Comparative Effectiveness of Population Interventions to Improve Access to Reperfusion for ST-Segment–Elevation Myocardial Infarction in Australia

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Background—Improving timely access to reperfusion is a major goal of ST-segment–elevation myocardial infarction care. We sought to compare the population impact of interventions proposed to improve timely access to reperfusion therapy in Australia.

Methods and Results—Australian hospitals, population, and road network data were integrated using Geographical Information Systems. Hospitals were classified into those that provided primary percutaneous coronary intervention (PPCI) or fibrinolysis. Population impact of interventions proposed to improve timely access to reperfusion (PPCI, fibrinolysis, or both) were modeled and compared. Timely access to reperfusion was defined as the proportion of the population capable of reaching a fibrinolysis facility ≤60 minutes or a PPCI facility ≤120 minutes from emergency medical services activation. The majority (93.2%) of the Australian population has timely access to reperfusion, mainly (53%) through fibrinolysis. Only 40.2% of the population had timely access to PPCI, and access to PPCI services is particularly limited in regional and nonexistent in remote areas. Optimizing the emergency medical services’ response or increasing PPCI services resulted in marginal improvement in timely access (1.8% and 3.7%, respectively). Direct transport to PPCI facilities and interhospital transfer for PPCI improves timely access to PPCI for 19.4% and 23.5% of the population, respectively. Prehospital fibrinolysis markedly improved access to timely reperfusion in regional and remote Australia.

Conclusions—Significant gaps in timely provision of reperfusion remain in Australia. Systematic implementation of changes in service delivery has potential to improve timely access to PPCI for a majority of the population and improve access to fibrinolysis to those living in regional and remote areas. (Circ Cardiovasc Qual Outcomes. 2012;5:429-436.)

Key Words: acute coronary syndromes ■ geo-spatial data analysis ■ epidemiology ■ health policy ■ outcomes

Primary percutaneous coronary intervention (PPCI) and fibrinolysis are well-established as lifesaving therapies in ST-segment–elevation myocardial infarction (STEMI). Trial evidence supports PPCI as the reperfusion strategy of choice, given established mortality benefit. Recent data have highlighted the importance of timeliness of reperfusion, (either PPCI or fibrinolysis), with delays beyond guideline-recommended times associated with adverse 30-day and 1-year outcomes. Improving access to timely reperfusion and, preferably, to PPCI is a major goal in improving STEMI care.

Several interventions have been advocated to maximize access to timely reperfusion. These include improving emergency medical services (EMS) response, increasing the number of PPCI facilities, transferring patients from noninterventional to PPCI-capable facilities, EMS diversion to PPCI facilities (bypassing noninterventional facilities), and prehospital fibrinolysis. These interventions have been identified through clinical trial evidence demonstrating improved outcomes for individual patients or from perceived benefit based on clinical consensus.

From a health policy perspective, however, evidence of clinical efficacy alone is insufficient. It is critically important to define the situations where these interventions are of benefit and the magnitude of benefit likely to be achieved by implementing these interventions at a population level. Access to reperfusion is time-critical and is dependent on the

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The online-only Data Supplement is available at http://circoutcomes.ahajournals.org/lookup/suppl/doi:10.1161/CIRCOUTCOMES.111.965111/-/DC1. Correspondence to David Brieger, MBBS, PhD, FRACP, FACC, Department of Cardiology, Level 3 West, Concord Repatriation General Hospital and the University of Sydney, Sydney Hospital Rd, Sydney, NSW 2139, Australia. E-mail davidb@email.cs.nsw.gov.au © 2012 American Heart Association, Inc.
population distribution, EMS response, and travel times and the distribution of PPCI and fibrinolysis facilities. Determining how to maximize timely access to PPCI (and to fibrinolysis if PPCI is not available) in the context of these population-specific factors is critical. We sought to model and compare the relative benefits of different interventions advocated to improve timely access to reperfusion. Specifically, hospital strategies involving investment in PCI programs and EMS strategies involving EMS optimization, diversion to PPCI facilities, interhospital transfer, and prehospital fibrinolysis were compared.

