito problems at a local level and hence reduce the overall disease risk and nuisance to the local community. However, the effectiveness of mosquito control programs is not clearly known due to difficulties associated with the valuation of program costs and benefits.

In order to conduct economic evaluations such as cost-benefit analysis and assess the effectiveness of mosquito control programs, it is necessary to identify whether an appropriate impact valuation paradigm exists to estimate the full costs of potential mosquito-borne diseases on an annual or lifetime basis. According to the comprehensive literature survey conducted, there is no appropriate valuation paradigm presently in place to capture the full disease impact.

This chapter has presented a comprehensive review of the three common valuation methods and their applications under a wide range of circumstances. The disease impact valuation methods discussed in this chapter – the cost-of-illness method, the contingency valuation method and the averting behaviour method have significant importance in designing an appropriate valuation paradigm. In doing so, it is now possible to develop an appropriate methodology to value social, economic and environmental health impacts of mosquito-transmitted diseases. The incidence-based cost-of-illness valuation is capable of estimating the total costs of health care resources and lost production due to mosquito-transmitted disease. On the other hand, the willingness-to-pay valuation can be applied to assess the health-related quality of life impacts of mosquito-transmitted diseases. These two cost estimation methodologies have been integrated in this study to derive the full costs of mosquito-transmitted diseases. Next chapter provides an overview of methodology applying cost-of-illness and willingness-to-pay valuation for mosquito-transmitted Ross River virus.
CHAPTER 4: METHODOLOGICAL OVERVIEW

4.1 Introduction

This chapter describes the methodological approach used in this study and covers the questionnaire survey schedule, data collection process and adopted method of analysis. The primary source of information for the research findings presented in the thesis has been a structured phone and mail survey of Ross River virus victims conducted across Queensland. The full range of social and economic impacts of the disease can only be ascertained by contacting people who contracted the virus. Due to timing constraints, however, data were collected only from people who were diagnosed and notified with the infection between April and July 2002. Hence, may have been up to three weeks after actually contracting the disease. A combination of mail and phone surveys was designed and conducted during the study period to capture the full range of social and economic impacts of the disease.

4.2 Survey methodology and data collection

The conduct of clinical and health studies are often challenging tasks since it may be difficult to obtain a reasonable number of subjects with a specific illness (Bland 1987). Firstly, targeted persons need to be medically diagnosed and confirmed with a specific illness. Secondly, health professionals or authorities responsible for such information typically manage access to personal information about patients and it may be difficult to obtain required data. Thirdly, any study that involves human subjects requires ethical clearance prior to approaching them. Finally, participation in such studies is necessarily voluntary in nature and hence obtaining the cooperation of an adequate number of people in a prospective health study of this kind can be a daunting task. Because of these constraints, clinical and healthcare researchers often use

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39 In this thesis, people diagnosed contracting Ross River virus are referred to as Ross River virus victims.
40 This period may vary between 2 and 4 weeks, and is called “at onset” in subsequent discussions.
convenient or purposive sampling techniques to draw a study group from the target population (Bland 1987).

The Ross River virus survey aimed to collect disease-related information from the whole target population – that is, Queensland residents notified as contracting Ross River virus between April and July 2002. Thus, no representative sampling method was required as the entire population was contacted (census approach) and equal opportunity to participate in the survey was attached to all individual units in the target population. Several strategies were adopted to obtain a high response rate throughout the survey. For example, all survey-related correspondence such as invitations, survey instructions and reminders were personally addressed using their first name (see Appendix 1). In addition, consenting victims were informed that a token gift would be given away for every returned survey form. Furthermore, potential participants were offered to be sent a copy of summary findings on completion of the study (Dillman 1978).

4.2.1 Pre-testing of survey instruments

Pre-testing was completed to refine the survey questions (wording, clarity and simplicity) and their sequence in the various survey forms. In addition, it contained an open-ended willingness-to-pay question to obtain an indicative range of WTP amounts. The pilot study was performed upon a group of people who had contracted the Ross River virus in the last one to two years (not a part of the target population). Based on the results of pre-testing, several questions were reworded and simplified. In addition, some question formats were changed to facilitate more effective responses. Willingness-to-pay answers received for the open-ended question were used to estimate the mean and standard deviation of willingness-to-pay ($AUD 130 and $AUD 26, respectively) and hence to design the actual willingness-to-pay question (a bidding-type question format) in the first follow-up survey.

41 Around 24 people participated in the pre-testing.
42 Presumably it has minimised the starting point and range biases in the WTP question.
4.2.2 Ethics, privacy and data confidentiality

Approval was obtained from relevant research ethic committees in order to contact notified Ross River virus victims and hence to conduct the Ross River virus survey.\textsuperscript{43}

Initially, an open invitation to participate in the study was sent to all notified Ross River virus victims. It contained a detailed description of the study objectives, the disease-related data collection procedure, and the likely benefits of the research project. In addition, victims were informed about their freedom to withdraw from the study at any time. Those who were willing to take part in the study were advised to provide contact information and sign and return the consent form (see Appendix 1). Information provided in the consent form was entered into a computer database and an identification number was assigned to each victim. This provided the main reference to identify the three stages of individual survey forms and other victim-related documents. In order to assure privacy and data confidentiality, returned consent forms and victim’s contact information were kept secure in a locked filing cabinet and the electronic database of entered data was protected by security passwords.

4.2.3 Targeting Ross River virus victims

Ross River virus is a notifiable disease in Australia and hence positive serological test results are recorded in State and Commonwealth notifiable diseases database (\textit{the Communicable Diseases Network Australia}). In general, diagnosis of Ross River virus infection is based on the outcome of a blood test (Mackenzie and Smith 1996). The routine detection of Ross River virus antibodies in victim’s blood specimens is based on enzyme-linked immunosorbent assays test (Fraser and Marshall 1989).\textsuperscript{44} A positive sera test

\textsuperscript{43} In accordance with the guidelines issued by the National Health and Medical Research Council (NHMRC), ethical approval was obtained from the Griffith University Research Ethics Committee and the Princess Alexandra Hospital Research Ethics Committee.

\textsuperscript{44} Commonly known as ELISA test, helps to identify Ross River virus antibodies, IgG and IgM proteins, in victim’s blood.
result indicates Ross River virus infection. However, it does not necessarily validate the level of diagnosis to reveal whether the tested person is a presumptive or confirmed victim of Ross River virus. In order to confirm Ross River virus diagnosis (1) at least two sera tests should be conducted in parallel by the same laboratory within 7, and 8 to 28 days, respectively, of onset of the illness, and (2) two sera test results, at acute and convalescent period, should show a four-fold change in antibody titre (Mackenzie et al. 1998; Harley et al. 2001). However, such detailed information was difficult to extract from the current Ross River virus database and hence the target population appears to be a collection of both presumptive and confirmed victims of Ross River virus disease (Curran et al. 1997).45

4.2.4 Getting individual consent

Initially, an invitation letter comprised of an information sheet describing the survey procedure and a consent form, was sent to the target population of 367 notified victims (see Appendix 1). The letters were distributed through Queensland Health (QH) so that contact information regarding non-consenting victims was not disclosed. Around 226 victims (62% of the target population) returned consent forms indicating their willingness to take part in the survey. Five invitations were returned unopened due to changes in address. Three of the 226 victims who consented were not enlisted due to various reasons (such as planned overseas travel and hospitalisation). In addition, 22 victims did not complete the whole survey (three questionnaires). As a result, the Ross River virus study sample included 201 victims – 55% of the target population of 367.

4.2.5 Collecting disease-related data

It is reported that chronic disorders such as arthritis and chronic fatigue syndrome may have adverse impacts upon the social and economic life of the

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45 Some victims had only one blood test while others had two or more.
patient and their family (Pincus 1995). In general, Ross River virus disease is known for its debilitating and persistent symptoms that are similar to those of arthritis and chronic fatigue syndrome (Russell 2002). Therefore, in order to value the full disease costs it is necessary to collect the whole range of disease-related health and non-health impacts. According to pilot survey findings, the majority of people did not seem to keep records about disease-related spending such as diagnosis and management costs. Therefore, a treatment item recording sheet was designed to facilitate self-reporting of treatment-related expenses so that participating victims could record Ross River virus treatment-related information such as costs of health professional consultations, pathology services and medicines on-going basis (see Appendix 2). It was anticipated that this recording process would increase the accuracy of treatment-related cost data.

The consenting victims were contacted progressively at three stages. The initial contact was made about 1 to 2 months after notification to QH. The first and second follow-ups were at around 6 and 12 months following the initial notification. There were two reasons for this timing choice. Firstly, it has previously been reported that most of the previous Ross River virus studies had been conducted on a retrospective basis and hence failed to capture all disease-related impacts (Mylonas et al. 2002). Secondly, it was necessary to assess and compare temporal changes in health-related quality of life aspects of participating Ross River virus victims. Therefore, a longitudinal approach was adopted and Ross River virus victims were contacted at three stages so that the majority of disease impacts and effects could be captured. The initial, and first follow-up stages used self-administered survey instruments to collect disease-related data while the second follow-up involved a phone survey. In addition, a standard health-related quality of life instrument (Short Form 36) was incorporated in the initial and the first follow up stages (see Appendix 2).

4.2.6 Survey instruments

⁴⁶ In addition to declined functional status, the disease has severe long term economic consequences; costs of medical treatment, lost productivity, interference with social activities, intangible costs of fear, pain, fatigue, helplessness, loss of self-efficacy (health-related quality of life).
Three survey instruments were designed to collect data from consenting Ross River virus victims in the initial and follow up surveys (see Appendix 2). A separate instruction sheet accompanied each survey stage. Furthermore, a general practitioner and an epidemiologist validated relevant survey questions. Questions relevant to disease symptoms, severity, recovery, treatment-related spending and physical disability were repeated in the follow-up surveys. It was expected that this procedure would fulfil two purposes – the validation of survey responses in the first survey and the capture of the full range of disease-related impacts over the longer term. The second follow-up (phone survey), was conducted after 12 months from onset. It was basically aimed at assessing length of recovery time, health state and treatment-related recurrent spending.

### 4.2.6.1 Initial survey form (approximately 1-2 months from onset)

The initial survey form, *Ross River virus - Part I*, aimed at collecting general information about the disease and demography of survey participants (see Appendix 2). It was comprised of 40 questions and split into four sections. The first section “*Your case of Ross River virus*” was designed to collect information about disease symptoms, severity, diagnosis, treatment-related expenditure, disease-related disability and help received from others during the sick period.

The second section “*Your state of health*” was intended to collect information about participant’s health state before and after contracting Ross River virus including co-existing illnesses (co-morbidity). It was followed by a series of typical health-related quality of life questions (see Appendix 2). Short Form 36 health survey (SF-36) was used to assess the health-related quality of life impacts of Ross River virus upon survey victims (Ware and Sherbourne 1992). Short Form - 36 is the most common quality of life measuring instrument used in health care studies. SF-36 is used to weigh up the overall health status

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47 Their input had been obtained to check content accuracy and validity of survey questions.
across eight dimensions.\footnote{These health dimensions include physical functioning, role limitations, pain, vitality, general health, social functioning, emotion and mental health.} The survey form consists of items or questions, which present respondents with structured choices about their perception of their own health status. The physical functioning dimension, for example, has 10 items to which the patient can make one of three responses: ‘limited a lot’, ‘limited a little’ or ‘not limited at all’ (see sample question below).

<table>
<thead>
<tr>
<th>Activities</th>
<th>Yes, limited a lot</th>
<th>Yes, limited a little</th>
<th>No, not limited at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These responses are coded 1, 2 and 3, respectively, and the 10 coded responses summed to produce a score from 10 to 30. These raw dimension measures are first transformed onto a 0 – 100 scale and then standardised using average SF-36 norms for the Australian population (ABS Catalogue No. 4399). Accordingly, each scale (that is, eight health dimensions and two summary measures) is scored to have the same average (50) and the same standard deviation (10). The interpretation of population norms-based SF-36 scores is clear and easy. At any time, a score below 50 indicates a below average health status. So that higher SF-36 measure indicates better state of health. Hence, SF-36 measures at two different points in times can be used to highlight an improvement or deterioration of health (Ware and Sherbourne 1992). Since the SF-36 is intended to reflect the victim’s health state in terms of physical, mental and social functioning, derived measures can be considered as proxies for health-related quality of life impacts of Ross River virus.

The third section “Your experience with mosquito problem” was designed to collect information about the victim’s exposure to mosquitoes, use of personal protective methods and their attitude towards current mosquito control programs within local government jurisdictions.
The final section “Information about you” was aimed to collect information related to the socio-demographic profile of survey victims such as age, gender, marital status, education, occupational status and gross weekly income. A question about source of healthcare financing including subscriptions to private health insurance, eligibility to health care concessions at the time of Ross River virus illness was also incorporated in this section.

4.2.6.2 Six month follow up survey form

The first follow-up survey form, Ross River virus - Part II, was administered at around six months after the initial survey and was similar to that for Part I (see Appendix 2). It aimed to collect information about changes in conditions such as disease severity, symptoms, recovery status and treatment-related spending after the first survey. Compared to the initial survey, the follow-up survey form (Part II) was shorter and comprised only 28 questions. The form consisted of three sections including two repeated sections from Part I (“Your case of Ross River virus” and “Your state of health”). The third section (“Costs and effects associated with Ross River virus”) was designed to collect specific information about post-illness effects on paid and unpaid work, leisure activities and other impacts. A willingness-to-pay question (WTP) based on a hypothetical scenario, was presented at the end of this section (see Appendix 2).

4.2.6.3 Willingness-to-pay question

A major concern about existing disease costing approaches has been their failure to capture disease impacts that are intangible in nature (Drummond et al. 1997). These impacts may include fear, pain, fatigue, depression, restricted social and leisure activities. Literature focusing on the valuation of health impacts strongly suggests that stated preference methods such as WTP could be used as an alternative approach to capture the total disease impacts including intangible effects (O’Brien and Gafni 1996). Most often these impacts change the level of overall health state of individual and hence well-being.
In fact, stated maximum WTP of individual reflects the monetised value of changed level of utility (deterioration in health). This information is useful and can be used in an attempt to quantify health impacts of Ross River virus in dollars. In order to elicit maximum WTP amount, a hypothetical market scenario was developed and a bidding type question format was used to quantify victim’s maximum WTP for an imaginary pill.49

Imagine that re-infection with Ross River virus is possible and you face the prospect of similar symptoms that you had with your previous infection. Say that a pill was available that would reduce the chance of another Ross River virus infection to almost nothing. The imaginary pill would work for one year and you would have to pay the full cost. Therefore, you would have to give up spending that money on other things in order to get the pill.

4.2.6.4 Twelve month follow up survey

The second follow-up survey, Ross River virus - Part III, was a phone survey administered approximately 12-14 months after the onset of illness (see Appendix 2). In general, the survey took around five to ten minutes to complete. It was designed to assess disease recovery state, persistent symptoms and treatment-related spending after the first follow-up.

4.2.7 Survey procedure and response

The first two survey forms were sent to Ross River virus victims (223) at one to two months and six months after notification. Every letter contained an instruction sheet, a survey form and a reply-paid, self-addressed envelope. After two weeks without a response a written reminder was posted. Another reminder was mailed after four weeks time to those who did not return the completed survey following the first reminder. If the victim had not received, or had misplaced the survey form, a new form was sent out. As indicated in the

49 Assuming neither Pharmaceutical Benefit nor insurance claim available for the imaginary medicine.
invitation, token gifts were sent to victims those returned completed survey forms.

4.2.8 Survey biases and weaknesses

In this research, there was no sampling procedure as the entire population was contacted. Each unit of the target population was given equal opportunity to participate in the survey. However, the total number of victims agreed to participate in the survey was 61% of the target population. Of this sample, about 90% did return completed survey forms. Hence, results are only for a portion, albeit a majority, of the target population and inferences can only be drawn on a conditional basis.

4.2.8.1 Selection of victims

Selection bias occurs when the victims studied are not representative of the target population about which conclusions are to be drawn (Coggon, Rose and Barker 1997). Although the entire population was invited, there was likely to be an element of selection bias in the Ross River virus survey due to the voluntary nature of the participation process. For example, those who had severe Ross River virus illness might be more likely to respond to the survey since they feel more committed to highlight real problems. In addition, having more spare time, retirees and other people outside the formal workforce would be more likely to enrol in the survey.

4.2.8.2 Clinical screening

Clinical screening aims to assess the overall health status of volunteer participants in health studies. Such screening helps to select more appropriate sample of participants. In general, the preference is for participants free of other illnesses so that research findings would relate only to the effects of a particular illness. However, there was no rigorous clinical screening conducted for the

50 An open invitation was sent to all notified Ross River virus victims.
51 Because people tend to overstate disease impact due to pre-existing chronic illnesses (Harley 2001; Mylonas et al. 2002).
Ross River virus survey. Instead, the initial survey form (Part I) contained a question asking consenting Ross River virus victims to provide information related to known co-existing illnesses. Those who had a history of diagnosed illness(es) should therefore have reported the co-existing illness(es) in the survey form. Ideally, a clinical screening by a health professional (that is, general practitioner or registered nurse) would have been conducted to select suitable victims and progressively monitor the overall health-state along the survey period. However, limited resources constrained the adoption of such an approach for this study.

4.2.8.3 Reporting errors

Generally, the pre-test revealed that people did not keep records of Ross River virus-related spending such as treatment-related medical and non-medical expenditure, disease preventive costs and relevant other expenditure. Therefore, cost data collected in the survey appear to be rough estimates. Efforts were taken to minimise reporting errors by introducing a Treatment Record Sheet after the first survey. Ross River virus victims were encouraged to record treatment-related expenditure in this sheet as they occurred. Therefore, it was assumed that reporting errors were kept at minimum level in the Ross River virus survey.

4.3 Valuation of disease impacts

Valuation of disease impacts is important in order to highlight disease burden to the society. This information can be used as a proxy to estimate and project approximate savings by avoiding new cases and hence to evaluate the net benefits of disease intervention programs. In the case of mosquito-transmitted Ross River virus disease cost information may be used to evaluate current and new mosquito control programs. Since there is no general agreement as to what impacts should or should not be counted for in case of mosquito-transmitted diseases, it is critical to identify the whole range of impacts (negative effects) associated with the disease and apply appropriate valuation methods to quantify those impacts in dollars.
4.3.1 Enumeration and measurement of negative effects

Disease impacts associated with Ross River virus were enumerated, measured and valued methodically. Firstly, the whole array of negative effects associated with the disease were listed and linked to relevant cost components. The next stage was to identify required data and data sources of cost components. Finally, appropriate market prices or proxy values or valuation methods were applied to derive dollar amounts. Table 4.1 presents a list of negative effects, relevant cost item, data collection and data sources.\textsuperscript{52} For example, in the case of health care expenditure, reported costs (survey data) and/or recommended charges for specified health service (Medicare Benefit Schedule, personal communication with pathology services) were applied to estimate approximate costs.

Medical treatment-related transport costs were estimated based on the information provided by the victims (for example, mode of travel and approximate cost per trip).

Indirect costs of Ross River virus due to lost production – total waiting time for medical consultations and productive time (both paid and unpaid work) lost due to the illness-related physical disability – were estimated based on the human capital approach. ABS published data was used in these cost estimations (ABS Catalogue 6302.0). The maximum willingness-to-pay stated by the victims was assumed to equal to health-related quality of life impacts of the virus (that is, changed health state due to Ross River virus). Accordingly, valid willingness-to-pay responses were used to estimate the mean costs in 2002 dollars.

\textsuperscript{52} A detailed table including a list of negative effects, relevant survey questions and valuation approach is in the Appendix 3.
<table>
<thead>
<tr>
<th>Negative effect (Cost)</th>
<th>Cost item</th>
<th>Data collected</th>
<th>Data source/s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health care</td>
<td>Consultation of health professionals</td>
<td>Number of visits, cost of consultation</td>
<td>Patient survey, Medicare Benefit Schedule</td>
</tr>
<tr>
<td></td>
<td>Pathology services</td>
<td>Number of tests, cost per test</td>
<td>- same as above -</td>
</tr>
<tr>
<td></td>
<td>Medicines</td>
<td>Money spent for prescribed and over-the-counter medicines</td>
<td>Patient survey, Schedule of Pharmaceutical Benefits</td>
</tr>
<tr>
<td>Non-health care</td>
<td>Treatment-related transport</td>
<td>Frequency and cost of travel</td>
<td>Patient survey</td>
</tr>
<tr>
<td><strong>Indirect</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lost production</td>
<td>Waiting time (consultation)</td>
<td>Length of waiting time</td>
<td>Patient survey and ABS weekly earning data</td>
</tr>
<tr>
<td></td>
<td>Absenteeism</td>
<td>Days off</td>
<td>- same as above -</td>
</tr>
<tr>
<td></td>
<td>Shorter working hours</td>
<td>Number of hours missed</td>
<td>- same as above -</td>
</tr>
<tr>
<td></td>
<td>Early retirement</td>
<td>Number of years for the retirement</td>
<td>- same as above -</td>
</tr>
<tr>
<td></td>
<td>Help/assistance</td>
<td>Number of hours/days</td>
<td>- same as above -</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease prevention</td>
<td>Personal protection</td>
<td>Cost of personal protective methods against mosquitoes</td>
<td>Patient survey</td>
</tr>
<tr>
<td>Health-related aspects</td>
<td>Physical functioning</td>
<td>Maximum willingness-to-pay</td>
<td>- same as above -</td>
</tr>
<tr>
<td></td>
<td>Mental functioning</td>
<td>Maximum willingness-to-pay</td>
<td>- same as above -</td>
</tr>
<tr>
<td></td>
<td>Social functioning</td>
<td>Maximum willingness-to-pay</td>
<td>- same as above -</td>
</tr>
</tbody>
</table>

**Note:** Some negative effects such as costs of publicly funded mosquito control and management plans, costs of mosquito research, costs of negative serological tests and costs to the real estate and tourism industries are not included.
4.3.2 Conceptual disease costing framework

A conceptual disease-costing framework was developed to organize negative effects associated with Ross River virus (see Figure 4.1). It was aimed at facilitating disease cost valuation to ensure that none of them were overlooked in the valuation process. The whole range of negative effects (and associated costs) were categorised as direct, indirect and other costs.

4.3.2.1 Direct costs

Direct cost category comprised of health care (health professional consultations, pathology services and medicines) and non health care spending (treatment-related transport). These costs were valued based on actual market prices. Health care costs associated with Ross River virus were estimated based on data provided by the surveyed victims. These data included individual treatment-related spending such as health professional consultations, pathology services and medicines (see Figure 4.1). A significant proportion of Ross River virus victims reported use of Medicare benefits to cover their medical costs such as general practitioner consultations and pathology tests. In order to capture the actual costs of health care resources, proxy values were assigned to those who did indicate so in the survey form. Non-health care costs comprised of out-of-pocket expenses and individual spending for treatment-related transport. Approximate costs were estimated based on data provided in the survey forms.

4.3.2.2 Indirect costs

Indirect costs reflect the opportunity cost of lost productivity on account of Ross River virus. This productive time loss (both paid and unpaid work) may attribute to disease-related disability and/or waiting time for medical treatment (see Figure 4.1). For example, disability caused by Ross River virus may lead to work place absenteeism, shorter working hours and early retirement. These indirect costs were estimated for Ross River virus victims engaged in paid and unpaid work. The human capital approach was applied to value the indirect costs.

53 This includes bulk billing and other concessions received under Medicare and Pharmaceutical benefits.
associated with Ross River virus. For example, the median weekly income reported by survey participants was used to estimate indirect costs.

4.3.2.3 Other costs

Apart from direct and indirect costs, the remaining impacts of Ross River virus were considered as other costs (see Figure 4.1). For example, these included disease impact upon health-related quality of life, personal spending on disease control and prevention, costs of public funds for mosquito control, public health and education, research and development. Furthermore, disease impact upon market activities such as tourism and real estate businesses.

However, due to various limitations only selected negative impacts were considered in this research. For example, Ross River virus survey collected cross-sectional data therefore, possible costs were quantified using relevant market and non-market valuation methods. A non-market approach, willingness-to-pay valuation was applied to quantify deterioration in health-related quality of life. Furthermore, actual spending for personal protection methods against mosquitoes reported in the survey was used to estimate disease prevention costs. As highlighted earlier (due to cross-sectional data), disease impact upon other economic activities such as tourism and real estate industries were not estimated.
Figure 4.1  Conceptual disease-costing framework for mosquito-transmitted Ross River virus

- **Direct Costs**
  - Health care
    - Consultations
    - Pathology services
    - Medicines
  - Non-health care
    - Treatment-related transport

- **Indirect Costs**
  - Lost productivity
    - Days off (paid/unpaid)
    - Restricted work hours (paid/unpaid)
    - Waiting time (paid/unpaid)
  - Informal/formal care

- **Other Costs**
  - Hidden
    - Health-related quality of life
    - Disease control and prevention
    - Public health and education
    - Research and development
    - Real estate
    - Tourism

- **Full Social and Economic Costs**

- **Resource Allocation**

- **Benefits of Control and Management Programs**
4.3.3 Major explanatory variables

According to the literature, disease impact upon health care resources, productivity and health-related quality of life contribute to a substantial proportion of the disease burden. It is assumed factors such as victim’s age, gender, disease severity, health state and disease duration are closely linked with overall disease impact. Therefore, it is critical to look at individual health care costs and health-related impacts in the context of his or her demography, state of health and relevant other contributing factors. Appropriate explanatory variables selected from the Ross River virus survey database are presented in Table 4.2.

The selection of the major explanatory variables was based on the evidence from health care literature, well-known ‘facts’ about the disease, logical interpretation and existing major related economic influences. These variables were derived from demographic (that is, victim’s age, gender, marital status and income) disease (that is, severity, duration and disability) and state of health (that is, co-morbidity and SF-36 summary measures) data. Some data were transformed while others were used in the original form as recorded in the Ross River virus survey. For example, disease duration was estimated in months based on approximate onset and recovery information collected in the survey. The analytical format of the variable was determined based on the measured scale such as nominal, ordinal or ratio.

4.3.4 Bivariate statistical analyses

Valuation of disease impacts was based on the survey outcome and hence it was vital to substantiate the quality and reliability of the survey data. Around half of selected explanatory variables were measured on either nominal or ordinal scales and their frequency distributions ranged from normal to highly skewed distributions.
Table 4.2  Selection of major explanatory variables

<table>
<thead>
<tr>
<th>Variable (Code)</th>
<th>Nature of variable</th>
<th>Data recorded in the survey as</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (GEN)</td>
<td>Nominal</td>
<td>Gender (male;female)</td>
</tr>
<tr>
<td>Age (AGE)</td>
<td>Ordinal</td>
<td>Age group (18-24;25-34;35-44;45-54;55-64;65-74;75+)</td>
</tr>
<tr>
<td>Marital status (MST)</td>
<td>Nominal</td>
<td>Unmarried, separated, divorced; widowed married; de facto</td>
</tr>
<tr>
<td>Income (INC)</td>
<td>Ordinal</td>
<td>Gross weekly income (less than $159; $160-$299; $300-$499; $500-$699; $700-$999; $1000-$1499; $1500+)</td>
</tr>
<tr>
<td>Co-morbidity (COM)</td>
<td>Nominal</td>
<td>Co-existence of two or more illnesses (yes; no)</td>
</tr>
<tr>
<td>Disease severity (SEV)</td>
<td>Ordinal</td>
<td>Self-perceived disease severity (very mild; mild; moderate; severe; very severe)</td>
</tr>
<tr>
<td>Standard health measure (PCS)</td>
<td>Interval</td>
<td>SF-36 survey responses</td>
</tr>
<tr>
<td>Standard health measure (MCS)</td>
<td>Interval</td>
<td>SF-36 survey responses</td>
</tr>
<tr>
<td>Disease duration (LEN)</td>
<td>Interval</td>
<td>Time of onset and recovery (months)</td>
</tr>
<tr>
<td>Disabled period (DIS)</td>
<td>Ratio</td>
<td>Length of disability (days)</td>
</tr>
<tr>
<td>Health care costs</td>
<td>Ratio</td>
<td>Costs of consultations, pathology services (HCC) and medicines ($)</td>
</tr>
<tr>
<td>Willingness-to-pay (WTP)</td>
<td>Ratio</td>
<td>Stated maximum willingness-to-pay ($)</td>
</tr>
</tbody>
</table>

This limited the application of parametric techniques in the statistical analyses (see Table 4.2). In general, non-parametric tests were applied to test variable independence and the strength and direction of associations. For
example, the chi-square test of independence was applied to show if differences observed in the sample cross-tabulations can be extrapolated to the population. Since it does not measure the strength and direction of the association between the variables, appropriate correlation tests were applied to quantify bivariate associations.

It is assumed that the outcome of hypothesis testing (chi-square test of independence) and bivariate correlation analyses of major variables (Spearman’s rho) can be used to evaluate relationships proposed and observed in current theory and empirical research. Thus, interpreting Ross River virus impact upon health care resources (health care costs) and health-related quality of life (willingness-to-pay) is rational and pragmatic.\(^{54}\)

The chi-square test for independence was applied assuming that:
- \(H_0\) – there is no relationship between selected variables
- \(H_1\) – there is a relationship between selected variables

The chi-square test statistic for independence defined as:

\[
\chi^2 = \sum (O - E)^2/E
\]

Where, \(O\) is the observed frequency (for example, percentage) and \(E\) is the expected frequency.

Correlation analyses were performed using appropriate association test (for example, Spearman’s rho) to quantify the strength and direction of relationships including their statistical significance. The outcome of correlation analyses was evaluated assuming degree of correlation, direction and their statistical significance.\(^{55}\)

\(^{54}\) Valuation of disease impacts focused on a market-based (for example, health care costs) and a non market-based (for example, health impact) approach.

\(^{55}\) For example, bivariate correlation is very strong = over 0.91; strong = 0.71 to 0.90; modest = 0.41 to 0.70; weak = 0.21 to 0.40 and very weak = 0.20 or less (Pfeifer 2000).
4.3.5 Age and gender analysis

The prime objective of this research is to assess the full costs of Ross River virus so that cost information can be used to extrapolate Ross River virus costs by local government area in Queensland. In order to estimate costs accurately, however, it is necessary to assess whether disease costs vary according to age and gender characteristics of the victims. It is assumed that demographic characteristics such as the age and gender of Ross River virus victims are prime candidates for investigation due to the ease of access to such information in the Ross River virus notification database.

Based on the number of categories of age and gender used in the survey, the possible age-gender combinations would be 12. However, in order to minimise bias and obtain sufficient cases in each combination cell, several categories were combined. Consequently, eight combinations were formed by age and gender of Ross River virus victims (see Table 4.3). A non-parametric Kruskal-Wallis analysis of variance (ANOVA) was conducted to examine significant differences in disease costs between age-gender groups.

