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ORIGINAL ARTICLE

Impact of Reducing Pre-Hospital Delay in Response to Heart Attack Symptoms in Australia

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Background This research estimates the broader socioeconomic impacts of reducing pre-hospital delay times across Australia in patients with heart attack symptoms.

Methods A cost benefit analysis (CBA) was undertaken to demonstrate the costs and benefits of a public awareness/education campaign to reduce pre-hospital delay time from 5.2 hours (Base Case) to 4.1 hours (Scenario 1) and 2.0 hours (Scenario 2). All assumptions underlying the CBA are supported by academic literature. Financial impacts considered include campaign/public education costs, direct inpatient costs and long-term health care costs. Socioeconomic impacts considered include burden of disease, productivity losses, informal care costs and net deadweight loss.

Results The campaign is expected to generate an additional net benefit of $41.2–139.1 million in comparison to the Base Case, resulting in a benefit cost ratio (BCR) of 3.23–5.06. Disability Adjusted Life Years (DALYs) reduced by 6,046-7,575 years.

Conclusion This research illustrates that an investment in public awareness/education campaign can generate considerable benefits, more than offsetting the costs associated with the campaign and keeping people living longer such as ongoing health care costs. However, significant effort, supplementary strategies and sustained investment will be required to ensure the impact and benefit is sustained over the long term.

Keywords Acute coronary syndrome • Pre-hospital delay • Health education • Mass media campaigns • Cost benefit analysis

Introduction

Coronary heart disease (CHD) affects around 1.2 million Australians [1] and was the leading cause of death in Australia in 2016, accounting for 19,077 deaths or 12.0% of all deaths Australia wide [2].

Delay to treatment is a major contributor of increased mortality and morbidity for those with CHD. Numerous studies demonstrate increased survival rates and average life expectancy, and reduced odds of mortality with timely treatment. For example, Berger et al. 1999 [3] found that in patients undergoing angioplasty for acute myocardial infarction (AMI), those who received the first balloon inflation within 60 minutes of arrival at the hospital had a 30-day mortality rate of 1.0%, but for every 15 minutes longer than one hour, the odds of death increase 1.6 times.

Delay to treatment can occur during various intervals between symptom onset and definitive treatment [4], including:

- Pre-hospital delay: includes patient delay (interval between onset of symptoms and the patient's decision

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to seek help) and transport delay (interval between seeking help and arrival at the Emergency Department (ED))
- Hospital delay: interval between ED arrival and definitive treatment.

So while delays due to transport and initiation of reperfusion therapy may contribute to late treatment, the major component of delay is the time patients take in deciding to seek help by calling emergency services ('triple zero' (000) in Australia) [4,5]. Recent data collected from six sites across Australia from 2009 to 2015 found the mean pre-hospital delay time to be 5.2 hours (National Heart Foundation of Australia, unpublished data, 2016).

A national mass media campaign was implemented by the National Heart Foundation of Australia from 2008 to 2012 to reduce pre-hospital delay time in responding to the warning signs of heart attack. Bray et al. 2015 [6] undertook an evaluation to investigate the campaign's influence on pre-hospital behaviour at one Australian hospital and found that 64% of patients presenting to the ED with acute coronary syndrome (ACS) were aware of the campaign. Of these patients, 43% reported that it influenced their actions in response to symptoms.

The purpose of this research is to estimate the broader socioeconomic impacts of the campaign in reducing pre-hospital delay times due to patient delay across Australia using cost benefit analysis (CBA). To date, no such analysis has been published.

Materials and Methods

CBA involves a systematic evaluation of the impacts of an investment, which accounts for effects on the community and economy in addition to the direct/financial effects on one group. It aims to value costs and benefits from an investment in monetary terms, converting all impacts into net present value (NPV) terms. CBA enables the assessment of whether an investment delivers a net benefit. It also enables alternative investments to be compared to identify which has the greatest net benefit.

A benefit cost ratio (BCR) is also estimated as part of the CBA, which enables the costs and benefits of an investment to be compared against a base case/status quo and alternative investments. A BCR greater than 1 indicates that benefits exceed costs.