WHAT IS KNOWN

- Many strategies are advocated to improve access to reperfusion therapy for STEMI. The population impacts of these interventions are unknown

WHAT THE STUDY ADDS

- We evaluated time access to reperfusion therapy for the Australian population and found that, overall, 93.2% had timely access predominately through fibrinolysis (53.0%) rather than PPCI (42.0%).
- We found that the population interventions varied widely in their ability to improve timely access to reperfusion. Interhospital transfer and EMS diversion to PPCI facilities increased timely access to reperfusion the most.
- Our analysis suggests significant potential to improve timely access to reperfusion by systematic deployment of interventions. Geographical Information Systems provides a robust tool to model the population effects of health service interventions.

Methods

Data Sources

Geographically distributed Australian population, acute hospitals, and road network data were integrated using Geographical Information Systems (GIS) software (ArcGIS version 9.3). Population data were derived from the Australian 2006 Census and assessed at the level of a collection district (CD), defined as an area including 225 dwellings and forming the smallest available population unit for analysis. Analysis was restricted to adults aged ≥20 years. A total of 38,704 collection districts were located in Australia. Acute care hospitals were identified from the Australian Institute of Health and Welfare hospital statistics database. Nonacute and specialized women’s, children’s, psychiatric, rehabilitation, and correctional health services were excluded. Hospitals that provided PPCI services were identified by accessing published official reports and consulting key experts involved in the provision of regional cardiac services and verified by contacting hospitals directly. All other acute care hospitals were considered capable of providing fibrinolysis. All hospitals and PPCI facilities were geocoded for the GIS analysis. Incorporation of national road network data (GEODATA Topo Series 3, Geoscience Australia) allowed precise calculation of distance and estimation of driving times between population units (CDs) and hospitals along existing roads. In keeping with previous methods, driving times were calculated as the product of estimated distances and project travel speeds across different road types. (See online-only Data Supplement.) The closest hospital was determined with a heuristic algorithm and based on shortest driving time. Air transport was not considered for this analysis owing to the limited availability of air transport and the lack of availability of reliable estimates for flying times required for analysis in Australia.

Baseline Analysis

For the baseline analysis, 49% of the population was estimated to use EMS when experiencing chest pain, based on data from the Heart Foundation of Australia Early Warning Signs Program (personal communication, Christopher Poulter, National Heart Foundation). We assumed that the EMS transported the patient to the nearest available hospital and that patients who self-presented also drove to their nearest hospital. Times to reperfusion were established by estimating the median EMS dispatch, assessment, and transport time (hereafter referred to as driving time) to the nearest hospital.

In estimation of prehospital driving times, we included an EMS dispatch time of 1 minute for major cities and 2 minutes for regional and remote areas, as well as an EMS response time of 9 minutes for major cities, 11 minutes for regional areas, and 15 minutes for remote areas. Additionally, time at the scene was estimated to be 15 minutes for major cities and 17 minutes for regional and remote areas. These estimates are derived from published Australian data. We assumed that patients who self-refer have the same driving time as those using EMS. The hospitals were then stratified into PPCI and fibrinolysis facilities, allowing estimation of the proportion of adult Australians for whom a PPCI or fibrinolysis facility was the nearest hospital.

Outcome Measures

The primary outcome was the proportion of the adult population who had timely access to reperfusion defined as the proportion of the population capable of traveling to a fibrinolysis facility ≤60 minutes or a PPCI facility ≤120 minutes from EMS activation from their place of residence (CD) for each scenario. The 60-minute time window for fibrinolysis was selected as guidelines recommend reperfusion within a total ischemic time of ≤90 to 120 minutes as target of therapy for optimal outcomes, and this can be achieved when prehospital assessment and transport time is ≤60 minutes. Additionally, the 60-minute time frame is consistent with other published studies that have evaluated timely access to reperfusion. We assumed that equipoise in outcomes between PPCI and in-hospital fibrinolysis occurs when the differential delay to the former reaches 60 minutes.