Table 4.3 Age-gender combinations used for costs analyses (N = 201)

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Gender Male (% of total)</th>
<th>Gender Female (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 – 34</td>
<td>12 (6)</td>
<td>23 (11)</td>
</tr>
<tr>
<td>35 – 44</td>
<td>22 (11)</td>
<td>34 (17)</td>
</tr>
<tr>
<td>45 – 54</td>
<td>25 (12)</td>
<td>26 (13)</td>
</tr>
<tr>
<td>Over 55</td>
<td>31 (15)</td>
<td>28 (14)</td>
</tr>
</tbody>
</table>

4.3.6 Extrapolating disease costs

Calculation of the median cost estimates of Ross River virus (that is, the costs of health care, lost productivity and health-related quality of life impact) and the number of Ross River virus notifications enabled the calculation of total disease costs by local government area. For example, the number of Ross River virus cases notified in 2002 in respective local government areas was multiplied
by the respective median full social costs (in 2002 $AUD) estimated in this research. It is important to note that Ross River virus notifications in 2002 were unusually low. As a result, the total disease costs were also compiled across the 1994 - 2003 period.

Spatial disease cost information (that is, the total disease costs of Ross River virus for 1994-2003 period in 2002 dollars) was applied to existing local government area maps so that major disease impact areas can be identified. The spatial distribution of disease costs provides general overview of the geographic nature of the problem and helps highlight local government areas in which the proposed economic evaluation using the cost minimisation approach can effectively be applied.

4.4 Summary and conclusion

This chapter has presented an overview of the research methodology applied in an attempt to value the full disease impacts of mosquito-transmitted Ross River virus.

The study was designed to identify and quantify the social and economic impacts of the virus. A sample of Ross River virus victims (201) was progressively monitored and contacted at near disease onset, six months, and 12 months from onset to collect the required disease-related data. The demographic, health state and disease-related data were collected using phone and self-administered questionnaires. The onset and six months survey forms aimed at collecting general information about the disease, victim’s health state, illness effects and demography of the victims. The hypothetical scenario based on a willingness-to-pay question was presented in the six-month survey form. The final survey was designed to assess disease recovery state, persistent symptoms and any treatment-related spending after the six-month survey.

Predominantly non-parametric statistical techniques were applied to examine variable independence and their correlations and to assess whether
survey data were consistent and adequately reliable to be used as the basis to estimate disease costs. Direct and indirect impacts of Ross River virus (such as the costs of health care resources and lost productivity) were valued using market prices. A non-market valuation (willingness-to-pay) method, in conjunction with a standard health measure (Short Form 36), was used to quantify more intangible health-related quality of life effects such as victim’s perceived changes in physical, mental and social functioning.

Estimated disease costs were analysed across eight age - gender groups. Based on the median cost estimates, total disease costs have been calculated for local government areas and compiled across the 1994 - 2003 period. Disease cost information, together with resource costs of current mosquito control and management, is a vital input for economic evaluation using the cost-minimisation approach. The application of economic evaluation approaches in disease management will have substantial benefits facilitating efficient resource allocation decisions at the local level and will help maximise net social welfare of the affected communities.
CHAPTER 5 RESULTS AND ANALYSIS PART I: VALUATION OF DISEASE IMPACT – A MARKET-BASED APPROACH

5.1 Introduction

The absence of reliable cost information about mosquito-transmitted diseases such as Ross River virus is a major limitation in the economic evaluation of disease control and management programs. In general, mosquito control and management programs are aimed at reducing disease risk and nuisance at the local level. Therefore, valuation of disease impacts is appropriate for local authorities that need to know the relevant full economic costs and benefits to facilitate local resource allocation decisions. The primary purpose of data collected in the Ross River virus study undertaken in this project was to value the direct and indirect impacts associated with the viral illness. Supplementary information for the valuation of direct and indirect costs was obtained from a wide range of sources such as the Commonwealth Department of Health and Ageing, the Health Insurance Commission, Pathology Services and the Australian Bureau of Statistics.

The first part of this chapter gives an overall description of the direct and indirect costs of Ross River virus. It provides a detailed account of resource and opportunity costs associated with Ross River virus including health care and non-health care costs, costs of disease preventive actions, and the opportunity costs of lost work and leisure time by the victim and time devoted by caregivers. In addition, the section includes a comprehensive analysis of victims’ occupation data by category and industry.\(^56\)

Comparable statistics for the general Queensland population are also presented. This information will be analysed and used to provide insight into the impact of Ross River virus on productivity.

\(^{56}\) Using standard ABS classification guidelines such as ASCO for occupation and ANZIC for industry.
The valuation of disease costs (that is, health care and lost production) is presented in part 2 of the chapter. Relationships between characteristics of the study participants and Ross River virus costs is presented in this section and includes their gender, age, marital status, income, individual and aggregate treatment-related costs, performance on a standard health measure, disease severity, disease duration and disability period. These variables and appropriate transformations were used as the major basis for the analysis of disease costs of Ross River virus.

For example, treatment-related costs of Ross River virus were individually measured and used to create an aggregate measure called “health care cost”. Similarly performance on the standard health measure was individually measured (at disease onset and after six months) and used to create physical and mental summary measures.

Furthermore, self-perceived disease severity was individually measured by a Likert scale question. The length of disability was based on individual’s reported number of days in this condition. On the other hand, disease duration was computed on the basis of individually reported disease onset and recovery time.

Bivariate statistical analyses (that is, chi-square test and correlation analysis) were conducted to test for independence and associations between the major variables investigated. Results of these analyses are also used to test the consistency of survey data with more comprehensive measures based on current knowledge and understanding. In addition, health care and lost productivity costs of Ross River virus were analysed and compared by demographic variables such as victim’s age and gender. Results of the age-gender analyses of estimated disease costs are also presented in this section.\(^{57}\)

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\(^{57}\) The main focus here is to assess Ross River virus impact upon health care resources. Therefore, survey data were used to identify and establish links between health care costs and major study variables. The age-gender analysis was conducted to ascertain whether these categories enhance the cost estimate for Ross River virus.
5.2 Direct and indirect costs

The valuation of the direct and indirect costs of Ross River virus is vital to accurately identify the nature of its burden on society. These costs have been estimated using data collected in this study’s survey. The accuracy of estimated disease costs appears to be influenced by a range of factors including the number of surveyed Ross River virus victims, the quality and availability of data and the valuation approach used.

The valuation of direct costs, such as health care costs and treatment-related transport costs has been based on market prices (obtained either by victim recall or from relevant sources such as service providers). Indirect costs have been based on published data from sources such as the Australian Bureau of Statistics.

These cost estimates provide an insight into the impact of Ross River virus and help answer a wide range of questions regarding resource and opportunity costs. For example, they reveal what type and level of health care services are used to treat Ross River virus and its related health consequences. In addition, they indicate what proportions of victims rely on publicly-funded health care systems such as Medicare and Pharmaceutical Benefits Scheme and hence the consequent cost to the health care system at a society-wide level. Furthermore, they reveal the magnitude of economic costs of non-health care resources such as treatment-related transport, disease prevention and disease avoidance strategies associated with Ross River virus. On the other hand, the economic opportunity costs of Ross River virus are derived on the basis of the number of victims experiencing disability (that is, lose the ability to work productively) and the effect the illness has on individual productivity and the supply of goods and services to the market. More importantly, opportunity costs help to ascertain the economic dimensions of the effect of Ross River virus for a
victim’s health-related quality of life (including physical, mental and social functioning)\textsuperscript{58}

In order to answer these questions, disease impacts were classified into three major groups; direct, indirect and other impacts.\textsuperscript{59} For example, health care and non-health care spending have been considered as direct costs while indirect cost has been attributed to lost productivity. The remaining costs such as health-related quality of life impact and disease prevention have been treated as other costs. The costs associated with these impacts were estimated using appropriate valuation methods and, taken together, they are considered to represent the full costs of Ross River virus. This chapter focuses specifically on the valuation of direct and indirect costs associated with Ross River virus. In the case of direct costs, actual expenditure incurred by Ross River virus victims was used while proxy market values were applied for production time and output lost as a result of Ross River virus. In the following chapter, we discuss the results of the contentious approach of valuing costs associated with health-related quality of life impacts (based on a non-market willingness-to-pay approach).

### 5.2.1 Direct costs

Direct costs are the private costs incurred by the victim or by the government as a result of Ross River virus illness over the full period disease onset to the full recovery. They are mainly comprised of health care and non-health care spending. Ross River virus victims paid some direct costs while government-funded programs such as Medicare and private health insurance cover other aspects. Since markets do exist for these goods and services, direct costs can be valued using actual market prices. However, some market prices, such as prescribed fees published in the Medicare schedule, are distorted as these costs, in general, reflect an arbitrary payment the government is willing to cover.

\textsuperscript{58} These issues are one of the major focal points of this research. A comprehensive analysis of health-related impacts and their valuation is presented in chapter 6 (Valuation of health-related quality of life impacts – a non-market approach).

\textsuperscript{59} A detailed discussion of disease impacts and associated costs are presented in chapter 4.
5.2.1.1 Health care products and services

Health care costs include individual expenditure for a range of products and services including consultation of health professionals, pathology services and purchase of medicines. Non-health care diagnostic and treatment costs include expenditure for other treatment-related goods and services such as transport to medical centres, pathology labs and pharmacists.

5.2.1.1a Medical consultations

In general, a minimum of two general practitioner consultations are required to treat a Ross River virus victim (Harley et al. 2001) – the first to arrange a pathology test, and the second to interpret test results and arrange a treatment plan. In this survey, victims visited a general practitioner on an average of three times during their illness whilst the range of visitation frequency varied between one and 10 per victim (see Table 5.1).

Table 5.1 Costs of medical consultation (N = 201)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Minimum (per person)</th>
<th>Maximum (per person)</th>
<th>Sample Median</th>
<th>Sample I-Q Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Practitioner</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visits (number)</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Waiting time (minutes)</td>
<td>10</td>
<td>90</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>24.50</td>
<td>65.00</td>
<td>32.00</td>
<td>3.25</td>
</tr>
<tr>
<td><strong>Specialist</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visits (number)</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Waiting time (minutes)</td>
<td>15</td>
<td>90</td>
<td>45</td>
<td>26</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>60.00</td>
<td>180.00</td>
<td>110.00</td>
<td>43.75</td>
</tr>
<tr>
<td><strong>Alternative Health Practitioner</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visits (number)</td>
<td>0</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Waiting time (minutes)</td>
<td>10</td>
<td>120</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>20.00</td>
<td>75.00</td>
<td>44.00</td>
<td>17.50</td>
</tr>
</tbody>
</table>

Note:  

* All victims consulted a general practitioner at least once  
* Around 10% consulted a specialist at least once  
* Around 28% consulted an alternative health practitioner at least once  
* All amounts are in 2002 Australian dollars.

The average cost of a general practitioner visit was approximately $AUD 30. 42% of general practitioner consultations were bulk-billed and covered
under Medicare while 32% reimbursed their medical consultation costs through private health insurance. To maintain consistency in disease cost calculations, the average general practitioner fee was used.\textsuperscript{60}

Table 5.1 presents a summary of consultation costs reported by Ross River virus victims during the 12-month period from disease onset. The summary table describes each consultation by type of health professional, length of waiting time and cost per visit. These figures show the range of consultation costs involved in treating each Ross River virus victim. According to the survey data, one in four victims consulted an alternative health practitioner such as naturopath or homeopath, while every one in eight consulted a medical specialist such as rheumatologist or psychiatrist. Consultation fees for alternative health practitioners and medical specialists ranged between $AUD 44 and $AUD 110.\textsuperscript{61}

Figure 5.1  Self-perceived disease severity and number of GP visits (N = 201)

Disease severity appears to be a major contributing factor to the number of general practitioner consultations. For example, those Ross River virus victims who reported very severe symptoms visited general practitioners more often

\textsuperscript{60} During the reference period, a general practitioner consultation fee (a standard consultation of Level B) was scheduled at $AUD 28.75 (Medicare Benefits Schedule 2001).

\textsuperscript{61} Based on the amounts reported in the survey. As highlighted earlier, reported specialist consultation fees were higher than that of Medicare scheduled fee.
(around four times) while those with very mild symptoms typically made only two visits during the 12-month reference period (see Figure 5.1).\textsuperscript{62}

Many victims reported receiving alternative health care such as naturopathy and homeopathy for disease symptoms. 28\% of victims (56) received alternative health care at some stage of the illness. According to survey responses, the main reasons behind the increased popularity of these alternative treatments are the ineffectiveness of treatment in conventional Western medicine, personal recommendations from past victims and a growing aversion to using Western medicine.\textsuperscript{63}

5.2.1.1b Pathology services

The diagnosis of a Ross River virus infection is based on blood test results.\textsuperscript{64} Firms that provide pathology services charge a standard fee for these tests (that is, enzyme-linked immunosorbent assays test – ELISA). Generally, the blood test service includes collection, handling and testing of the specimen. According to two major pathology services, approximate cost of a blood test was approximately $AUD 45 at the time of the survey.\textsuperscript{65}

The cost of blood tests reported by the study sample ranged between $AUD 30 and $AUD 63 (Table 5.2). The majority of Ross River virus victims (75\%) used bulk-billing to cover the costs of their pathology tests. In order to facilitate cost calculations, the average of the test fees charged by two leading pathology services was imputed for bulk-billed cases. Table 5.2 presents a summary of diagnostic test costs reported in the survey.

Ross River virus victims reported an average of two blood tests. Each test costs approximately $AUD 45. In addition, 22\% of victims reported that they

\textsuperscript{62} Although this may seem obvious, this information was used to cross-check survey data accuracy.

\textsuperscript{63} For example, non-steroidal anti-inflammatory drugs – NSAIDs.

\textsuperscript{64} The presence of Ross River virus anti-bodies, IgM and/or IgG, in a victim’s blood sample.

\textsuperscript{65} T.Murtagh and A. Williams, pers. comm., 24/02/2002.
had undergone other tests such as urine testing and diagnostic imaging to facilitate diagnosis. 

**Table 5.2** Costs of diagnostic tests (N = 201)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Minimum (per person)</th>
<th>Maximum (per person)</th>
<th>Sample Median</th>
<th>Sample I-Q Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blood tests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of tests</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Cost per test ($)</td>
<td>30.00</td>
<td>63.00</td>
<td>44.90</td>
<td>0</td>
</tr>
<tr>
<td><strong>Other tests(^a)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of tests</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cost per test ($)</td>
<td>34.00</td>
<td>220.00</td>
<td>46.90</td>
<td>16.80</td>
</tr>
</tbody>
</table>

Note: \(^a\) Urine testing was the most commonly used “other” test. All amounts are in 2002 Australian dollars.

5.2.1.1c Prescribed and over-the-counter medicines

According to the survey results, the medicines most often prescribed included non-steroidal anti-inflammatory drugs such as Celebrex, Vioxx, Nurophen, Brufen and Voltaren. Commonly used over-the-counter medicines included pain relievers (such as Panadol and Panadeine), multi-vitamins, herbal and natural pharmaceutical products. In contrast to the assessment of other health care costs such as consultation and pathology services, estimating prescription medicine costs is complex due to varying levels of pharmaceutical benefits that distort the actual prices paid by respondents.

Generally, prescription medicines are sold at a subsidised price with the buyer meeting only part of the full medicine cost. This co-payment or contribution varies according to the buyer’s socio-economic and other circumstances. For example, concession cardholders such as low-income groups, pensioners and war-veterans pay only a nominal amount per prescription (Schedule of Pharmaceutical Benefits 2002).\(^67\) For this reason, the mean cost of prescription medicines reported by non-concessionary victims was used as a

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\(^{66}\) Diagnostic imaging tests include x-rays, ultrasounds and computed tomography (CT).

\(^{67}\) Patient co-payment per prescription is either $AUD 3.60 (concession cardholders) or $AUD 22.40 (others).
proxy. Despite using this proxy, cost of prescription medicines reported by non-concessionary victims is likely to be an underestimate due to across-the-board subsidies on medicine. Although victims were asked to provide detailed information about prescription and over-the-counter medicines, very few provided relevant and detailed information and hence it was not possible to identify the full medicine costs from other sources.

Approximate costs of prescription medicine and over-the-counter medicine to aid treatment through the entire course of the disease ranged between $AUD 36 and $AUD 63 per victim. However, unlike other health care costs, medical consultation and diagnostic tests, cost of medicines showed a considerable variation across the sample. This variation needs to take into account in total health care cost estimation. 65% of victims purchased prescription medicine while 68% purchased over-the-counter medicine. Table 5.3 presents a summary of spending on prescription and over-the-counter medicines reported in the survey.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Minimum (per person)</th>
<th>Maximum (per person)</th>
<th>Sample Median</th>
<th>Sample I-Q Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medicines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prescription ($)</td>
<td>12.00</td>
<td>260.00</td>
<td>36.00</td>
<td>45.75</td>
</tr>
<tr>
<td>Over-the-counter ($)</td>
<td>7.00</td>
<td>700.00</td>
<td>63.00</td>
<td>120.00</td>
</tr>
</tbody>
</table>

Note: 16% of the sample did not purchase any medicine; 19% (prescription), 17% (over-the-counter) and 48% (prescription & over-the-counter) did purchase medicine. In general, those used alternate health care (28%) spent larger amounts for over-the-counter medicines. All amounts are in 2002 Australian dollars.

5.2.1.1d In-hospital treatment

According to the survey data, none of the Ross River virus victims reported in-hospital treatment. However, three victims aged over 75 years with co-morbidity (that is, reporting the co-existence of other illnesses such as rheumatoid arthritis and diabetes) reported in-hospital treatment.
5.2.1.2 Non-health care products and services

Non-health care diagnostic and treatment costs related to Ross River virus includes transport related to treatment and spending on disease prevention. In general, these costs are small when compared with health care costs, and are often overlooked in conventional disease cost valuations. They need to be accounted in a full cost valuation. However, if these costs are included in the total disease cost estimation, their variation across the sample may influence overall cost trends.

5.2.1.2a Treatment-related transport

Treatment-related transport costs are incurred in travelling to medical centres for consultations, or to receive pathology services or related treatment. According to the survey, 88% of Ross River virus victims reported treatment-related transport costs. In the survey, respondents were asked to provide total costs of treatment-related travel in terms of private (cost of fuel) or public (bus, train and ferry) transport. Because these costs are relatively small, an approximate estimate should be sufficient to get a reasonable idea of the costs involved. Accordingly, the mean cost of transport per Ross River virus victim was estimated at $AUD 27 (see Table 5.4).

5.2.1.2b Disease control and prevention

A wide-range of disease control and prevention methods were reported in the Ross River virus survey. According to survey data, personal spending on mosquito control and prevention per year was estimated at $AUD 30 per person (see Table 5.4). Control and prevention methods by individuals are aimed at reducing mosquito nuisance and the risk of contracting mosquito-transmitted diseases. One major problem regarding the interpretation of this information in

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68 The survey revealed two major tiers of disease preventive measures at household level: (1) long-term measures that require initial spending such as fly screens and nets for beds (2) short-term personal protective methods such as mosquito coils, insect sprays, repellents and citronella candles. Table 5.4 presents total spending for personal protective methods (2nd tier only) in the last 12 months.
disease costing is confusion as to whether reported spending is specifically aimed at reducing the risk of Ross River virus or what percentage implicitly allocated.

**Table 5.4** Treatment-related transport and disease preventive costs (n = 177)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Minimum (per person)</th>
<th>Maximum (per person)</th>
<th>Sample Median</th>
<th>Sample I-Q Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport(^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per victim ($)</td>
<td>4.00</td>
<td>340.00</td>
<td>27.00</td>
<td>38.75</td>
</tr>
<tr>
<td>Disease Prevention(^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal protection ($)</td>
<td>3.00</td>
<td>380.00</td>
<td>30.00</td>
<td>41.50</td>
</tr>
</tbody>
</table>

Note:  
\(^a\) Around 88% of the sample reported treatment-related transport costs.  
\(^b\) Around 97% of the sample reported spending on disease prevention (personal protection).  
All amounts are in 2002 Australian dollars.

### 5.2.2 Indirect costs

Indirect costs can be defined in several ways depending on the perspective and objective of disease impact valuation. In this thesis, the indirect cost is defined as the value of production lost to society due to Ross River virus, with respect to paid work and unpaid work (that is, house duties including child care). Severe disease symptoms incapacitated many Ross River virus victims and removed their ability to engage in productive work and necessary home duties.

#### 5.2.2.1 Productivity loss

Loss of productivity can be due to (1) days absent from work, (2) incapacity to perform house work, (3) waiting time for medical treatment, and (4) working at below normal performance levels (paid and/or unpaid). The survey mainly focused on collecting information relevant to the first three sources while the last item was not included due to its difficult nature. The number of days absent from work (in the case of paid work) or number of days incapacitated (in the case of house work) reported in the survey has been identified as the study’s “disability period” (in accordance with the human capital approach). Productivity loss due to disability caused by Ross River virus can be valued by assuming that
the marginal product of labour is equivalent to the wage rate.\textsuperscript{69} Accordingly, indirect costs were estimated by multiplying average disability period by median weekly income.\textsuperscript{70}

5.2.2.1a Disability by nature of work

According to the survey, longer disability periods were reported by victims engaged in paid work (full or part time) and unpaid work (house work) when compared to their counterparts such as retired, unemployed (see Figure 5.2). The average disability period reported by those victims in paid work ranged between five and seven days while victims performing housework reported a disability period of four days. For comparison purposes the average disability periods reported by different victim groups are presented in Figure 5.2.

\textbf{Figure 5.2} Average disability reported by different groups (n = 197)

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
Category & Average disability days \\
\hline
FT & 5 \\
PT & 4 \\
HW & 3 \\
UE & 2 \\
RE & 2 \\
OT & 2 \\
\hline
\end{tabular}
\end{table}

\textbf{Note:} FT - Full-time work (49%) \hspace{1cm} PT - Part-time work (17%)
HW - Housework (10%) \hspace{1cm} UE - Unemployed (5%)
RE - Retired (17%) \hspace{1cm} OT - Others e.g. students, volunteers (2%)

The average disability period for paid work, housework and unemployed groups was estimated as five days. Based on median weekly income reported by Ross River virus victims, the opportunity cost of lost productivity was estimated at $AUD 610 per victim.

\textsuperscript{69} Assuming full employment and that firms will try to maximise their profits, the value gained by adding units of labour is equal to the wage rate (see Chapter 3 for more discussion).

\textsuperscript{70} Estimate based on gross annual income reported by employed Ross River virus victims.
5.2.2.1b Disability by occupation

Several occupational groups (including tradespersons and related workers, intermediate production and transport workers, elementary clerical, sales and service workers, and labourers and related workers) reported a longer disability period than occupational groups such as managers and administrators, professionals, clericals, sales and service workers (see Figure 5.3). This may be because of the physical demands required to perform work-related tasks in these occupations whilst productively employed. Thus, the magnitude of Ross River virus impact upon victims in the labour force appears to linked to the nature of work they perform. Figure 5.3 illustrates the average disability period of Ross River virus victims by occupation group.

Figure 5.3  Average disability period by occupation - Australian Standard Classification of Occupations (n = 101)

![Bar chart showing average disability period by occupation.](image)

Note: Key to Australian Standard Classification of Occupations (ASCO Code)
1 – Managers/Administrators  
2 – Professionals  
3 – Associate professionals  
4 – Tradespersons and related  
5 – Advanced clerical, sales and service workers  
6 – Intermediate clerical, sales and service  
7 – Intermediate production and transport  
8 – Elementary clerical, sales and service  
9 – Labourers and related workers

These results suggest that debilitating symptoms of the virus have considerable impact upon the victim’s health state (such as physical strength) and consequently leads to a differential effect on disability in different occupations. For example, it is apparent that victims in white-collar jobs are affected less than their counterparts. In addition, some Ross River virus victims stated in the survey that, after recovery, they worked less hours per day or could only perform
lighter duties than normal. Although the human capital approach values the overall disease impact on productivity in terms of average earnings, it does not recognise links between disease impact and ongoing work efficiency and other qualitative changes in work that can affect productive output of the victim.

5.2.2.1c Disability by industry of employment

The occupation data provided by Ross River virus victims were also analysed according to industry of occupation. Table 5.5 presents the employment industries of survey respondents alongside the proportion of the Queensland workforce employed in each industry.

Table 5.5  Ross River virus victims’ employment by industry – Australian New Zealand Industry Classification (n = 101)

<table>
<thead>
<tr>
<th>Industry (ANZIC)</th>
<th>Total Qld (%)</th>
<th>RRv sample (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry and fishing</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Mining</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Electricity, gas and water supply</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Construction</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Wholesale and retail trade</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>Accommodation, cafes and restaurants</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Transport and storage</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Communication services, finance and insurance</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Property and business services</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Government administration and defence</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Education, health and community services</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Others</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Based on occupational information provided by part-time and full-time employed Ross River virus victims. 31 victims were not included because of insufficient information.

The occupational structure of the Ross River virus sample is very different from that of the Queensland workers as a whole. According to survey data, around 50% of employed Ross River victims were working in agriculture, fisheries and forestry, mining and construction industries. This is substantially higher than the proportion of the Queensland workforce employed in these

---

71 Around 22 victims reported working less hours per day, six victims moving to lighter work, two victims changing job and one victim retiring early due to Ross River virus.
industries. These findings could imply the high probability of contracting Ross River virus for those in agriculture, fisheries and forestry, mining, construction, government administration and defence sectors and has important policy implications.

In general, the majority of occupations in these industries have a larger outdoor activity component and the results suggest that the probability of contracting the virus may be closely linked to the victim’s occupation. This was examined by analysing victims’ responses (of those employed) to the survey question: “According to your knowledge, where do you think was the most likely place you were bitten by mosquitoes to get Ross River virus?” However, the survey data could not be used to substantiate this observation as only a small proportion of victims suspect that they contracted Ross River virus at their workplace. For example, according to the survey, employed victims (n=104) thought they may have contracted Ross River virus in the following situations: home or garden or backyard (50%); leisure time including sports, fishing, camping and bushwalking (21%); workplace (14%); a combination of these locations (15%).

5.2.2.2 Waiting time

Ross River virus victims also lost productive time whilst waiting for health care services such as medical consultations. These waiting times are also considered as an indirect cost.72 A similar approach to that applied for valuing the disability period was used to assign a monetary value for waiting time. For example, Ross River virus victims’ cumulative waiting times for health professional consultations (from disease onset to recovery) was multiplied by reported median weekly income.

Table 5.6 presents a summary of costs of productivity loss due to disability and waiting time.

72 There is no general agreement as to whether waiting time costs should be included in indirect costs since it could overlap with lost productive time hence possible double counting (Luce et al. 1996).
### Table 5.6  Costs of productivity loss due to Ross River virus

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Minimum (per person)</th>
<th>Maximum (per person)</th>
<th>Sample Median</th>
<th>Sample I-Q Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disability period</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days</td>
<td>1</td>
<td>35</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Imputed cost ($)</td>
<td>121.00</td>
<td>4,250.00</td>
<td>610.00</td>
<td>1,275.00</td>
</tr>
<tr>
<td><strong>Waiting time</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours</td>
<td>0.25</td>
<td>37</td>
<td>2</td>
<td>0.10</td>
</tr>
<tr>
<td>Imputed cost ($)</td>
<td>1.25</td>
<td>187.00</td>
<td>14.20</td>
<td>16.50</td>
</tr>
</tbody>
</table>

Note:  
<sup>a</sup> Around 51% of Ross River virus victims reported disability. Five outliers were not included (50, 56, 60, 60 and 112 days)  
<sup>b</sup> Based on the total waiting time reported for health professional consultations  
All amounts are in 2002 Australian dollars.

Accordingly, the median cost of total waiting time for paid, unpaid and unemployed Ross River virus victims was estimated at $AUD 14 per victim (see Table 5.6). The estimated cost of waiting time per victim seems to be low since it covers only medical consultations. Ideally, it should have been the total waiting time and transport time of the victim for receiving all health care products and services such as pathology services and prescription and over-the-counter medicines.

In this analysis, the human capital approach was applied to estimate economic costs of lost productivity. It assumes that the monetary value of lost productivity is equivalent to average wage rate multiplied by lost productivity time. However, Ross River virus also affects victim’s leisure and social activities. These quantitative and qualitative time losses are not captured by the conventional human capital approach. Thus, some argue that indirect costs estimated by the human capital approach do not comprehensively reflect the relevant disease impacts (Pauly et al. 2002). In order to partially address these criticisms, time spent by those caring for Ross River virus victims was valued using average wage rates.<sup>73</sup>

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<sup>73</sup> Although there is no payment involved, the opportunity cost of the time sacrificed by informal caregivers needs to be taken into account.
5.2.2.3 Time by those caring for victims

Ross River virus victim’s caregiver time was measured directly by asking victims about the care and assistance they received during their disability period. According to the survey data, the majority of Ross River virus victims (51%) received some care and/or assistance. Most often, the spouse, family members and friends were the informal caregivers. The duration and type of care received varied a lot across the sample. For example, 36% received help for housekeeping, 28% received help for gardening, 28% received help for driving and/or shopping, 15% received help for personal care and 3% received help for childcare.

However, a small proportion of victims stated that disability caused by Ross River virus compelled them to use paid services for lawn mowing (6% of victims), housekeeping (4% of victims) and childcare (1% of victims) during their disability period.

These services were valued in order to help capture the full costs associated with Ross River virus. Hourly wage rates reported by the Australian Bureau of Statistics for these services were applied to value the approximate costs of caregiver’s time (ABS Catalogue No. 6302). For example, based on valid responses, the average number of hours of service used was multiplied by relevant hourly wage rate. Accordingly, the median cost of informal care (unpaid) was estimated at $AUD 146 per victim (see Table 5.7).

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Minimum (per person)</th>
<th>Maximum (per person)</th>
<th>Sample Median</th>
<th>Sample I-Q Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal care&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.00</td>
<td>1,757.00</td>
<td>146.00</td>
<td>1,212.00</td>
</tr>
</tbody>
</table>

Note: <sup>a</sup> Estimates based on the average of prevailing hourly wage rates for cleaning, housekeeping, personal care and childcare. All amounts are in 2002 Australian dollars.

<sup>74</sup> While caring Ross River virus victims they (informal care givers) sacrifice their precious time.
Direct and indirect costs, as described so far in this chapter, can be used to highlight the tangible impacts of Ross River virus in terms of the costs of society’s resources and lost production. Opportunity costs of lost productivity due to disability caused by Ross River virus contribute to a significant proportion of tangible impacts. For example, of the total direct and indirect costs, lost production accounts for about 60% (see Figure 5.4). Among resource costs, a large proportion of costs comprised of health care services. Figure 5.4 illustrates the percentage composition of direct (that is, costs of health care and non health care resources) and indirect costs (that is, the opportunity costs of lost production due to disability, waiting time and patient care) of Ross River virus.