This CBA explores the socioeconomic impacts of a reduction in pre-hospital delay time in Australia by estimating the likely patient outcomes and burden of disease that may occur. Two scenarios are analysed, with the Base Case used as the counterfactual to measure the incremental impact:

- Base Case: mean pre-hospital delay time of 5.2 hours (continuation of the status quo);
- Scenario 1: a reduction in mean pre-hospital delay time to 4.1 hours. This is based on Bray et al. 2015 [6], who found that 64% of patients presenting to ED with ACS were aware of the campaign and of these patients, 43% reported that it influenced their actions in response to symptoms. It is therefore assumed that 28% of patients saw the campaign and were influenced to change their behaviour. This assumption is applied to the Base Case presentation delay pattern, where 28% of patients who had a presentation delay of more than 2 hours under the Base Case were transferred into the less than 2 hour category (which results in a mean pre-hospital delay time of 4.1 hours);
- Scenario 2: a reduction in pre-hospital delay time to 2.0 hours, which equates to a behaviour change in 80% of patients (based on alignment with optimal patient outcomes [7]).

The Base Case has been estimated to differentiate between the outcomes that would occur if pre-hospital delay times remained at current levels. The following impacts are analysed:

- *Benefits*: reduction in productivity loss (due to a reduction in mortality and illness), reduction in informal care costs and reduction in burden of disease;
- *Costs*: campaign costs, direct inpatient costs, long-term health care costs and increase in net deadweight loss (DWL) from taxation (i.e. the additional taxation revenue required to fund health services).

The research is based on ACS data from the Australian Institute of Health and Welfare (AIHW) from 2008 to 2012. Data was also collected from six major public hospitals from 2009 to 2015 across Australia (Victoria: n = 3, South Australia: n = 1, Australian Capital Territory: n = 2) to provide more detailed observations of presentation delay patterns and emergency services utilisation not captured by the AIHW data. To estimate longer term patient outcomes, associated costs and impacts on productivity, key assumptions were derived from a variety of data sources (based on the literature and other research) which will be further detailed in the following sub-sections.

Approach

The modelling approach is illustrated in Figure 1, which shows the different pathways for patients once a patient experiences heart attack symptoms and calls emergency services (triple zero). Based on pre-hospital delay data, patients are assigned a pre-hospital delay category. Each pre-hospital delay category is associated with various health and functional outcomes, as well as associated costs. The analysis is undertaken for a cohort of patients presenting with heart attack symptoms in a given year, quantifying the broader socioeconomic impact over the course of their lifetime.

General Assumptions[1]

This analysis only considers ST-elevation myocardial infarction (STEMI) hospitalisations given the lack of available data on presentation delay patterns and associated outcomes across other conditions. Of the 55,000 AMIs in Australia from 2009–10, around 15,222 (28%) were classified as STEMI [8].

[1] A detailed outline and derivation of all assumptions can be provided upon request.