Interventions to Improve Timely Access to Reperfusion

The population implications of several interventions that have been proposed to improve timely access to PPCI, fibrinolysis, or both were modeled.

1. Optimizing EMS response was assessed by substituting guideline-recommended times for existing estimates of EMS response times (1 minute for EMS dispatch, 8 minutes for EMS response, and 8 minutes for time at scene). A 20% increase in EMS use from a baseline of 49% was also projected, based on the maximum potential improvement in EMS use observed in the randomized trial setting.

2. Increasing PPCI services was assessed by evaluating the effect of establishing 10 new PPCI facilities (representing a substantial increase in the total number of PPCI facilities) in the most densely populated areas without existing proximate PPCI facilities.

3. Routine interhospital transfer was assessed by evaluating the proportion of the population capable of being transferred from a fibrinolysis-enabled to a PPCI-enabled facility, provided that the total time (EMS activation to first hospital plus transfer to PPCI facility) was ≤120 minutes consistent with the American Heart Association (AHA) recommendations. There are no published Australian data on the estimated time delay at the noninterventional facility. Therefore, the estimate of transfer time included an estimated door-in, door-out (DIDO) time of 68 minutes at the noninterventional hospital, reflecting median DIDO time reported in contemporary
international literature. We also modeled the impact of routine inter-hospital transfer time if the DIDO time was 30 minutes. This allowed us to represent the potential gain from improving DIDO time from the current practice to guideline-recommended time.

4 EMS diversion to PPCI facilities was assessed by evaluating the proportion of the population for whom EMS triage and diversion to a PPCI facility (bypassing fibrinolysis hospitals) resulted in an additional delay ≤60 minutes and a total time to PPCI facility ≤120 minutes. An extra 4-minute EMS delay was included in calculating driving times to allow for a prehospital ECG. This strategy was assumed to be applicable only for the 49% of the population using EMS.

5 Prehospital fibrinolysis was assessed by evaluating the proportion of the population using EMS and capable of receiving prehospital fibrinolysis for whom the additional delay to PPCI or in-hospital fibrinolysis services exceeded 60 minutes. This assumed: (1) PPCI is superior to fibrinolysis, provided the additional delay is ≤60 minutes; and (2) the benefit of prehospital fibrinolysis is only present where the additional delay to in-hospital fibrinolysis exceeds 60 minutes, based on existing literature.

### Data Analysis

Data were stratified by geographical region using the 2006 Australian Standard Geographical Classification (ASGC) Remoteness classification. This classified regions as Major Cities, Inner and Outer Regional centers, Remote, and Very Remote, based on physical distance of a location from the nearest urban center based on population size. To assess the implications of projected driving speeds on our baseline analysis, a sensitivity analysis was performed by varying the projected driving speeds by ±25%. Driving times and distances were not normally distributed and are therefore presented as medians and interquartile range. All statistical analyses were performed using SAS version 9.0 (SAS Institute).

### Results

Of the 351 acute care hospitals in Australia, 42 (12.0%) had PPCI facilities. The 2006 Australian Census identified 14.5 million adults, constituting 69% of the total population. Most (69.2%) resided in major cities, which represent 0.2% of the total land area of Australia. Most PPCI facilities (81.0%) were also located in major cities, with 8 PPCI facilities (19.0%) located in regional Australia. There were no PPCI facilities in remote Australia (Figure 1 and Table 1). When the proportion of the population residing close to PPCI and fibrinolysis facilities was evaluated, an estimated 82.1% of the adult population resided close to a PPCI facility and 87.1% resided close to a fibrinolysis-capable hospital (Table 2).