**Figure 5.4** The composition of direct and indirect costs of Ross River virus per person $AUD 2002 (based on 2002 data)

![Pie chart showing the percentage composition of direct and indirect costs of Ross River virus per person $AUD 2002 (based on 2002 data).](image)

Although the opportunity costs of lost production contribute to around one-half of market-related costs, the economic implications of this form of costs are difficult to apprehend due to large variation in victims’ work status (paid and unpaid), occupation and industry of employment. In this context, a major interest of policy analysis is the extent to which Ross River virus impacts upon current demand for resources – specifically, health care products and services.

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75 That is indirect costs associated with the disease. Yet, in health care there is no general consensus about its inclusion in the total cost analysis.
5.3 Valuation of health care resource costs

Health care resource costs of Ross River virus from society’s viewpoint are comprised of all the medical expenses relating to health professional consultations, pathology services and medicines. Based on the survey data in this study, it is apparent that Ross River virus victims’ spending for health care products and services contribute to a significant proportion of disease costs. The valuation of health care costs is critical as this information can be used to quantify the burden of the disease upon the private and public health care systems. It is assumed that a range of factors, including a victim’s socio-demographic profile (such as age and gender), health state prior to infection, and the severity of viral illness all influence individual health care costs.\footnote{This may well be related to socio-demographic characteristics.}

This section aims to examine major socio-economic, demographic and other characteristics of the study participants and assess their influence upon individual health care costs. This information can be used to help explain health care cost variation across the sample. The selection of major descriptors for investigation (that is, the assumed major explanatory variables) was based on evidence from the health care literature, well-known management ‘facts’ about the disease, logical interpretation, and economic influences that have been established for this and related diseases in the past.

For example, there is considerable existing evidence that age and co-morbidity incidence is closely associated (WHO 2002). Furthermore, it is logical to deduce that the duration of illness may increase the use of health care products and services and underline a positive correlation between length of illness and health care costs. In addition, as health is considered as a form of a normal good, increased income should result in increased spending to improve individual health state. Hence, a positive relationship between victim’s income and health care spending is expected.
Accordingly, the following key sets of descriptors have been selected as appropriate variables for the analysis of health care costs of Ross River virus:

- socio-demographic profile (victim’s age, gender, marital status and income)
- health state (co-morbidity and standard health measures)
- disease severity, disease duration and disability period

5.3.1 Major explanatory variables

Major explanatory variables included nominal, ordinal, interval and ratio scaled measures. For example, victim’s gender, marital status and co-morbidity were recorded as nominal (categorical) variables while age, income group data and self-perceived disease severity data were recorded as ordinal (ranked) variables. In contrast, the remaining variables were measured on interval/ratio scales. Table 5.8 presents a list of major explanatory variables selected for the analysis of health care costs associated with Ross River virus.

The table provides a description of the selected variables including a description of the variable (and its variable name used for the statistical analyses), the scale of measurement, and the way they were recorded in the survey form. In order to facilitate data analysis, marital status responses were transformed into a dichotomous variable as (1) single (unmarried, separated, divorced and widowed) or (2) not single (de facto and married). Furthermore, in case of standard health measure, two summary measures (physical and mental health summaries) were used instead of eight health measures in Short Form 36.

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77 Age and income categories used in this study are similar to that of used by the Australian Bureau of Statistics.

78 Standard health measure (SF-36) was used in this research to assess the health-related quality of life impact of Ross River virus. A detailed discussion about state of health and its measurement using standard health measures are discussed in chapter 6.
Table 5.8    Description of major explanatory variables

<table>
<thead>
<tr>
<th>Variable (CODE)</th>
<th>Nature of variable</th>
<th>Recorded in the survey as</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (AGE)</td>
<td>Ordinal</td>
<td>Age group (18-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75+)</td>
</tr>
<tr>
<td>Co-morbidity (COM)</td>
<td>Nominal</td>
<td>Co-existence of two or more illnesses (yes/no)</td>
</tr>
<tr>
<td>Disease duration (LEN)</td>
<td>Interval</td>
<td>Approximate time of onset and recovery of illness (months)</td>
</tr>
<tr>
<td>Disease severity (SEV)</td>
<td>Ordinal</td>
<td>Self-perceived disease severity (very mild, mild, moderate, severe, very severe)</td>
</tr>
<tr>
<td>Disability period (DIS)</td>
<td>Ratio</td>
<td>Length of disability period (days)</td>
</tr>
<tr>
<td>Gender (GEN)</td>
<td>Nominal</td>
<td>Gender (male/female)</td>
</tr>
<tr>
<td>Income (INC)</td>
<td>Ordinal</td>
<td>Gross weekly income (&lt;$159, $160-299, $300-499, $500-699, $700-999,$1000-1499, $1500+)</td>
</tr>
<tr>
<td>Marital status (MST)</td>
<td>Nominal</td>
<td>Unmarried, separated, divorced, widowed, married, de facto</td>
</tr>
<tr>
<td>Standard health measure</td>
<td></td>
<td>SF-36 survey responses (Likert scaled)</td>
</tr>
<tr>
<td>Physical (PCS)</td>
<td>Interval</td>
<td>SF-36 survey responses (Likert scaled)</td>
</tr>
<tr>
<td>Standard health measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental (MCS)</td>
<td>Interval</td>
<td></td>
</tr>
</tbody>
</table>

5.3.2 Frequency distribution

For further analysis of the selected variables (that is, health care costs and major explanatory variables), it is imperative to examine their frequency distributions. Figure 5.5 presents frequency distributions for major explanatory variables. The frequency distribution for the dependent variable, health care costs, is illustrated in Figure 5.6. Observed values of the variable and the proportion of observations as a percentage of the total are depicted on the vertical (y) and horizontal (x) axes respectively.
Figure 5.5  Major explanatory variables and their frequency distributions for Ross River virus victims

a. Age (AGE)

b. Gender (GEN) and Marital status (MST)

c. Co-morbidity (COM)

d. Disease severity (SEV)

e. Disease duration (LEN)

f. Disability period (DIS)

g. Gross weekly income (INC)

h. Standard health measure (PCS/MCS)
A large proportion of both male and female victims indicated that they were either married or in de facto relationships (see Figure 5.5b). In addition, 55 Ross River virus victims reported coexisting illness – co-morbidity (see Figure 5.5c). The Shapiro-Wilk test of normality has shown that age, disease severity, disease duration, income, standard health measure and disability period frequency distributions do not appear to be normal. This suggests that the median and I-Q Range (inter-quartile-range) are appropriate co-descriptors to describe the summary data.

A large proportion of Ross River virus victims experienced a relatively short disability period (less than six days) and incurred health care costs less than $650. There were no victims without health care costs in the study group as, at minimum, every Ross River virus victim consulted a general practitioner and submitted a blood test at least once. The Shapiro-Wilk test of normality has shown statistically significant results for health care cost (0.733, df=199, p<0.001). Having examined frequency distributions, we can now move to the critical investigation of independence and correlations amongst selected variables and full social costs of the disease.

Figure 5.6 Health care cost distribution for Ross River virus victims (HCC)

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Shapiro-Wilk test of normality: AGE (0.935, df=194, p<0.001); SEV (0.878, df=194, p<0.001); LEN (0.954, df=181, p<0.001); INC (0.894, df=190, p<0.001); PCS (0.959, df=199, p<0.001); MCS (.979, df=199, p<0.004).
5.3.3 Bivariate statistical analysis

The correlation analyses between selected variables (including both major explanatory variables and health care costs) were aimed at measuring strength, direction of association and the statistical significance of observed relationships. This information (that is, variable independence, and strength, direction and statistical significance of their associations) can be used to test the quality and reliability of the survey data and variables and is the main approach used to identify key links between health care costs and disease incidence traits. This helps to substantiate their consistency with current knowledge, understanding and theory. Furthermore, the outcome of independence and correlation tests provides a basis for further application of quantitative methods such as the age by gender to see if such characteristics can help improve the estimation or prediction of health care costs.

The majority of variables were measured on either a nominal or ordinal scale (except disease duration, disability period and standard health measures). Moreover, the moderate size of the study group (N=201) and the inadequate number of observations for some variables were considered in selecting appropriate statistical techniques. Although there was a risk of losing information (due to transformation of data from interval/ratio scales to ordinal/nominal scales), non-parametric techniques such as the chi-square test of independence and Spearman’s rank order correlation index were considered appropriate to test the strength of association between key variables.

The chi-square test statistic tests whether there are relationships between selected major variables in the entire population of Ross River virus victims from which current group was drawn. The results of the chi-square test of independence have shown that many variables are not independent of each other (the null hypothesis $H_0$ is rejected at 1% or 5%). Thus the relationships found in the Ross River virus sample were unlikely to have occurred by chance. The following section presents a summary outcome of the chi-square tests including
variables and their relatedness. However, the reader should take note of that only significant test results are reported here.  

**Age and presence of co-morbidity**

The survey data support the claim that there is a close link between age and co-morbidity. According to Table 5.9a, a large proportion of the Ross River virus sample reported no co-morbidity (73% of the total). The majority of them are in 18-34, 35-44 and 45-54 age groups. In contrast, the presence of co-morbidity is relatively high among victims aged over 55 years. Survey data presented in Table 5.9a show a positive trend between Ross River virus victim’s age and co-morbidity. These findings are supported by chi-square test results. That is, Ross River virus survey data have enough evidence to support the claim that age and the presence of co-morbidity are related (see Table 5.9a).

**Table 5.9a  Presence of co-morbidity by age group**

<table>
<thead>
<tr>
<th>Co-morbidity</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18-34</td>
</tr>
<tr>
<td>No</td>
<td>32 (91%)</td>
</tr>
<tr>
<td>Yes</td>
<td>3 (9%)</td>
</tr>
<tr>
<td>Total</td>
<td>35 (100%)</td>
</tr>
</tbody>
</table>

N = 201  
χ² = 17.8; d.f. = 3; p<0.001

**Age and physical health (PCS)**

According to the ABS (1995), ageing is one of the major contributing factors for the deterioration of physical health. Thus, survey data were examined to find evidence to substantiate this claim. Table 5.9b presents frequencies of measured health state by age group. A large proportion of victims in 18-34 aged group ranked their physical health was high in contrast to a large proportion of victims over 55 age group. The majority of victims in 35-44 and 45-54 age groups reported a moderate physical health.

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80 Chi-square test results that are vital interpreting the survey outcome.
Age and health state data in Table 5.9b show a negative relationship. The chi-square test result provides sufficient evidence to show that ageing and deterioration in physical health are closely linked.

Table 5.9b  Measured physical health (PCS) by age group

<table>
<thead>
<tr>
<th>Physical health (PCS)</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18-34</td>
</tr>
<tr>
<td>Very low</td>
<td>4 (11%)</td>
</tr>
<tr>
<td>Low</td>
<td>5 (14%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>4 (11%)</td>
</tr>
<tr>
<td>High</td>
<td>13 (37%)</td>
</tr>
<tr>
<td>Very high</td>
<td>9 (26%)</td>
</tr>
<tr>
<td>Total</td>
<td>35 (100%)</td>
</tr>
</tbody>
</table>

N = 201
$\chi^2 = 28.4$; d.f. = 12; p<0.01

Age and gross income

A relationship is expected between victim age and gross income since it is assumed that as age increases, people possess more skills and experience and hence increase their potential earning capacity. Table 5.9c presents the survey proportions of reported income by age group. A large proportion of victims reporting low income was in over 55 age group. On the contrary, a considerable number of victims earning relatively high income were in 18-34, 35-44 and 45-54 age groups.

Table 5.9c  Stated gross income by age group

<table>
<thead>
<tr>
<th>Income (S$000)</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18-34</td>
</tr>
<tr>
<td>&lt;11.9</td>
<td>9 (29%)</td>
</tr>
<tr>
<td>12.0-20.8</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>20.9-31.2</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>31.3-44.2</td>
<td>9 (29%)</td>
</tr>
<tr>
<td>44.3&lt;</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Total</td>
<td>31 (100%)</td>
</tr>
</tbody>
</table>

N = 190
$\chi^2 = 35.1$; d.f. = 12; p<0.001
However, a different trend (negative) is observed in survey data. This may be due to the large representation of low income victims in over 55 age group (for example, retirees and pensioners). Despite the different trend observed in survey data, chi-square test shows that survey results provide enough evidence to support a relationship between age and income (see Table 5.9c).

**Physical health (PCS) and co-morbidity**

It is logically correct to assume that Ross River virus victims reporting co-morbidity also report a lower physical health (PCS) than their counterparts. This was examined in the survey data. Table 5.9d shows survey proportions of measured physical health by co-morbidity. A large proportion of co-morbid victims reported a low physical health (58%) while a similar proportion of non co-morbids experience a moderate to high physical health (68%). According to Table 5.9d, there is a negative trend between co-morbidity and physical health (PCS). Chi-square test revealed that survey data produce enough evidence to substantiate the assumption co-morbidity and physical health (PCS) is related (see Table 5.9d).

**Table 5.9d** Measured physical health (PCS) by co-morbidity

<table>
<thead>
<tr>
<th>Physical health (PCS)</th>
<th>Co-morbidity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Very low</td>
<td>25 (17%)</td>
<td>15 (27%)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>22 (15%)</td>
<td>17 (31%)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>35 (24%)</td>
<td>7 (13%)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>33 (23%)</td>
<td>7 (13%)</td>
<td></td>
</tr>
<tr>
<td>Very high</td>
<td>31 (21%)</td>
<td>9 (16%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>146 (100%)</td>
<td>55 (100%)</td>
<td></td>
</tr>
</tbody>
</table>

N = 201
χ² = 12.1; d.f. = 4; p<0.01

**Disease duration and co-morbidity**

There is a general perception that some disease symptoms would persist for a long period in the victim. However, this claim has been disputed by several recent studies. For example, Harley *et al.* (2001) and Mylonas *et al.* (2002) have reported that disease duration is influenced by the presence of co-morbidity in
Ross River virus victims. Therefore, survey data were tested to see if this relationship holds in the study sample.

Table 5.9e presents disease duration data by reported co-morbidity. A significant proportion of Ross River virus victims without co-morbidity (73%) recovered within six months. Conversely, a large proportion of co-morbidity victims (81%) reported a longer recovery time spanning more than six months. These proportions show a positive trend between disease duration and the presence of co-morbidity. The chi-square test result revealed ample evidence to support the claim that co-morbidity and disease duration is related (see Table 5.9e).

<table>
<thead>
<tr>
<th>Disease duration (months)</th>
<th>Co-morbidity No</th>
<th>Co-morbidity Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>32 (25%)</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>3 - 4</td>
<td>30 (23%)</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>5 - 6</td>
<td>32 (25%)</td>
<td>4 (8%)</td>
</tr>
<tr>
<td>7 - 9</td>
<td>31 (24%)</td>
<td>16 (31%)</td>
</tr>
<tr>
<td>9 or over</td>
<td>3 (2%)</td>
<td>26 (50%)</td>
</tr>
<tr>
<td>Total</td>
<td>128 (100%)</td>
<td>52 (100%)</td>
</tr>
</tbody>
</table>

N = 180
$\chi^2 = 71.6$; d.f. = 4; p<0.000

Physical health (PCS) and disease severity

Ross River virus is widely known for its debilitating and persistent symptoms. Therefore, it is expected that severe disease conditions may affect the victim’s physical health (PCS). That is, the higher the perceived disease severity, the lower the measured physical health. Survey results show that a large proportion of victims (75%) with very mild to mild disease severity report a relatively high physical health. In contrast, lower physical health were observed in victims who suffered from a severe disease condition. Accordingly, the survey data show a negative trend between physical health and disease severity.
The chi-square test results provide sufficient evidence to claim that a victim’s physical health (PCS) and disease severity are related (see Table 5.9f).

### Table 5.9f  Physical health (PCS) by disease severity

<table>
<thead>
<tr>
<th>Physical health (PCS)</th>
<th>Disease severity</th>
<th>Very mild to Mild</th>
<th>Moderate</th>
<th>Severe to Very severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td></td>
<td>2 (7%)</td>
<td>12 (14%)</td>
<td>25 (29%)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>3 (11%)</td>
<td>15 (17%)</td>
<td>21 (24%)</td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td>2 (7%)</td>
<td>13 (15%)</td>
<td>27 (31%)</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>6 (21%)</td>
<td>29 (34%)</td>
<td>6 (7%)</td>
</tr>
<tr>
<td>Very high</td>
<td></td>
<td>15 (54%)</td>
<td>17 (20%)</td>
<td>8 (9%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>28 (100%)</td>
<td>86 (100%)</td>
<td>87 (100%)</td>
</tr>
</tbody>
</table>

N = 201
\( \chi^2 = 54.1; \text{ d.f.} = 8; \text{ p<0.000} \)

### Disease severity and disability period

It is logical to assume that victims who suffer from severe disease symptoms also experience a longer disability period. Survey data revealed that around 71% of victims suffered from very mild to mild disease condition and hence experienced a shorter disability period (for example, less than two days). On the other hand, victims who reported severe to very severe illness reported a longer disability period. Thus, there exists a positive relationship between disease severity and disability period. Chi-square test was applied to test the validity of this supposition. According to test results, there is enough evidence to support this supposition disease severity and disability period are associated (see Table 5.9g).

### Table 5.9g  Reported disability period by disease severity

<table>
<thead>
<tr>
<th>Disability (days)</th>
<th>Disease severity</th>
<th>Very mild to Mild</th>
<th>Moderate</th>
<th>Severe to Very severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 2</td>
<td></td>
<td>17 (71%)</td>
<td>58 (67%)</td>
<td>24 (28%)</td>
</tr>
<tr>
<td>3 – 6</td>
<td></td>
<td>3 (13%)</td>
<td>19 (22%)</td>
<td>27 (32%)</td>
</tr>
<tr>
<td>7 or over</td>
<td></td>
<td>4 (17%)</td>
<td>10 (11%)</td>
<td>34 (40%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>25 (100%)</td>
<td>87 (100%)</td>
<td>85 (100%)</td>
</tr>
</tbody>
</table>

N = 197
\( \chi^2 = 33.2; \text{ d.f.} = 4; \text{ p<0.000} \)
Disease severity and health care cost

This chapter reports that the frequency of health professional consultation is high for Ross River virus victims reporting severe disease symptoms (see Figure 5.1). Therefore, it is postulated that disease severity and health care costs are related, with increased severity leading to increased health care costs. This was examined using survey data summarised in Table 5.9h. A large percentage of victims (84%) with very mild to mild severity spent less than $AUD 290 for medical treatment. In contrast, considerably large amounts were spent by victims who suffered from a severe to a very severe disease condition. Survey data revealed a positive trend between disease severity and health care costs. The chi-square test result supports the above postulation that disease severity and health care costs are related (see Table 5.9h).

Table 5.9h  Disease severity and health care costs

<table>
<thead>
<tr>
<th>Health care cost ($)</th>
<th>Disease severity</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very mild to Mild</td>
<td>Moderate</td>
<td>Severe to Very severe</td>
<td></td>
</tr>
<tr>
<td>&lt;200</td>
<td>11 (44%)</td>
<td>30 (34%)</td>
<td>9 (10%)</td>
<td></td>
</tr>
<tr>
<td>201 – 290</td>
<td>10 (40%)</td>
<td>23 (26%)</td>
<td>16 (18%)</td>
<td></td>
</tr>
<tr>
<td>291 – 450</td>
<td>2 (8%)</td>
<td>21 (24%)</td>
<td>27 (31%)</td>
<td></td>
</tr>
<tr>
<td>451 or over</td>
<td>2 (8%)</td>
<td>13 (15%)</td>
<td>35 (40%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>25 (100%)</td>
<td>87 (100%)</td>
<td>87 (100%)</td>
<td></td>
</tr>
</tbody>
</table>

N = 199  
$\chi^2 = 36.6$; d.f. = 6; p<0.000

Gross income and health care costs

From an economic viewpoint, it is assumed that a victim’s health care cost is related to his or her income, as ability to spend on health care is dependent on his or her level of income. Table 5.9i presents the survey proportions by income and health care costs. Around 66% of victims with annual income exceeding $44,000 spent over $291 for health care services. Yet, around half of low-income earners (that is, less than $11,900) spent less than $200 for medical treatment.
There is no clear trend of health care spending by the remaining income groups (that may due to market distortions such as public health care benefits and health insurance). According to the chi-square test, there is enough evidence to claim that income and health care costs are related (see Table 5.9i).

Table 5.9i  Level of income and health care costs

<table>
<thead>
<tr>
<th>Health care cost ($)</th>
<th>Income ($)</th>
<th>&lt;11.9</th>
<th>12.0-20.8</th>
<th>20.9-31.2</th>
<th>31.2-44.2</th>
<th>44.3&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;200</td>
<td></td>
<td>22 (43%)</td>
<td>8 (25%)</td>
<td>5 (14%)</td>
<td>6 (15%)</td>
<td>5 (16%)</td>
</tr>
<tr>
<td>201 – 290</td>
<td></td>
<td>12 (24%)</td>
<td>4 (13%)</td>
<td>11 (31%)</td>
<td>13 (33%)</td>
<td>6 (19%)</td>
</tr>
<tr>
<td>291 – 450</td>
<td></td>
<td>10 (20%)</td>
<td>7 (22%)</td>
<td>10 (29%)</td>
<td>10 (26%)</td>
<td>12 (38%)</td>
</tr>
<tr>
<td>451 or over</td>
<td></td>
<td>7 (14%)</td>
<td>13 (41%)</td>
<td>9 (26%)</td>
<td>10 (26%)</td>
<td>9 (28%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>51 (100%)</td>
<td>32 (100%)</td>
<td>35 (100%)</td>
<td>39 (100%)</td>
<td>32 (100%)</td>
</tr>
</tbody>
</table>

N = 189  
χ² = 23.9; d.f. = 12; p<0.05

The outcomes of the chi-square tests between major explanatory variables and health care costs provide some valuable insight about variable associations and the potential influences upon health care costs associated with Ross River virus. This facilitates the next stage of disease cost analysis. For example, the analysis of health care costs and co-morbidity data revealed that there is not sufficient evidence to support the claim that health care cost is influenced by the presence of co-morbidity. These results imply that it is safe to use health care cost estimates for the entire group in further analysis (that is, in order to analyse health care costs, there is no need to separate Ross River virus victims into those with co-morbidity and without co-morbidity).

5.3.3.1 Correlation analyses

The chi-square tests of independence discussed in this chapter have examined whether the variables are related and hence valid to project study group observations to the whole Ross River virus population. However, it is also important to measure the strength and direction of observed relationship between

---

81 Test statistic for health care costs and co-morbidity: χ² = (7, N=199) = 13.3, p=0.066.
these variables. Accordingly, Spearman’s rank order correlation test was applied to assess the strength and direction of association between appropriate variables (ordinal). The outcome of the correlation analyses presented in this section can be used to identify strength and direction of association between major explanatory variables and health care costs that have a statistically significant influence upon victim’s health care costs. The summary outcome of correlation analyses is presented in Table 5.10.

Table 5.10 Summary of correlation analyses: strength, direction and statistical significance (Spearman’s rho)

<table>
<thead>
<tr>
<th>Variable</th>
<th>AGE</th>
<th>DIS</th>
<th>HCC</th>
<th>INC</th>
<th>LEN</th>
<th>MCS</th>
<th>PCS</th>
<th>SEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIS</td>
<td>−0.11</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCC</td>
<td>−0.01</td>
<td>0.33</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INC</td>
<td>−0.17</td>
<td>0.18</td>
<td>0.21</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEN</td>
<td>0.16</td>
<td>0.04</td>
<td>0.15</td>
<td>−0.04</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCS</td>
<td>−0.11</td>
<td>−0.19</td>
<td>−0.11</td>
<td>0.10</td>
<td>−0.09</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCS</td>
<td>−0.22</td>
<td>−0.21</td>
<td>−0.26</td>
<td>0.07</td>
<td>−0.18</td>
<td>0.05</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>SEV</td>
<td>0.11</td>
<td>0.38</td>
<td>0.48</td>
<td>0.01</td>
<td>0.19</td>
<td>−0.30</td>
<td>−0.42</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Median 49.0 5.0 293 31.2 5.8 41.9 34.5 ---
I-Q Range 20.0 3.0 274 32.3 3.2 14.3 15.0 ---

Note: Key to variable code
AGE – Age (years) DIS – Disability period (days) HCC – Health care costs (S AUD)
INC – Gross income (S AUD 000) LEN – Disease duration (months) MCS – Health state (mental)
PCS – Health state (physical) SEV – Disease severity
(Statistical significance: * P < 0.05; ** P < 0.01; *** P < 0.001)

The most significant relationships with health care costs were found with disease severity (+ve), disability period (+ve), gross income (+ve), disease duration (+ve), health state-physical (-ve) and health state-mental (-ve). The strength of associations in the correlation analysis varies from very weak to modest (see Table 5.10). Observed direction of associations (+ve and -ve) between variables provides evidence of the quality of the survey data and hence more confident use of these indicators for accurate disease cost estimations. 82

82 Strengths were assessed based on the magnitude of correlation: very weak 0 – 0.20; weak 0.21 – 0.40; modest 0.41 – 0.60; strong 0.61 – 0.80; very strong 0.81+ (Pfeifer 2000).
For example, negative associations are expected between disease severity and health state measures. Bivariate correlation analysis revealed statistically significant modest to weak relationships between disease severity and two health measures (–0.42 and –0.30). Although weak, a significant correlation is reported between income and health care costs (0.21). However, a couple of the estimated correlation indices are inconsistent with the expected direction. For example, a significant negative correlation is reported between age and income variable (–0.17). This negative association may be due to a large proportion of low-income cases in the over 55 age group (see Table 5.9c). The following section presents a further discussion of selected bivariate correlations justifying the use of survey data for accurate disease cost estimation of Ross River virus.

**Disease severity and health care costs**

A significant positive correlation (0.48, p<0.001) is reported between disease severity and health care costs (see Table 5.10). This implies that disease severity is one of the major variables affecting the magnitude of health care costs. However, the absence of accepted criteria to assess disease severity is a major concern. For example, in this research, disease severity was measured using a Likert-scaled question and hence survey responses were determined solely by individual perception about the severity of the illness.

**Disease severity and standard health measures**

Negative associations are expected between standard health measures (PCS and MCS) and disease severity as poor physical and mental states of health (that is, lower health measures) should reflect disease severity. This, in turn, would tend to result in longer disability, recovery periods and high treatment costs. Statistically significant negative associations (-0.42 and -0.30, p<0.001) were observed between disease severity and the PCS and MCS (see Table 5.10).
Disease severity and disability

A significant positive correlation (0.38, p<0.001) has been found between disease severity and disability. Thus supports the general proposition that severe disease symptoms have considerable impact upon the victim’s ability to engage in productive work.

Gross income and health care cost

A significant and positive correlation between income and health care costs (0.21, p<0.01) provides evidence that victims earning a higher income also spend greater amounts for health care products and services. The weak association may be due to distorted health care expenditures (for example, many health care costs are covered by the public health care system and/or health insurance).

According to the bivariate correlations, it appears that health care cost of Ross River virus are linked to disease severity, disability, health state, income and disease duration. Therefore, empirical methods can be applied to estimate health care costs of the virus. However, a major impediment is the absence of established guidelines and valid instruments to measure these variables. For example, in this thesis, disease severity was measured using a simple Likert scale (constructed by the researchers) while an industry standard self-administered quality of life health survey was used to measure victim’s state of health. In addition, disease duration and disability period were calculated based solely on the responses of the sample respondents. These measures are highly subjective and survey responses depend on the victim’s perception about the illness and personal circumstances.

On the other hand, a victim’s income appears as a valid predictor of health care costs. However, this information is not available in the Queensland Health Ross River virus database and such information is subject to privacy issues and individual consent requirement to release information for disease cost estimation.
Therefore, the findings of the correlation analyses have limited use in terms of health care cost estimation.

### 5.4 Disease costs analyses by age and gender

Due primarily to their data availability in conventional Ross River virus records, the costs of health care resources and lost productivity were analysed in terms of age and gender characteristics of the Ross River virus victims. It is postulated that there would be significant differences in health care and lost productivity costs between age and gender groups.

Age and gender groups were formed so that a sufficient number of observations were included in each group. Accordingly, eight age-gender groups were identified: female and male victims of 18-34; 35-44; 45-54 and over 55 year age groups. The median health care costs of Ross River virus varied between $AUD 250 (female victims aged 18-34 years) and $AUD 381 (female victims aged 45-54 years). Although no trend or pattern was observed in health care costs, in general, male victims reported a higher cost than their counterparts (except victims of 45-54 age group). On the other hand, the median costs of lost productivity ranged between $AUD 335 and $AUD 878. Table 5.11 presents the median costs by age-gender group.

### Table 5.11 Median disease costs by age and gender group

<table>
<thead>
<tr>
<th>Age-Gender group&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Number in group</th>
<th>Health care costs ($)</th>
<th>Lost productivity ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F 18-34</td>
<td>23</td>
<td>250</td>
<td>878</td>
</tr>
<tr>
<td>M 18-34</td>
<td>12</td>
<td>267</td>
<td>527</td>
</tr>
<tr>
<td>F 35-44</td>
<td>34</td>
<td>287</td>
<td>351</td>
</tr>
<tr>
<td>M 35-44</td>
<td>21</td>
<td>350</td>
<td>702</td>
</tr>
<tr>
<td>F 45-54</td>
<td>26</td>
<td>381</td>
<td>527</td>
</tr>
<tr>
<td>M 45-54</td>
<td>24</td>
<td>284</td>
<td>351</td>
</tr>
<tr>
<td>F 55+</td>
<td>28</td>
<td>266</td>
<td>335</td>
</tr>
<tr>
<td>M 55+</td>
<td>31</td>
<td>280</td>
<td>351</td>
</tr>
</tbody>
</table>

Note:

<sup>a</sup> Gender: F = Female; M= Male
N: Number of observations in the group
All amounts in 2002 Australian dollars
A non-parametric Kruskal-Wallis analysis of variance (ANOVA) was applied separately to each of these cost estimates to assess whether there were statistically significant differences between age-gender groups. In terms of health care costs, no significant difference was found between the different age-gender groups ($H (7, n=199) = 7.90, p>0.05$). Furthermore, a focus on just the values of lost production revealed similar results; that is, no significant difference between age-gender groups ($H (7, n=197) = 3.82, p>0.05$).\(^83\)

Thus, these results suggest that differences in age-gender composition of Ross River virus victims do not appear to influence median costs of health care and lost productivity. Accordingly, the median health care and lost productivity costs of Ross River virus based on all Ross River virus notifications were adopted as the main estimates for this research. These values were $\text{AUD} 293$ and $\text{AUD} 527$ per person respectively.\(^84\) This information can be used to identify the full social costs of Ross River virus (including health care and lost productivity cost components) for all local government areas.

### 5.5 Summary and conclusion

The valuation of direct and indirect costs associated with Ross River virus is vital to highlight disease burden from society’s viewpoint. The valuation exercise completed here has been based on Ross River virus survey data where direct and indirect costs were quantified using market information. The tasks were performed by identifying treatment-related health care, non-health care and lost productivity costs. Further analyses were conducted to identify variable independence and the statistical significance of apparent associations so as to understand the influence of key factors on disease costs and its variation across the sample. Given the methodological and empirical limitations of the study, attempted average per capita disease cost estimate was based on victim’s age and gender characteristics.