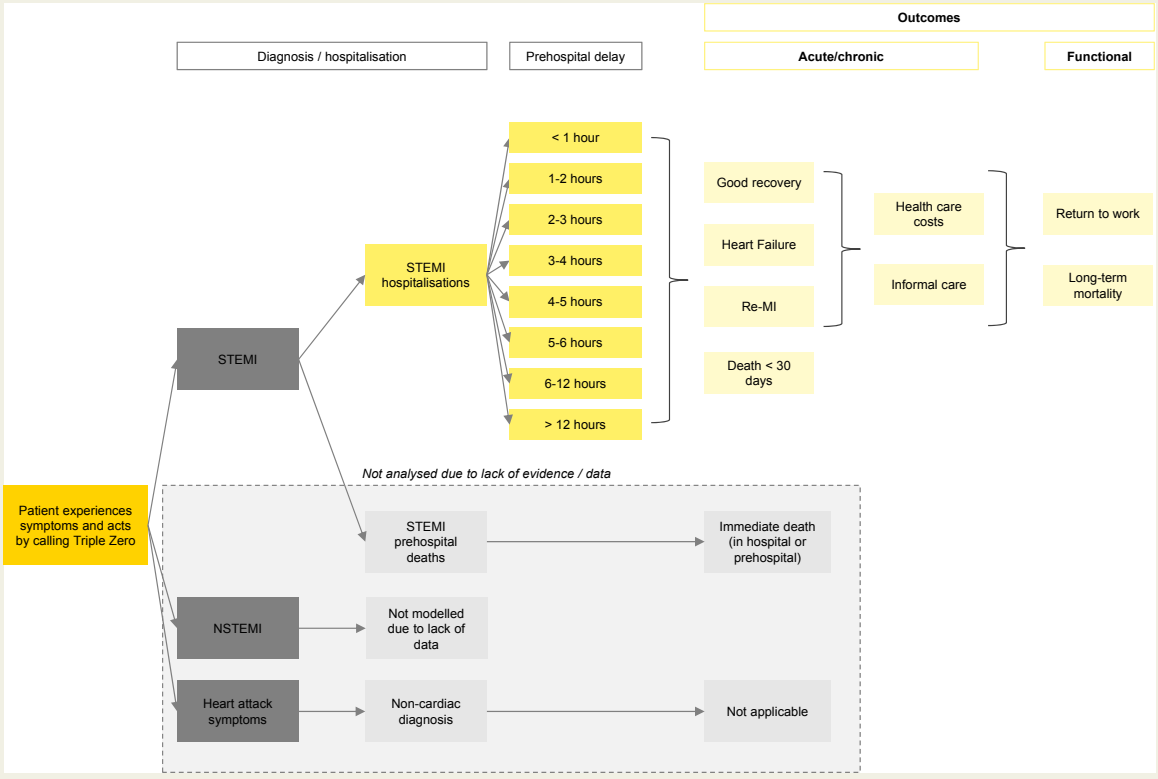

Figure 1 Approach.
Abbreviations: STEMI, ST Segment Elevation Myocardial Infarction, NSTEMI, non-ST Segment Elevation Myocardial Infarction; Re-MI, repeat myocardial infarction

The majority of STEMI patients were male (72%), with mortality rates for AMI similar across males and females [8]. Given that AMI separations have declined by an average annual rate of 1.4% from 2008–12 [8], the total number of STEMI separations in 2016 is an estimated 13,987.

The cost base date for the CBA was 1 July 2017 and a 2.5% consumer price index was used as per the Reserve Bank of Australia target. A real financial discount rate of 4.0% was used to discount future years [9].

Patient Outcomes

There are four possible outcomes modelled in the CBA that occur following STEMI: death (less than 30 days); congestive heart failure (CHF); repeat myocardial infarction (re-MI); and good recovery. The likelihood that patients will experience one of these outcomes is related to pre-hospital delay time and is based on the literature, as outlined in Table 1.

It is recognised that a broader range of patient outcomes may occur following STEMI such as stroke, angina, chronic ischaemic heart disease or a combination of multiple morbidities. These were excluded from the analysis due to the lack of data.

Longer term mortality also varies according to the different patient outcome categories. Following STEMI, most death occurs within the first 30 days [10]. This is captured by the death <30 days category and is reflected for all patient outcome categories.

Over the longer term, patients with re-MI and/or CHF have a greater likelihood of death compared to the standard population. Dharmarajan et al. 2015 [11] found that those with CHF had a 17 times greater chance of death compared to the standard population. This broadly aligns with the British Heart Foundation's estimate of the overall mortality rate for CHF at 5 years (61%). Based on mortality rates from repeat ACS [12] and comparison with Australian Bureau of Statistics (ABS) Life Tables [13], those with re-MI have a 2.8 times greater chance of death compared to the standard population.

Burden of Disease

Burden of disease is quantified through disability adjusted life years (DALYs). It is calculated as the sum of Years of Life Lost (YLL) and Years of Life Lost due to Disability (YLD).

To estimate YLD, the number of incident cases is multiplied by the average duration of disability and a disability weight that reflects the severity of the disease, which is based on AIHW estimates [14].

To estimate YLL, the number of deaths is multiplied by standard life expectancy at age of death. This was based on ABS Life Tables and comparing expected residual life for the average group of Australians with similar age and gender distribution to the STEMI survivors, to expected residual years of life for patients in each of the outcome groups. Future years have been discounted at 3% per annum [14].

Table 1 **Likelihood of patient outcome by presentation delay category [10,27].**

Pre-hospital delay (hours)	Death <30 days	Congestive heart failure (CHF)	Repeat myocardial infarction (re-MI)	Good recovery*
<1	4.7%	3.3%	1.6%	90.4%
1-2	4.2%	6.8%	3.9%	85.1%
2-3	5.1%	10.1%	4.9%	80.0%
3-4	5.4%	13.5%	4.7%	76.5%
4-5	5.6%	16.8%	4.5%	73.2%
5-6	7.1%	20.3%	4.6%	68.1%
6-12	8.5%	30.3%	4.7%	56.6%
>12	8.5%	40.4%	4.7%	46.5%

*Represents remaining patients after all other categories summed.