### Table 1. Hospitals and Population Distribution, Land Area, and Density by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>PPCI Hospitals*</th>
<th>Fibrinolysis Hospitals*</th>
<th>Population No.</th>
<th>% Total Population</th>
<th>Land Area (km²)</th>
<th>% Total Land Area</th>
<th>Density per km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major cities</td>
<td>34</td>
<td>54</td>
<td>100 48 494</td>
<td>69.2%</td>
<td>17 426</td>
<td>0.2%</td>
<td>576.63</td>
</tr>
<tr>
<td>Inner regional</td>
<td>5</td>
<td>122</td>
<td>2 819 174</td>
<td>19.4%</td>
<td>243 654</td>
<td>3.2%</td>
<td>11.57</td>
</tr>
<tr>
<td>Outer regional</td>
<td>3</td>
<td>91</td>
<td>1 346 972</td>
<td>9.3%</td>
<td>834 270</td>
<td>10.8%</td>
<td>1.61</td>
</tr>
<tr>
<td>Remote</td>
<td>0</td>
<td>22</td>
<td>208 000</td>
<td>1.4%</td>
<td>1 019 728</td>
<td>13.2%</td>
<td>0.20</td>
</tr>
<tr>
<td>Very remote</td>
<td>0</td>
<td>20</td>
<td>100 859</td>
<td>0.7%</td>
<td>5 586 988</td>
<td>72.5%</td>
<td>0.02</td>
</tr>
<tr>
<td>Australia overall</td>
<td>42</td>
<td>309</td>
<td>14 523 499</td>
<td>100%</td>
<td>7 702 066</td>
<td>100.0%</td>
<td>1.89</td>
</tr>
</tbody>
</table>

PPCI indicates primary percutaneous coronary intervention.

*No. of hospitals.
Interventions to Improve Access to Reperfusion: Optimizing Emergency Medical Services Response

Optimized EMS response resulted in improvement in timely access for an additional 1.8% of the adult population, with all of the improvement resulting from improved timely access to fibrinolysis (Table 3). Benefit from optimized EMS response occurred primarily in inner and outer regional areas, with an estimated 6.2% to 6.4% increase in population access to timely reperfusion in these areas (Figure 2B).

Establishing New PPCI Facilities

Modeling the establishment of 10 new PPCI facilities resulted in a modest 3.7% improvement in timely access to PPCI (Figure 2C), with benefit primarily occurring in inner regional areas, but resulted in a corresponding decline in access to fibrinolysis, with no improvement in overall timely access to reperfusion (Table 3).

Interhospital Transfer From Noninterventional to Interventional Facilities

Modeling interhospital transfer for PPCI resulted in additional timely access to PPCI services for an estimated 23.5% (3.42 million) of the adult population who would have otherwise received fibrinolysis in hospital (Figure 2D, Table 3). For those who were transferred, the median additional distance and time delay resulting from interhospital transfer was 12.4 (interquartile range [IQR], 10.0 to 16.4) km and 78.3 (IQR, 75.1 to 83.0) minutes, with a median total time to reach PPCI facilities from EMS activation (driving time to initial hospital plus interhospital transfer time) of 115.0 minutes and a total distance of 19.2 (IQR, 14.6 to 24.5) km. The benefits of interhospital transfer primarily occurred in major cities, where PPCI and fibrinolysis facilities were located in proximity, making interhospital transfer feasible. Although the above results were obtained estimating a DIDO time of 68 minutes, adopting a DIDO time of 30 minutes (as recommended by current guidelines) resulted in an increase in timely access to PPCI services for an estimated 34.4% (4.91 million), representing an additional 10.9% improvement in access to PPCI.
Prehospital EMS Triage and EMS Diversion to PPCI Facilities

A strategy of EMS triage and diversion to a PPCI facility resulted in a 19.4% (2.82 million) increase in the proportion of the population who had timely access to PPCI services (Figure 2E, Table 3). For those who underwent diversion, the median driving time and distance to the PPCI facility was estimated to be 46.4 (39.4 to 59.3) minutes and 20.1 (11.8 to 40.2) miles.