\(^83\) $H$ is the observed Kruskal-Wallis test value (Morgan, Reichert and Harrison 2002).

\(^84\) Valuation of these costs (health care and lost productivity) have been described in sections 5.2.1.1 and 5.2.2.1 of this chapter.
According to the survey data, around 28% of the total costs of Ross River virus can be attributed to health care resources alone. These resources included health professional consultations (general, specialist and alternative health practitioners), pathology services and medicines. The analysis revealed that a large proportion of Ross River virus victims, 57%, used the public health care system for medical treatment (that is, Medicare and Pharmaceutical Benefit Scheme).

In terms of indirect costs, 49% of the surveyed victims reported disability (as defined in this study) due to Ross River virus. The average length of disability reported by the victim is five days. In general, employed people reported a longer disability period averaging seven days. Several occupational groups such as tradespersons, transport workers and labourers reported longer disability periods in comparison to other occupations. A large proportion of Ross River virus victims were in occupations in which work is often performed outdoors. Although information collected in the Ross River virus survey cannot link to the locational aspects, there is a high probability of a link between occupation and the risks of contracting Ross River virus.

The chi-square tests and bivariate correlation analyses suggests that the survey results are reliable and are of good quality and confirm the relevance of their use in the disease cost estimations. For example, statistically significant modest correlations were observed between disease severity and standard health measures, and disease severity and health care costs. A further analysis of health care and lost productivity costs by victim age and gender was conducted. A non-parametric Kruskal-Wallis analysis revealed that there were no statistically significant differences in these costs across age-gender groups. Accordingly, the median health care and lost productivity costs of Ross River virus were estimated at $AUD 293 and $AUD 527 per person. This information will provide the basis for the full social cost estimates for geopolitical units in Chapter seven.
CHAPTER 6  RESULTS AND ANALYSIS II: VALUATION OF HEALTH-RELATED QUALITY OF LIFE IMPACT – A NON-MARKET APPROACH

6.1 Introduction

The cost-of-illness method, the most common methodology used to value disease impacts, considers costs only in the form of health care resources and lost productivity. It does not take into account less tangible (often rather subjective) impacts such as the health-related quality of life and well-being of individuals. These intangible impacts are typically neglected in all disease-costing studies (Johannesson and Jonsson 1991; Chestnut et al. 1996). Their failure to be included can be attributed to the difficulties and absence of established guidelines on how to measure and assign economic values to health-related disease impacts.

Despite these barriers, it is clear that diseases with chronic symptoms, such as rheumatoid arthritis, chronic fatigue syndrome and depression, do have significant negative impacts on health-related quality of life (Schultz and Kopec 2003). Therefore, neglecting these impacts in disease cost valuation will lead to an underestimation of the full social costs of disease. This is a major problem in assessing the benefits of environmental health interventions such as mosquito control and management programs which are aimed at improving social welfare by the cost-effective reduction of nuisance levels and disease risks. Due to incomplete valuation, intervention programs may appear less economically beneficial than they are in reality – thus creating concern over whether scarce resources are being utilised appropriately at the local level. This is especially true for diseases, which may only have limited or relatively “cheap” medical treatments but generate very profound social and economic costs (such as viral and mental illnesses). In this context, complete information on full disease costs is vital to highlight the true

85 Such as fear, pain, suffering, fatigue, lost leisure and limited social functioning.
extent of the impact of Ross River virus and to allow policy makers to recognise and prioritise resource use for local intervention programs.

Non-market valuation techniques such as contingent valuation, hedonic pricing and the travel cost method are being widely used in environmental and transport economics. However, their application to the health care sector is limited and is still at an experimental stage, despite the fact that the existing literature strongly supports development of coherent cost valuation guidelines and methodologies that can effectively capture total disease impacts (for example, see O’Brien and Viramontes 1994; Klose 1999). These developments are necessary to facilitate economic evaluation of existing environmental health intervention programs and accurate identification of the net benefits of alternative program options (O’Brien and Gafni 1996; Smith 2000).

This chapter presents the findings of aspects of the research project specifically designed to assess the health-related quality of life impacts of Ross River virus in Queensland. In the study, a standard health-related quality of life measure was used to assess each Ross River virus victim’s state of health. This measure also assists in establishing and verifying other results about the impact of Ross River virus upon physical, mental and social functioning. In parallel, hypothetical willingness-to-pay questions have been used to elicit maximum amounts that individuals were willing to pay to avoid the discomfort, inconvenience and deterioration in health experienced (and measured in the quality of life data) as a result of contracting the virus.\footnote{Either WTP or WTA question can be used to measure the overall health impact in monetary terms. However, WTA amounts are difficult to elicit since the value an individual states is not bound by personal income.}

The first part of the chapter describes how each victim’s state of health was assessed using a standard health measure – the SF-36 survey. The standard health measures at disease onset and after six months were used to assess the disease
impact and health deterioration: (1) the differential impact of increased co-morbidity on quality of life impacts from Ross River virus victims reporting co-morbidity from their counterparts and (2) health-related quality of life impact of Ross River virus on surveyed victims.

The outcome of the bivariate statistical analyses between major explanatory variables, health care costs and willingness-to-pay are discussed in the second part of the chapter. However, only important significant results are presented in this section (for example, major variables that have significant influence upon WTP).

In general, it is important to assess the validity and reliability of willingness-to-pay estimates before interpreting them (Hoevenagel 1994). Although the reliability test of the willingness-to-pay valuation was not conducted in this study (for example, a sample of victims would be asked to respond to the same question at two different times), the outcome of correlation analyses can be used to check the content and construct validity of the hypothetical question. For example, a significant positive correlation is expected between a victim’s income and willingness-to-pay. Results of the willingness-to-pay analysis by victim’s age and gender group are presented in the final part of the chapter.

6.2 Quality of life and state of health

The concept of quality-of-life is broad and should cover all aspects of an individual’s existence. For example, quality-of-life encompasses health as well as economic, political, cultural, environmental and aesthetic factors. Health-related quality of life is a subset of total quality of life. The definition of quality of life in the health context is vague (O’Connor 1993). This is due to a wide and diverse range of concepts, used to describe health and quality of life, such as health status, functional status and disability status (Deyo and Patrick 1989). In this context, there seems to be a general acceptance that health-related quality of life is a multi-
dimensional concept encompassing physical, mental and social components (Revicki 1989). 87

Physical health refers to the lack of physical disabilities such as incapacity (unable to perform daily tasks such as personal care and housework) while mental health pertains to mental disabilities such as depression. Social functioning reflects the impact of illness upon the victim’s social activities and interaction. In this study, the selection and inclusion of appropriate aspects of each of these dimensions has been central to the validity of the measures used to assess health-related impacts. The use of a holistic measure to rank individuals’ state of health in terms of physical, mental and social functioning is a significant part of assessing the overall impact of Ross River virus.

6.2.1 Measuring state of health

Despite the absence of a universally accepted state of health measure, there are a range of instruments that have been developed to measure and indicate overall state of health. Although there are some concerns about their credibility, these measures can be used to attempt to compare individuals’ health in relative terms (Stewart, Hays and Ware 1988; Tengs and Wallace 2000). For this reason, state of health measures have become popular, among clinical researchers, as relative measures providing useful information about the effectiveness of health care interventions (Brazier, Harper, Jones, O’Cathain, Thomas, Usherwood and Westlake 1992).

A wide range of health-state measures have been developed and used over time to evaluate changes in health-related quality of life. These measures include the Quality of Well-Being scale (QWB), the Nottingham Health Profile, the Euro

87 However, there is less agreement over which precise dimensions need to be included to measure health-related quality of life. For example, some argue that physical and mental functioning together constitute health-related quality of life while others disagree, arguing for the inclusion of a social dimension (Torrance 1987; Kaplan and Anderson 1988).
Quality of life index (EuroQol EQ-5D) and the Medical Outcome Study Short Form 36 (SF-36). In general, these instruments assess overall health by considering a range of physical and mental (psychometric) factors as the basis for formulating a health-state measure.

For example, SF-36 places the objective and subjective components of health along a continuum of functional health status which is then transformed into a summary score indicating different levels of health (Torrance 1986). The items included by this instrument have been developed through a long process involving literature reviews, psychometric testing, and elements of researcher intuition (Stewart and Ware 1992). Generally, these scores give a quantitative measure of relative health ranging from perfect health to death.

6.2.2 Validity and reliability

Although health state measures offer conceptually appealing results, some argue that there are problems regarding their validity, reliability and stability (Palmer, Byford and Raftery 1998). Central issues relate to the degree to which instruments measure what they are supposed to measure (validity), the degree to which instruments can produce consistent results on different occasions (reliability), and the ability to detect health-related changes over time (stability) (Torrance 1986; Mehrez and Gafni 1989; Johnson, Fries and Banzhaf 1997). Another major concern is whether health aspects included by these measuring instruments adequately describe health-related quality of life, as most instruments focus on physical functioning and emotional well-being at the partial neglect of social functioning and interaction (Brazier et al. 1992).

Despite these concerns, health care researchers use these measures to assess and compare overall state of health before, and after, intervention programs. Among these measures, the “Short Form 36” (SF-36) has become the most widely used.
The popularity of the SF-36 health measure has arisen because of its easier data collection aspect (for example, self-administered survey), international acceptance and reported effectiveness. Further, it has been found to achieve sufficient levels of internal consistency, re-test reliability and construct validity (Brazier et al. 1992; Jenkinson, Coulter and Wright 1993).

When compared with other health measures such as EuroQol and Nottingham Health Profile, SF-36 was found to be more sensitive in detecting low levels of change in perceived health status (Brazier et al. 1992). In addition, a large number of countries including Australia, Germany, the US and UK have established their own population norms for SF-36, thus facilitating health comparisons across different groups within the general population.

6.2.3 Short Form – 36 (standard health measure)

The Short Form - 36 is a self-administered health survey designed to measure health by assessing physical, mental and social functioning. It was derived from a larger set of questions used in the Medical Outcomes Study in the US in the 1980s. The instrument measures eight health attributes such as physical functioning, role limitation, bodily pain, vitality and mental health using multi-item scales containing two to 10 items each. These scales are scored using the Likert method. It assumes that each item has a linear relationship with the score for its scale. In addition, two summary measures – Physical Component Summary (PCS) and Mental Component Summary (MCS) – can be derived from the results of SF-36. These summary measures are useful as they are aggregates of the eight scores derived through principal component factor analysis.

The calculation of PCS and MCS involved three steps. First, the eight SF-36 health measures were standardised using a Z-score transformation and means and

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88 SF-36 survey form contains 36 questions relating to physical, mental and social health dimensions.
standard deviations from the general population. Second, the Z-scores were aggregated using factor score coefficients from the general population as weights. Finally, the aggregated summary scores were transformed to component scores (that is, physical and mental) with a mean of 50 and a standard deviation of 10 the same as for the Australian population. The aim of this process is to produce two summary scales from the original eight scales without substantial loss of information.

Short Form – 36 can be used to measure impacts of either acute or chronic illnesses. The acute version of SF-36 aims to collect information about a respondent’s health and well-being in the immediate past week (one week recall) while the standard version, better used for measuring impacts of chronic illness, collects information about the immediate past four weeks (four week recall). Because of these appealing characteristics SF-36 has become one of the most widely applied measures of health in the US and UK (Brazier et al 1992). In the case of Ross River virus, the standard version (four week recall) was used to collect health-related quality of life impact information.

The eight health dimensions measured in SF-36 include:

- **Physical functioning** - indicates the extent to which, on a typical day, a person is limited by their health in performing a range of physical activities, including bathing and dressing;
- **Role limitation** - indicates the effects of physical health on a person’s performance of their work or other daily activities; that is, whether a person is limited in the kind of work or activities they were able to do, reduced the time spent on those activities, or had difficulty in performing those activities due to physical problems;
- **Bodily pain** - indicates the severity of pain experienced and the extent to which it had interfered with normal activities during a typical day;
- **General health** - combines self-assessed health status with indicators of current expectations and perceptions of health relative to the health of others;
- **Vitality** - indicates a person’s energy level and level of fatigue;
- **Social functioning** - indicates the impact of health or emotional problems on the quality and quantity of a person’s social activities with others;
- **Role-emotional** - indicates the effects of emotional health on a person’s performance of their work or other daily activities; that is, whether a person is limited in the kind of work or activities they were able to do, or reduced the time spent on those activities, or had difficulty in performing those activities due to emotional problems;
- **Mental health** - indicates the amount of time a person experienced feelings of nervousness, anxiety, depression and unhappiness. (Ware and Sherbourne 1992)

### 6.2.3.1 Measuring and interpretation

The latest version of SF-36 (Version 2) was used in the Ross River virus survey that formed the core of the research for this study (see questions 14-24:Part I and questions 11-21:Part II in Appendix 2). Version 2 is an improved version of the original SF-36 form. Improvements include clearer instructions, item wording, layout and question format. Raw measures for different health dimensions (eight dimensions) within the survey cannot be compared since different scales are used to derive measures for each health dimension. The physical functioning dimension, for example, has 10 items to which the respondent can make one of three responses: ‘limited a lot’, ‘limited a little’ or ‘not limited at all’. These responses are coded 1, 2 and 3 respectively, and the 10 coded responses summed to produce a measure ranging from 10 to 30. These raw measures are first transformed into a 0-100 scale and are then standardised according to the average population norms. The SF-36 was included in the 1995 National Health Survey to establish general population-based benchmarks (that is, average population norms) for the instrument in Australia (ABS Catalogue 4399). Accordingly, each scale (that is, eight health dimensions and two summary measures) was scored to have the same average (50) and the same standard deviation (10).

The interpretation of population norms-based SF-36 scores is clear and easy. At any time, a score below 50 indicates a below average health status, so that a higher SF-36 measure (that is, around 50 or over) indicates better state of health. Hence, SF-36 measures of an individual at two different points in times can be used to highlight an improvement or deterioration in health. For example, physical functioning is measured so that a higher measure (around 50) indicates better physical health state (Ware and Sherbourne 1992). Since SF-36 measures reflect the victim’s health in terms of physical, mental and social functioning, these measures
can be considered as proxies for health-related quality of life, and they have been used to assess the health impact of Ross River virus in this study.

### 6.2.4 Standard health measure and co-morbidity

In the absence of a clinical screening process, standard health measures (SF-36 scores) were recorded at disease onset, and after six months.\(^{89}\) This information was used to identify Ross River virus victims with co-morbidity. In general, a low SF-36 health score indicates a deterioration in health and thus it is assumed that standard health measures taken at disease onset would be less than the scores taken after six months. A large proportion of co-morbid subjects (81%) stated they had not recovered from the illness after six months from the disease onset. Hence, it is expected that the standard health scores would corroborate these presumptions. Figures 6.1 and 6.2 presents the median standard health scores for co-morbid and non co-morbid subjects at disease onset and after six months.

**Figure 6.1** A comparison of standard health scores: at disease onset

![Bar chart showing comparison of standard health scores](image)

Note:
- PF – Physical functioning
- RL – Role limitation
- BP – Bodily pain
- GH – General health
- VT – Vitality
- SF – Social functioning
- RE – Role emotion
- MH – Mental health

\(^{89}\) This information, standard health measures, were obtained from two mail questionnaires administered at disease onset and after six months.
Non-parametric Mann-Whitney test (equivalent to independent sample $t$-test) was conducted to examine statistical differences between these two groups. According to the survey data, no significant difference was found between standard health scores of co-morbid and non co-morbid groups at the onset of the illness except “general health” dimension. That is, the health state of Ross River virus victims early in disease period was essentially the same for victims identified as co-morbidity and those who were not (see Figure 6.1).

The comparison of standard health scores after six months, however, differs substantially between co-morbid and non co-morbid groups. For example, statistically significant results (Mann-Whitney test) were observed in physical functioning, general health, vitality and mental health scores (see Figure 6.2). That is, the health improvement in non-comorbids is significantly different from their counterparts.

**Figure 6.2** A comparison of standard health scores: after six months

![Graph showing median scores for various health dimensions for co-morbid and non co-morbid groups after six months.]

Note: 
- PF – Physical functioning
- RL – Role limitation
- BP – Bodily pain
- GH – General health
- VT – Vitality
- SF – Social functioning
- RE – Role emotion
- MH – Mental health

90 Mann-Whitney test statistic: general health ($p<0.001$).
91 Mann-Whitney test statistic: physical functioning ($p<0.05$), general health ($p<0.001$), vitality ($p<0.05$) and mental health ($p<0.05$).
6.2.5 Standard health measure and disease impact

In order to assess the actual disease impact, it is vital to remove other distorting influences upon victims’ health state such as the presence of co-morbidity. That is, to control for confounding influences due to co-existing other illnesses in the Ross River virus victims. Accordingly, standard health scores of non co-morbid subjects were assessed separately at disease onset and after six months. Table 6.1 presents the standard health measures for non co-morbid victims at disease onset and after six months.

Table 6.1 A comparison of standard health scores: victims reporting no co-morbidity (n=146) at disease onset and after six months

<table>
<thead>
<tr>
<th>Health dimension</th>
<th>Median health score (SF36)</th>
<th>Test statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>at onset</td>
<td>After 6m</td>
<td>(2-tailed)</td>
</tr>
<tr>
<td>Physical functioning</td>
<td>41.8</td>
<td>46.6</td>
<td>−4.973</td>
</tr>
<tr>
<td>Role limitation</td>
<td>37.5</td>
<td>43.3</td>
<td>−3.882</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>40.5</td>
<td>47.6</td>
<td>−6.550</td>
</tr>
<tr>
<td>General health</td>
<td>48.8</td>
<td>48.5</td>
<td>−1.447</td>
</tr>
<tr>
<td>Vitality</td>
<td>38.5</td>
<td>41.8</td>
<td>−4.277</td>
</tr>
<tr>
<td>Social functioning</td>
<td>43.4</td>
<td>47.6</td>
<td>−5.354</td>
</tr>
<tr>
<td>Role emotional</td>
<td>45.9</td>
<td>53.2</td>
<td>−4.142</td>
</tr>
<tr>
<td>Mental health</td>
<td>45.5</td>
<td>47.3</td>
<td>−1.682</td>
</tr>
</tbody>
</table>

\(^{1/}\) Wilcoxon Signed Ranks Test (similar to paired sample t-test) was conducted to compare health scores at disease onset and after six months.

\(^{2/}\) Health score (SF-36) for an average healthy person = 50

According to the comparison of standard health scores (of non co-morbids) at disease onset and after six months, there have been statistically significant changes in all health dimensions except general health and mental health. In general, all standard health scores (except general health) reported improvements (a net increase) when compared to standard health scores at disease onset. However, this is not very profound since they were sick and got better. These results reflect the SF-36 has some veracity to measure individual health state but lack assurance as to whether reported health improvements were mainly due to their recovery from Ross River virus.
6.2.5.1 Isolating disease impact

The mean population scores reported in the 1995 National health Survey (ABS Catalogue No. 4399.0) can be used as proxies to describe the health state of the average Australian population and hence potentially identify the impact of Ross River virus upon health (at various stages of the illness). In this analysis, the eight health scores have been reduced to two summary measures (physical and mental health) to highlight the difference between the average population and non co-morbid Ross River virus victim group. Figure 6.3 and 6.4 compares physical and mental health measures (at onset and after six months) by age group.

Figure 6.3 Physical health impact of Ross River virus: comparison to average Australian SF-36 health levels

In terms of physical and mental health measures of average population, it is apparent that Ross River virus had a substantial effect on the overall physical and mental health states of the victims. Physical health state was well below the average population score across all age groups at onset and after six months (see Figure 6.3). This indicates that people who contracted Ross River virus have a lower state of physical health. The difference between average population and sample measures were more substantial at the onset than after six months. Accordingly, we can assume a large decline in physical health at disease onset.
Furthermore, Figure 6.3 shows that older people, in general, have lower physical health scores than younger people, reflecting their relatively lower state of physical health.

On the other hand, mental health scores, revealed a similar trend when compared with the average Australian population. However, the survey data show that there was no substantial improvement in victims’ mental health even after six months (see Figure 6.4).

**Figure 6.4** Mental health impact of Ross River virus: comparison to average Australian SF-36 health levels

6.3 **Valuation of deteriorated health**

The contingent valuation method was applied to identify the monetary value people attached to the deterioration in health from Ross River virus (over entire period). Stated preference methods such as contingent valuation aim to directly elicit monetary valuations of a hypothetical commodity or change in consumption welfare. They typically use survey techniques. Although early applications of these methods were mainly focused on valuing recreational benefits and changes in air quality, current use covers a wide range of public policy issues including the valuation of morbidity-related changes in health. For example, contingent valuation
has been used to value the amount people would be willing to pay to avoid respiratory disease and other symptoms of air pollution exposure, avoidance of asthma-related illness, a reduction in skin cancer risk, and avoidance of chronic bronchitis (USEPA 2002).

The contingent valuation method is consistent with welfare economic theory and willingness-to-pay method can be applied to assess welfare effects related to health. Given that each survey respondent fully understands the “commodity” (for example, “change in health state”) that is to be valued in question and answers the questions honestly, this method yields a viable estimate of individual health-related willingness-to-pay. Contingent valuation appears to be one of the few existing methods capable of measuring altruistic benefits and preference for different levels of mental (including pain and discomfort) condition as altered by a disease or an accident. Unlike many CV applications, survey subjects that have actually experienced the disease have relatively good information about the effects of the choice they are valuing.

6.3.1 Survey response

In order to capture the full range of personal health effects, Ross River virus victims participating in the survey were asked (in Part II of survey questions – see Appendix 2) to state their maximum willingness-to-pay by presenting a hypothetical scenario:

“Imagine that re-infection with Ross River virus is possible and you face the prospect of similar symptoms that you had with your previous infection. Say that a pill was available that would reduce the chance of another Ross River virus infection to almost nothing. The imaginary pill would work for one year and you would have to pay the full cost. Therefore, you would have to give up spending that money on other things in order to get the pill”.

Of the total sample, around 84% of Ross River virus victims surveyed answered the willingness-to-pay question. This relatively high response rate may be
attributed to: (1) a good understanding of the hypothetical scenario, as all survey respondents were familiar with the effects of Ross River virus, and (2) an appropriate question format that created a situation similar to well-known market transactions. Twenty-one Ross River virus victims (10% of the total) did not answer the willingness-to-pay question while 12 others (6% of the total) stated various reasons why they would be unwilling to pay. These reasons and the number of Ross River virus cases in each category are presented in Table 6.2.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of victims</th>
<th>(% of total response)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not like taking medicine</td>
<td>5</td>
<td>(3)</td>
</tr>
<tr>
<td>Do not buy without Pharmaceutical Benefit</td>
<td>4</td>
<td>(2)</td>
</tr>
<tr>
<td>Other (e.g. need more information/do not believe)</td>
<td>3</td>
<td>(1)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>(6)</strong></td>
</tr>
</tbody>
</table>

According to the valid willingness-to-pay responses, the range of WTP stated by Ross River virus victims ranged from $AUD 5 to $AUD 5,000. That is, the people were willing to pay from $AUD 5 to $AUD 5,000 for a medicine that reduces the chance of another Ross River virus infection to almost nothing. These WTP amounts were plotted using a Boxplot and this information was used to identify likely outliers (see Figure 6.5). Accordingly, the $AUD 1,000 (9) and $AUD 5,000 (1) values were treated as outliers and excluded from the WTP data set. Based on this information, the median willingness-to-pay was estimated at $AUD 250.\(^92\) Although estimated median WTP in the final survey was greater than that of the pilot survey ($AUD 130), the willingness-to-pay estimate ($AUD 250) seems to be low for a disease known for its debilitating effects.\(^93\) For example, only around 18% of Ross River virus victims stated a willingness-to-pay exceeding $500.

\(^92\) Inter-quartile-range = $AUD 210

\(^93\) This low figure may be due to unclear conditions in the question and remote chances (known) of contracting Ross River virus for the second time. In addition, wrong timing of questionnaire (WTP question should have been asked when the victims experience severe disease symptoms).
6.3.2 Factors affecting willingness-to-pay

The direct use of willingness-to-pay estimates to quantify monetary value of health condition change is subject to many problems. Because willingness-to-pay can be influenced by many other factors. For example, the respondent’s ability to pay (that is, his or her income) is considered as one of the major determinants of willingness-to-pay for any welfare change. In addition, a positive association can be expected between willingness-to-pay and disease severity (that is, those suffered from severe disease symptoms may also state a higher willingness-to-pay). Therefore, it is important to analyse and provide statistical evidence to support potential relationships between willingness-to-pay and relevant major variables.

The following section presents the findings of chi-square tests and bivariate correlation analyses focused upon measured Ross River virus health care costs and willingness-to-pay estimate. Although the chi-square tests were conducted across the whole range of variables (that is, willingness-to-pay, health care costs and major explanatory variables), only statistically significant, important test results are discussed in this section.
Gross income and willingness-to-pay

According to economic theory, individual willingness-to-pay is influenced by the individual’s ability to pay (wealth and earnings). Assuming that income is an adequate proxy of wealth and earnings, willingness-to-pay in our sample is expected to vary across income levels – specifically, a positive relationship is expected so that willingness-to-pay increases with income. Table 6.3a and Figure 6.5 present the proportion of victims by stated willingness-to-pay (grouped ranges) and reported gross income level category.

The survey data reveal that victims reporting low income were indeed willing to pay less to avoid the illness. For example, around 67% of Ross River virus victims earning less than $11,900 per annum indicated they are willing to pay only $130 or less for a disease prevention medicine. However, as income increases the stated willingness-to-pay also increases showing a positive trend between level of income and willingness-to-pay. For instance, a large proportion of Ross River virus victims (69%) earning $44,200 or more per annum are willing to pay higher amounts (as high as $356 or more) to avoid another Ross River virus infection.

These findings are substantiated by chi-square test results. Accordingly, there is sufficient evidence in the survey data to support the claim that income and willingness-to-pay are closely related. (see Table 6.3a).

Table 6.3a  Gross income and willingness-to-pay

<table>
<thead>
<tr>
<th>WTP ($)</th>
<th>Income ($000)</th>
<th>&lt;11.9</th>
<th>20.8</th>
<th>31.2</th>
<th>44.2 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;130</td>
<td></td>
<td>29 (67%)</td>
<td>6 (14%)</td>
<td>5 (12%)</td>
<td>3 (7%)</td>
</tr>
<tr>
<td>131 – 240</td>
<td></td>
<td>13 (31%)</td>
<td>7 (17%)</td>
<td>9 (21%)</td>
<td>13 (31%)</td>
</tr>
<tr>
<td>241 – 355</td>
<td></td>
<td>4 (8%)</td>
<td>14 (28%)</td>
<td>11 (22%)</td>
<td>9 (20%)</td>
</tr>
<tr>
<td>356 or more</td>
<td></td>
<td>2 (4%)</td>
<td>3 (7%)</td>
<td>9 (20%)</td>
<td>31 (69%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>43 (100%)</td>
<td>42 (100%)</td>
<td>50 (100%)</td>
<td>45 (100%)</td>
</tr>
</tbody>
</table>

\[ N = 180 \]

\[ \chi^2 = 73.4; \text{ d.f.} = 9; p<0.000 \]
Age and willingness-to-pay

Table 6.3b presents the cross-tabulation of age and willingness-to-pay. A considerable proportion of victims aged over 55 years (43%) stated that they were willing to pay $130 or less for a medicine that prevents another infection of Ross River virus. On the contrary, the majority of victims (over 53%) in other age groups, 18-34, 35-44 and 45-54 willing to pay $240 or more. The distribution of proportions is heterogenous and hence difficult to identify any trend between age and willingness-to-pay. The chi-square test result shows that age and willingness-to-pay are not independent (see Table 6.3b).

**Table 6.3b  Age and willingness-to-pay**

<table>
<thead>
<tr>
<th>WTP ($)</th>
<th>18-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55+</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;130</td>
<td>8 (28%)</td>
<td>9 (18%)</td>
<td>3 (7%)</td>
<td>23 (43%)</td>
</tr>
<tr>
<td>131 – 240</td>
<td>5 (17%)</td>
<td>15 (29%)</td>
<td>7 (15%)</td>
<td>15 (28%)</td>
</tr>
<tr>
<td>241 – 355</td>
<td>10 (34%)</td>
<td>15 (29%)</td>
<td>17 (37%)</td>
<td>8 (15%)</td>
</tr>
<tr>
<td>356 or more</td>
<td>6 (21%)</td>
<td>12 (24%)</td>
<td>19 (41%)</td>
<td>8 (15%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>29 (100%)</td>
<td>51 (100%)</td>
<td>46 (100%)</td>
<td>54 (100%)</td>
</tr>
</tbody>
</table>

N = 180
$\chi^2 = 30.3; \text{ d.f.} = 9; p<0.000$

Co-morbidity and willingness-to-pay

The analysis of standard health scores of survey participants revealed a significant difference between co-morbid and non co-morbid groups. It is assumed this difference may also be observed in willingness-to-pay estimates since perceived deterioration in health shall be reflected by willingness-to-pay.

Table 6.3c shows the proportion of Ross River virus victims grouped by the presence or absence of co-morbidity and stated willingness-to-pay. A large proportion of co-morbid victims (around 72%) were willing to pay $240 or less whereas the majority of non co-morbs (63%) indicated willingness-to-pay exceeding $240. This suggests that co-morbid respondents were actually willing to
pay less than non co-mORBIDS. The chi-square test shows that these differences are statistically significant (see Table 6.3c).

Table 6.3c  Co-morbidity and willingness-to-pay

<table>
<thead>
<tr>
<th>WTP ($)</th>
<th>Co-morbidity</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;130</td>
<td>27 (21%)</td>
<td>16</td>
<td>(32%)</td>
</tr>
<tr>
<td>131–240</td>
<td>22 (17%)</td>
<td>20</td>
<td>(40%)</td>
</tr>
<tr>
<td>241–355</td>
<td>40 (31%)</td>
<td>10</td>
<td>(20%)</td>
</tr>
<tr>
<td>356 or more</td>
<td>41 (32%)</td>
<td>4</td>
<td>(8%)</td>
</tr>
</tbody>
</table>

Total     130 (100%) 50 (100%)

N = 180
$\chi^2 = 19.7; \text{d.f.} = 3; p<0.000$

6.3.2.1 Bivariate correlations

The Spearman’s rank order correlation test was conducted to measure the bivariate correlations, including the strength and direction, between a range of survey variables and the primary valuation measures – health care cost and willingness-to-pay.