Productivity Losses

Productivity losses refer to the loss of production due to illness and mortality. Productivity losses are estimated using the human capital approach which assumes that productive output is equal to the compensation paid to the worker, so work time is valued according to gross wage.

The productivity losses converted to monetary terms include:

1. Productivity loss due illness (reduced workforce participation)

Survivors of a STEMI experience a level of ill-health and disability following discharge from hospital, so the productivity losses due to STEMI-related morbidity is estimated as the present value of lost gross wage over the period of the illness. The extent of disability is determined by the characteristics of the population, including:

- Average wage by gender;
- Proportion of people employed at each age and gender;
- Proportion of full time and part time employees;
- Likelihood of return to work;
- Pre-retirement mortality.

Assumptions for each of these have been derived from the Australian Bureau of Statistics [13,15]. As at November 2015, ABS data estimated that the average full time earnings was $87,807 for males and $69,982 for females [16]. It is assumed that part-time earnings are 35% of full-time earnings [16]. A retirement age of 65 years and a real discount rate of 4% were applied.

A greater number of patients with a good recovery were assumed to return to work (77%) in comparison to CHF and re-MI (68%), and those with a good recovery were assumed to return to work sooner (2 months) than those with re-MI (5 months) [17,18]. There was limited evidence in the average time taken to work with those developing CHF following STEMI, so, given the similar proportion of these patients returning to work in comparison to the re-MI category, it is assumed that time taken to return to work is the same.

2. Productivity loss due to premature mortality

Following a STEMI, patients have a greater likelihood of death compared to the standard population. Productivity losses due to premature death is estimated as the present value of lost gross wage from time of death to retirement age (assumed to be 65 years). Accounting for gender, employment rate and age, the productivity loss per person is calculated as the net present value of the average yearly wage [16], with a 4% real discount rate [9].

Other assumptions

Other assumptions incorporated in the analysis included:

- Campaign costs: AU$10.2 million (National Heart Foundation of Australia, unpublished data, 2016);
- Direct inpatient costs: AU$18,068 per separation [19];
- Long-term health care costs (includes general practitioner, out of hospital specialists, pharmaceuticals and readmissions): AU$5367–$13,231 per annum depending on patient outcome category [20];
- Informal care costs: AU$2058–$5881 per annum depending on patient outcome category [15,18,21];
- Net DWL: 27.5% marginal social cost per dollar of public funds [22].

Results

Socioeconomic Impacts (Monetised)

Table 2 outlines the results from a CBA perspective, incremental to the Base Case. Due to the reduction in mortality under the scenarios, there is an estimated overall net saving of $41.2 million and $139.1 million under Scenarios 1 and 2 respectively. This equates to a BCR of 3.23 and 5.06 under Scenario 1 and 2 respectively.

Results are driven by the improved presentation delay patterns, which result in a reduction in mortality under the scenarios. With a greater number of survivors under each scenario, there are higher ongoing long-term health care costs and net DWL. This is more than offset by the productivity gains and reductions in informal care costs.

Table 2 Cost benefit analysis results (AU$m) – incremental to the Base Case (2017 dollars).

	Base Case	Scenario 1	Scenario 2
Benefits			
Reduction in productivity loss due to mortality	–	43.8	127.3
Reduction in productivity loss due to illness	–	1.9	5.6
Reduction in informal care costs	–	13.9	40.4
Total benefits	**–**	**59.6**	**173.3**
Costs			
Campaign costs	–	10.2	10.2
Direct inpatient costs	–	–	–
Long-term health care costs	–	6.5	18.9
Increase in net deadweight loss	–	1.8	5.2
Total costs	**–**	**18.5**	**34.2**
Net benefit/savings	**–**	**41.2**	**139.1**
Benefit Cost Ratio	**–**	**3.23**	**5.06**

Burden of Disease (Non-Monetised)

The impacts on burden of disease are outlined in Table 3. Disability adjusted life years were lower by 6046 and 17,575 years for Scenarios 1 and 2 respectively in comparison to the Base Case. As a result, DALYs lost per STEMI hospitalisation were lower by 0.43 and 1.26 for Scenarios 1 and 2 respectively in comparison to the Base Case.