Table 3. Population Effects of Strategies to Improve Timely Access to Reperfusion

<table>
<thead>
<tr>
<th>Strategy</th>
<th>PPCI ≤120min</th>
<th>Δ Baseline*</th>
<th>Fibrinolysis ≤60min</th>
<th>Δ Baseline*</th>
<th>Overall Timely Access</th>
<th>Δ Baseline*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>40.2%</td>
<td>–</td>
<td>53.0%</td>
<td>–</td>
<td>93.2%</td>
<td>–</td>
</tr>
<tr>
<td>Optimized EMS response</td>
<td>40.2%</td>
<td>0.0%</td>
<td>54.8%</td>
<td>1.8%</td>
<td>95.1%</td>
<td>1.8%</td>
</tr>
<tr>
<td>New PPCI facilities</td>
<td>43.9%</td>
<td>3.7%</td>
<td>49.3%</td>
<td>−3.7%</td>
<td>93.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Interhospital transfer for PPCI</td>
<td>63.8%</td>
<td>23.5%</td>
<td>29.4%</td>
<td>−23.5%</td>
<td>93.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Direct transfer for PPCI</td>
<td>59.6%</td>
<td>19.4%</td>
<td>33.5%</td>
<td>−19.4%</td>
<td>93.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Prehospital fibrinolysis†</td>
<td>40.2%</td>
<td>0.0%</td>
<td>56.7%</td>
<td>3.7%</td>
<td>96.9%</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

PPCI indicates primary percutaneous coronary intervention; EMS, emergency medical services.

*Refers to population change from baseline levels of access.
†Values for fibrinolysis ≤60 min includes in-hospital fibrinolysis and prehospital fibrinolysis.
after STEMI.27–29 The benefits are largely limited to major
cities where fibrinolysis and PPCI facilities are located in
remote areas. The estimated 7.4% to 36.9% incremental benefits of
prehospital fibrinolysis noted in regional and remote areas was
markedly higher than any other strategy evaluated in these
regions (Figure 2F, Table 3).

Prehospital Fibrinolysis
A strategy of prehospital fibrinolysis led to an estimated 3.7%
increase in the adult population who received timely reperfu-
tion. The benefit was exclusively seen in regional and remote
areas. The estimated 7.4% to 36.9% incremental benefits of
prehospital fibrinolysis noted in regional and remote areas was
markedly higher than any other strategy evaluated in these
regions (Figure 2F, Table 3).

Discussion
These analyses, based on GIS, a robust means of assessing
access to healthcare services, show that timely access to reper-
fusion is currently provided to the majority of the Australian
population; however, current systems of care in which the
default strategy is to transport patients to the nearest acute
care hospital means that only 40.2% of population has timely
access to PPCI. In-hospital fibrinolysis remains the main mode
of timely reperfusion throughout Australia, and in regional
and remote areas, many individuals do not have timely access
to any form of reperfusion therapy.

The population impact of interventions advocated to
improve reperfusion, modeled in this analysis, varied mark-
edly in both scope and magnitude. Optimizing EMS response
alone (without preferential diversion to PPCI facilities or pro-
viding prehospital fibrinolysis) resulted in a modest increase
in access to timely reperfusion; however, most (66% to 75%)
deaths from STEMI occur before hospitalization.23,24 Rapid
EMS response and treatment (especially defibrillation) may
improve survival.25 A near 25% increase in PPCI facilities
resulted in a modest 3.7% improvement in timely access to
PPCI facilities. This limited impact most likely reflects the
population densities of regional and remote areas, which are
50-fold lower than in major cities. Any increase in the number
of PPCI facilities in these areas results in only modest over-
all population gain. The limited benefit of increasing PPCI
facilities in improving access has also been noted in other
recent studies.26 Conversely, 82.1% of the adult population in
Australia resides within 120 minutes of driving time of PPCI
facilities. This indicates that existing PPCI facilities are sub-
stantially underused in the absence of systems to preferen-
tially divert patients to these facilities.

Interhospital transfer and diversion to PPCI facilities
preferentially direct patients to PPCI services for those who
would otherwise receive fibrinolysis. These interventions both
provide the potential for pre-PCI hospital activation of cath-
erization laboratories, which can result in marked reduc-
tion in door-to-balloon times and improved patient outcomes
after STEMI.27,28 The benefits are largely limited to major
cities where fibrinolysis and PPCI facilities are located in
proximity, making access to PPCI facilities within an addi-
tional 60-minute delay feasible. In addition, the benefit of
diversion to PPCI facilities is limited to those who use EMS.