The analyses of correlations between variables that appear to be main socio-demographic and other individual characteristics (including disease) can be used to identify significant links with willingness-to-pay and health care costs of Ross River virus. For example, higher income enhances the victim’s ability to pay. Consequently, a strong positive correlation is expected between victim’s income and stated willingness-to-pay. Given that limited capacity of using statistical analysis methods in this research, the outcome of correlation analyses can be used as statistical evidence to support the consistency of some aspects of the survey data. This cross-checking process enhances confidence with which willingness-to-pay can be used as a proxy monetary value for the health-related quality of life impact of Ross River virus. Summary results of the correlation analyses, including strength, direction and level of statistical significance, are presented in Table 6.4. The following section discusses the key results of the correlation analyses.
### Table 6.4
Summary of correlation analyses: strength, direction and statistical significance (Spearman’s rho)

<table>
<thead>
<tr>
<th>Variable</th>
<th>AGE</th>
<th>DIS</th>
<th>HCC</th>
<th>INC</th>
<th>LEN</th>
<th>MCS</th>
<th>PCS</th>
<th>SEV</th>
<th>WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIS</td>
<td>−0.11</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCC</td>
<td>−0.01</td>
<td>0.33**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INC</td>
<td>−0.17**</td>
<td>0.18**</td>
<td>0.21**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEN</td>
<td>0.16*</td>
<td>0.04</td>
<td>0.15*</td>
<td>−0.04</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCS</td>
<td>−0.11</td>
<td>−0.19</td>
<td>−0.11</td>
<td>0.10</td>
<td>−0.09</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCS</td>
<td>−0.22**</td>
<td>−0.21**</td>
<td>−0.26***</td>
<td>0.07</td>
<td>−0.18*</td>
<td>0.05</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEV</td>
<td>0.11</td>
<td>0.38***</td>
<td>0.48***</td>
<td>0.01</td>
<td>0.19*</td>
<td>−0.30***</td>
<td>−0.42***</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>WTP</td>
<td>−0.12</td>
<td><strong>0.19</strong></td>
<td><strong>0.19</strong></td>
<td><strong>0.59</strong>*</td>
<td>0.05</td>
<td>0.07</td>
<td>0.03</td>
<td>0.13</td>
<td>1.00</td>
</tr>
</tbody>
</table>

| Median | 49.0 | 5.0 | 293 | 31.2 | 5.8 | 41.9 | 34.5 | --- | 250 |
| I-Q Range | 20.0 | 3.0 | 274 | 32.3 | 3.2 | 14.3 | 15.0 | --- | 210 |

Note: Key to variable code

- AGE – Age (years)
- DIS – Disability period (days)
- HCC – Health care costs ($AUD)
- INC – Gross income ($AUD’000)
- LEN – Disease duration (months)
- MCS – Mental health measure
- PCS – Physical health measure
- SEV – Disease severity
- WTP – Willingness-to-pay($AUD)

(Statistical significance: * P < 0.05; ** P < 0.01; *** P < 0.001)

### Gross income and willingness-to-pay

Correlation analysis revealed a significant modest positive association between victim’s income and willingness-to-pay (0.59, p<0.001). Accordingly, this information can be used to substantiate the fact that Ross River virus victims earning a higher income are prepared to pay increasing amounts to avoid the disease risk (see Table 6.6). This finding is consistent with economic theory since health can be considered as a form of “normal good” where people with higher income would spend more for an improvement in health (for example, in this case to avoid another Ross River virus infection).

### Health care cost and willingness-to-pay

Since health care cost is a direct cost to the victim (although partly subsidised) and constitutes a considerable part of all costs of Ross River virus, it is assumed that there would be a positive association between health care costs paid...
and willingness-to-pay to avoid the disease – that is, victims who spend a large amount for health care product and services should state a higher willingness-to-pay to avoid another infection. Although weak, the observed positive correlation reveals that those who spent more for health care services are in fact willing to pay a higher amount to avoid the illness (0.19, p<0.01). This weak relationship between health care costs and willingness-to-pay may be due to: (1) the large proportion of victims using the public health care system such as Medicare and Pharmaceutical Benefits and (2) observation that some victims may have been reimbursed for their health care expenditure through their private health insurance arrangements.

**Disability and willingness-to-pay**

A statistically significant but weak positive correlation is observed between disability level and willingness-to-pay (0.19, p<0.01). Since disability levels have a direct influence upon the victim’s ability to engage in productive work (that is, earning capacity), it is reasonable to assume that Ross River virus victims who experienced a longer disability period stated a higher willingness-to-pay. However, the sample results do not substantiate this proposition. For example, while there is a significant relationship between disease severity and disability period (see section 5.3.3.2 in chapter 5) we expect a significant correlation between disease severity and willingness-to-pay. However, there is not enough evidence found in the correlation analysis to support this claim (see Table 6.4).

**6.3.3 Using willingness-to-pay estimate**

The outcome of the statistical analyses (that is, the chi-square tests and bivariate correlation analysis) has provided some evidence to suggest that the willingness-to-pay levels elicited in this research are reliable and hence can be used as proxies to describe the monetary values of deteriorated health due to Ross River virus. However, there are many other issues that should be considered before using a willingness-to-pay estimate for disease cost calculations.
Generally, willingness-to-pay estimates capture the overall disease impact borne directly by the victim and hence overlap with other disease impacts such as health care, non-health care, out-of-pocket and lost production costs. Therefore, it is important, when interpreting and using willingness-to-pay, to acknowledge potential risks of double counting the costs involved. However, this risk can be minimised by making some appropriate adjustments. For example, individual willingness-to-pay may include personal spending for medical treatment, treatment-related transport, disease prevention and associated services (such as child care). An effective solution is to examine the whole range of direct and indirect cost components and exclude components that are likely to overlap with willingness-to-pay thus minimising potential risks of double counting.

6.3.4 Willingness-to-pay by age and gender

Since age and gender data of Ross River virus victims are available in the disease notification database, estimated disease costs were analysed by age-gender group. For example, health care and lost production costs estimated in this research were also analysed by age-gender group so that this information could be used as an effective tool to improve estimates of the overall disease costs of Ross River virus. In order to maintain this consistency, estimated willingness-to-pay was further analysed by age-gender group.

As in the health care cost analysis, eight age-gender groups were identified: female and male victims of 18-34; 35-44; 45-54 and over 55 year age groups. Table 6.5 presents the median willingness-to-pay by age-gender group. The median willingness-to-pay varied between $AUD 105 (female victims aged over 55 years) and $AUD 400 (male victims aged 45-54 years). The analysis of willingness-to-pay by age and gender has revealed an explicit trend and pattern (see Table 6.5).
Table 6.5  Median willingness-to-pay by age and gender group

<table>
<thead>
<tr>
<th>Age-Gender group(^a)</th>
<th>Number of cases</th>
<th>WTP ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F 18-34</td>
<td>18</td>
<td>250</td>
</tr>
<tr>
<td>M 18-34</td>
<td>11</td>
<td>260</td>
</tr>
<tr>
<td>F 35-44</td>
<td>31</td>
<td>210</td>
</tr>
<tr>
<td>M 35-44</td>
<td>20</td>
<td>280</td>
</tr>
<tr>
<td>F 45-54</td>
<td>23</td>
<td>300</td>
</tr>
<tr>
<td>M 45-54</td>
<td>22</td>
<td>400</td>
</tr>
<tr>
<td>F 55 and over</td>
<td>26</td>
<td>105</td>
</tr>
<tr>
<td>M 55 and over</td>
<td>28</td>
<td>210</td>
</tr>
</tbody>
</table>

Note: \(^a\) Gender: F = Female; M= Male
All amounts in 2002 Australian dollars

For example, up until 55+ the higher the age of the victim, the larger the amounts they are willing to spend to avoid another Ross River virus infection. Furthermore, male Ross River virus victims, in general, are willing to pay more than female victims of same age to avoid another Ross River virus infection. The trend and pattern observed in willingness-to-pay also reflect existing links between age, gender and earning capacity. For instance, male workers paid more than their counterparts while work experience gained over the years attribute to a high income.

A non-parametric Kruskal-Wallis analysis of variance (ANOVA) was conducted to examine significant differences in stated willingness-to-pay between age-gender groups. The test results revealed that there were statistically significant differences in willingness-to-pay between age-gender groups \((H(7, N=180) = 39.8, p>0.001)\). Therefore, it is evident that victims’ stated willingness-to-pay may be influenced by a wide range of inter-related factors such as age, gender, income, co-morbidity, health care costs and disability period. Further analysis of these preliminary relationships may be very useful but unfortunately more detailed analysis is beyond the scope of this project.
6.4 Summary and conclusion

The valuation of the impact of disease on health-related quality of life in monetary terms is a contentious issue. Yet, the findings in this research suggest that it is possible to assess these impacts using non-market valuation methods in parallel with a standard health measure (the SF-36). The Ross River virus survey results have revealed that the viral disease has significant impact on victim’s health-related quality of life due to its effects on physical, mental and social functioning. A comparison of standard health measure (SF-36) at disease onset and after six months has shown significant differences across six health dimensions – physical functioning, role limitation, bodily pain, vitality, social functioning and role emotion.

The impact of Ross River virus disease appears to be influenced by the co-existence of other illness (co-morbidity). Some evidence for this influence was observed in the analyses of standard health measures at disease onset and after six months. For example, the standard health measures of Ross River virus victims reporting co-morbidity were not significantly different at disease onset and after six months (except for “bodily pain” and “vitality” health dimensions). In contrast, significant differences were observed in the two health measures (that is, at onset and after six months) of Ross River virus victims without co-morbidity (except “general health” and “mental health” dimensions). The results support existing claims that longer recovery periods and persistent disease symptoms may be linked with co-morbidity. These outcomes are consistent with recent research findings reported by Harley et al. (2001) and Mylonas et al. (2002), where Ross River virus victims with co-existing illness have reported a longer recovery period (for example, over six months) than their counterparts.

The outcome of Ross River virus survey has revealed that the contingent valuation method (that is, willingness-to-pay) is a useful non-market valuation technique to assess the health-related quality of life impacts. Provided that
appropriate scenario has been designed and elicitation format has been applied, one can expect a good monetary estimate for health-related quality of life impacts. However, in this research, several factors such as limited number of observations, poor timing of the willingness-to-pay question seem to have constrained getting an accurate cost estimate. According to valid responses, the median willingness-to-pay was estimated at $AUD (2002) 250 per victim. Several factors – including victim’s income and co-morbidity – were found to have a statistically significant influence upon the stated willingness-to-pay to avoid another Ross River virus infection with similar disease symptoms and severity. For example, victims reporting a higher income (that is, higher ability to pay) would pay relatively high sums while co-morbid Ross River virus victims were less willing to pay to avoid another similar infection of Ross River virus.

Theoretically, the willingness-to-pay approach covers all aspects of the disease impact. However, the majority of Ross River virus victims have suffered adverse health quality effects but have been shielded against most direct monetary health care costs and lost income due to various social arrangements such as health care benefits (that is, Medicare and Pharmaceutical Benefits), paid sick leave and insurance. The following section discusses how this information can be used to estimate disease costs and incorporate findings in decision-making at the local government level.
7.1 Introduction

Mosquito-transmitted diseases such as malaria, dengue and yellow fever are among the world’s leading causes of illness today. According to World Health Organization (WHO) estimates, every year more than 300 million clinical cases can be attributed to mosquito-transmitted diseases alone (WHO 2000). Despite great strides in control measures over the past few years, mosquito-transmitted diseases such as Ross River, Barmah Forest and dengue fever continue to pose significant risks to much of the population in Australia. Apart from the suffering and economic loss endured by persons who contract these diseases, additional pressure is placed on the public and private health systems. As no vaccines are currently available against mosquito-transmitted diseases such as Ross River virus, regulatory measures, mosquito control activities, and human behavioural changes are the only means of limiting disease incidence.

Current challenges posed by the emergence of mosquito-transmitted diseases in tropical and sub-tropical regions illustrate the importance of co-operation and partnership at all levels of government (including the Commonwealth, State/Territory and local governments) in order to effectively protect public health. To combat mosquitoes and the public health hazards they present, local authorities in collaboration with State and Territory public health services, have established mosquito control and management programs in problem areas. The responsibility of the supervision and execution of mosquito control has been devolved to local governments in Queensland while State health authorities assist local governments in this role through the provision of advice, training, health promotion material and technical assistance. For example, in Queensland, the State health department
(Queensland Health) assists in mosquito control and management by taking public health initiatives to control diseases in problem areas and funding mosquito research. For instance, in tropical regional Queensland, where the risk of contracting mosquito-transmitted diseases is comparatively high, Queensland Health plays a major role in disease control. While benefiting from State health department initiatives, local governments also execute their own control programs. Mosquito control and management programs implemented by local governments are mainly based on ground and aerial application of chemical and biological pesticides as well as surveillance and non-chemical forms of prevention and control. For example, larval and adult mosquito sampling before and after treatment is used to assess the program effectiveness while habitat modification and biological control methods are also considered as important forms of prevention and control.

The success of mosquito control and management programs executed by local governments is currently monitored using several criteria – the observed reduction in vector density (both larval and adult), the reduction in biting nuisance perceived by the affected community, and the reduction in reported disease incidence. However, these assessments do not, in themselves, directly indicate whether current mosquito control programs are effective, efficient and equitable. The absence of coherent and transparent criteria to evaluate control programs raises social, economic and political concerns regarding resource use at local level. In the context of this study, access to the full disease costs of the mosquito-transmitted Ross River virus will facilitate the incorporation of a wide range of management outcomes to allow a comprehensive evaluation of control programs at the local level.

This chapter provides an overview of existing mosquito control and management in Queensland and will discuss how disease cost information can

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94 Although local authorities are responsible for mosquito control within their jurisdictions, in tropical regional Queensland, health department administers mosquito control programs.

95 M. Muller and G. Santagiuliana, pers. comm., 15/12/2004.
be efficiently used to unravel resource allocation issues relevant to control and manage at the local level. The first part of the chapter presents the conceptual background required to apply an economic approach targeted at attaining optimum resource allocation for mosquito control. The basic criterion applied is the use of scarce societal resources so as to maximise net community welfare or economic benefits (Tietenberg 2000 p339). Part two of the chapter highlights key policy issues that must be considered carefully in utilising the economic valuation outcomes. It is vital that the policy analyst is aware of these issues and acknowledges their role when evaluating control programs. In addition, this chapter presents some recommendations that would enhance program evaluations thus improving their rigour and accuracy.

7.2 Mosquito control programs

Local governments play an important role in improving the liveability of their communities by providing many services and facilities. Pest control services such as mosquito control and management are significant amongst these services in terms of quality of life, living standards and health amenity.

While an integrated approach is generally adopted, larval control appears to be the main focus for mosquito control and management in local government areas. Integrated vector management (IVM) is a sustainable approach to manage mosquitoes by using all information, appropriate technology and management practices in a way that minimises health, environmental and economic risks (WHO 2002). The approach includes, but is not limited to, monitoring and surveillance of mosquito populations (both larval and adult), public education, and when necessary, sanitation, solid waste

96 The current pro-active approach to mosquito control and management at the local level includes larviciding (ground and/or aerial spraying of “Bacillus thuringiensis var israelensis” and “Methoprene”) of identified breeding habitats, that are accessible, after heavy rains and/or high tides. In addition, close co-operation between local governments, effective surveillance systems, proper timing of applications, research and development, and awareness programs can be attributed to successful mosquito control and management (M. Muller and G. Santaggiuliana, pers.comm., 15/12/2004).
management, water management, structural maintenance, physical, mechanical, biological and chemical controls. Integrated management strategies are effective at mitigating mosquito problems as they consider all dimensions and are capable of developing comprehensive strategies to remove the cause of the problem in a cost-effective manner.

7.3 Rationale for the economic evaluation

Control and management programs at the local level typically concentrate upon reducing larval and adult mosquito populations. This means that the probability of human exposure to mosquitoes can be kept at a minimum level thus reducing the risks of the local community contracting mosquito-transmitted Ross River virus. Every year, local authorities allocate considerable financial resources for mosquito control and management. For example, the average annual growth of the budget for aerial larviciding program (between 1993/94 – 1999/2000) for Brisbane City, Redcliffe City, Caboolture Shire and Pine River Shire Councils alone was estimated at 14% (Queensland Health 2002).  

Intervention programs may produce significant results on targeted disease outcomes. However, without economic evaluation, one cannot judge whether the intervention involves the best use of society’s limited resources. It is often assumed that existing and seemingly effective disease prevention programs are cost-effective but this may not be the case, especially when the analyst accounts for the full costs of the program (Russell 1986).

Furthermore, economic evaluation has other benefits as well. It enables the analyst or policy maker to compare programs in terms of a common outcome metric (such as net benefits). This allows a clear idea about what levels and/or types of control expenditure actually produce net benefits for

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97 Combined annual budget in constant dollars for aerial larviciding program including the cost for treatment of private lands (Queensland Health 2002).
society and can help show which scenarios are optimal. For example, let us assume that an allocation of $AUD 200,000 for mosquito control reduces the number of Ross River virus cases by 100 in a given local government area. However, this information does not indicate whether net community welfare has increased as a result of this additional expenditure (for example, if full social costs of Ross River virus are $AUD 1,000 per victim then there is actually a loss). In addition, since economic evaluation discounts future monetary costs or benefits, it also provides a practical way of comparing intervention benefits that stretch across different years.

7.3.1 Conceptual background

In practice, the implementation of mosquito control programs is unlikely to achieve zero disease incidence. Yet, an optimistic decision maker could divert substantial resources in order to achieve this goal. Alternatively, it would also be possible to ignore the disease risks and not allocate any social resources to mosquito control.

However, if a local area is designated as a high disease risk zone by public health officials (because of a large number of disease notifications and/or volume of complaints from residents/visitors), the respective local authority has a legal obligation to take remedial action to reduce the disease risks and nuisance by executing mosquito control and management programs. Because it is the responsibility of local government in Queensland to supervise and execute mosquito destruction, including land under its control, this process occurs in the same manner as for the owner and occupier of private premises.\(^\text{98}\)

Accordingly, the respective local authority would execute mosquito control and management programs (larval and/or adult mosquitoes) to mitigate

the mosquito problem and hence reduce disease risks and nuisance level. For example, current mosquito control programs (that is, ground and aerial spraying of accessible breeding habitats) aim to achieve around 85% - 95% reduction in larval mosquito population (M. Muller and G. Santagiuliana, pers.comm., 15/12/2004). However, from society’s perspective, this is unlikely to be the optimum level of resources that should be allocated to mosquito control and management as program costs and benefits can be assessed from different perspectives (for example, by focusing on specific costs and benefits only).

7.3.2 Selecting a program evaluation framework

Generally, economists should emphasise the societal perspective in which all costs and benefits are considered. This is the fundamental goal of economics and is used to gauge the program efficiency and overall desirability of a societal allocation of resources (Foster, Dodge and Jones 2003). Therefore, resource allocations for mosquito control may not be socially or economically efficient in the absence of appropriate program evaluation criteria and assessment. Economic principles can be applied to enhance the efficiency and accountability of control programs.

Cost-benefit analysis is a commonly used economic decision making tool which can, theoretically, be extended to incorporate the full range of economic, social and environmental costs and benefits. It is probably the most conceptually straightforward evaluation method. However, there are problems in practice as significant costs or benefits often do not have existing and direct market prices. Given this situation, several options exist for the policy analyst. For instance, cost-effective analysis identifies the most cost-effective means of meeting a specified goal. This goal can be expressed in terms of economic, social or environmental criteria, or a combination of all three. This method avoids the need to place a dollar value on the social benefits associated with the adopted goal.
Given the significance of existing costs and benefits, one major problem encountered by the policy analyst is the selection of appropriate economic evaluation techniques to assess mosquito control resource allocation that maximise net benefits to society. Given practical constraints, one alternative is to select an evaluation approach that addresses broad aspects of the control program such as efficiency, effectiveness and equity.

7.3.3 Optimal resource allocation

The overall objective of the policy analyst is to select the best model of resource allocation at the local level in order to achieve optimum net benefits to the broader community so that its welfare levels (that is, quality of life and living standards) can be sustained and/or improved. Assuming current budget constraints and difficulties in achieving zero disease costs, one convincing alternative for the policy analyst is to minimise the overall costs (that is, total control costs and disease costs) associated with local problems. Yet, regardless of the form of economic evaluation chosen, the fundamental basis of effective evaluation is the accurate and comprehensive estimation of costs. These costs should include both implicit and explicit costs associated with control programs and disease concerned. For example, in the case of Ross River virus, it is vital to incorporate the full disease costs and the costs of current mosquito control programs in an economic evaluation.

In order to capture the full costs of Ross River virus, a systematic approach has been followed in this thesis by identifying, enumerating, measuring and valuing negative effects of the disease. For example, in the case of health care resources, a range of health care products and services used by Ross River virus victims was identified. This resource use was measured based on the information provided by the victims in the survey. Relevant market prices (for example, per unit costs) were applied to value expenditure in dollar terms. Ross River virus impact upon victim’s productive time (both paid and unpaid work) was measured and valued applying the human capital
approach. Health-related quality of life effects of the virus were also quantified by applying a non-market valuation method, contingent valuation (willingness-to-pay).

Although the majority of negative effects of the virus were captured and quantified, some effects could not be measured and valued. For example, health care products and services used by people suspected having contracted Ross River virus (that is, negative sera tests). Furthermore, disease impact upon the tourism and real estate sectors could not be captured with the cross-sectional data. Thus, these costs were not included in the disease costs estimation.

**Figure 7.1** Cost minimisation – allocating resources for disease control

Marginal costs ($’000)

![Cost minimisation diagram](image)

Note: MCC – Marginal control costs
MDC – Marginal disease costs
C – Cost minimisation (MDC = MCC)

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99 In general, this includes medical consultations (GP) and pathology service. At times of low and high disease incidence, the proportion of positive sera tests could vary between 5% - 25% (Harley et al. 2001).
Figure 7.1 illustrates a hypothetical situation where the number of Ross River virus notifications (N) and marginal costs (marginal control and marginal disease costs in dollars thousands) are depicted on the x and y axes respectively. In the absence of a control program (E) we would expect the highest number of Ross River virus cases within the local area.

However, marginal increases in resources for mosquito control (for example, moving right to left on graph) would reduce the number of cases. One of the major problems faced by the policy analyst is how far he or she should increase control expenditure and what would be the ideal level of disease incidence from the viewpoint of the community. The marginal cost curves for both control and the disease (MCC and MDC) can be used to identify this situation. Up to \( N^* \), the area between MDC and MCC is the change in net social benefits to the community (where marginal disease costs exceeds marginal control costs). Hypothetically, the policy analyst’s aim should be to change control expenditure from current levels so that the net social costs of both control and disease are reduced or ideally minimised (for example, if current levels are \( N_2 \), control measures should be increased to \( N^* \)).

From a cost minimisation point of view, point C indicates the lowest costs to the society, where cumulative costs (control costs + disease costs) are at the minimum (see Figure 7.1). This position optimises the net social benefits to the affected community. At this level, we can assume efficient use of resource for mosquito control programs. In practice, it may not be feasible to identify the exact location of point C. However, a trial and error approaches may help the analyst to approximate this point together with relevant knowledge, past experience and accurate information about extent and magnitude of disease costs per person.
7.4 Factors affecting economic evaluation

Mosquito control and management programs produce a wide range of benefits to society including increased welfare, quality of life and living standards. However, a clear understanding about program benefits (or costs avoided) is a critical issue for efficient resource allocation. The underlying theme of this thesis has been to value the social and economic costs of mosquito-transmitted Ross River virus so that disease cost information can be applied in decision making about current mosquito control and management programs.

Although economic evaluation produces appealing results, there are many factors that can influence and distort the derived estimates hence the usefulness of the results. For instance, mosquito control expenditure is reported on a financial year basis hence it is important that policy analysts select appropriate disease notification data (for example, number of Ross River virus notifications during the reference period) to calculate disease costs. Furthermore, it is crucial that analysts use constant prices (that is, inflation adjusted costs) to estimate disease and control costs. Therefore, the policy analyst should select appropriate data, make adjustments and acknowledge relevant factors in program evaluation. The following section lists some critical factors and their implications for economic evaluation.

7.4.1 Quantifying control costs

It is imperative to include the complete range of costs of mosquito control programs in the economic evaluation. For example, in order to measure the costs of intervention, it is necessary to identify the resources, apportion their actual use and value the resources used in dollar terms (Gold, Russell, Siegel and Weinstein 1996). In general, cost analyses often consider direct capital and operating costs of the program but commonly overlook indirect administrative and other expenditures associated with health and
related programs (Shaw 1989). For example, there are many costs that are difficult to quantify, such as space costs and office utilities such as photocopying and telecommunication services.

A description of major cost items relevant to mosquito control and management programs is presented in Table 7.1. In addition, there may be additional activities involved in specific control and management program at local levels. All these costs should be accounted for in cost calculation.

In general, local authorities have a designated service provider unit – pest control services, pest management services or environmental health services – to deal with declared pests in their jurisdiction. Because of this arrangement, some resources are inputs, “joint costs”, for more than one activity. For example, apart from mosquito control, some resources may also be used for other pest control services within the local area (such as biting midges or weed control) or used to fulfil services of external clients (for example, by renting or hiring vehicles and equipment). Hence, the specific nature of all expenditure should be accounted for in quantifying control costs.

**Table 7.1 Costs of mosquito control and management**

<table>
<thead>
<tr>
<th>Cost category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital and operating</td>
<td>Equipment and vehicles, buildings and structures, repair and maintenance, supplies, insurance, training, salaries and benefits, quality protection and contractual services (for example, aerial spray)</td>
</tr>
<tr>
<td>Administrative</td>
<td>Spray record keeping, reporting, government liaison, surveillance and notification</td>
</tr>
<tr>
<td>Contingent</td>
<td>Safety, public relations, legal and environmental consulting fees</td>
</tr>
</tbody>
</table>
Nonetheless, there are considerable problems involved in gauging what share of resources should actually be attributed to mosquito control and management. Failure to account or adjust for these costs accurately could overstate or understate actual expenditure for mosquito control and management at the local level. Therefore, proper accounting and record keeping of mosquito control and management is a critical issue in economic evaluation.

7.4.2 Quantifying disease costs

Effective control and management programs reduce mosquito populations within a local environment and thus should lessen the disease incidence. Apart from improved quality of life and living standards, lower disease incidence will save public and private health care resources and prevent productivity losses due to the disease (see Table 7.2). The total costs of Ross River virus can be quantified on the basis of the estimated full social costs of the disease and reported number of disease notifications within the jurisdiction for the reference period (for example, calendar year or financial year).

Table 7.2 Costs of mosquito-transmitted Ross River virus

<table>
<thead>
<tr>
<th>Cost category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Costs of health care and other resources</td>
</tr>
<tr>
<td>Lost productivity</td>
<td>Opportunity costs of lost production due to disability (both paid and unpaid work)</td>
</tr>
<tr>
<td>Health-related impacts</td>
<td>Costs of deteriorated health, quality of life, leisure and living standards</td>
</tr>
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</table>

Most often, fairly accurate annual budgetary outlays for mosquito control and management are available in authority records. This is a result of relevant planning sections, which prepare rough estimates of resource
requirements for the following year or years. Approved allocations are reported in the annual or corporate documents and hence actual spending (that is, capital and operating costs) for mosquito control and management can be calculated.

In contrast, it is not possible to expect the same level of accuracy in disease cost estimations. Disease cost estimates are based on per person costs valued in this study (that is, costs of health care resources, lost productivity and health deterioration). Some costs, such as the costs to the pharmaceutical benefit scheme and the costs of health care resources used for testing of people who actually have negative test results, are not included in our study. This omission will tend to underestimate the estimated health care resource cost.

### 7.4.3 Disease notifications

The main source of Queensland Ross River virus notifications is the database maintained by the National Notifiable Disease Surveillance System (CDA 2004). The State and Territory health authorities based on the information provided by participating public and private pathology services compile these data. Although spatial data can be accessed from the database, it is not possible to ascertain the exact geographic location where the victim has been bitten by the mosquito leading to contracting Ross River virus. A wide range of factors, including occupation and sports and leisure activities, influence peoples’ geographic movement and people may be exposed to Ross River virus vectors away from their residential area. Therefore, one can argue about the validity of proposed economic evaluation approach linking disease notifications by place of residence related to mosquito control spending based on local government area.

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100 People with similar disease symptoms may consult a general practitioner and receive pathology services (for example, sera test). Yet, negative test results are neither reported nor recorded.
Furthermore, it appears that a significant proportion of Ross River virus victims without symptoms (asymptomatic) or very mild symptoms are unaccounted since they are not included in the disease notification database.\textsuperscript{101} According to Harley \textit{et al.} (2001), there appears to be a considerable variation in asymptomatic-symptomatic ratios of Ross River virus infection (for example, 3:1 during disease outbreak in Fiji in 1979 (Aaskov \textit{et al.} 1979) and 1.2:1 during a US marine exercise in Queensland in 1997 (Russell \textit{et al.} 1998). Therefore, the total disease cost estimate based on notified number of Ross River virus cases is an underestimation.

7.4.4 Equity aspects

The outcome of economic evaluation facilitates rational decisions that improve the efficiency of resource use. Scarce resources can be more appropriately allocated for socially-desired goals that improve the overall welfare levels of the community. However, the economic approach adopted does not take into account equity aspects. Therefore it is important that policy analysts give due consideration to specific geographic, social and economic impacts in conducting program evaluation. The risks of contracting Ross River virus vary from region to region and are influenced by a range of factors including geo-physical characteristics, climate and environment. For example, Ross River virus disease risk appears to be high for people live in tropical/sub-tropical coastal areas, rural irrigation areas and some inland areas where abundant mosquito breeding habitats exist (Russell 1994).

It is assumed that the relevant local authority has the financial capacity to vary resource allocation for disease control and hence can change control expenditure so as to increase net community welfare (for example, obtain gains from the BCD region in the graph in Figure 7.1). However, this may not be the case if a local authority has serious resource constraints and is unable to improve welfare levels of the community in that jurisdiction.

\textsuperscript{101} Because, these victims do not seek medical treatment hence unaccounted for contracting the virus.
7.4.5 Unaccounted benefits

Control and management programs reduce the risks of contracting Ross River virus for people living in mosquito-infested areas. In addition, these programs also reduce the nuisance level and danger of infection from other mosquito-transmitted diseases such as dengue fever and Barmah Forest virus. As a result, mosquito control programs also raise the overall quality of life and living standards of the community by reducing social costs for these other diseases. In addition, improved environmental health could boost other economic activities (such as tourism, tourism-related industries and real estate industry) in the local area. These positive spill-over effects have not been considered in this analysis. However, they are likely to influence the outcome of economic evaluation (for example, economic evaluation using cost-benefit analysis).