The improved presentation delay patterns under the scenarios also led to a reduction of 61 and 178 deaths within 30 days under Scenarios 1 and 2 respectively.

Discussion

This research estimates that a reduction in mean pre-hospital delay time to 2.0–4.1 hours could result in net benefits of $41.2–$139.1 million across Australia. The majority of the benefits are expected to result from a reduction in productivity losses due to a reduction in premature mortality. Patients with shorter pre-hospital delay times are likely to have better functional outcomes and quality of life, so will require less support in terms of informal care.

Reducing mortality leads to an increase in morbidity, resulting in greater ongoing longer term health care costs and net DWL. However, these costs are more than offset by the benefits associated with improvements in quality of life and workforce participation.

This research demonstrates that a relatively small investment has the potential to generate considerable benefits across Australia, as demonstrated by the BCR of 3.23–5.06.

Realising these benefits is dependent on implementing effective, evidence-based interventions. Many organisations have launched awareness campaigns to educate the public, however the influence on pre-hospital delay times have been mixed [23].

The campaign implemented by the National Heart Foundation of Australia was part of a multi-faceted strategy which included social marketing campaigns aimed at creating greater relevance in the community about the risk of heart attack, improving confidence in knowing what to do when experiencing symptoms, and increasing the likelihood that people would call an ambulance as a first-line response. It also addressed some of the known barriers impacting pre-hospital delay times including lack of awareness of typical

Table 3 Reduction in burden of disease incremental to the Base Case.

	Base Case	Scenario 1	Scenario 2
Burden of disease			
Years of life lost to premature mortality	–	−5,473	−15,910
Years of life lost to disability	–	−573	−1,665
Disability Adjusted Life Years (DALYs) lost	**–**	**−6,046**	**−17,575**
DALYs lost per STEMI hospitalisation	**–**	**−0.43**	**−1.26**
Deaths within 30 days	–	**−61**	**−178**

Abbreviations: STEMI, ST Segment Elevation Myocardial Infarction.

and atypical symptoms and being too embarrassed to ask for assistance [18]. These elements may explain the effectiveness of the campaign [6]. However, significant effort, supplementary strategies and sustained investment will be required over the long term to reinforce messages and ensure that key messages remain relevant, enabling benefits to be realised into the future [24,25].

There are several limitations to this analysis driven by the lack of available data and research. Patients presenting to the hospital very early (i.e. < 1 hr) and having a potential STEMI averted by treatment are not captured in this analysis because the STEMI event is avoided. Consequently, the analysis may underestimate the impact of the campaign on patients presenting to the hospital within one hour. Furthermore, there is evidence that this cohort is increasing, with evidence that procedures such as pre-hospital thrombolysis increasingly common.

A number of other clinical scenarios could also occur. Four outcome categories are presented in this analysis, however, there are several other outcomes that may occur following STEMI, such as stroke, angina, chronic ischaemic heart disease or a combination of multiple morbidities. For example, it has been estimated that 20% of patients developed angina following AMI [26].

The analysis considers STEMI only, but benefits of the campaign are likely to hold true for non-STEMI events, even if not to the same magnitude. This means the analysis could understate the benefits of the campaign. In addition, the analysis does not capture the impact of averting pre-hospital deaths that could occur from a reduction in pre-hospital delay time, which could understate the benefits.

There is limited research on the longer term outcomes and ongoing costs associated with each pre-hospital delay category. The four patient outcome categories that were identified could vary in severity, but assumptions were based on average costs across each disease group more broadly. For example, there are varying degrees of severity of CHF and CHF could occur in the absence of an initial heart attack. However, the available literature considers CHF as a disease group more broadly so costs and outcomes in this analysis are based on this.

Further research is needed to address these limitations in order to determine the impacts of behaviour change with greater accuracy.

Conclusions

Implementing an effective, evidence-based public awareness/education campaign can generate significant benefits for society and the broader economy. Benefits include a reduction in productivity losses due to mortality and illness, reduction in the burden of disease and reduction in informal care costs. These gains more than offset the costs associated with implementing a campaign and keeping people living longer such as ongoing health care costs. Many of the benefits occur in the longer term and may not be immediately apparent (and cashable). Policy-makers should therefore consider the broad range of socioeconomic impacts in addition to the immediate financial impacts during investment decision-making.

Conflicts of Interest

There are no conflicts of interest associated with this research.

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