Our evaluation of interhospital transfer resulted in an
estimated additional transfer time to PPCI facility of 78.3
(IQR, 75.1 to 83.0) min. This is consistent with findings of
meta-analysis of interhospital transfer trials, which suggests
benefit of PPCI over thrombolytic therapy persists for time
delays of up to 70 to 130 minutes.30 The estimated DIDO
time of 68 minutes used in our analysis is reflective of actual
clinical practice39,41 but is substantially longer than the rec-
ommended time interval of 30 minutes; however, a small propor-
tion of patients do achieve DIDO time ≤30 minutes,
suggesting this optimistic target is plausible. Our estimates
suggest additional capacity to further improve access to PPCI
by interhospital transfer if a DIDO time of 30 minutes can be
routinely achieved in clinical practice. Concerted measure
to improve DIDO time, routine measurement of interhospital
transfer delay as a quality indicator, and adoption of system-
based interventions associated with reduced transfer times
identified in recent analyses may overcome existing barriers
to rapid interhospital transfer.32,33

Prehospital fibrinolysis and improving EMS response
were the only interventions associated with improvement in
overall timely access to reperfusion for the Australian popu-
lation. Primary benefit of prehospital fibrinolysis occurs in
out regional and remote areas, where hospitals are sparse
and existing timely access is suboptimal. Implementing this
strategy alone would ensure 96.9% of our adult population
would have timely access to reperfusion regardless of their
residential location.

A hybrid approach of fibrinolysis (pre- or in-hospital) fol-
lowed by rapid transfer to PPCI facilities may be associated
with reduced mortality compared with fibrinolysis alone.34–37
Our analysis evaluated access to the initial mode of reper-
fusion, which, we believe, is the most time-critical; however,
existing timely access to a fibrinolysis or PCI-capable fac-
ility for the majority of the population limits the applicability
of prehospital lysis to a small proportion (3.7%) for whom
prehospital-based facilitated PCI or a pharmaco-invasive
approach may be considered. Conversely, in-hospital fibrin-
olysis and rapid transfer for PPCI is likely to be highly fea-
sible, given that 33.8% of the population are already capable
transfer within 1 hour, which is substantially shorter than
the 3 to 24 hours advocated for a pharmaco-invasive
approach.38

Our study does have several limitations. There is cur-
rently no national database that reports services offered by
individual hospitals in Australia and, although PPCI services
are relatively readily identifiable, it is possible, but unlikely,
that some of the acute care hospitals included in our study
did not provide fibrinolysis. We used projected driving speeds
based on road type, and we did not take into consideration
other factors such as traffic conditions; however, our sensitiv-
ity analysis does suggest that variation in driving times does
not significantly influence access to PPCI facilities, and traf-
fic patterns have limited effect on EMS response times.29 Our
baseline analysis assumed that all patients are transported to
the nearest hospital and did not take into account hospitals
with existing prehospital triage systems; however these facilities are currently very few in number and constrained by restricted EMS capacity. We did not consider air transport for STEMI owing to the relative lack of availability of this resource in Australia and the inconsistent evidence of the benefit of air transport in shortening reperfusion times in the literature. \(^{30-40}\) Our analysis did not consider the duration of symptoms before EMS activation, which may influence the choice of PPCI or fibrinolysis. Additionally, we did not consider the cost-effectiveness of each intervention, which may also influence their implementation.