7.5 Evaluating control programs by local government area (LGA)

Economic evaluation based on the cost minimisation approach is a theoretically justifiable and viable practical option for the evaluation of mosquito control programs at the local level. Most often, the outcome of economic evaluation is used to facilitate improved policy decisions. For example, in the absence of valid criteria, the decision maker might change his or her position regarding resource allocation and divert resources from priority areas due to intimidation by lobbying groups or external pressure. However, such resource allocations are neither desirable nor socially optimum. In this context, the results of cost minimisation analysis will have substantial benefits to the policy analyst in terms of actually improving community welfare. The outcome of economic evaluation can be used to support his or her position thus directing efficient resource allocation in the local area.
Figure 7.2  Distribution of Ross River virus cases by Queensland local government areas (total 1994 - 2003)
In order to conduct economic evaluation, it is essential that disease and control cost information is readily available to the policy analyst. Given that accurate information on mosquito control spending is available, per capita disease costs valued in this thesis can be applied to estimate the full disease costs within the local area. Since the number of disease notifications by local government area is available from the national database, the overall disease cost estimates (that is, health care resources, lost productivity, and health-related quality of life impact) can be calculated for all local government areas of Queensland.

In general, disease notifications have spread throughout the State, with a large concentration in tropical and sub-tropical coastal areas from north to south including a few inland local government areas (see Figure 7.2 and 7.3). Although the reasons are not clear, the lowest numbers of Ross River virus notifications (887) were reported in 2002 in Queensland since 1991.  

Therefore, estimated costs for that year do not necessarily reflect the typical level of virus costs for local government areas. Hence, total disease costs for a ten-year period (1994 - 2003) have been estimated. Table 7.3 presents the number of Ross River virus cases and estimated disease costs for 2002 (on left hand side) and total disease costs for 1994 – 2003 period (on right hand side) by local government area reported in $AUD 2002.

On both sides of Table 7.3, the first column reports the number of Ross River virus cases notified in respective local government areas during the reference period (for example, number of cases in 2002 or total cases during 1994 – 2003 period). The next three columns show the calculated disease costs – health care costs (1), lost productivity (3) and, health-related quality of life (7) for respective reference periods by local government area.

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Figure 7.3  Disease incidence by Queensland local government areas (average 1994 – 2003)
Figure 7.4  Ross River virus costs by Queensland local government areas (total 1994 - 2003)
The last column presents the estimated total social costs of Ross River virus (Table 7.3 presents only a part, complete data set for all local government areas in Queensland is in Appendix 4).

7.5.1 Spatial distribution of disease burden

The spatial relationship between estimated disease costs and local government area are shown in Figure 7.4. This pattern directly reflects the distribution of Ross River virus cases over this period as the costs have simply been calculated by multiplying the observed number of cases in each local government area by the Queensland average estimated disease cost.

Based on 2002 disease notifications, Ross River virus seems to be a considerable social and economic burden for around 20 local governments, Shires (S) and Councils (C) in Queensland. These areas include Brisbane (C), Caboolture (S), Cairns (C), Calliope (S), Caloundra (C), Cardwell (S), Douglas (S), Gladstone (C), Gold Coast (C), Hervey Bay (C), Johnstone (S), Livingstone (S), Mackay (C), Maroochy (S), Rockhampton (C), Thuringowa (C), Townsville (C) and Whitsunday (S). Two local government areas, Banana (S) and Emerald (S) and are located inland (see Figure 7.4 and Appendix 4).

On the other hand, a large proportion of local government areas have experienced less impact due to considerably low number of disease notifications (for example, estimated disease costs in these local government areas is between 0 and $AUD (2002) 1,500 (see Appendix 4).

103 Estimated social cost of Ross River virus exceeds $ AUD (2002) 15,000.
Table 7.3  Estimates of the full social costs of Ross River Virus by LGA – 2002 and 1994 – 2003 (see Appendix 4 for complete data set)

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</tbody>
</table>

Note: ¹Based on actual number of Ross River virus cases reported in each LGA.

(S) – Shire    (C) - Council
7.5.2 Evaluating mosquito control programs

Disease costs presented in Table 7.3, together with mosquito control and management expenditure, can be used to estimate the current predicament of local government areas based on the cost minimisation approach (see Figure 7.1).

For example, let us assume that we want to evaluate current resource allocation in Banana Shire to ensure that the Shire using of scarce social resources are at optimum for the maximum benefit of its residents. In order to apply proposed cost-minimisation approach in Banana Shire, the first step would be to compile time series data of mosquito control spending and number of Ross River cases for the past 10-15 years. Data should be compiled either on calendar year or financial year basis so that cost figures (that is, control costs and disease costs) are compatible. Ross River virus disease costs estimated in this thesis can be used to calculate approximate costs of the virus to the Shire on annual basis. It is important to use constant prices in this exercise (for example, convert all costs into a base year price) so that both costs are comparable.\footnote{Because estimated disease costs are in 2002 dollars.}

Having estimated comparable dollar figures, the next step would be to estimate relevant marginal disease and marginal control costs. Using trial and error approach, it would be possible to establish two marginal cost curves for the Banana Shire (see Figure 7.1). This task would be easier provided that the time series data covers a longer period such as 15 – 20 years. The final step would be to plot relevant data points on the marginal cost plain (as in Figure 7.1). These points will show the trend and/or pattern of resource use for disease control in the Shire during the reference period. This will provide sufficient information to facilitate the policy analyst’s next course of actions.
7.5.3 Ameliorating economic evaluation

The valuation of disease costs and subsequent economic evaluation presented in this thesis has been based on accessible information and Ross River virus survey data. However, there is a possibility to improve both disease cost estimations and economic evaluation. The following section highlights some major issues that should be considered in order to enhance the accuracy and rigour of economic evaluations.

In this research, several cost components could not be captured and quantified. Therefore, the following measures are suggested to improve disease cost valuation. In order to improve health care cost estimates, it is essential statistics relevant to prescribed blood tests (including both positive and negative test results) are collected from participating public and private pathology laboratories. This facilitates more accurate health care cost estimation. Furthermore, this thesis captured waiting time cost of medical consultations only. However, it is important to account for the total waiting times of all health care products and services used by the Ross River virus victims. Moreover, it appears that the mean willingness-to-pay estimated in this thesis is a relatively low estimate. Therefore, it is suggested to improve willingness-to-pay scenario, question format and timing of the question (for example, the best time to ask willingness-to-pay question) so that accurate monetary responses in terms of health-related quality of life impacts can be collected.

Major disease costs presented in this thesis, health care resources, lost productivity and health-related quality of life impact, show a considerable variation across the study group. These variations may largely attribute to differences in demography, socio-economic status, disease severity and current health state. Thus, it would be useful to conduct sensitivity analyses to assess which variables have major influence upon disease costs.
In addition, several measures can be taken to improve the economic evaluation of control programs. For instance, the Ross River virus database consists of notified cases only (that is, positive tests). However, many Ross River virus infections are unreported. Hence, it is important to compile an accurate disease database, by local government area using available other information such as blood-screening data (for example, blood donation records).

7.6 Summary and conclusion

It appears that current mosquito control and management programs at local level produce satisfactory results on targeted disease outcomes. However, without economic evaluation, it is difficult to judge whether these programs are efficient and cost-effective in terms of society’s limited resources. Therefore, it is vital to identify the optimum level of resources for disease control programs. One of the major concerns regarding program evaluation is the selection of appropriate economic evaluation technique.

In order to evaluate mosquito control and management programs, this thesis proposes the cost minimisation approach. The cost minimisation method is a trial and error approach where the policy analyst’s task is to achieve the minimum overall cost level that is socially desirable (optimum level of resource allocation). The overall cost comprised of disease costs and control costs. Therefore, it is critical that appropriate methods have been used to quantify control and disease costs. For example, Ross River virus disease costs valued in this thesis can be used to estimate disease costs by local government area while control costs can be derived from control expenditure records. Although economic evaluation produces appealing results, there are many factors that need the analyst’s attention as they can influence and/or distort the outcome. It is vital to acknowledge these factors and give due consideration to them in program evaluation.
CHAPTER 8  SUMMARY AND CONCLUSION

8.1 Introduction

Mosquitoes transmit diseases, are widely perceived as a nuisance and are becoming a serious health concern for the public. Currently, Ross River virus is the most prevalent mosquito-transmitted viral disease in Australia with up to 8,000 cases reported annually (Curran et al. 1997). Studies have shown that the incidence of Ross River virus is closely linked to climatic factors such as rainfall, temperature and humidity (Tong et al. 2001). Current challenges posed by mosquito-transmitted diseases in tropical and sub-tropical regions illustrate the importance of co-operation and partnership at all levels of government (including Commonwealth, State/Territory and local) in order to effectively protect public health.

To combat mosquitoes and the public health hazard they present, local authorities in Queensland, in collaboration with State and Territory public health services, have established mosquito control and management programs in problem areas. In Queensland, the responsibility of the supervision and execution of mosquito control has been devolved to local governments while State health authorities assist local governments in this role through the provision of advice, training and technical assistance. For example, the State health department (Queensland Health) assists mosquito control and management by taking public health initiatives to control diseases in problem areas and by funding mosquito research. While benefiting from State health department initiatives, local governments execute their own control and management programs to reduce disease risk and nuisance.

Mosquito control and management programs implemented by local governments are mainly based on ground and aerial application of chemical and biological pesticides as well as surveillance and non-chemical forms of prevention and control. These programs typically concentrate upon reducing
larval and adult mosquito populations. This means that the probability of human exposure to mosquitoes can be kept at a minimum level and thus reduce the risks of contracting mosquito-transmitted Ross River virus in the local community. Each year, local authorities allocate considerable financial resources for mosquito control and management programs. These programs usually have significant success on targeted mosquito populations. However, without economic evaluation, one cannot judge whether intervention involves the best use of communities’ limited resources. It is often assumed that existing and seemingly effective prevention programs are cost-effective but this may not be the case, especially when the analyst accounts for the full costs of the program (Russell 1986). On the other side of the equation, there is little information about the actual magnitude of the cost of diseases such as Ross River virus upon the community. Moreover, the allocation of resources for mosquito control and management at the local level is becoming critical due to: (1) increasing nuisance levels and disease risks; (2) mounting pressure for environmentally-friendly control methods; and (3) competing demands upon resources currently used to manage the disease.

Until now the absence of documented evidence about the economic costs and social consequences of mosquito-transmitted diseases in relation to the benefits of mosquito control and management programs has been a barrier for effective policy, as there has been no economic rationale underlying resource allocation. Because of the lack of reliable information on disease costs, local authorities do not have a clear understanding about the magnitude of disease burden and hence the appropriate resource allocation priorities for mosquito control and management at the local level. Therefore, in order to make socially optimal decisions about societal resource use, it is necessary to assess the whole range of social and economic impacts of mosquito-transmitted diseases. This information is vital to policy analysts conducting economic evaluations of intervention programs.
Current valuation methods such as the cost-of-illness method used in health care mainly focus upon private costs and ignore the external costs associated with the disease that are felt by the wider community or those personal effects that do not pass directly through markets. For example, while the cost-of-illness method accounts for health care expenditure and the monetary value of lost productivity, it does not consider spillover effects of the disease such as the costs of deteriorated health, lost leisure, reduced social activities and interaction. In order to assess the full disease impact, it is vital to include the whole range of private and social costs of the disease. The valuation method used in this study covers the comprehensive set of private and spillover impacts associated with mosquito-transmitted Ross River virus. Failure to apprehend these private and social costs understates the net welfare effects of existing mosquito control and management programs.

This study was designed to help address these issues and facilitate the economic evaluation of control programs by identifying and quantifying the social and economic impacts of mosquito-transmitted Ross River virus in Queensland, Australia. An invitation to participate in the study was sent to all Queensland residents notified as contracting Ross River virus between April and July 2002. This group of around 367 notifications represented just over 40% of the total Ross River virus cases for Queensland in 2002.\textsuperscript{105} 226 people agreed to partake in the original study.

The Ross River virus victims were progressively contacted around onset, six months and 12 months from onset. Their demographic, health state and disease-related data were collected using phone and self-administered questionnaires. For example, two self-administered surveys were conducted at onset and six months from onset while a phone survey was conducted at 12 months from onset. The onset and six months survey forms aimed at collecting general information about the disease, health state, illness effects

\textsuperscript{105} Ross River virus notifications in 2002 was unusually low.
and demography of the victims. The hypothetical scenario including a non-market valuation method (willingness-to-pay) in conjunction with a standard health measure (Short Form 36) was presented in the six-month self-administered survey. The final phone survey was designed to assess disease recovery state, persistent symptoms and any treatment-related spending after the six-month survey.

Direct and indirect impacts of Ross River virus such as the costs of health care resources and lost productivity were valued using market prices while stated willingness-to-pay was used as the proxy for health-related quality of life impact. Estimated disease costs were analysed across eight age and gender groups (female and male victims of 18-34; 35-44; 45-54; 55+ years of age).

8.2 Major findings

This is the first known scientific attempt to capture the whole range of Ross River virus impacts in monetary terms. A wide spectrum of costs including costs of health care and non-health care resources, lost productivity due to disease disability and waiting time for medical consultations, formal and informal care, disease control and prevention, and health-related quality of life impact have been estimated. However, because of potential risks of double-counting the impacts of some cost types, the total cost estimates have been based on a more limited set of cost components. As a result, the primary social cost estimates for Ross River virus have been calculated by assuming the costs of health care resources, lost productivity and health-related quality of life impacts.

8.2.1 Costs of Ross River virus

Given the methodological and empirical limitations of the study, the most accurate estimate of the average per capita full social costs of Ross River
virus in Queensland (based on 2002 disease and monetary data) is $AUD 1,070. The survey questionnaire covered a wide range of social and economic costs associated with Ross River virus. This level of detail has been very useful in terms of analysing the relative contributions of different types of costs upon society. However, the derived costs for each of these components cannot be summed into a total estimate as several of these values overlap in terms of coverage (see Table 8.1). For example, the health-related quality of life component (based on a willingness-to-pay survey) would implicitly include the other disease-related cost components where a victim of Ross River virus had to, or felt obliged to, personally pay. Hence, stated willingness-to-pay is likely to have substantial overlaps with some cost components such as treatment-related transport costs, waiting time costs, and disease prevention and nuisance costs and to a lesser extent of costs of caregiver’s time. On the other hand, job-related income loss and most medical expenses, are likely to be largely covered by social means (for example, sick leave, Medicare or other form of health insurance) and would not be considered in the values measured in health-related quality of life impact cost component.

Based on this estimate of the full costs of Ross River virus (that is, health care resources plus lost productivity plus health-related quality of life impacts), the actual per capita costs vary from $AUD 706 to $1,378 across the different age-gender categories of the study sample. Figure 8.1 presents the median social costs of Ross River virus, health care costs (item 1 in Table 8.1), lost production (item 3 in Table 8.1) and health-related quality of life impacts (item 7 in Table 8.1), by different age and gender groups. In terms of health care and lost productivity, no statistically significant differences were found between the main age and gender groups in the sample. However, age and gender do appear to have a statistically significant influence upon cost estimates of health-related quality of life impacts (that is, hypothetical willingness-to-pay to avoid being reinfected by the disease).
Table 8.1  Estimated per capita social and economic costs of Ross River virus

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Per person ($ AUD)</th>
<th>Of total cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Health care resources</td>
<td>292.80</td>
<td>(27)</td>
</tr>
<tr>
<td>2. Treatment-related transport (^{ab})</td>
<td>27.00</td>
<td></td>
</tr>
<tr>
<td>Sub-total (direct costs)</td>
<td>319.80</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Lost production (^{ab})</td>
<td>526.80</td>
<td>(50)</td>
</tr>
<tr>
<td>4. Waiting time (consultations) (^{ab})</td>
<td>14.20</td>
<td></td>
</tr>
<tr>
<td>5. Caregiver’s time (formal/informal) (^{ab})</td>
<td>146.00</td>
<td></td>
</tr>
<tr>
<td>Sub-total (indirect costs)</td>
<td>687.00</td>
<td></td>
</tr>
<tr>
<td><strong>Other costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Disease prevention and nuisance (^{ac})</td>
<td>30.00</td>
<td></td>
</tr>
<tr>
<td>7. Health-related quality of life impacts (^{ad})</td>
<td>250.00</td>
<td>(23)</td>
</tr>
<tr>
<td>Sub-total (other costs)</td>
<td>280.00</td>
<td></td>
</tr>
<tr>
<td><strong>Total annual costs based on the sum of components 1, 3 and 7</strong></td>
<td>1,070</td>
<td></td>
</tr>
</tbody>
</table>

Note:
All amounts are in 2002 dollars
The following costs are not included:
- costs of publicly funded mosquito control and research programs
- costs of negative sera tests
- costs upon tourism and real estate industries

\(^a\) Based on valid responses
\(^b\) Estimates based on published data (ABS)
\(^c\) Costs of personal protective methods such as repellents, insect sprays and mosquito coils (costs of fly screens and bed nets not included)
\(^d\) Based on willingness-to-pay valuation
\(^e\) As discussed in the text, only components 1, 3 and 7 can be considered as mutually exclusive in the cost analysis

A substantial proportion of disease costs, around 52% of the total, was a result of lost productivity – loss of paid or unpaid productive work due to deterioration in the health related to the disease (see Figure 8.1). In this research, disability has been defined as the victim’s incapacity to engage in
productive work (paid or unpaid) due to disease symptoms. Ross River virus victims engaged in paid and unpaid work (that is, including people employed and doing house work) reported longer disability periods than their counterparts such as retired and unemployed victims. Based on valid responses, the average disability period for a Ross River virus victim in the labour force (employed and unemployed) was estimated at five days (n = 102; SD = 3 days).

**Figure 8.1** Median per capita costs of Ross River virus by age and gender Group

Health care costs expended by the study respondents were comprised of relevant treatment-related spending between onset and complete recovery due to the effects of a person contracting Ross River virus. It includes individual expenditure for a range of health care products and services linked to Ross River virus diagnosis and treatment including consultation of health professionals, use of pathology services and purchase of prescription and over-the-counter medicines. Health care spending contributed to around 27% of the total social costs of the disease (see Table 8.1, Figure 8.1). According to Ross
River virus survey data, three factors: disease severity, disease duration and disability period – have significant influences upon estimated health care costs (at p<0.001, p<0.01 and p<0.001 significant levels respectively). Neither demographic factors, nor co-morbidity, appear to affect health care cost levels.

According to the valuation of health-related quality of life impacts, victims who are not co-morbid typically experienced a significant deterioration in their health status in terms of physical, mental and social functioning. This has contributed to a reduction in health-related quality of life and living standards (deteriorated health) of the afflicted community. Based on the willingness-to-pay valuation, around 23% of the total social costs of Ross River virus were due to disease effects upon perceived health-related quality of life (see Table 8.1, Figure 8.1). Several factors – including victim’s age, income and co-morbidity – were found to have a statistically significant influence upon the stated willingness-to-pay to avoid another infection with similar disease symptoms and severity.\(^\text{106}\)

### 8.2.2 A lower-bound cost estimate?

The total per capita cost estimated in this research ($AUD 1,070) seems very low. Apart from health care and lost productivity costs, the median willingness-to-pay estimate ($AUD 250) appears to be an underestimate for what is commonly considered as a very debilitating and unpleasant disease. Only a small number of victims (10) have stated a willingness-to-pay greater than $AUD 1,000. Comparatively small willingness-to-pay values observed in this study may be due to methodological weaknesses thus needs improving. The willingness-to-pay values drawn from the survey are determined by the characteristics of the respondent and the characteristics of the market specified

\(^{106}\) This is a contentious cost measure and one can question the accuracy of willingness-to-pay techniques in capturing the health-related quality of life impacts of Ross River virus. Theoretically, the willingness-to-pay approach covers all aspects of the disease impact. However, the majority of Ross River virus victims have suffered adverse health quality effects but have been shielded against most direct monetary health care costs and lost income due to various arrangements such as Medicare, PBS, paid sick leave and insurance.
to respondents. Therefore, the design, specification and presentation of the market are critical to the veracity of the willingness-to-pay values obtained in the survey (Smith 2003). In addition, timing of willingness-to-pay question (for example, the time at which victims answer the question—six months from onset of the illness) appears to be another critical reason for small values.

Moreover, the Ross River virus costs presented in this research are the lower bound estimates. Apart from underestimated health care costs such as costs of negative blood tests and pharmaceutical benefits, the valuation has not accounted for some substantial disease impacts such as costs of public health and mosquito control programs, spending on research and development, foregone tax revenue and costs related to economic activities such as tourism and real estate industries.

### 8.2.3 Economic evaluation

In the absence of a vaccine and prescribed treatment for Ross River virus, control of virus-transmitting mosquitoes is the most effective option to manage the disease. Current mosquito control and management programs at local level aim to achieve this task though the cost-effectiveness of such programs is largely unknown. In addition, there is no formally accepted threshold level or set standard that should be targeted by current mosquito control programs. In this context, the evaluation of mosquito control programs for economic efficiency is a priority issue.

Disease costs, estimated in this thesis, can be used to conduct economic evaluations of current mosquito control and management programs and thus facilitate effective and economic decision-making that makes the best use of scarce community resources. The overall objective of the policy analyst tends to be consistent with this approach. Ideally, resource scenarios are selected at the local level in order to achieve optimum net benefits to the broader community and the improvement of welfare levels (that is, quality of life and
standard of living). Assuming current budget constraints and difficulties of achieving zero disease costs, one convincing alternative for the policy analyst is to minimise the overall costs (that is, total control costs and disease costs) associated with local problems.

It is vital to incorporate the full costs of both current mosquito control programs and Ross River virus disease in an economic evaluation. The mean disease costs presented in this research together with the number of Ross River virus notifications can be used to estimate the total disease costs by local government area. The whole range of control costs can be derived from the local government records. Thus, by applying the cost minimisation approach, the optimal level of resources that should be allocated for mosquito control and management can be determined as shown in Figure 7.1 and discussed in chapter seven.

In view of these observations, economic evaluation can help ensure socially-desirable optimal resource allocation for mosquito control and management at local and regional levels. In addition, estimated costs can be used to highlight disease impact upon the economy and community and hence draw attention to politicians at all levels so that they consider mosquito problem and mosquito-transmitted diseases as a priority issue in the political agenda. Moreover, disease cost information is a valuable input for the assessment of disease impact at the regional level. For example, in the case of disease outbreaks, estimated disease costs can be applied to quantify the economic impact of the virus using appropriate assessment techniques.

8.3 Future directions

Mosquito control and management programs are likely to remain as an integral part of public and environmental health interventions. The risk of contracting mosquito-transmitted diseases is likely to increase due to a wide range of social, economic and environmental factors. For example, rapid
expansion in global trade and increased human movement across regions pose significant threats of disease outbreaks and re-emergence of already eradicated diseases. Moreover, global warming, real estate developments around mosquito-prone areas and human behavioural changes will increase the level of ongoing disease risks.

Although Ross River virus is not fatal, the illness has far-reaching consequences on an ageing population. Both men and women are equally likely to be affected by the virus.

Ross River virus has a significant impact upon productivity and efficiency of people in the workforce. Occupations that reported higher disease risk are concentrated in rural and regional Australia. Accordingly, it could be postulated that the virus has substantial impact upon rural and regional communities such as farming and mining. Economic impact assessment techniques would help identify the flow-on effects of losses in these sectors.

The results suggest a possible link between occupation and disease risks (although the survey has not been capable of providing empirical substantiation). For example, the majority of surveyed Ross River virus victims who were employed were working in agriculture, fisheries and forestry, mining and construction industries. This distribution is very different from the occupational structure of Queensland workers as a whole and may well reflect the higher probability of contracting Ross River virus for those employed in agriculture, fisheries and forestry, mining and construction industries. This needs further investigation and validity test for its accuracy.

Maintaining systematic and complete records of mosquito control and management expenditure can enhance the process of economic evaluation. Therefore, local governments should be encouraged to keep and maintain
these records as a priority. This would facilitate more extended analysis for accurate assessment of optimal resource allocations such as the ongoing cost-benefit analysis of control and management programs. For example, mosquito control expenditure is often reported on a financial year basis whereas Ross River virus notifications are published on a calendar year basis.

Finally, according to the study responses, there appears to be a lack of community knowledge about mosquito-transmitted Ross River virus, its diagnosis, effects and treatment. This emphasises the need for well co-ordinated education and awareness programs about the risks of mosquitoes and mosquito-transmitted diseases (of which Ross River virus is a major form).
BIBLIOGRAPHY


APPENDIX 1

Invitation, Information and Consent
Dear Patient,

Every year, Queensladers report an increasing number of Ross River virus infections. It is believed the disease has very significant impacts on social and economic conditions in this State. Proper control and management require accurate information about the size and range of costs linked to this disease.

Griffith University, in partnership with Queensland Health is working on a project to assess the consequences and the full range of costs of Ross River virus. We seek your kind cooperation in a survey about how you were affected by Ross River virus.

Please spend a little time to read the attached information sheet for more information and how you could help us to make this effort a success. We are unaware of your name and address and if you decide to help us, your privacy and confidentiality will be strictly maintained.

Yours sincerely,

Dr. Peter Daniels
Dr. Pat Dale
Dr. Neil Sipe
Jay Ratnayake

Encl.
Appendix 1 – Invitation, information and consent

Request and Information for Potential Participants
A Study of the Full Social and Economic Costs of Ross River Virus

We are a team of Griffith University scientists undertaking research to help combat the growing problems linked to Ross River virus. Our study aims to get an idea of the full range of costs of this illness - not just the costs of medical expenses and lost earnings. To effectively manage and control this increasingly recognised disease, it is necessary to weigh up its full impacts on people and the community, against the costs of prevention.

We have only been able to contact you indirectly and have no idea of who you are or any means to make further contact on this issue. However, the group of people who have contracted Ross River virus, at some stage in their life, is quite small in our study area, and the usefulness of our research will depend vitally upon gaining your approval to participate in our study. In addition to the effects of the disease, we will be seeking a few details about you (similar to the recent Census) to help us calculate the full costs of Ross River virus.

If you are willing to participate in this study we will contact you at three stages:
➢ first, we will send you a survey form containing a series of questions to assess your illness, related costs and affects on your life
➢ after six months, we will send you a second survey form to assess your recovery from Ross River virus
➢ after 12 months, we will contact you (either by phone or mail) to assess the recovery state

We seek your help by completing the two survey forms and we will provide you with reply-paid envelopes so that you can easily mail the completed survey forms back to us (at no cost to you).
Your identity, and the information provided, will be maintained in strict confidence and will only be presented as overall statistical summaries describing the impacts of Ross River virus. If you choose to, we are happy to provide you with a copy of the summary report and a small reward for taking the time and effort to help us. To receive these, please tick the relevant boxes in the attached Consent Form.

Participation in this study is completely voluntary and you can freely withdraw at any time. In addition, if you have any concerns about the manner in which the study is conducted, you can notify the chief researcher or investigator. If an independent person is preferred, you can notify either

1) Griffith University’s Research Ethics Officer, Griffith University, Nathan, Qld 4111. Phone: (07)3875 6618, or,

2) The Pro Vice-Chancellor (Administration), Griffith University, Nathan, Qld 4111. Phone: (07) 3875 7343.

If you are happy to help us, please complete, sign and return the attached “Consent Form” (in the reply-paid envelope) to us.

MANY THANKS

If you need more information please contact us at Griffith University by either:

PHONE:  Jay (07) 3875 6665
FAX:  Jay (07) 3875 7459
E-MAIL:  J.Ratnayake@mailbox.gu.edu.au

Chief investigators:  Dr. Peter Daniels (BSc, MA, PhD)
Dr. Pat Dale (BA(Hons), MSocSc, LLB, PhD)
Dr. Neil Sipe (BA, MAURP, PhD)
Jay Ratnayake (BSc, MPhil, MA)
Consent Form
A Study of the Full Social and Economic Costs of Ross River Virus

Chief investigators: Dr. Peter Daniels (BSc, PhD)
Dr. Pat Dale (BA(Hons), MSocSc, LLB, PhD)
Dr. Neil Sipe (BA, MAURP, PhD)
Jay Ratnayake (BSc, MPhil, MA)

Patient’s consent

I, ____________________________, agree to participate in Griffith University’s study of the full social and economic costs of Ross River virus. I have read and understand the document entitled “Request and Information for Potential Participants: A Study of the Full Social and Economic Costs of Ross River Virus”.

I also understand that investigators will contact me for more information about the Ross River illness.

I also know that I can withdraw from this study at any time. Any information about me will remain confidential and will only be summarised and presented in overall statistics.

Signature: ____________________________  Date __/__/____
(PLEASE PRINT)
Name: _______________________________
Address: _______________________________
Postcode: __________________________
(OPTIONAL)
Phone: (07) _________________________
E-mail: ______________________________

Witness signature __________________________
(Any person of the age of 18 or above)

Witness Name (PLEASE PRINT) ____________________________
Date __/__/____

* Please return completed consent form in the envelope provided.
APPENDIX 2

Survey Instruments (Part I, Part II, Part III) and Treatment Record
Appendix 2—Survey instruments (Part I, II and III) and Treatment record

About Your Illness with Ross River Virus – Part I

Introduction

- Thank you for agreeing to participate in the Ross River virus study
- Please take a little time and effort to complete this survey as your answers will be used to make the best decisions about the future management of Ross River virus
- Your privacy and confidentiality will be strictly maintained and information will be presented as summary totals only
- Please return the completed survey in the reply-paid envelope provided

Your Case of Ross River Virus

Q1 When were you diagnosed with Ross River virus?
   Month
   Year
   e.g. 02 2002

Q2 How long do you think you were ill (with Ross River virus) before you went to the doctor or for other medical help?
   Please tick one box
   - 1 day
   - 2 days
   - 3 days
   - 4 days
   - More than 4 days please specify ___ days

Q3 How serious do you believe your case of Ross River virus to be?
   Please tick one box.
   - Very Mild – has very little effect on my daily life
   - Mild – has little effect on my daily life
   - Moderate – has some effect on my daily life
   - Severe – has severe effects on my daily life
   - Very Severe – has very severe effects on my daily life
### Q4

Have you discussed how serious your case of Ross River virus is with anyone?

*Please tick relevant boxes.*

- [ ] Yes
- [ ] No (Go to next question)

I have discussed the severity of my Ross River virus illness with a ...

*You can tick more than one box*

- [ ] Doctor (General Practitioner)
- [ ] Specialist doctor
- [ ] Pharmacist
- [ ] Community/Public health nurse
- [ ] Spouse/Partner/Family member/Friend
- [ ] Other (please specify)  

### Q5

What symptoms did you experience when you first sought medical attention for your Ross River virus illness?

*Please tick relevant boxes (one per row)*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stiff joints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stiff neck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin rash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fever/chills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headache</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Please specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

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Which health professionals have you consulted for treatment for Ross River virus?

Visited

☐ General Practitioner(s)
If you visited a general practitioner please tick the box and complete the table below.

<table>
<thead>
<tr>
<th>How often? (number of visits)</th>
<th>How much time spent per visit? (total time including waiting and consultation - please circle)</th>
<th>Approximate average cost per visit ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mins / hrs</td>
<td>yes no</td>
<td></td>
</tr>
</tbody>
</table>

Visited

☐ Specialist(s) please specify, e.g. rheumatologist, dermatologist
If you visited a specialist please tick the box and complete the table below.

<table>
<thead>
<tr>
<th>Specialist (Type)</th>
<th>How often? (number of visits)</th>
<th>How much time spent per visit? (total time including waiting and consultation)</th>
<th>Approximate average cost per visit ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mins / hrs</td>
<td>yes no</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>mins / hrs</td>
<td>yes no</td>
<td></td>
</tr>
</tbody>
</table>

Visited

☐ Alternative health practitioner(s) please specify e.g. acupuncturist, homeopath
If you visited an alternative health practitioner please tick the box and complete the table below.

<table>
<thead>
<tr>
<th>Alternative health practitioner (Type)</th>
<th>How often? (number of visits)</th>
<th>How much time spent per visit? (total time including waiting and consultation)</th>
<th>Approximate average cost Per visit ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mins / hrs</td>
<td>yes no</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>mins / hrs</td>
<td>yes no</td>
<td></td>
</tr>
</tbody>
</table>
Across the whole period you have had Ross River virus, have you spent any money on medication for treating the disease?  

Please tick relevant boxes (one per row)

- Yes
- No (Go to next question)

About how much did you spend in total on medication?

<table>
<thead>
<tr>
<th>Medication</th>
<th>About $25 or less (please write rough amount)</th>
<th>$26-50</th>
<th>$51-75</th>
<th>$76-100</th>
<th>About $100 or more (please write rough amount)</th>
<th>Did you get any concession for these medication (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With prescription</td>
<td>$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes no</td>
</tr>
<tr>
<td>Without prescription</td>
<td>$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes no</td>
</tr>
</tbody>
</table>

Do you remember the names of the drugs/medication (optional)?

Please write.

__________________________  ____________________________  ____________________________

Did you have to take blood tests because of your Ross River virus illness?  

Please tick relevant box and/or write.

- Yes
- No (Go to next question)

<table>
<thead>
<tr>
<th>How often (number of tests)</th>
<th>Total cost of blood tests (before you got any money from Medicare or insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>About $50 or less (please write rough amount)</td>
<td>$51-100</td>
</tr>
<tr>
<td></td>
<td>$</td>
<td></td>
</tr>
</tbody>
</table>

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Appendix 2—Survey instruments (Part I, II and III) and Treatment record

Q9 Did you have to take any other procedure (e.g. urine, X-ray) relating to your Ross River virus illness?
Please complete.

☑ Yes
☑ No (Go to next question)

<table>
<thead>
<tr>
<th>Procedure (Please specify)</th>
<th>How often? (number)</th>
<th>Average cost per procedure ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

Q10 Have you received in-hospital treatment for your Ross River virus illness?
Please tick ☑ relevant boxes.

☑ Yes
☑ No (Go to next question)

10a How many days did you spend in hospital? _____ day(s)

10b Type of Hospital?
☐ Public  ☐ Private  ☐ Don’t know

10c Did you have to pay for in-hospital treatment?
☐ Yes  ☐ No (Go to Question 11)

10d About how much did your in-hospital treatment cost?
Please write the total amount before you got any money back from Medicare or insurance.

$ _________
Appendix 2 – Survey instruments (Part I, II and III) and Treatment Record

Q11 Have you travelled for medical treatment during your Ross River virus illness (e.g. for consultation, blood test or other procedures)?
Please tick [ ] one box.

- [ ] Yes
- [ ] No (Go to next question)

11a What sort of transport did you generally use to get to medical services for Ross River virus illness?
Please select relevant mode of transport from the following list.
(C)=car (B)=bus (T)=train (F)=ferry (O)=other

Consultation

<table>
<thead>
<tr>
<th>Mode of transport (please specify)</th>
<th>Number of trips (number)</th>
<th>Average cost per trip ($/trip) (for a private car, just consider the cost of petrol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. C (car)</td>
<td>3</td>
<td>$12.00</td>
</tr>
</tbody>
</table>

Blood tests

<table>
<thead>
<tr>
<th>Mode of transport (please specify)</th>
<th>Number of trips (number)</th>
<th>Average cost per trip ($/trip) (for a private car, just consider the cost of petrol)</th>
</tr>
</thead>
</table>

Other procedure(s)

<table>
<thead>
<tr>
<th>Mode of transport (please specify)</th>
<th>Number of trips (number)</th>
<th>Average cost per trip ($/trip) (for a private car, just consider the cost of petrol)</th>
</tr>
</thead>
</table>
Appendix 2 – Survey instruments (Part I, II and III) and Treatment record

Q12 Have you received any help from other people because of your Ross River virus illness?

☐ Yes
☐ No (Go to next question)

12a For what activity and for how many days or hours you received help?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total number of hours or day(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>hours in total</td>
</tr>
<tr>
<td>Personal care (e.g. dressing, grooming)</td>
<td>hrs</td>
</tr>
<tr>
<td>Household work (e.g. cooking, cleaning)</td>
<td>hrs</td>
</tr>
<tr>
<td>Driving</td>
<td>hrs</td>
</tr>
<tr>
<td>Grocery shopping</td>
<td>hrs</td>
</tr>
<tr>
<td>Gardening/yard cleaning</td>
<td>hrs</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>hrs</td>
</tr>
<tr>
<td></td>
<td>hrs</td>
</tr>
<tr>
<td></td>
<td>hrs</td>
</tr>
</tbody>
</table>
Appendix 2 – Survey instruments (Part I, II and III) and Treatment record

Your Health Related Quality of Life

Q13 Did you have any other illness at the time you contracted Ross River virus? Please tick relevant boxes.

☐ Yes  ☐ No

13a. Could you please indicate what sort of illness?

☐ Arthritis (i.e. osteo/ rheumatoid/ psoriatic)
☐ Chronic fatigue syndrome
☐ Other (please specify)


Q14 In general, would you say your health is: Please tick one box.

☐ Excellent
☐ Very good
☐ Good
☐ Fair
☐ Poor

Q15 Compared to one year ago, how would you rate your health in general now? Please tick one box.

☐ Much better now than one year ago
☐ Somewhat better now than one year ago
☐ About the same as one year ago
☐ Somewhat worse now than one year ago
☐ Much worse now than one year ago

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Appendix 2—Survey instruments (Part I, II and III) and Treatment record

Q16 The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?
*Please tick ✓ relevant boxes (one per row).*

<table>
<thead>
<tr>
<th>Activities</th>
<th>Yes, limited a lot</th>
<th>Yes, limited a little</th>
<th>No, not limited at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Lifting or carrying groceries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Climbing several flights of stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Climbing one flight of stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Bending, kneeling, or stooping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Walking more than a mile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Walking several blocks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Walking one block</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Bathing or dressing yourself</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q17 During the past four weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health?
*Please tick ✓ relevant boxes (one per row).*

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cut down on the <em>amount of time</em> you spent on work or other activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. <em>Accomplished less</em> than you would like</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Were limited in the <em>kind</em> of work or other activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Had <em>difficulty</em> performing the work or other activities (for example, it took extra effort)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Appendix 2 – Survey instruments (Part I, II and III) and Treatment record

Q18  During the **past four weeks**, have you had any of the following problems with your work or other regular daily activities **as a result of any emotional problems** (such as feeling depressed or anxious)?

*Please tick relevant boxes (one per row)*

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cut down on the <strong>amount of time</strong> you spent on work or other activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Accomplished <strong>less than you would like</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Did not do work or other activities as <strong>carefully as usual</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q19  During the **past four weeks**, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

*Please tick **one box**.*

- Not at all
- Slightly
- Moderately
- Quite a bit
- Extremely

Q20  How much **bodily pain** have you had during the **past four weeks**?

*Please tick **one box**.*

- None
- Very mild
- Mild
- Moderate
- Severe
- Very severe
Appendix 2—Survey instruments (Part I, II and III) and Treatment record

Q21 During the past four weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Please tick ☑ one box.

☐ Not at all
☐ Slightly
☐ Moderately
☐ Quite a bit
☐ Extremely

Q22 These questions are about how you feel and how things have been with you during the past four weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past four weeks -

Please tick ☑ relevant boxes (one per row).

<table>
<thead>
<tr>
<th></th>
<th>All of the time</th>
<th>Most of the time</th>
<th>A good bit of the time</th>
<th>Some of the time</th>
<th>A little of the time</th>
<th>None of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Did you feel full of life?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Have you been a very nervous person?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Have you felt so down in the dumps that nothing could cheer you up?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Have you felt calm and peaceful?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Did you have a lot of energy?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Have you felt downhearted and depressed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Did you feel worn out?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Have you been a happy person?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Did you feel tired?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2 – Survey instruments (Part I, II and III) and Treatment record

Q23 During the past four weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives etc.)? Please tick one box.

- All of the time
- Most of the time
- Some of the time
- A little of the time
- None of the time

Q24 How TRUE or FALSE is each of the following statements for you? Please tick relevant boxes (one per row).

<table>
<thead>
<tr>
<th></th>
<th>Definitely true</th>
<th>Mostly true</th>
<th>Don’t know</th>
<th>Mostly false</th>
<th>Definitely false</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>I seem to get sick a little more easily than other people</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>I am as healthy as anybody I know</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>I expect my health to get worse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>My health is excellent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Your attitude to problems with mosquitoes

Q25

Please select the answer that best fits to your situation.

25a Mosquitoes are a problem around my house...

☐ Very often - throughout most of the year
☐ Often - mainly after heavy rains or/and high tides
☐ Sometimes
☐ Rarely

25b How much are you affected by mosquitoes in your home (e.g. reading, watching TV, doing housework etc.)?

☐ No effect
☐ Minor effect
☐ Moderate effect
☐ Major effect

25c How much are you affected by mosquitoes in your yard/garden (e.g. social events, gardening etc.)?

☐ No effect
☐ Minor effect
☐ Moderate effect
☐ Major effect

25d How much are you affected by mosquitoes in the neighbourhood close by (e.g. playing tennis, running)?

☐ No effect
☐ Minor effect
☐ Moderate effect
☐ Major effect

25e How much are you affected by mosquitoes in your suburb/Council area (e.g. walking/jogging in the park)?

☐ No effect
☐ Minor effect
☐ Moderate effect
☐ Major effect
Appendix 2 – Survey instruments (Part I, II and III) and Treatment record

Q26 Have you been involved in any outdoor activities (e.g. fishing, bushwalking, camping) 2-3 weeks before your Ross River virus illness?
Please tick ☑ relevant boxes.
☑ Yes ☑ No (Go to Question 27) ☑ Don’t know (Go to Question 27)

26a If yes, what activity and where?
e.g. camping at Fraser Island

☑ Bushwalking at _____________________________
☑ Camping at _____________________________
☑ Fishing at _____________________________
☑ Other (please specify)

Q27 According to your knowledge, where did you think you were bitten by mosquitoes?
Please tick ☑ relevant boxes.

☑ At home
☑ In the yard/garden
☑ While playing tennis/golf/bowl game
☑ Social event/party
☑ Bushwalking
☑ Camping
☑ Fishing
☑ Other (please specify)
Do you know about any mosquito control programs active in your local government area?

Please tick relevant boxes.

☐ Yes  ☐ No (Go to Question 29)  ☐ Don’t know (Go to Question 29)

28a If yes, how satisfied are you with mosquito control programs in the area you live?

☐ Very satisfied (Go to Question 29)
☐ Satisfied (Go to Question 29)
☐ Neutral - neither satisfied nor dissatisfied (Go to Question 29)
☐ Dissatisfied (Go to Question 28b)
☐ Very dissatisfied (Go to Question 28b)

28b Why do you feel current mosquito control programs are unsatisfactory in your area?

If dissatisfied Please list any reason(s) starting with your highest priority.
Appendix 2 – Survey instruments (Part I, II and III) and Treatment record

Q29  Does your house have fly screens?
     Please tick relevant boxes and answer.
     □ Yes  □ No (Go to Question 30)
     29a  Did you add them to house?
          □ Yes  □ No (Go to Question 29d)
     29b  About how much did they cost?
          $ ______
     29c  When were they installed?
          Year ______
     29d  Was the presence of screens important in deciding to live here?
          □ Yes  □ No
     29e  How important are these screens to you?
          □ Not important at all
          □ Of minor importance
          □ Of some importance
          □ Of great importance

Q30  Do you use mosquito nets for beds at home?
     Please tick relevant box and answer.
     □ Yes  □ No (Go to Question 31)
     30a  How many mosquito nets do you have in your home?
          ______
To avoid mosquitoes, have you spent any money on the following items? If so, please tell us about how much you have spent in the last year to avoid mosquitoes.

*Please tick [✓] relevant boxes.*

<table>
<thead>
<tr>
<th>Item</th>
<th>$0</th>
<th>About $10 or less (please write rough amount)</th>
<th>$10 - 50</th>
<th>$50 - 100</th>
<th>About $100 or more (please write rough amount)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repellents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mosquito coils</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plug-in 'zappers'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insect spray</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citronella candles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

31a Have you taken any action(s) to avoid mosquitoes other than screens, nets and above mentioned items?

*Please describe the action and cost involved (if any).*

__________________________________________

__________________________________________

__________________________________________

__________________________________________
Q32 Do you think that the presence of mosquitoes and risk of getting Ross River virus could affect house prices in your suburb? Please tick relevant boxes.

☐ Yes  ☐ No (Go to next question)  ☐ Don’t know (Go to next question)

32a What impact do you think it might have on a typical $150,000 house in the area?

☐ No impact
☐ Reduce value by about $5,000
☐ Reduce value by $5,001 – 10,000
☐ Reduce value by $10,001 – 15,000
☐ Reduce value by more than $15,000
☐ Don’t know

32b If you answered Question 32a, what source(s) of information are you using to rate this impact?

☐ Own opinion
☐ Information from real estate agent
☐ Other people (friend, family, neighbour)
☐ Something I read/heard/watched (media)
☐ Other (please specify)

Q33 Do you think that the presence of mosquitoes and risk of getting Ross River virus could reduce the number of people (e.g. tourists) visiting your suburb/local government area? Please tick one box.

☐ Yes
☐ No
☐ Don’t know
Appendix 2—Survey instruments (Part I, II and III) and Treatment record

Please tell us about yourself

- This information is important to ensure that your answers represent the views of the larger population of people who have had Ross River virus illness in Queensland
- Please remember that your answers are highly confidential and will only be used in overall summaries.

Q34 What is your gender?
Please tick  one box.

☐ Male  ☐ Female

Q35 What age group do you belong to?
Please tick  one box.

☐ Below 18 years  ☐ 18–24 years
☐ 25–34 years  ☐ 35–44 years
☐ 45–54 years  ☐ 55–64 years
☐ 65–74 years  ☐ Over 75 years

Q36 What is the highest level of education you have completed?
Please tick  one box.

☐ Primary school  ☐ Secondary school (completed Grade 10)
☐ Secondary school (completed Grade 12)  ☐ Trade/Technical Certificate
☐ Diploma or Associate Diploma  ☐ Undergraduate degree
☐ Postgraduate degree  ☐ Other (please specify)
Q37 Are you working (full-time or part-time)?
Please tick relevant box(es).

☐ Yes  ☐ No

If yes, what is your occupation?
Please write. (e.g. school teacher, plumber)

37a

☐ Full-time  ☐ Part-time

37b Normally, where do you spend most of your work-time?
Indoor  Outdoor

☐  ☐

37c If not, are you currently

☐ Unemployed ☐ please write your last occupation

☐ Retired ☐ please write your last occupation

☐ Other (please explain)

Q38 What was your source of health care at the time of your Ross River virus illness?
Please tick one box.

☐ Medicare
☐ Private health insurance (hospital cover)
☐ Private health insurance (hospital + extras)
☐ Private health insurance (hospital + extras + ambulance)
Thank you for taking the time to complete this survey. Your assistance in providing this information is very much appreciated. We will be contacting you for the follow up survey about six months time.

Please return the completed survey in the self-addressed, reply-paid envelope to:

"Ross River Virus Study"
Australian School of Environmental Studies
Griffith University
Nathan
Qld 4111

*This address is on the reply-paid envelope provided. It is repeated here for your information.*
Appendix 2—Survey instruments (Part I, II and III) and Treatment record

About Your Illness with Ross River Virus – Part II

Introduction

- Thank you for participating in the Ross River virus study
- Please note that couple of questions from the previous survey have been asked again to check on changes in your health
- Please return the completed questionnaire in the reply-paid envelope provided

Your Case of Ross River Virus

Q1
Do you consider that you have fully recovered from Ross River virus illness?
Please tick one box.

☐ Yes

☐ No (Go to next question)

When do you think you recovered fully?
Month

Year

Q2
How serious do you believe was your case of Ross River virus?
Please tick one box:

☐ Very Mild – had very little effect on my daily life
☐ Mild – had little effect on my daily life
☐ Moderate – had some effect on my daily life
☐ Severe – had severe effects on my daily life
☐ Very Severe – had very severe effects on my daily life
Q3 Which health professionals did you consult for treatment for Ross River virus?

I visited

☐ General Practitioner(s)

*If you visited a general practitioner please tick [ ] the box and complete the table below.*

<table>
<thead>
<tr>
<th>How often? (number of visits)</th>
<th>How much time spent per visit? (total time including waiting and consultation - please circle)</th>
<th>Approximate average cost per visit ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mins / hrs</td>
<td></td>
<td>yes no</td>
<td></td>
</tr>
</tbody>
</table>

I visited

☐ Specialist(s) please specify, e.g. rheumatologist, dermatologist

*If you visited a specialist please tick [ ] the box and complete the table below.*

<table>
<thead>
<tr>
<th>Specialist (Type)</th>
<th>How often? (number of visits)</th>
<th>How much time spent per visit? (total time including waiting and consultation)</th>
<th>Approximate average cost per visit ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mins / hrs</td>
<td></td>
<td>yes no</td>
<td></td>
</tr>
</tbody>
</table>

I visited

☐ Alternative health practitioner(s) please specify e.g. acupuncturist, homeopath

*If you visited an alternative health practitioner please tick [ ] the box and complete the table below.*

<table>
<thead>
<tr>
<th>Alternative health practitioner (Type)</th>
<th>How often? (number of visits)</th>
<th>How much time spent per visit? (total time including waiting and consultation)</th>
<th>Approximate average cost per visit ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mins / hrs</td>
<td></td>
<td>yes no</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>mins / hrs</th>
<th>yes no</th>
<th></th>
</tr>
</thead>
</table>
### Q4
Across the whole period you were sick with Ross River virus, did you spend any money on medication for treating the disease?

*Please tick relevant boxes (one per row).*

- [ ] Yes
- [ ] No (Go to next question)

#### 4a
About how much did you spend in total on medication?

<table>
<thead>
<tr>
<th>Medication</th>
<th>About $25 or less (please write rough amount)</th>
<th>$26-50</th>
<th>$51-75</th>
<th>$76-100</th>
<th>About $100 or more (please write rough amount)</th>
</tr>
</thead>
<tbody>
<tr>
<td>with prescription</td>
<td>$</td>
<td></td>
<td></td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>without prescription</td>
<td>$</td>
<td></td>
<td></td>
<td>$</td>
<td></td>
</tr>
</tbody>
</table>

### Q5
Did you have to take any other procedure (e.g. urine, X-ray) relating to your Ross River virus illness?

*Please complete.*

- [ ] Yes
- [ ] No (Go to next question)

<table>
<thead>
<tr>
<th>Test/treatment (Type)</th>
<th>How often? (number of tests)</th>
<th>Average cost per test/treatment ($) (the amount before you got any money back from Medicare or health insurance)</th>
<th>Bulk billed (please circle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>yes no</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>yes no</td>
</tr>
</tbody>
</table>
Appendix 2—Survey instruments (Part I, II and III) and Treatment record

**Q6** Did you have to travel for medical treatment during your Ross River virus illness (e.g. for consultation, blood test or other test/treatment)?

Please tick one box.

- **☐ Yes**
- **☒ No (Go to next question)**

**6a** What sort of transport did you **generally** use to get to medical treatment for Ross River virus illness?

Please select relevant mode of transport from the following list.

- (C)=car
- (B)=bus
- (T)=train
- (F)=ferry
- (O)=other

### Consultation

<table>
<thead>
<tr>
<th>Mode of transport (please specify)</th>
<th>Number of trips (number)</th>
<th>Average cost per trip ($/trip) (for a private car just consider the cost of petrol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. C (car)</td>
<td>3</td>
<td>$12.00</td>
</tr>
</tbody>
</table>

### Blood tests

<table>
<thead>
<tr>
<th>Mode of transport (please specify)</th>
<th>Number of trips (number)</th>
<th>Average cost per trip ($/trip) (for a private car just consider the cost of petrol)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Other test/treatment

<table>
<thead>
<tr>
<th>Mode of transport (please specify)</th>
<th>Number of trips (number)</th>
<th>Average cost per trip ($/trip) (for a private car just consider the cost of petrol)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Appendix 2 – Survey instruments (Part I, II and III) and Treatment record**

Q7 Did you receive any help from other people because of your Ross River virus illness?

Please tick [ ] relevant boxes.

- [ ] Yes
- [ ] No (Go to next question)

7a For what activity and for how many days or hours you received help?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total number of hours or day(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>hours in total</td>
</tr>
<tr>
<td>Personal care (e.g. dressing, grooming)</td>
<td>___ hrs</td>
</tr>
<tr>
<td>Household work (e.g. cooking, cleaning)</td>
<td>___ hrs</td>
</tr>
<tr>
<td>Driving</td>
<td>___ hrs</td>
</tr>
<tr>
<td>Grocery shopping</td>
<td>___ hrs</td>
</tr>
<tr>
<td>Gardening/yard cleaning</td>
<td>___ hrs</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>___ hrs</td>
</tr>
</tbody>
</table>

**Your Health Related Quality of Life**

SF-36

Q8 In general, would you say your health is:

Please tick [ ] one box:

- [ ] Excellent
- [ ] Very good
- [ ] Good
- [ ] Fair
- [ ] Poor
Q9  Compared to one year ago, how would you rate your health in general now?  
Please tick [✓] one box.

☐ Much better now than one year ago  
☐ Somewhat better now than one year ago  
☐ About the same as one year ago  
☐ Somewhat worse now than one year ago  
☐ Much worse now than one year ago

Q10  The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?  
Please tick [✓] relevant boxes (one per row).

<table>
<thead>
<tr>
<th>Activities</th>
<th>Yes, limited a lot</th>
<th>Yes, limited a little</th>
<th>No, not limited at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Lifting or carrying groceries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Climbing several flights of stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Climbing one flight of stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Bending, kneeling, or stooping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Walking more than a mile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Walking several blocks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Walking one block</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Bathing or dressing yourself</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
During the past four weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health?
*Please tick relevant boxes (one per line).*

| a. Cut down on the amount of time you spent on work or other activities | Yes | No |
| b. Accomplished less than you would like | |
| c. Were limited in the kind of work or other activities | |
| d. Had difficulty performing the work or other activities (for example, it took extra effort) | |

During the past four weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?
*Please tick relevant boxes (one per row).*

| a. Cut down on the amount of time you spent on work or other activities | Yes | No |
| b. Accomplished less than you would like | |
| c. Did not do work or other activities as carefully as usual | |

During the past four weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
*Please tick one box.*

- [ ] Not at all
- [ ] Slightly
- [ ] Moderately
- [ ] Quite a bit
- [ ] Extremely
Appendix 2—Survey instruments (Part I, II and III) and Treatment record

Q14 How much bodily pain have you had during the past four weeks?
Please tick one box.

- None
- Very mild
- Mild
- Moderate
- Severe
- Very severe

Q15 During the past four weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?
Please tick one box.

- Not at all
- Slightly
- Moderately
- Quite a bit
- Extremely

Q16 During the past four weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives etc.)?
Please tick one box.

- All of the time
- Most of the time
- Some of the time
- A little of the time
- None of the time
These questions are about how you feel and how things have been with you during the past four weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past four weeks -
Please tick relevant boxes (one per row).

<table>
<thead>
<tr>
<th></th>
<th>All of the time</th>
<th>Most of the time</th>
<th>A good bit of the time</th>
<th>Some of the time</th>
<th>A little of the time</th>
<th>None of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Did you feel full of life?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Have you been a very nervous person?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Have you felt so down in the dumbs that nothing could cheer you up?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>Have you felt calm and peaceful?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>Did you have a lot of energy?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>Have you felt downhearted and depressed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g.</td>
<td>Did you feel worn out?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h.</td>
<td>Have you been a happy person?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Did you feel tired?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2—Survey instruments (Part I, II and III) and Treatment record

Q18 How TRUE or FALSE is each of the following statements for you?
*Please tick relevant boxes (one per row).*

<table>
<thead>
<tr>
<th></th>
<th>Definitely true</th>
<th>Mostly true</th>
<th>Don’t know</th>
<th>Mostly false</th>
<th>Definitely false</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I seem to get sick a little more easily than other people</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. I am as healthy as anybody I know</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. I expect my health to get worse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. My health is excellent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q19 What were you doing around the time you caught Ross River virus?
*Please tick relevant box.*

- Working (on the job)
- Working (just house work)
- On holidays
- Other (please explain)

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Appendix 2 - Survey instruments (Part I, II and III) and Treatment record

Q20 Did you take time off from work because of Ross River virus illness? Please tick relevant boxes.

☐ Yes  ☐ No (Go to Question 21)  ☐ I don’t work (Go to Question 21)

20a How many days were you off work? ________ day(s)

20b Did you return to work after this period?

☐ Yes (Go to Question 21)  ☐ No

20c Why did you not return to work?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Q21 Did Ross River virus illness have any effect(s) on your holiday plans or work? Please tick relevant box.

☐ Yes  ☐ No (Go to next question)

Please describe?

1. _____________________________________________

2. _____________________________________________

3. _____________________________________________
**Other costs and effects associated with Ross River virus**

**NOTE:** Currently there is no vaccine or any other treatment available which prevents Ross River virus. Keeping this in mind, please answer the following hypothetical question.

Imagine that re-infection with Ross River virus is possible and you face the prospect of SIMILAR SYMPTOMS that you had with your previous infection. Say that a pill was available that would reduce the chance of another Ross River virus infection to almost NOTHING. The imaginary pill would work for ONE YEAR and you would have to pay the FULL COST. Therefore, you would have to give up spending that money on other things in order to get the pill.

**If the pill did exist, it would cost $130** (NOTE: THE PAYMENT WOULD NOT BE COVERED BY MEDICARE OR INSURANCE)

**Q22** Would you be willing to pay $130 for this pill?

*Please tick relevant box.*

- [ ] Yes
- [ ] No

**Q23** Would you be willing to pay $210 for the pill?

*Please tick relevant box.*

- [ ] Yes
- [ ] No

**Q24** Would you be willing to pay $50 for the pill?

*Please tick relevant box.*

- [ ] Yes
- [ ] No

**Q25** What would be the maximum amount you would be prepared to pay for the pill?

*Please write the biggest dollar amount you would pay.*

$__________
If you said an amount greater than $0 in Q25, please skip this question and go to Question 27.

If you were not prepared to pay for the pill at all (that is, you said $0 in Question 25), please complete this question (Q26)↓

**Q26** What was the main reason(s) for your unwillingness to pay a dollar amount for the Ross River pill?

*Please tick [ ] relevant box(es).*

- [ ] I didn’t have enough information to estimate a dollar value
- [ ] I couldn’t afford to pay for the treatment (out of my pocket)
- [ ] I would have it only if subsidised by the government
- [ ] I don’t care about getting Ross River virus again
- [ ] Other (please specify)

**Q27** Have there been any other good or bad effects of Ross River virus illness on your life?

*Please list them starting with the most important effect.*

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
To estimate a realistic cost of Ross River virus we need to adjust some of your answers by your approximate yearly income. Which of the following best describes your rough yearly income (before tax)?
(This information is completely confidential and will only be used for weighting purposes)

Please tick one box.

☐ Less than $8,300
☐ $8,301 – 15,600
☐ $15,601 – 26,000
☐ $26,001 – 36,400
☐ $36,401 – 52,000
☐ $52,001 – 78,000
☐ More than $78,001

Thank you for taking the time to complete this survey. Your assistance in providing this information is very much appreciated. If there is anything else you would like to tell us about the survey or mosquito problems or Ross River virus in particular please do so in the space provided below.

My comments:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
About Your Illness with Ross River Virus – Part III

Dear ————,

- We greatly appreciate your participation in the RRv survey. This phone survey is to check on your disease recovery progress.
- At this stage, we also would like to know about any disease-related spending (if you had any after the second survey).
- Could you please spend a couple of minutes to answer these questions?

Q1. Have you fully recovered from Ross River virus illness?
   Please tick one box.

   □ Yes
   □ No (Go to Question 2)

   Roughly when was it?
   Month
   Year

   We are glad to hear your full recovery. Many thanks for your participation in the survey!

Q2. Could you please tell us what RRv symptoms still you have?
   Please tick relevant boxes (one per row).

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Joint pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Muscle pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Stiff joints</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Stiff neck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Skin rash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Fever/chills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Headache</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Depression</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Other (Please specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

255
After the follow up survey (second survey), did you spend any money on your Ross River virus illness?

- Yes
- No (Many thanks for your participation in the survey!)

If yes, could you please tell us for what?

<table>
<thead>
<tr>
<th>Consultation</th>
<th>Pathology tests</th>
<th>Medication</th>
<th>Other (specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.1 Consultation

<table>
<thead>
<tr>
<th>Health professional</th>
<th>How often?</th>
<th>Average cost</th>
<th>Bulk billed</th>
</tr>
</thead>
<tbody>
<tr>
<td>GP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative health practitioner(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.2 Pathology tests

<table>
<thead>
<tr>
<th>Test</th>
<th>How many?</th>
<th>Average cost</th>
<th>Bulk billed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.3 Medication

<table>
<thead>
<tr>
<th>Item</th>
<th>Average cost/week</th>
<th>Concession</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescribed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over the counter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.4 Other (pl. specify)

<table>
<thead>
<tr>
<th>Item</th>
<th>How often?</th>
<th>Average cost</th>
<th>Concession</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thank you!
APPENDIX 3

Initial Data Analysis
INITIAL DATA ANALYSIS

An initial data analysis was conducted to examine and summarise trends and key characteristics of survey findings concerning the demographic profile of survey victims, disease symptoms, medical treatment activities, and disease-related impacts. The demographic profile of the sample included description of age and gender distribution, marital status, level of education and training, occupation and labour force participation. Age and gender distribution were compared with total Ross River virus population in Queensland. However, it was not possible regarding other characteristics. Therefore, wherever relevant, survey data were compared with appropriate patterns for the Queensland population overall. In addition, the initial data analysis examined individual attitudes and behaviour relevant to the mosquito problem, average spending to protect from mosquitoes and perceptions on mosquito control programs conducted by local government authorities.