Despite these limitations, this study does have a number of strengths. Decisions regarding implementation of health services are often made on clinical evidence alone, which, in part, reflects the lack of robust methodology to facilitate incorporation of population-specific factors into the decision-making process. GIS methods overcome this limitation by providing an objective process to incorporate population-specific factors. Although this involves modeling based on best available estimates, GIS is, nonetheless, a powerful tool that allows for both large area (national) and precise (small area) analysis. Although the use of GIS methods for quantifying access to services is not novel, \(^{10-12}\) we believe there is great potential for the wider use of GIS methods in conducting population-level comparative effectiveness research (CER), leading to substantially better-informed decision-making regarding implementation. These analyses are critical for informing future health policy innovation, particularly in the current era of increasing healthcare costs and increased demand for better use of limited resources. Although we have used Australian data in the context of reperfusion for STEMI, GIS methods can be readily adapted to other health services or populations. We believe increasing knowledge of GIS methods, ease of use of GIS software, and increasing accessibility to spatially distributed population datasets will facilitate the wider use of GIS methods by clinicians and healthcare policy planners.

**Conclusions**

We have identified deficiencies in current service provision in Australia that reflect a failure to implement nationwide policies to maximize timely access to lifesaving treatments for STEMI. Concerted efforts to improve outcomes for patients with STEMI will require multiple system-level changes. Interventions whereby prehospital triage and diversion to a PPCI site is provided to patients who call EMS, expedited interhospital transfer is provided to those who self-present to a fibrinolysis hospital, and prehospital fibrinolysis is facilitated in remote Australia are likely to result in the greatest improvement in health outcomes.

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**Disclosures**

None.

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SUPPLEMENTAL MATERIAL

Projected driving speeds:

Projected driving speeds were based on the National road type classification (Geoscience Australia*). Road type, projected speeds and the ±25% variation for sensitivity analyses is given below.

Projected driving speeds based on road type.

<table>
<thead>
<tr>
<th>Road Type*</th>
<th>Projected Speed (Km/Hr)</th>
<th>Minus 25%</th>
<th>Plus 25%</th>
<th>Definition of Road Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Carrigeway</td>
<td>100</td>
<td>75</td>
<td>125</td>
<td>Divided Highway, Freeway, Tollway, or other major roads with separated carriageways in opposite directions</td>
</tr>
<tr>
<td>Principle Road Sealed</td>
<td>70</td>
<td>52.5</td>
<td>87.5</td>
<td>Highways, major through routes and major connecting roads</td>
</tr>
<tr>
<td>Principle Road Unsealed</td>
<td>40</td>
<td>30</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Secondary Road Sealed</td>
<td>50</td>
<td>37.5</td>
<td>62.5</td>
<td>Connecting roads that provide a connection between major through routes and/or major connecting roads, or connections</td>
</tr>
<tr>
<td>Secondary Road Unsealed</td>
<td>40</td>
<td>30</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Minor road Sealed</td>
<td>40</td>
<td>30</td>
<td>50</td>
<td>All other roads which form part of the public roads system between Principal roads and Secondary roads.</td>
</tr>
<tr>
<td>Minor road Unsealed</td>
<td>30</td>
<td>22.5</td>
<td>37.5</td>
<td></td>
</tr>
<tr>
<td>Vechical Track Unsealed</td>
<td>20</td>
<td>15</td>
<td>25</td>
<td>Public or private roadways of minimum or no construction which are not necessarily maintained</td>
</tr>
</tbody>
</table>


Appendix 1:

Appendix 1: Effect of altering projected driving speeds

<table>
<thead>
<tr>
<th>Region</th>
<th>Minus 25% Driving Speed</th>
<th>Plus 25% Driving Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Timely Access to PPCI</td>
<td>% change‡</td>
</tr>
<tr>
<td>Major Cities</td>
<td>51.22%</td>
<td>-0.13%</td>
</tr>
<tr>
<td>Inner Regional</td>
<td>10.75%</td>
<td>-2.00%</td>
</tr>
<tr>
<td>Outer Regional</td>
<td>21.67%</td>
<td>-2.13%</td>
</tr>
<tr>
<td>Remote</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Very Remote</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Australia Overall</td>
<td>39.54%</td>
<td>-0.68%</td>
</tr>
</tbody>
</table>

Appendix 1 Footnote:

Abbreviations: PPCI = Primary percutaneous coronary intervention