The initial data analysis also aimed to identify survey victims with pre-existing chronic illnesses “co-morbidity” since the inclusion of victims with co-morbid conditions often leads to overstated disease impacts. Co-morbidity is reported as one of the main contributing factors for longer recovery periods of Ross River virus (Mylonas et al. 2002). The illnesses such as rheumatoid and other forms of arthritis, chronic fatigue syndrome, depression, diabetes, hypertension and Barmah Forest virus disease were considered as co-morbid conditions.

Demographic profile

This section describes the main characteristics of the Ross River virus sample including demographic features such as age and gender distribution, marital status, level of education, training and occupation. Since the research was designed to assess the social and economic implications of Ross River virus, it was critical to examine disease impacts upon productivity and related human capital aspects.

---

1 Other information such as victim’s marital status and occupation were not available.
**Age and gender**

Comparable gender and age group data for total Queensland and survey sample are presented in Figure 1.0. Although reasons are not known, unusually low Ross River virus notifications, around 888, were reported in 2002 across Queensland. Of the 226 consented, 201 Ross River virus victims completed the whole survey. It is clear that the relative probability of contracting Ross River virus is higher in the 35 – 45 year old categories (for both men and women). The mean age of study cases was estimated at 47.5 years (SD = 13.7 years) and the male to female ratio in the group was 0.8.

**Figure 1.** Demographic profiles of Ross River virus victims notified in 2002 – RRv population (888) and RRv sample (201)

The study sample had a very similar age-sex profile to that of all Ross River virus victims in 2002 with the exception of the absence of children (who
made up around a small proportion of all cases in Queensland) and also a slightly lower proportion of 18-24 year olds in the study group (see Figure 1.0).

Marital status

It is reported marital status may be closely linked with disease-related indirect costs and recovery rates (Andersen et al., 2000). This could be due to the potential help and assistance received from spouse or partner (married or de facto) to carry out day-to-day tasks (such as personal care, household work and driving) during the illness.

Because Ross River virus disease is known for its debilitating and persistent symptoms, such day-to-day tasks are often impeded by temporary physical disability and incapacity caused by the illness. Therefore, marital status may have a significant association with indirect disease costs and health-related quality of life. According to the survey responses, around 75% (150 victims) indicated that they were either married or de facto. The remaining 25.4% (51 victims) was either unmarried, widowed, divorced or separated (see Table 1.0).

<table>
<thead>
<tr>
<th>Marital status</th>
<th>Total Queensland</th>
<th>RRv Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>51.3</td>
<td>62.7</td>
</tr>
<tr>
<td>De facto</td>
<td>n.a</td>
<td>11.9</td>
</tr>
<tr>
<td>Divorced</td>
<td>8.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Separated</td>
<td>3.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Widowed</td>
<td>5.8</td>
<td>3.0</td>
</tr>
<tr>
<td>Unmarried</td>
<td>31.2</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Note: 1 Registered marital status for persons aged 15 years and over  
n.a. Not available

Level of education and training

Of the total sample surveyed, 90% completed secondary school or a higher level of formal education. The majority had secondary school or trade/technical certificate qualifications (Table 2.0). It is noteworthy that the
proportions of possessing trade/technical qualifications and diploma/advance diploma are approximately the same for total Queensland and Ross River virus sample.

Table 2.0 Demographic profile of Queensland population vs. Ross River virus sample – level of education and training (proportion as a %)

<table>
<thead>
<tr>
<th>Level completed</th>
<th>Total Queensland</th>
<th>RRv Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary/Secondary school</td>
<td>50.0</td>
<td>65.2</td>
</tr>
<tr>
<td>Trade/Technical certificate</td>
<td>18.5</td>
<td>17.8</td>
</tr>
<tr>
<td>Diploma/Advanced diploma</td>
<td>6.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>9.7</td>
<td>4.0</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>2.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Not stated</td>
<td>12.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Note: 1 Include persons aged 15 years and over

According to the survey responses, the number of male participants possessing trade/technical qualifications appears to be much higher than that of females. A similar trend was observed among the Queensland population. Lost output linked to work place absenteeism and inefficiency. Since the majority of survey victims are in the labour force, indirect costs on account of lost out put could be substantial given the nature of the Ross River virus disease symptoms and severity.

Labour force participation

The labour force participation rate reported in the Ross River virus survey was slightly higher than that of the Queensland population (Table 3)\(^2\). Around 66% of the Ross River virus sample indicated that they were employed on full or part-time basis\(^3\). This comprised of an equal proportion of males and females (32%). Of the total sample, around 5% indicated that they were unemployed at the time they contracted Ross River virus\(^4\). These unemployment figures were similar to that of the Queensland population (Table 3.0).

---

\(^2\) The labour force (persons employed or unemployed) as a percentage of the total population (ABS)

\(^3\) Full time – work over 35 hours or more per week in total (ABS)

\(^4\) Actively looking for work and ready to start work (ABS, 2001)
Table 3.0 Demographic profile of Queensland population vs. Ross River virus sample – labour force participation (proportion as a %)

<table>
<thead>
<tr>
<th>Status</th>
<th>Total Queensland 1</th>
<th>RRv Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employed</td>
<td>55.8</td>
<td>65.6</td>
</tr>
<tr>
<td>Unemployed</td>
<td>5.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Not in the labour force</td>
<td>35.2</td>
<td>28.9</td>
</tr>
<tr>
<td>Not stated</td>
<td>4.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note: 1 Include persons aged 15 years and over

The majority of employed Ross River virus victims were working on full-time basis (50%) while 15% were part-timers. Most of the male employees worked on full-time basis while female employees appear to prefer part-time work. In addition, a similar trend was observed in the latest Census data for Queensland (Table 4). Those not in the labour force (29%) were, either at retirement age (17%) or performing housework (10%) or continuing studies (2%).

Table 4.0 Demographic profile of Queensland population vs. Ross River virus sample -- employment status (proportion as a %)

<table>
<thead>
<tr>
<th>Employment Status</th>
<th>Total Queensland 1</th>
<th>RRv Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time</td>
<td>63.9</td>
<td>76.2</td>
</tr>
<tr>
<td>Part-time</td>
<td>33.0</td>
<td>23.8</td>
</tr>
<tr>
<td>Not stated</td>
<td>3.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Note: 1 Include persons aged 15 years and over

Income distribution

Table 5.0 presents the average weekly earnings (before tax) reported in the Ross River virus survey. Eleven people did not respond to this question. Relevant weekly earnings of the Queensland population are also given in the table (ABS catalogue No. 6302.0). According to income data in table 7.0, middle income groups (with a weekly income between $300 and $1500) were well represented while lower and higher income groups were not. These income
data will be used as a major explanatory variable to explain the variations in health care costs and willingness-to-pay.

Table 5.0  Queensland population vs. Ross River virus sample - average income distribution (proportion as a %)

<table>
<thead>
<tr>
<th>Weekly income</th>
<th>Total Queensland¹</th>
<th>RRv Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $199</td>
<td>1.4</td>
<td>10.0</td>
</tr>
<tr>
<td>$200 - $299</td>
<td>1.6</td>
<td>15.9</td>
</tr>
<tr>
<td>$300 - $499</td>
<td>17.7</td>
<td>15.9</td>
</tr>
<tr>
<td>$500 - $699</td>
<td>12.4</td>
<td>17.4</td>
</tr>
<tr>
<td>$700 - $999</td>
<td>16.1</td>
<td>19.4</td>
</tr>
<tr>
<td>$1,000 - $1,499</td>
<td>19.5</td>
<td>10.9</td>
</tr>
<tr>
<td>Over $1,500</td>
<td>18.7</td>
<td>5.0</td>
</tr>
<tr>
<td>Not available²</td>
<td>12.6</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Note: ¹ Weekly household income living in private dwellings ² Not reported, missing or incomplete information

Sources: ABS Catalogue 2001.0

Co-morbidity

In general, health studies involving actual patients follow clinical screening or individual reviews by a trained health professional. This often involves a face-to-face interview and examination aimed at collecting first-hand information about patient's health-related history (reported and unreported illnesses) and the existing illness. This information is also useful to identify co-existing illness/es (co-morbidity).

The enrolled Ross River virus victims in this study were not clinically screened or reviewed hence the presence of co-morbid condition was exclusively based on the information provided in the survey. For consistency and transparency, co-morbidity was defined as the presence of chronic illness/disease other than Ross River virus at the time they were diagnosed with Ross River virus. Accordingly, in the first survey form Ross River virus survey victims were asked to provide relevant information. This includes the chronic illness/disease and current state of the illness/disease⁵.

⁵ For example, whether survey victims were receiving any medical treatment or on medication at the time they were contracted Ross River virus illness.
Table 6.0 presents a summary of reported co-existing illness/es. According to survey responses, around 27% (55 cases) reported the presence of a co-morbid condition at the time they were diagnosed with Ross River virus. The co-morbidity was due to a wide range of diseases/illnesses such as arthritis, depression, chronic fatigue, Barmah Forest virus, glandular fever, diabetes, blood pressure, thyroid related disorders, stomach ulcers and Parkinson’s disease.

<table>
<thead>
<tr>
<th>Co-morbidity</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthritis</td>
<td>21 (10.4)</td>
</tr>
<tr>
<td>Depression</td>
<td>5 (2.5)</td>
</tr>
<tr>
<td>Barmah Forest virus</td>
<td>2 (1.0)</td>
</tr>
<tr>
<td>Glandular fever</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4 (1.5)</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>3 (1.0)</td>
</tr>
<tr>
<td>Other (chronic fatigue syndrome)</td>
<td></td>
</tr>
<tr>
<td>Parkinson’s, gout, heart-related,</td>
<td></td>
</tr>
<tr>
<td>thyroid-related, stomach ulcers, skin-related</td>
<td></td>
</tr>
<tr>
<td>Sub total</td>
<td>55 (27.4)</td>
</tr>
</tbody>
</table>

In order to value the true costs of Ross River virus disease, it is vital to select survey victims free from co-morbidity. According to the survey data, around 38% of the co-morbid victims reported more than one illness. In addition, about 57% of the co-morbid victims reported that they were receiving medical treatment for their co-morbid illness at the time they were diagnosed with Ross River virus.

The initial data analysis also examined associations between study variables such as age, disease incidence and co-morbidity. According to the survey findings and previous studies, there is no significant evidence of relationships between age, gender and disease incidence. However, the initial data analysis revealed a significant association between age and co-morbidity (Spearman’s rank, r(201) = 0.27, p<0.001).
Disease prevention strategies

Mosquito control and personal protection appear to be two major disease preventative strategies. Local governments take reasonable effort to keep mosquito population under control (LGAQ, 2000) in high disease incidence areas while households too take various measures to reduce mosquito contacts and hence to minimise the overall disease risks. According to the survey, in general, people take a variety of actions to keep mosquitoes away. For example, regular checking and emptying of water holding containers, wearing of appropriate dress to cover body, limiting and timing of outdoor activities such as gardening, jogging and fishing, using fans and air conditioners, and keeping lawn, grass and shrubs clean in surrounding areas.

In addition, people also spend money to minimise mosquito bites and contracting of mosquito-transmitted diseases. There appear to be two tiers of safeguard measures at household level. The first tier comprised of preventative actions that require an initial spending (a fixed cost) such as fly screens and nets for beds. In general, they aim to reduce nuisance and insect contacts including mosquitoes by controlling their free movement. On the other hand, the second tier comprises of personal protective measures such as mosquito coils, insect sprays, repellents and citronella candles that demand recurrent spending (a variable cost).

Spending on mosquito control

The survey (part I) collected information related to all mosquito preventative actions. According to survey data, around 80% were residing in places protected by fly screens while nine% use nets for beds. Around four% of the survey population did not answer the question. An average household had spent around $1,435 (2002) on fly screens. However, none of the cases reported the cost of nets for beds. The survey also asked a question about the importance of having fly screens, Was the presence of fly screens important in deciding to

---

6 21 survey victims reported presence of more than one chronic illness at the time they contracted Ross River virus. In case of more than one illness, the first one considered as the main co-morbid condition.
live here? Around 64% of study population appear to consider it as an important factor. However, information collected in the survey was insufficient to attribute revealed perception was due to insects, in general or mosquitoes, in particular.

**Figure 2** Dependency on personal protection methods such as repellents, mosquito coils, insect spray, plug-ins and citronella products

Use of personal protective methods such as repellents, mosquito coils, insect sprays, plug-ins and citronella candles appear to be the most popular methods of preventing mosquito bites. A summary of personal protective methods reported in the survey is shown in figure 3.3. Accordingly, it appears that a combination, e.g. mosquito coils, repellents and insect spray together (69%) as the most popular approach of avoiding mosquito contacts. Contrarily, a very small proportion of respondents (6%) indicated non-use of protective methods.

**Demand for healthcare resources**

In general, medical treatment for Ross River virus begins with the first visit to General Practitioner. According to approximate duration reported between onset of the disease and the first visit to GP, it appears moderate to severe disease symptoms such as joint pain, muscle pain, stiff joints and fatigue condition urged infected case to consult a GP for medical treatment. While treating symptoms with appropriate medications, the GP advises suspected

---

7 Just to fix fly screens on an average house (initial cost in 2002 dollar terms). It does not include repair and maintenance expenditure over the years.
person to undergo pathological tests (usually a sera test) to facilitate diagnostic procedure. At this point, disease diagnosis is mostly based on the presence of Ross River virus antibodies in blood. This could be considered as formal approach of Ross River virus diagnosis (both confirm and presumptive cases) and management using medications. All these processes place an increasing demand on the existing healthcare resources such as GP and pathological services. In general, around 80% of medicare services account for GP consultations and pathology tests (Health Insurance Commission, 1999).

**Onset of illness and disease symptoms**

Survey participants were diagnosed with Ross River virus infection between April and July 2002 period. The majority of victims reported having mild symptoms prior to the first consultation of the GP. However, it is not clear whether reported symptoms were largely due to Ross River virus infection. In general, the majority of participants (61%) sought medical treatment within 14 days (mean = 18 days) of onset of the illness. Incubation period for Ross River virus is reported to be around 7-9 days (Harley *et al.*, 2001). Therefore, presumably survey respondents contracted the virus or exposed to virus-carrying mosquitoes 2 - 4 weeks before the notification. Figure 3.4 illustrates how long participants waited to consult a doctor (General Practitioner) for the first time to obtain medical treatment for the illness.

**Figure 3.** Number of days waited to see a doctor (GP) as a percentage
Appendix 3 - Initial data analysis

It is reported debilitating disease symptoms such as joint pain, muscle pain could have implications for day-to-day activities of sick person (Russell, 2002). The survey also collected information about major symptoms, their severity and duration. Over 50 % of survey population had reported joint pain, muscle pain, stiff-joints, swollen joints and fatigue as major symptoms of Ross River virus. Mostly affected (painful) joints include knees, wrists, ankles, fingers, neck, shoulders and back. However, severity of symptoms varied from mild to severe across the population.

Table 7 presents comparable disease symptoms reported in the recent survey and previous studies by Westley-Wise et al., (1996), Selden and Cameron (1996) and, Condon and Rouse (1995). It appears results reported in these studies are consistent with Ross River virus survey findings.

<table>
<thead>
<tr>
<th>Table 7.0</th>
<th>Major symptoms reported in Ross River virus studies (as a percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptom</td>
<td>Qld(^1) (N = 201)</td>
</tr>
<tr>
<td>Joint pain</td>
<td>96</td>
</tr>
<tr>
<td>Muscle pain</td>
<td>70</td>
</tr>
<tr>
<td>Stiff joints</td>
<td>75</td>
</tr>
<tr>
<td>Swollen joints</td>
<td>52</td>
</tr>
<tr>
<td>Skin rash</td>
<td>33</td>
</tr>
<tr>
<td>Fever/Chills</td>
<td>47</td>
</tr>
<tr>
<td>Headache</td>
<td>49</td>
</tr>
<tr>
<td>Fatigue</td>
<td>82</td>
</tr>
<tr>
<td>Depression</td>
<td>44</td>
</tr>
<tr>
<td>Nausea</td>
<td>17</td>
</tr>
</tbody>
</table>

Note: \(^1\) across Queensland – 2002 \(^2\) north coast of New South Wales - 1992 \(^3\) South Australian outbreak - 1992/93 \(^4\) South West region of Western Australia – 1988/89 n.a. not available

There is no prescribed treatment for Ross River virus illness. This result infected people to visit their GP several times during the illness. A small proportion of survey population (11 %) reported getting the services of specialist medical practitioners such as rheumatologists, physicians, and psychiatrists. The
survey results also revealed that a considerable proportion of survey population (27%) rely on alternative medical treatments such as naturopathy, homeopathy and acupuncture to relieve from Ross River virus symptoms.

**Diagnosis and management of the disease**

Apart from clinical symptoms, the diagnosis of Ross River virus is based on pathological test results, the presence of Ross River virus antibodies (IgG and IgM) in patient’s sera. A standard test known as ELISA (Enzyme linked immunosorbent assay) is used to identify the presence of IgG and IgM antibodies in the specimen. On behalf of GP’s request, pathological laboratories perform these tests and positive test results indicate Ross River virus infection. However, according to Hervey *et al.*, (2001), during low and high disease incidence times the probability of having positive test results vary between less than 5% and 25%, respectively. Survey results revealed that over 72% of victims had two or more sera tests conducted to diagnose Ross River virus during the study period (Figure 4).

**Figure 4** Number of blood tests conducted to diagnose Ross River virus

Incidentally, there is no prescribed treatment for Ross River virus infection. It appears that health professionals recommend a variety of medications (both prescribed and unprescribed) to treat disease symptoms. These medications range from over-the-counter medications such as paracetamol, aspirin to prescribed medications such as non-steroidal anti-inflammatory drugs (NSAID).
Appendix 3- Initial data analysis

Over 82% of victims (166 cases) indicated that they spend money for medication (both prescribed and unprescribed) to relieve from Ross River virus symptoms while around 16% (32 cases) did not buy any medications at all. Three cases did not answer the relevant survey questions. Around half of the survey population used prescribed medication to relieve from Ross River virus symptoms. The proportion of victims that used both prescribed and unprescribed drugs was about 41%.

According to the survey responses, around 25% (49 cases) revealed they were beneficiaries of the Pharmaceutical Benefit Scheme (PBS). These patients used concessional cards such as Health Care Card, Pensioner Concession Card and Commonwealth Seniors Health Card issued from Centrelink and the Department of Veteran Affairs to purchase prescribed medications under the PBS. For example, a Ross River virus case holding one of the above concession card pay only a nominal fee\(^8\) to purchase a prescribed medication at a time (HIC, 2002).

**Medical consultations**

In general, it is reported that a minimum of two consultations would be necessary for each Ross River virus case, once to have the testing arranged and once for counseling and to arrange treatment (Harley et al., 2001). The majority of survey victims (93%) reported that they had consulted a general practitioner (GP) for Ross River virus-related treatment more than once during the study period (Figure 3.6).

\(^8\) Approximately around $3.50 per prescription however, this amount varies annually since concessional patients' contribution rates are indexed in line with the CPI
The mean value of number of GP visits was three with a range of 1 – 14 visits. It is consistent with previous figures reported by Mylonas et al., (2002), Harley et al., (2001) and Condon and Rouse, (1995).

The cost of level B consultation specified in Medicare Benefit Schedule include advising and counseling the patient, ordering tests, or referring the patient to a specialist medical practitioner or other allied health professional (Commonwealth Department of Health and Aged Care, 2001). According to the survey, each GP visit cost around $35 which is slightly higher than the standard level B consultation fee (Medicare Item number 23). Around 46% of victims reported that their GP consultation fees were bulk billed while waiting time was about 35 minutes, on an average.

Only a small proportion of survey victims, 23 (11%), sought attention of specialist medical practitioners (Figure 3.7). The most common specialists include rheumatologist (10), general physician (6), neurologist (4) and psychologist (3). Seven of these victims who consulted specialist medical practitioners were reported having co-morbid conditions. The average waiting time for consultation of specialist medical practitioners was around 50 minutes, higher than that of GPs. In addition, each consultation costs around $110, on an average, and was paid out-of-pocket.
A larger proportion of patients, around one-third of patients (58), reported that they sought help of alternative health practitioners to relieve from Ross River virus symptoms (Figure 3.8). Around 14 of them were reported with co-morbid conditions. The alternative health practitioners include naturopaths (20), homeopaths (8), acupunturists (6), chiropractors (6), masseurs (3) and iridologists (2). Five patients had sought the services of more than one alternative health practitioner. The average cost for alternative health practitioner was around $45 per visit and was paid from out-of-pocket. In general, waiting time was about 50 minutes.
Appendix 3- Initial data analysis

Use of medications

The majority of cases reported their dependency on medications to relieve from disease symptoms (Figure 3.9). In general, around half of them revealed use of both prescribed and over the counter medications. However, the duration of medication use varied a lot across the study population. A small proportion of cases (16%) reported that they did not use medications however, some of them sought help from alternative medicines. Around 24% of cases have used their concession cards and paid a nominal amount to buy prescribed medications under the pharmaceutical benefit scheme.

Figure 8 Dependency on medications

[Diagram showing dependency on medications]


Hospital and nursing care

In general, paid hospital and nursing care were not utilised by Ross River virus patients. According to the survey, only three% (six cases) reported hospital or nursing care for Ross River virus illness. Four of those patients were co-morbid cases. However, around 40% (80 cases) of Ross River virus cases reported of having some nursing care at home (unpaid) due to Ross River virus illness. Often such services provided by either spouse (if married or de facto) or immediate family members. These impacts need to be accounted for valuing disease costs from societal point of view.
Rate of disease recovery

According to the first follow-up survey, Only one % (2 cases) reported full recovery from Ross River virus within a month while four % (8 cases) recovered within three months from the onset. Around 25 % (50 cases) reported complete recovery within six months\(^9\). Around 32 % (65 cases) reported moderate to severe disease symptoms even after six months.

Although reasons are not clear, reported recovery rates were slightly different to rates reported in previous studies. For example, Condon and Rouse (1995) reported 2 % of patients were completely recovered within a month while 14 % and 27 % recovered within three months and six months, respectively. According to Selden and Cameron (1996), 21 % recovered within six months while 33 % by twelve months. In New South Wales study, Westley-Wise (1996) reported seven % recovered within four weeks while 40 % within six months.

Ross River virus illness appears to be severe at onset but resolves within six to twelve months (Mylonas et al., 2002). A conservative estimate of rate of recovery was made based on the above information and survey data. For example, by taking into account cases with moderate to severe symptoms after six months of onset as unrecovered cases (38% or 76 cases), it appears that roughly 68 % (136 cases) recovered within six months of onset of Ross River virus. The majority of co-morbid cases (80% or 44 cases) reported they were not recovered from Ross River virus within six months.

Disability and restricted activities

Ross River virus is reported to be one of the main causes of morbidity in high disease incidence areas (Russell, 2002). Thus likely to have an impact upon the regional economy since disease is most common among people of the working age (e.g.25 – 65 years). In order to value the economic and social costs due to disability and restricted activities, the survey collected relevant information such as disease severity, the length of disable and restricted period,

\(^9\) However, around 38% (76 cases) of this reported irregular (on and off) mild symptoms
and actual number of days off from the job/work. Figure 3.10 illustrates the disease severity reported by individuals\textsuperscript{10}. Around 90% of survey cases perceived their Ross River virus illness condition was moderate to very severe.

**Figure 10**  Self-perceived disease condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>35%</td>
</tr>
<tr>
<td>Moderate</td>
<td>43%</td>
</tr>
<tr>
<td>Mild</td>
<td>10%</td>
</tr>
<tr>
<td>Very mild</td>
<td>3%</td>
</tr>
<tr>
<td>Very severe</td>
<td>9%</td>
</tr>
</tbody>
</table>


Based on the survey findings, it appears more than half of the survey population reported some form of disability due to Ross River virus. In this study, disability was defined as the incapacity of an individual (failure to perform daily tasks (job-related or housework) without help). Reported disability period varies from a couple of days to a couple of weeks (Table 3.12). According to the survey, average disability period reported was less than a week. In addition, a large proportion of cases, over 60%, reported restricted activities due to Ross River virus illness. Here, restricted activity defined as lack of energy and taking a longer time to complete a task (job-related or housework). Number of restricted days reported in the survey was around 13 (Table 3.12).

\textsuperscript{10} Own perception based on discussion had with GP, spouse and others such as friends, work-mates and previous Ross River virus patients
Table 8  Reported disability and restricted activity due to Ross River virus (% of total)

<table>
<thead>
<tr>
<th>Period</th>
<th>Disability</th>
<th>Restricted activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>48</td>
<td>35</td>
</tr>
<tr>
<td>Less than a week</td>
<td>23</td>
<td>8</td>
</tr>
<tr>
<td>1 – 2 weeks</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>2 – 3 weeks</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>3 – 4 weeks</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Over 4 weeks</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Not available</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Socio-economic implications of Ross River virus

In general, illness and disease could attribute for a wide variety of deterioration in the quality of life. It may bring about personal disasters that are not reflected in typical disease cost valuations (Hodgson and Meiners, 1982). For example, consequences of the illness such as disability and restricted activities may be forced into economic dependence and social isolation, loss of opportunities, unwanted job changes, and undesired changes in life. In addition, the environment created by illness often induces fear, anxiety, reduced self-esteem and feeling of well-being, resentment and emotional problems. Perhaps these may lead to problems of living, family conflicts, anti-social behaviour and suicide.

Disease impact on the life

According to the survey, it appears Ross River virus illness has an impact upon the overall life. In general, it could be attributed for associated disease symptoms, their duration and own perception about the illness. When survey participants were asked - Have there been any other good or bad effects of Ross River virus illness on your life? The majority, 64% (128 cases) perceived it had bad effects on life while three % (7 cases) had an opposite perception (Table 3.13). Around 16% (32 cases) refrained answering yes or no to this question while only a small proportion (nineteen cases) reported no impact.
Table 9 Overall disease impact on the life (% of total)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, only bad impacts</td>
<td>64</td>
</tr>
<tr>
<td>Don’t know</td>
<td>16</td>
</tr>
<tr>
<td>No impact</td>
<td>9</td>
</tr>
<tr>
<td>Not available</td>
<td>7</td>
</tr>
<tr>
<td>Yes, good impacts</td>
<td>3</td>
</tr>
</tbody>
</table>

**Impact on the employment status**

The majority of employed cases (83% of 130) reported Ross River virus illness had not affected their job circumstances. However, around 7% (9 cases) revealed they work shorter hours than usual due to the illness. In addition, 3% (4 cases) had changed or lost their job while 2% (2 cases) compelled to retire early on account of Ross River virus illness.

**SUMMARY AND CONCLUSION**

A survey was conducted among Ross River virus cases notified across Queensland between February and July 2002. It was aimed to collect the total impacts of the disease (such as health, economic and social) upon people who contract the virus. The information collected from consented cases used as the main source of data for disease cost valuation. Although there appear to be some degree of selection biases and measurement errors, survey database can be considered as a sufficient data source to value upper and lower limits of disease cost estimates.

Initial data analysis revealed typical characteristics of Ross River virus illness including demography of the risk group, morbidity and quality of life impacts. In general, survey findings were consistent with previous study reports. It appears that both males and females are likely to contract the virus and experience debilitating disease symptoms. However, survey results suggest relatively high disease risk among men and women of the middle age groups such as 35 to 55 years. Around one-fourth of the study population reported
Appendix 3- Initial data analysis

presence of other illnesses (co-morbid condition) at the time they contract Ross River virus. In addition, survey data proved a significant relationship between age and the presence of co-morbid conditions. Thus supporting a positive association between ageing and occurrence of illness, in general. The presence of co-morbid condition also suggests that care need to be taken in valuing true disease costs.

According to survey data, Ross River virus illness appears to exert increased demand on healthcare resources such as General Practitioners and pathology services. The absence of prescribed treatment for the illness compels patients to sought help from alternative health services such as naturopathy and homeopathy. Initial data analysis also suggests considerable economic, social and quality of life impacts upon people who contract the illness. Presumably some of these costs may be transferred to immediate family, the economy and the society. Therefore, valuing of disease costs from economic and social point of view appears to be desirable.
APPENDIX 4

Estimates of the Full Social Costs of Ross River Virus by LGA
### Table 7.3: Estimates of the full social costs of Ross River Virus by local government area – 2002 and 1994 – 2003

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30150</td>
<td>Aramac (S)</td>
<td>1</td>
<td>293</td>
<td>527</td>
<td>250</td>
<td>1070</td>
<td>6</td>
<td>1758</td>
<td>3162</td>
<td>1500</td>
<td>6420</td>
</tr>
<tr>
<td>30200</td>
<td>Atherton (S)</td>
<td>1</td>
<td>293</td>
<td>527</td>
<td>250</td>
<td>1070</td>
<td>51</td>
<td>14943</td>
<td>26877</td>
<td>12750</td>
<td>54750</td>
</tr>
<tr>
<td>30250</td>
<td>Aurukun (S)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>1172</td>
<td>2108</td>
<td>1000</td>
<td>4260</td>
</tr>
<tr>
<td>30300</td>
<td>Balonne (S)</td>
<td>3</td>
<td>879</td>
<td>1581</td>
<td>750</td>
<td>3210</td>
<td>78</td>
<td>22854</td>
<td>41106</td>
<td>19500</td>
<td>83460</td>
</tr>
<tr>
<td>30350</td>
<td>Banana (S)</td>
<td>16</td>
<td>4688</td>
<td>8432</td>
<td>4000</td>
<td>17120</td>
<td>206</td>
<td>60358</td>
<td>109562</td>
<td>51500</td>
<td>220420</td>
</tr>
<tr>
<td>30400</td>
<td>Barcaldine (S)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>7032</td>
<td>12848</td>
<td>6000</td>
<td>25680</td>
</tr>
<tr>
<td>30450</td>
<td>Barcoo (S)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>2051</td>
<td>3689</td>
<td>1750</td>
<td>7490</td>
</tr>
<tr>
<td>30500</td>
<td>Bauhinia (S)</td>
<td>2</td>
<td>586</td>
<td>1054</td>
<td>500</td>
<td>2140</td>
<td>34</td>
<td>9962</td>
<td>17918</td>
<td>8500</td>
<td>36380</td>
</tr>
<tr>
<td>30550</td>
<td>Beaudesert (S)</td>
<td>4</td>
<td>1172</td>
<td>2108</td>
<td>1000</td>
<td>4280</td>
<td>297</td>
<td>87021</td>
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Table 7.3  Estimates of the full social costs of Ross River Virus by local government area – 2002 and 1994 – 2003 (contd.)

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Table 7.3  Estimates of the full social costs of Ross River Virus by local government area – 2002 and 1994 – 2003 (contd.)

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1. Number of cases in QLD includes cases from all LGAs within the same LGA.
### Appendix 4 – Estimates of the full social costs of Ross River virus by LGA – 2002 and 1994-2003 (contd.)

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Estimates of the full social costs of Ross River Virus by local government area – 2002 and 1994 – 2003 (contd.)

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\(^1\) QLD: Queensland
### Table 7.3  Estimates of the full social costs of Ross River Virus by local government area – 2002 and 1994 – 2003 (contd.)

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